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Secondary Metabolites of Genus Nardostachys and their Medicinal Importance - Recent Updates

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Abstract

Nardostachys is an endangered, primitive and important herbal medicine found in Northern Himalayan region covering India, China Bhutan, and Nepal. The roots and rhizomes of this family have major contribution in Ayurveda and Unani medicines for various ailments. This plant is reported for their specific use in the treatment of bacterial, fungal, insomnia and cardiac diseases. It can also be used as an antioxidant, vasodilators, anti-CNS depressant and hepatoprotective. This plant includes many biologically active secondary metabolites; however nardostachone, jatamansone and actinides in major proportions. Overall, this review summarizes an exploration of the *Nardostachys* with respect to its medicinal importance and their important phytochemical secondary metabolites.

Keywords: Medicinal herb; *Nardostachys; N. grandiflora; N. jatamansi; N. chinensis*; Root; Rhizome

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Introduction

India comprises one of the largest biodiversity of the world due to its diverse range of altitudinal, climatic and ecological habitats. Such a biodiversity is rich with various herbal plants of great medicinal importance. Now day's herbal medicine attracts great attention towards healthcare due to its promising results and least side effects. Herbal medicinal plants are rich source of biomolecules and natural antioxidants, which can be major triggering factor to reduce many diseases viz. diabetes, aging, heart problem, cancer and neurodegenerative disorders. Many herbal medicinal plant species are at risk due to their illegal trade, excessive exploitations and lack of knowledge. Thus, these gifted herbal species need to be conserved by making strict guideline, however few groups of people working on it [1,2].

The plant species *Nardostachys* is one of them and is an important indigenous endangered medicinal herb found in North Himalayan region of India. Some other species are also reported as a *Nardostachys grandiflora*, *N. jatamansi* (D. Don) DC and two other species are also described *N. gracilis* and *N. chinensis* [3]. Although, this difference may be due to environmental influences (biotic or abiotic) [4,5]. They all are commonly known as jatamansi or Indian-nard in Indian Territory. They are distributed in sub-alpine to alpine regions in dry, open conifer forests, rocks, edges, small depressions, scrubs and in open meadows mostly on north facing slopes over east to west from Kumaon region of Uttarakhand to Sikkim in India and also in the Himalaya region of Bhutan and China from 2300-6000 m from the sea level [6]. However, substantial population of species exists in Nanda-Devi national park and Bagi area of Tehri forest division, yet extremely rare in finding. Traditional and medicinal uses of this genus are listed ahead. In this section author representing various secondary metabolites of genus *Nardostachys* and their traditional and medicinal uses [7-15].

Literature Review

Taxonomic description [16]:

Kingdom: Plantae

Division (Phylum): *Mangnoliophyta*

Class: *Magnoliopsida*

Order: *Dipsacales*

Family: *Valerianaceae*

Genus: *Nardostachys*

Botanical species: *Nardostachys grandiflora* DC, *N. jatamansi* DC, *N. gracilis* and *N. chinensis*

Common names: Balchara (hindi), Masi, Jatamasi, Bhytajata, Tapaswani (Hindi, Sanskrit and in Aayurveda), Musk root, Indian Spikenard (English), Baalchad (Gujarathi); Bhootajata (Kannada); Bhutijata (Kashmir); Manchi (Malayalam); Billilotan (Punjab), Gansong (Chinese) and Kanshoko (Japanees).

Botanical description

It is a dwarf, hairy, rhizomatous, perennial herb with aromatic woody rootstock cylindrical rhizome covered with brown or gray fibers, long and stout, covered with fibres from the petioles of withered leaves. Stem is 10-20 cm upward, glaborate and subscapose. Leaves elliptic, lanceolate or spathulate, rising mostly from the rootstock that is clothed in remnant fibre nets of old leaves. Around 15-20 radical leaves by 2.5 cm longitudinally nerved, glaborate and narrowed into the petiole. One or two pairs of caulines, are present which are 2.5-7.5 cm long, subovate, sessile and oblong in shape. Usually, adventitious stocks are red or brown in color with thin and branched roots. The colors of flowers are generally purple, pink, blue and white. Pubescent flower heads are usually 1, 3 or 5; bracts 6 mm oblong. Fruit is approximately 4 mm long, covered with ascending white hairs, crowned by the acute, ovate, dentate, calyx-teeth **(Figure 1)** [17].

Traditional impacts

Nardostachys has been used since 800 BC for various ailments such as cholera, epilepsy, hysteria and many other disorders in India, Nepal, Bhutan and China. Other traditional uses are as an antispasmodic, antiepileptic, potent stimulant, laxative and also in various Ayurvedic tonics [18-24]. It is also used in wide range of disorders such as; i) to improve digestive system, ii) nervous system, iii) reproductive system, iv) urinary system, respiratory system and in many skin diseases. The oil of *N. jatamansi* used in eye compounds and as a poison antidote [25]. According to Ayurveda, it helps in preventing wrinkles due to its oily (Snigdha) secondary metabolites. It also promotes wound healing due to its Ropan (healing) property. Jatamansi powder with honey once or twice a day can help improve memory and brain functions. *N. jatamsnsi* fruits can be taken orally in case of tonsillitis [7,26]. It can be taken with some other species to increase the sleep duration to give rest to the body [27].

Common and useful secondary metabolites from different parts of Genus *Nardostachys*

Some common and useful secondary metabolites were isolated from the different part of the genus *Nardostachys*, which are as follows **(Table 1).**

Important secondary metabolites from various parts of Genus *Nardostachys*

Particularly, roots and rhizomes are in focus of chemical studies due to their potent medicinal value. They contain a variety of coumarins and sesquiterpenes and other potent secondary metabolites. The sedative sesquiterpene (valeranone), terpenoids (Nardostachys in, calarenol, spirojatamo, jatamols A & B, coumarins (jatamansin) etc. are the common phytochemical constituents of the Jatamansi. Spikenard oil is extremely

Figure 1 *N. jatamansi* herb.

Table 1 Secondary metabolites found from Genus *Nardostachys.*

aCompounds	Herb	Medicinal Importance
9-Aristolen-1α-ol (Nardostachnol)	*N. jatamansi* (roots) *N. chinensis* (oil)	Antibacterial activity, moderate antifungal activity
1(10)-Aristolen-9-one (Gansongon)	*N. chinensis* (Batalin)	Antibacterial activity, moderate antifungal activity
Nardoaristolones A and B	*N. chinensis* (Batal and roots)	Increases erythrocytes
9,10-Dehydroaristolene	*N. jatamansi* (oil) *N. chinensis* (oil)	Protective effects on myocardial injury
1(10)-Dehydroaristolene (Calarene)	*N. jatamansi*, *N. chinensis*, *N. grandiflora* (rhizome oil)	Antibacterial activity, moderate antifungal activity
Calarenol	*N. jatamansi* (roots)	Antioxidative, anticholinesterase
	N. grandiflora (rhizome oil)	
Elemol	*N. jatamansi* (roots & rhizomes)	Antioxidative, anticholinesterase , Hair tonics for their growth
1(10)-Aristolen-2-one & 1(10), 8(9)-Aristoladien-2- one	*N. jatamansi* (roots) *N. chinensis* (oil)	Novel serotonin transporter regulators
3'-Hydroxy-nardoaristolone A	*N. jatamansi* (oil) *N. chinensis* (roots & rhizomes)	-
Debilon	*N. chinensis* (roots & rhizomes)	Cytotoxic activity against P-388 cells.
Secoaristolenedioic acid	*N. chinensis* (roots & rhizomes)	-
α,2β-Dihydroxy-aristolone	*N. chinensis* (roots & rhizomes)	-
9-Epidebilon	*N. chinensis* (roots & rhizomes)	-
β-Maaliene	*N. jatamansi* (oil) *N. chinensis* (oil)	Antioxidant activity
Maaliol	*N. jatamansi* (oil) *N. chinensis* (rhizomes)	Antioxidant Activities
Jatamansic acid	*N. jatamansi* (oil) *N. chinensis* (rhizomes)	Hair growth activity from rhizome extract
Jatamanins	*N. jatamansi* (roots & rhizomes)	Anti-ulcer activity
Jatamansine	*N. jatamansi*	effective in internal treatment of varicose veins
Jatamol A & B	*N. jatamansi* (roots)	
Jatamansinol (Lomatin)	*N. jatamansi*, *N. chinensis*	Hair tonics for their growth
		Antitumor
Valeranone (Jatamansone)	*N. jatamansi* (roots & rhizomes)	Sedative, antiarrythmic, anti-convulsant activity hypo-tensive, tranquilizing activity
		Antifungal, antibacterial
		Antitumor Antioestrogenic
Valeranol or	*N. jatamansi* (rhizomes)	Anti-ulcer action, weak hypotensive property
Jatamansi-2 or Pyranocoumarin		
Nardoguaianone E-K	*N. chinensis* (roots)	Antimalarial
Nardoguaianone A-D	*N. chinensis* (roots)	Antinociceptive, antimalarial activities
Nardostachysin	*N. jatamansi* (rhizomes)	Hair tonics for their growth [Antitumor
Nardol	*N. jatamansi* (roots)	Antioxidative, anticholinesterase
Nardal	*N. jatamansi* (rhizomes)	Hair growth
Nardin and Pyrocoumarin	*N. jatamansi* (rhizomes & roots)	Hair growth Antioxidant, anti-inflammatory
Angelicin	*N. jatamansi* (roots)	Antioxidative, anticholinesterase Hair tonics for their growth
Oroselol	*N. jatamansi*	Antioxidative, anticholinesterase Antitumor
Spirojatomol	*N. jatamansi* (roots)	Multipurpose
BR-606 (Epoxy-sesquiterpene)	*N. jatamansi* (roots)	Bone sorption inhibitor for the treatment of osteroporosis and hypercalcemia

aCompounds	Herb	Medicinal Importance
Nardoperoxide, Isonardoperoxide and Nardoxide	*N. chinensis* (roots)	Antimalarial activity
Nardosaldehyde	*N. chinensis* (roots)	
Actinidine	*N. jatamansi* (rhizomes)	Proteolytic activities
Lignans	*N. jatamansi* (roots)	Anti-tumour antimitotic, antiviral activity, specifically inhibit certain enzymes
Patchouli alcohol	*N. grandiflora* (rhizome oil)	Antioxidant activities
	N. jatamansi (roots)	antioxidant, antimicrobial analgesic action
β-Patchoulene	*N. jatamansi* (roots)	Anti-inflammatory activity
α-Patchoulene	*N. jatamansi* (roots)	Anti-inflammatory activity
1-Octadec-9',10'-dienoyl-2,3-*n*-diocta-decanoyl glycerol	*N. jataman* (rhizomes)	
Lup-20(29)-en-3β-D-galactofuranosyl-6'-octadec-9"-enoate	*N. jataman* (rhizomes)	
Isonardosinone	*N. chinensis* (rhizomes & roots)	Anti-neuroinflammatory
Kanshone A, B, E, D, F, G, J, K	*N. chinensis* (rhizomes & roots)	Cytotoxic against P-388 cells anti-neuroinflammatory antimalarial
Nardonoxide	*N. chinensis* (rhizomes & roots)	SERT enhancers
Nardofuran	*N. chinensis* (rhizomes & roots)	Mild antileukemia activity
Nardosinone F-I	*Nardostachys* (rhizomes)	Cytotoxic activity against P-388 cells antitumor
		reducing NF-κB and MAPK signaling pathways
		Anticardiache ,treatment of brain injury and neuro-degenerative diseases
Nardosinanones J-N & nardoaristolone C	*N. chinensis* (Batal)	Antiinflammatory activities
Nardosinonediol	*Nardostachys* (rhizome)	Cytotoxic activity against P-388 cells
desoxo-narchinol A and narchinol B	*N. jatamansi* (rhizomes & roots)	Cytotoxic activity against P-388 cells antineuroinflammatory effects anti-inflammatory
Narjatamanins A & B	*N. jatamansi*	Anti-Alzheimer's disease
Gallic acid	*Nardostachys* (rhizome & roots)	Antiinflammatory, antimutagenic, antifungal, antiviral, anticancer, antioxidant activities
Cinnamic acid	*Nardostachys* (rhizome & roots)	Anticancer, antituberculosis, antimalarial, antifungal, antimicrobial, antiatherogenic, antioxidant activities
p-Caffeic acid	*Nardostachys* (rhizome & roots)	Antiviral, antibacterial, antioxidant, anti-inflammatory, immune-stimulatory, antidiabetic, antiatherosclerotic, cardioprotective, anticancer, anti-proliferative, hepatoprotective, antihepatocellular carcinoma
p-Coumaric acid	*Nardostachys* (rhizome & roots)	Anti-melanogenic, anti-inflammatory, anticancer.
Ferulic acid	*Nardostachys* (rhizome & roots)	Anti-inflammatory, anticancer, antimicrobial, antioxidant, anti-ageing, antidiabetic, also used in skin care products
Kaempferol	*Nardostachys* (rhizome & roots)	Anti-inflammatory, antioxidant, antitumor, antidiabetic, neuroprotective, cardiovascular, hepatoprotective effects
Rutin	*Nardostachys* (rhizome & roots)	Antioxidant, antiviral, anticarcenogenic, antibacterial, antitumor, antiplatelet, antispasmodic, antiprotozoal, antiallergic, vaso- & cardio-protective, hypolipidaemic, antihypertensive -

valuable oil that is used in perfumery and cosmetics industry [28-30]. Despite know for great medicinal value, it is excessively exploited and trampled by sheep and goats in the alpine meadows, carelessly. Thus, we need to take strong precautionary measurements to protect this species from all dangers. Recently, the first study on de novo transcriptome analysis was done and revealed several tissue specific secondary metabolites that have not shown till now form *N. jatamansi*. Potent and very useful secondary metabolites of *Nardostachys* are as follows **(Figure 2 and Table 2).**

Discussion

Medicinal and biological importance

According to the traditional uses, scientists have developed and concluded that *Nardostachys* species is one of the important

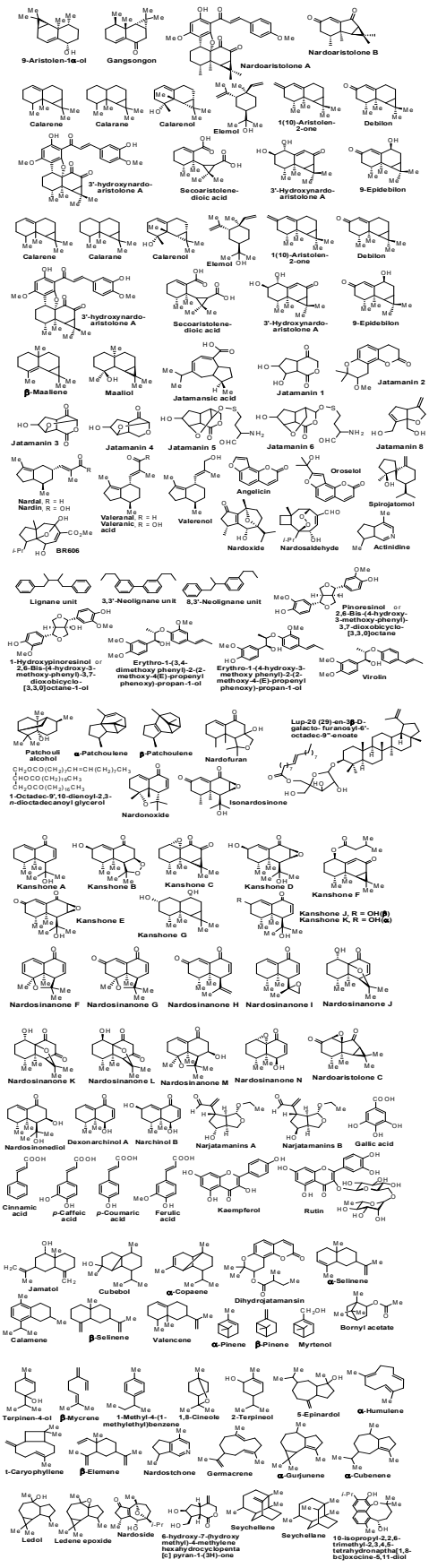

Figure 2 Potent secondary metabolites extracted from genus *Nardostachys*.

Table 2 Potent secondary metabolites and their sources of isolation from the Genus *Nardostachys.*

S. No	Parts	Secondary metabolites found from Genus *Nardostachys*
1	Roots	Coumarins [25,28], sesquiterpenes [29], Valeranone, calarene, valeranal, nardone, calarenol, nardostechone, seychellen, *n*-hexacosanyl arachidate, *n*-hexaconsanol, *n*-hexacosane, *n*-hexacosanyl isovalerate, *β*-sitosterol, patchouli alcohol, norseychelanone, *α*- and *β*-patchoulenese.
2	Rhizomes	Jatamansone, *β*-sitosterol, sesquiterpene (lignane and neolignane polyphenolic units), seychelane, seychellene.
3	Rhizomes and Roots	Volatile essential oil (0.5%) (Oleum Jatamansi), gum, resin, sugar, starch, bitter extractive matter.
4	Oil of Roots	Terpenic coumarins, oroselol, *β*-sitosterol, jatamansin, hydrocarbons, angelicin, *β*-eudesmol, jatamansinol elemol.

Table 3 Biological activities of potent secondary metabolite extracted from Genus *Nardostachys.*

S. No	Chemical Composition	Biological activity
1	Jatamansone	Tranquillizing hypothermic, antiemetic, reduce aggressiveness, restlessness, stubbornness, insomnia, anticonvulsant anti-Parkinson activity in rat
2	Essential oil	Hypotensive action in dogs, fungitoxic Antifungal, antimicrobial],prolonged hypotensive effects
3	Alkaloidal fraction from root and rhizome	Hypotensive action in dogs

Table 4 Biological activity of the different parts of Genus *Nardostachys.*

S. No	Parts	Biological action
1	Roots	Antianxiety, nerve Stimulant, nerve sedative, diuretic, antispasmodic, emmenagogue, bitter tonic, carminative, deobstruent, promote appetite and digestion.
2	Extracts of roots	Hypotensive, antianxiety, laxative, sedative, brain tonic, antibacterial, abdominal distension and pain, liver enlargement, jaundice, cough, dyspnoea, cardiac depressant, skin disorders, infertility dysmenorrhoea, uterine inflammation, antipyretic.
3	Infusion of roots	Antianxiety, jaundice, leprosy, spasmodic hysterical affections, palpitation of the heart, flatulence, nervous headache.
4	Extracts of rhizomes	Antifungal
5	Entire herb	Analgesic, antiseptic, antidote in scorpion sting, relief from insomnia and irritability.
6	Entire herb with Sesamum oil	Nerve sedative, promotes growth and blackness of the hairs.

class of medicinal herb, which can have vide biological applications. The root and rhizome (especially rhizome oil) are bitter in taste and considered as a tonic, nerve stimulant, nerve sedative diuretic, anti-spasmodic caminative, stomachic, laxative anti-inflammatory and anti-depressant and anxiolytic activity. It is also used in hysteria, insomnia, dysmenorhoea, many skin diseases, throat trouble, lumbago, ulcer, rheumatism, paralysis and promotes appetite and digestion etc. In Indian Ayurveda, it is used as a brain tonic; improve the mind function (by preventing cell damage due to its antioxidant property digestive system, anti-lipid peroxidative, fungicidal, anti-depressant tranquilizer, anti-malarial. In Unani medicine, it is used as a cardio tonic, analgesic, diuretic as well as hepatoprotective. Mostly, it is used as a nervine sedative in the treatment of insomnia, nervousness, chronic irritability, debility and exhaustion. Jatamansi extract is used as a hair tonic, hair oils, and promoting hair blackness, growth and luster. It is largely good for hair growth because it helps to increase the follicular size and elongate the growth phase of hair. In general, it can be used as antidepressant, anticholinesterase antioxidant anticonvulsant anti-aging (due to its antifungal and antioxidant properties) anticataleptic, anti-inflammatory antiathritic antipyretic cardioprotective antitumor anti-Parkinson's radioprotective, antimicrobial insect repellent, antifungal activity hepatoprotective protection from hair loss, ant seizures, nootropic, improve nervous system and anti-hyperglycemic, lipid peroxidation activities *N. jatamansi* roots act as a bone sorption inhibitor for the treatment of osteoporosis and hypercalcemia.

It is an excellent substitute for valerian (*Valeriana officinalis*) and used in the treatment of epilepsy, insomnia, depression, tension headaches nervous indigestion, hysteria and convulsive affections when taken internally. It can be used externally as a deodorant, to treat rashes, haemorrhoids and used in perfumery. Recent study also predicts that *Nardostachys* is very good Ayurveda drug used as a vascular dilatator **(Tables 2-4)** [30-50].

Conclusion

Therefore, authors have tried to summarize that the secondary metabolites obtained or extracted from the genus *Nardostachys* are very much useful and potent in various ailments. *Nardostachys* is an important medicinal plant especially in the traditional use of Unani and Ayurveda medicines for the treatment of various illnesses. In India, this family of plant is not well explored in respect chemical identification and characterization and comes under endangered medicinal plant group. Due to lack of awareness this family is not used properly in India, which is not a good practice as a medicinal and environmental point of view.

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