Nardostachys jatamansi : A Comprehensive Review of Its Botanical Characteristics, Phytochemistry, and Pharmacological Activities

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Abstract

Nardostachys jatamansi (D. Don) DC., commonly known as Jatamansi or spikenard, is an important medicinal plant widely used in traditional systems of medicine such as Ayurveda, Unani, Siddha, and Tibetan medicine. The plant is primarily valued for its rhizomes and roots, which have been traditionally employed in the management of neurological disorders, stress-related conditions, cardiovascular ailments, and inflammatory diseases. Phytochemical investigations have revealed the presence of diverse bioactive constituents, including sesquiterpenes (notably jatamansone), essential oils, lignans, coumarins, flavonoids, and phenolic compounds. These constituents are responsible for a broad spectrum of pharmacological activities, including neuroprotective, sedative, anxiolytic, antidepressant, anticonvulsant, antioxidant, anti-inflammatory, cardioprotective, hepatoprotective, and antimicrobial effects. Experimental studies using in vitro and in vivo models have provided scientific validation for many of the traditional claims associated with *N. jatamansi*, particularly its beneficial effects on the central nervous system. However, despite promising preclinical evidence, clinical studies remain limited, and challenges related to standardization, safety evaluation, and conservation of this endangered species persist. This review comprehensively summarizes the botanical profile, traditional uses, chemical constituents, and pharmacological activities of *Nardostachys jatamansi*, highlighting current research gaps and emphasizing the need for further clinical investigations and sustainable utilization strategies

Introduction

Medicinal plants have served as an essential component of traditional healthcare systems since ancient times and continue to play a significant role in modern drug discovery. According to the World Health Organization, nearly 80% of the global population relies on plant-based medicines for primary healthcare, particularly in developing countries. Many contemporary pharmaceuticals have originated from natural sources, underscoring the importance of ethnomedicinal knowledge as a foundation for pharmacological research [1,2].

Nardostachys jatamansi (D. Don) DC., commonly known as Jatamansi or spikenard, is a perennial aromatic herb belonging to the family Caprifoliaceae. The plant is indigenous to the alpine and sub-alpine regions of the Himalayas, growing at elevations between 3,000 and 5,000 meters across India, Nepal, Bhutan, Tibet, and southwestern China [3,4]. The rhizomes and roots of *N. jatamansi* are highly valued in traditional medicine systems and are characterized by a strong, distinctive aroma due to the presence of volatile sesquiterpenes.

In Ayurvedic medicine, *N. jatamansi* is classified as a “Medhya Rasayana,” a group of rejuvenating herbs known to enhance cognitive function, memory, and mental health. Classical Ayurvedic texts such as *Charaka Samhita* and *Sushruta Samhita* describe its use in the management of neurological disorders, epilepsy, hysteria, insomnia, anxiety, and mental fatigue [5,6]. The plant has also been used for treating cardiovascular disorders, digestive ailments, liver dysfunction, and inflammatory conditions. In Unani medicine, Jatamansi is

regarded as a potent brain and heart tonic, while Tibetan medicine employs it for liver disorders and circulatory disturbances [7,8].

Phytochemical investigations have revealed that *N. jatamansi* contains a diverse array of bioactive compounds, including sesquiterpenes such as jatamansone (valeranone), nardostachone, nardosinone, and spirojatamol, along with lignans, coumarins, flavonoids, and phenolic compounds [9–11]. These constituents are believed to be responsible for the plant's wide range of pharmacological activities. Among them, jatamansone has been extensively studied for its sedative, anxiolytic, and neuroprotective effects [12].

Modern pharmacological studies have provided scientific validation for many of the traditional claims associated with *N. jatamansi*. Experimental investigations have demonstrated its neuroprotective, antioxidant, anti-inflammatory, cardioprotective, hepatoprotective, and antimicrobial properties [13–16]. Notably, its potential role in the management of stress-related disorders, neurodegenerative diseases, and oxidative stress-mediated pathologies has attracted increasing research attention. Despite these promising findings, clinical evidence remains limited, and issues related to standardization, safety evaluation, and sustainable utilization persist.

Furthermore, *N. jatamansi* has been classified as an endangered medicinal plant due to overharvesting, habitat destruction, and slow natural regeneration. The increasing commercial demand for its rhizomes has led to a significant decline in wild populations, highlighting the urgent need for conservation strategies and sustainable cultivation practices [17,18].

Botanical Profile of *Nardostachys jatamansi*

Nardostachys jatamansi (D. Don) DC. is a perennial, aromatic, rhizomatous herb belonging to the family Caprifoliaceae. The plant is commonly known as Jatamansi or spikenard and is widely recognized for its medicinally valuable underground parts, particularly the rhizomes and roots. Botanically, the plant is well adapted to alpine and sub-alpine Himalayan environments and exhibits slow growth, which contributes to its vulnerability in the wild [19,20].

Morphology

The plant possesses a stout, woody rhizome that is cylindrical to oblong in shape and densely covered with reddish-brown fibrous remains of leaf sheaths. These rhizomes emit a strong, characteristic aromatic odor due to the presence of volatile essential oils and serve as the primary medicinal part of the plant [21]. Numerous fibrous roots arise from the rhizome base, aiding in anchorage and nutrient absorption.

Figure 1- Morphology of Nardostachys jatamansi

Leaves are radical, forming a basal rosette. They are ovate to lanceolate, entire, and glabrous, with long petioles. The leaf lamina is dark green, with prominent venation, and shows adaptation to cold climatic conditions. The flowering stem is erect and arises from the center of the leaf rosette [22].

Flowers are small, tubular, and pink to bluish-purple in color, arranged in terminal cymose inflorescences. Flowering generally occurs during the summer months. The fruit is a dry achene, crowned with persistent calyx lobes that assist in seed dispersal by wind. The plant primarily reproduces through seeds; however, vegetative propagation through rhizomes is also observed [23].

Taxonomy

Rank	Classification
Kingdom	Plantae
Division	Tracheophyta
Class	Magnoliopsida
Order	Dipsacales
Family	Caprifoliaceae
Genus	*Nardostachys*
Species	*Nardostachys jatamansi* (D. Don) DC.

Table 1. Taxonomic Classification of *Nardostachys jatamansi*

Geographical Distribution and Habitat

N. jatamansi is native to the Himalayan region and is distributed across India, Nepal, Bhutan, Tibet, and southwestern China. In India, it is predominantly found in Uttarakhand, Himachal Pradesh, and Jammu & Kashmir at altitudes ranging from 3,000 to 5,000 meters. The plant thrives on moist, rocky slopes and prefers well-drained soils rich in organic matter [24].

Due to excessive harvesting for medicinal and commercial purposes, combined with habitat destruction and low natural regeneration rates, wild populations of *N. jatamansi* have declined significantly, leading to its classification as an endangered species [25].

Chemical Constituents of *Nardostachys jatamansi*

Phytochemical investigations of *Nardostachys jatamansi* have revealed the presence of a wide range of bioactive secondary metabolites that contribute to its therapeutic properties. The chemical composition of the plant varies depending on geographical location, altitude, harvesting time, and extraction method. The rhizomes and roots are the primary reservoirs of bioactive compounds [26].

Sesquiterpenes and Essential Oils

The most prominent chemical constituents of *N. jatamansi* are sesquiterpenes present in its essential oil fraction. The essential oil is responsible for the characteristic aroma and many of the plant's pharmacological effects. Major sesquiterpenes identified include jatamansone (also known as valeranone), nardostachone, nardosinone, spirojatamol, calarene, and β-maaliene [27–29].

Among these, jatamansone is considered a key bioactive compound and has been extensively studied for its sedative, anxiolytic, anticonvulsant, and neuroprotective activities. Nardosinone

has also attracted attention due to its potential role in modulating neurotransmitter systems and reducing neuroinflammation [30].

Lignans and Phenolic Compounds

Several lignans, including jatamansin and pinoresinol, have been isolated from the rhizomes of *N. jatamansi*. These compounds exhibit significant antioxidant activity by scavenging free radicals and inhibiting lipid peroxidation. Phenolic compounds and flavonoids present in the plant further contribute to its antioxidant and anti-inflammatory potential [31,32].

Coumarins, Steroids, and Other Constituents

In addition to sesquiterpenes and lignans, *N. jatamansi* contains coumarins, steroids, glycosides, and trace amounts of alkaloids. Coumarins such as umbelliferone have been reported to possess anti-inflammatory and hepatoprotective properties. The presence of these diverse chemical constituents supports the wide spectrum of pharmacological activities attributed to the plant in traditional medicine [33,34].

Phytochemical Class	Representative Compounds	Pharmacological Relevance
Sesquiterpenes	Jatamansone (valeranone), nardostachone	Neuroprotective, sedative
Essential oils	Spirojatamol, nardosinone	Anxiolytic, CNS depressant
Lignans	Jatamansin, pinoresinol	Antioxidant
Coumarins	Umbelliferone	Anti-inflammatory
Phenolics & flavonoids	Quercetin derivatives	Free radical scavenging

Table 2. Major Phytochemical Constituents of *Nardostachys jatamansi*

Pharmacological Studies of *Nardostachys jatamansi*

Extensive pharmacological investigations have been conducted on *Nardostachys jatamansi* to validate its traditional medicinal claims. Experimental studies using in vitro and in vivo models have demonstrated a wide spectrum of biological activities, particularly involving the central nervous system, oxidative stress modulation, inflammation, and organ protection. The pharmacological effects are primarily attributed to sesquiterpenes, lignans, and phenolic compounds present in the rhizomes and roots.

Activity	Experimental Model	Observed Effect
Neuroprotective	Rodent CNS models	Improved memory, reduced anxiety
Antioxidant	DPPH, lipid peroxidation assays	Reduced oxidative stress
Anti-inflammatory	Carrageenan-induced paw edema	Reduced inflammation
Cardioprotective	Ischemia-reperfusion models	Reduced myocardial injury
Hepatoprotective	CCl_4-induced liver toxicity	Improved liver enzymes
Antimicrobial	Bacterial & fungal strains	Moderate inhibition

Table 3. Pharmacological Activities of *Nardostachys jatamansi*

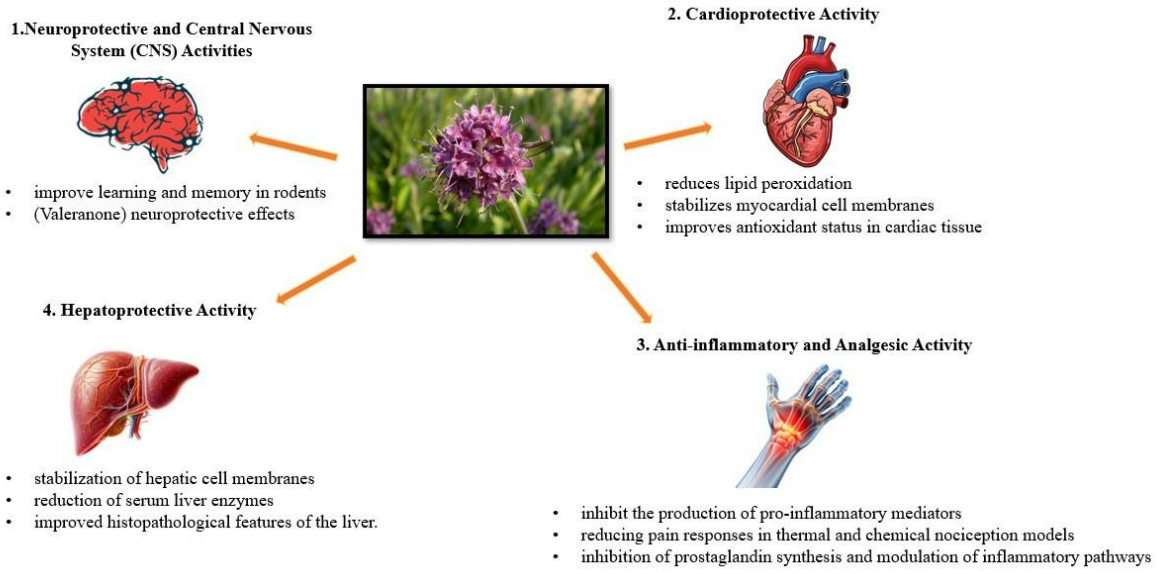

Figure 2- Pharmacological Activities of Nardostachys jatamansi

1. Neuroprotective and Central Nervous System (CNS) Activities

The most extensively studied pharmacological property of *N. jatamansi* is its effect on the central nervous system. Various extracts of the plant have demonstrated significant sedative, anxiolytic, antidepressant, anticonvulsant, and neuroprotective effects in experimental animal models.

Studies have shown that ethanolic and aqueous extracts of *N. jatamansi* improve learning and memory in rodents and exhibit anxiolytic activity comparable to standard drugs. These effects are believed to be mediated through modulation of neurotransmitters such as γ-aminobutyric acid (GABA), serotonin, and dopamine [35,36]. Jatamansone (valeranone), a major sesquiterpene constituent, has been identified as a key compound responsible for CNS depressant and neuroprotective effects.

Neuroprotective studies have demonstrated that *N. jatamansi* protects neuronal cells against oxidative stress-induced damage and neurodegeneration. Experimental models of cerebral ischemia and neurotoxicity have shown reduced neuronal damage and improved behavioral outcomes following treatment with *N. jatamansi* extracts [37,38].

2. Antioxidant Activity

Oxidative stress plays a crucial role in the pathogenesis of neurodegenerative diseases, cardiovascular disorders, and aging. Several studies have reported strong antioxidant activity of *N. jatamansi* extracts.

Methanolic and aqueous extracts have shown significant free radical scavenging activity in DPPH, ABTS, and lipid peroxidation assays. The antioxidant effect is attributed to the presence of phenolic compounds, lignans, and flavonoids, which enhance endogenous antioxidant defense systems such as superoxide dismutase, catalase, and glutathione peroxidase [39,40].

3. Anti-inflammatory and Analgesic Activity

Anti-inflammatory studies have demonstrated that *N. jatamansi* significantly reduces inflammation in experimental models such as carrageenan-induced paw edema and cotton

pellet-induced granuloma in rats. The extracts were found to inhibit the production of pro-inflammatory mediators, supporting its traditional use in inflammatory conditions [41].

Analgesic activity has also been reported, with extracts reducing pain responses in thermal and chemical nociception models. The anti-inflammatory and analgesic effects are likely mediated through inhibition of prostaglandin synthesis and modulation of inflammatory pathways [42].

4. Cardioprotective Activity

Cardioprotective effects of *N. jatamansi* have been demonstrated in several experimental studies. Administration of plant extracts has been shown to protect against myocardial ischemia-reperfusion injury and stress-induced cardiac damage.

Studies indicate that *N. jatamansi* reduces lipid peroxidation, stabilizes myocardial cell membranes, and improves antioxidant status in cardiac tissue. These effects contribute to the preservation of cardiac function and reduction of myocardial injury [43,44].

5. Hepatoprotective Activity

The hepatoprotective potential of *N. jatamansi* has been evaluated using chemically induced liver toxicity models such as carbon tetrachloride (CCl_4)-induced hepatotoxicity. Treatment with plant extracts resulted in significant reduction of serum liver enzymes and improved histopathological features of the liver.

The hepatoprotective effect is attributed to antioxidant mechanisms and stabilization of hepatic cell membranes, which prevent oxidative damage and lipid peroxidation [45,46].

6. Antimicrobial Activity

Antimicrobial studies have shown that essential oil and extracts of *N. jatamansi* exhibit moderate antibacterial and antifungal activity against several pathogenic microorganisms, including *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*.

The antimicrobial activity is primarily associated with sesquiterpenes present in the essential oil, which disrupt microbial cell membranes and inhibit microbial growth [47].

7. Antidepressant and Anti-stress Activity

Experimental studies using forced swim and tail suspension tests have demonstrated significant antidepressant-like effects of *N. jatamansi*. The plant has also shown anti-stress activity by normalizing stress-induced biochemical and behavioral changes.

These effects are believed to involve regulation of monoamine neurotransmitters and attenuation of stress-induced oxidative damage in the brain [48].

8. Toxicological Studies and Safety Profile

Acute and sub-chronic toxicity studies indicate that *N. jatamansi* is relatively safe at therapeutic doses. No significant mortality, behavioral abnormalities, or organ toxicity were observed in experimental animals. However, long-term safety and clinical toxicity data remain limited, emphasizing the need for further investigation [49].

9. Conclusion

Nardostachys jatamansi (D. Don) DC. represents a valuable medicinal plant with a long history of use in traditional systems of medicine, particularly for disorders of the central nervous system, cardiovascular ailments, and inflammatory conditions. The present review

comprehensively consolidates available information on its botanical characteristics, phytochemical composition, and pharmacological activities, providing a holistic understanding of its therapeutic potential.

Phytochemical investigations have confirmed that the rhizomes and roots of *N. jatamansi* are rich in bioactive constituents, especially sesquiterpenes such as jatamansone, along with essential oils, lignans, coumarins, flavonoids, and phenolic compounds. These constituents collectively contribute to the plant's wide spectrum of biological activities. Experimental pharmacological studies have provided substantial scientific evidence supporting its traditional claims, particularly highlighting its neuroprotective, anxiolytic, sedative, antidepressant, antioxidant, anti-inflammatory, cardioprotective, hepatoprotective, and antimicrobial effects.

Despite encouraging preclinical findings, the translation of these results into clinical applications remains limited due to a lack of well-designed clinical trials, standardized extracts, and comprehensive safety evaluations. Additionally, variability in chemical composition caused by geographical, environmental, and processing factors poses challenges for quality control and reproducibility of therapeutic effects.

Another critical concern addressed in this review is the endangered status of *N. jatamansi*, resulting from overexploitation, habitat loss, and slow natural regeneration. This underscores the urgent need for sustainable harvesting practices, cultivation strategies, and conservation programs to ensure the long-term availability of this medicinally important species.

In conclusion, *Nardostachys jatamansi* holds significant promise as a natural therapeutic agent, particularly for neurological and oxidative stress–related disorders. Future research should focus on detailed mechanistic studies, clinical validation, standardization of herbal formulations, and conservation-oriented approaches. Such integrated efforts will be essential to fully harness the medicinal potential of *N. jatamansi* while ensuring its sustainable utilization for future generations.

10. References

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