

## A REVIEW ON SPIKENARD (*NARDOSTACHYS JATAMANSI* DC.) - AN 'ENDANGERED' ESSENTIAL HERB OF INDIA

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### ABSTRACT:

The herb *Nardostachys jatamansi* DC. is known to be a popular medicinal and aromatic plant species. It is a reputed Ayurvedic herb and used in various multiple formulations. It has also been mentioned in the Holy Bible and Quran. The roots and rhizomes of *Nardostachys jatamansi* DC. have been used to treat epilepsy, hysteria, syncope and mental weakness. It also exhibits cardio protective activity and used in the treatment of neural diseases. The essential oil obtained from the roots of *jatamansi* showed various pharmacological activity including antimicrobial, antifungal, hypotensive, antiarrhythmic and anticonvulsant activity. Sesquiterpene is the major component of this plant, others include jatamansone, nardostachone. But this reputed plant species have become critically endangered and requires various conservation strategies. The review summarizes the conservation methodologies being investigated on the plant as well as its phytochemical and pharmacological investigations.

**Keyword:** *Nardostachys jatamansi*, conservation, rhizome, India

### 1. Introduction

*Nardostachys jatamansi* DC. is a known medicinal herb which is on the verge of extinction. The dependence of the *jatamansi* species on habitats has mainly caused its exploitation, making the species critically endangered<sup>1,2,3</sup>, the rhizomes of the herb being over-exploited for medicinal use, habitat degradation and other biotic interferences. The earlier workers therefore gave emphasis on its conservation and multiplication<sup>2,4,5,6,7</sup>. Various methods should be used for its conservation, in situ as well as ex situ being a few. The rhizome of the herb is considered as the official plant part, found to have excellent therapeutic potential. As mentioned in Ayurveda, the roots and the rhizomes of *Nardostachys jatamansi* DC. are used to treat epilepsy, hysteria, syncope and mental weakness<sup>8</sup>. In India, the rhizomes and roots are being marketed as an anticonvulsant Ayurvedic drug known as Ayush 56 and also used as an antistress agent<sup>9</sup>. The rhizome of *jatamansi* is used as an aromatic adjunct in the preparation of medicinal oils, to promote hair growth and blackness<sup>10</sup>. The roots of the herb is used in the preparation of an essential oil found to have fungi toxic activity<sup>11</sup>, antimicrobial<sup>12</sup>, antifungal<sup>13</sup>, hypotensive<sup>14</sup>, antiarrhythmic<sup>14</sup> and anticonvulsant activity<sup>14,15</sup>. As the species is reported to have become critically endangered, effective conservation, management and recovery of the species is highly important. It can be

deliberated through variability analysis. Study of reproductive biology is also necessary for effective conservation of endangered plants including study of pollination behaviour.

### 2. Historical background

The medicinal benefits of the plant has been valued for centuries in Indian Ayurveda, in Unani in ancient Greek and Arab, and in ancient Egypt and Rome. The *N. jatamansi* drug originates from 'Song Zhou' of Chuan Xi which has been registered in the book 'Ben Cao Shi Yi' in China. In the 'Book 18 of Homer's Iliad', the perfume of *N. jatamansi* is used Patroklos by Achilles.

The herb has been mentioned twice in the biblical love poem, the 'Song of Solomon (1:12 and 4:13)'; it is one of the Eleven Herbs used for the Incense in the Holy Temple in Jerusalem. It has also been mentioned that Mary uses a pound of pure *N. jatamansi* to anoint Jesus's feet. The fruit which Adam ate in Paradise, which God had forbidden him to eat is believed to be the powdered root of *N. jatamansi* as mentioned in some Islamic traditions. In Medieval European cuisine, the *jatamansi* herb is used for seasoning the foods<sup>16</sup>.

### 3. Botany and taxonomy of spikenard

The sages of Ayurveda have broadly categorized the diseases according to adhishthana (place of origin) into two types: sharirik (physical) and manasik (mental). Among the various herbs

mentioned in the texts as sangyasthapaka and manasdoshhar (psychotropic), *jatamansi* is the foremost of these herbs. It is known as sulomasa, bhutjata and tapaswini in Sanskrit and commonly known as spikenard, nard or muskroot. It belongs to the family Valerianaceae and its scientific classification is represented by table2. The *Valeriana jatamansi* which is similar to *nardostachys* is used as a substitute. Valerianaceae flowers and fruits are marked by a degree of differentiation in their morphology, characterized by sympetalous flowers, inferior 3 celled ovary, one fertile carpel, achene type of fruit and lack of endosperm<sup>17</sup>. *Nardostachys jatamansi* is an erect, perennial herb, reaching a height of 10-60 cm (Figure 1a) with woody rhizomatic rootstock (Figure 1b) covered with tail like brown fibers, while the root penetrates deep in the soil. Leaves are long and narrow. Arising in terminal corymbose cymes, the flowers are creamy white, often rosy or pale pink in appearance. Fruit is small, 4 mm long, covered with minute hairs. It has been described as a combination of three tastes — bitter, astringent and sweet. Within the family Valerianaceae, the genus *Nardostachys* is considered as most primitive<sup>17,18</sup>. Table1 represents the scientific classification of *Nardostachys jatamansi*.



(a)



(b)

**Figure1. Pictorial presentation of (a) *Nardostachys jatamansi* DC. herb and (b) Woody rhizome.**

**Table1. Scientific classification of *Nardostachys jatamansi* DC.**

Scientific Classification	
Kingdom	Plantae
Division	Mangnoliophyta
Class	Mangnoliophyta
Order	Dipsacales
Family	Valerianaceae
Genus	<i>Nardostachys</i>
Species	<i>Jatamansi</i>
Binomial name	<i>Nardostachys grandiflora</i>

#### 4. Occurrence and distribution

The *jatamansi* species is found to be distributed in the subalpine to alpine areas of India (Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim), Pakistan, Nepal, Tibet, China and Yunan. The herb mostly grows between 3300–5000m above sea level. Due to over-exploitation of the rhizome, the species has become endangered in most of its natural populations<sup>19,3</sup> and critically endangered in few other populations<sup>2</sup>.

Nautiyal *et al.* used vegetative propagules and seedling transplantation methods under different treatments to carry out cultivation trials of *jatamansi* at three altitudes (low – 1800 m, middle – 2200 m and natural habitat – 3600 m). Variation in the economic yield occurred with treatment, age of plant at the time of transplantation and altitude of nursery. With the addition of manure (FYM) in all the treatments and altitudes, the economic yield increased as compared to control. Cultivation was not found commercially viable at 1800 m in any of the treatments due to total mortality. At 3600 m, both vegetatively grown as well as transplanted seedling crop showed marked profit in polyhouse condition<sup>3</sup>.

#### 5. The Endangered species

The Himalayan region of India is known for its richness in medicinal plants with a total of 1,748 species. To safeguard economic and conservation concerns, the medicinal plants are attracting more attention<sup>20</sup>. The Red Data Book of Indian Plants enlists 17 species<sup>21</sup> which includes *Nardostachys jatamansi* (D. Don) DC. considered as vulnerable<sup>3</sup> at high altitudes. Kumar and Pal in 2011 investigated the *jatamansi* herb in order to standardize its rhizome to develop its quality parameters, so as to control substitution and adulteration. The result shows the organoleptic properties of *Nardostachys jatamansi* rhizome as follows- shape (cylindrical, covered with reddish

brown fibres forming a network which are skeletons of sheathing leaf bases), size (3 to 7 cm long, 0.5 to 1.5 cm in diameter), colour (dark brown externally and reddish brown internally), fracture (brittle), surface (fibrous), odour (strongly aromatic) and taste (Acrid, slightly bitter and aromatic). The physicochemical parameters were also studied in order to identify various adulterants and improper handling of drugs. The physicochemical parameters were measured in % w/w giving the ash values as follows: total ash (8.5), acid insoluble (3.8), water soluble (0.5) and sulphated ash (3.7) and extractive values as water soluble extractive (7.3) and alcohol soluble extractive (5.2). These data are mean of 3 values<sup>22</sup>.

Formulations of traditional medicines involve various herbal parts which have become a routine practice in India. Composition of traded herbs varied on account of (i) geo-climatic conditions of their growth, (ii) maturity at the time of collection, (iii) species variation at times, (iv) substitutability on the basis of supposed effectiveness and (v) doubtful trade practices. The variations were evident in case of *jatamansi* samples as well as other Rare, Endangered and Threatened (RET) listed plants collected from various herb markets. Pawar *et al.* prepared 15 samples of absolute ethanolic extracts of *Nardostachys jatamansi* to record (i) % yield ranging from 2.43 – 7.64 %; extracts prepared in 80% aqueous ethanol, (ii) total phenol content from 5.7 – 16.7 mg per g of dry mass, (iii) in vitro DPPH-free radical scavenging activity on the basis of anti-oxidant assays ranged from minimum 41.4 % to maximum 88.8 %, (iv) reducing power from 0.296 OD to 0.564 OD, higher OD indicates higher reducing capacity<sup>23</sup>, (v) anti-lipid peroxidation activity from 19.2% to 69.8% and (vi) isovaleric acid content from complete absence to 0.116%. As per Indian Herbal Pharmacopoeia, only few samples passed while others failed in identification test. This study was undertaken mainly to create awareness amongst the traders, researchers, clinicians and manufacturing units about the ambiguity for authenticity in the traded herbal raw materials<sup>24</sup>.

Variability studies can be another tool for conservation and crop improvement program. Interactions among natural selection, gene flow and genetic drift generally result in genetically differentiated populations in a single plant species<sup>25</sup>. Although sufficient information is available on distribution pattern of *N. jatamansi*<sup>2,3,6</sup>, medicinal properties<sup>26</sup>, chemical composition<sup>27</sup> and biological activities<sup>28</sup>, there is

a complete lacking of literature on the nature of variabilities. These variability studies could be highly useful for the conservation management as well as genetic improvement of *N. jatamansi*<sup>29</sup>.

Study of pollen behaviour can also be an important tool for the conservation of endangered species. For any crop improvement program, study of pollination behaviour is considered an integral part of reproductive biology. The study of pollination biology has remained limited for a large number of species while most of the endangered plants have remained untouched<sup>30</sup>. Absence of parthenogenesis in *N. jatamansi* has been confirmed through study of pollination behaviour as well as its self-compatibility and compatibility for geitonogamy and xenogamy. Xenogamy stands wide chances of opening new dimension for crop improvement program genetically in future<sup>7</sup>.

The population ecology of medicinal plants (MP) is mainly affected by harvesting patterns. Medicinal plants (MPs) and other non-timber forest products (NTFPs) are threatened by many factors, from both social and ecological perspectives. In response to differential harvesting strategies, the effect on demography of harvesting of the rhizome part of the plant varies greatly. The frequency of harvesting and the amount of *jatamansi* harvested should be strictly regulated, especially those growing in high altitude habitats on dry rocky outcrops. These rare and endangered Himalayan MPs require specific management plans based on their plant parts used, growth patterns in different habitats as well as the harvesting practices that are used<sup>5</sup>.

## 6. Phytochemistry

Ayurveda ascribes three characteristics to herbs:

- Gunna (properties) – laghu (light) and snigdha (slimy)
- Rasa (taste) – katu (pungent), madhur (sweet) and tikta (bitter)
- Virya (potency) – sheet (cold)

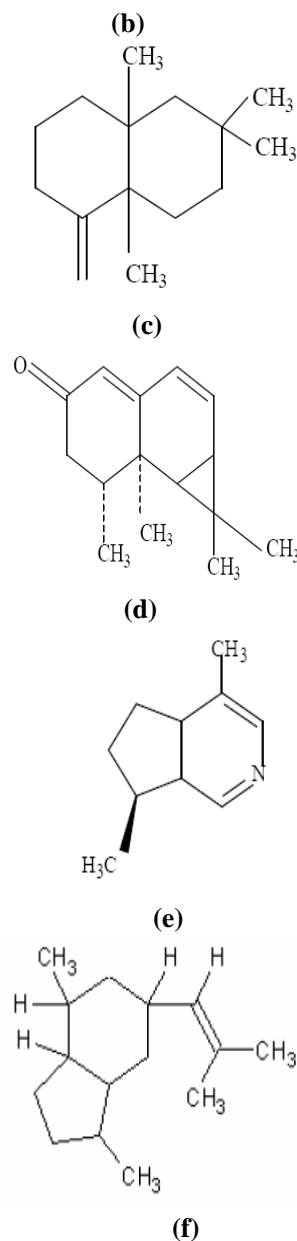
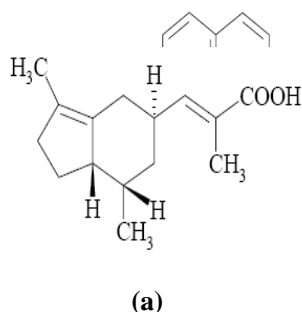
For any kind of drug discovery, prior knowledge of the chemical composition and their structure is utmost. Drug designing now depends more on rationality and evidences, thus evolving the discovery of drugs. Effective contributions have been made in fields such as cancer chemotherapy, drug resistant infections, and neurological diseases by structure-based drug designing. Developments in technology especially computers, bioassay techniques and calibrated instruments aid in discovering newer methods for drug designing as well as drug discovery. In modern medicine, computational structure-based

drug designing is the key to finding novel treatments<sup>31</sup>.

*N. jatamansi* has been discovered with both volatile and non-volatile constituents. Sesquiterpenes contribute to the major portion of the volatile compounds while sesquiterpenes, coumarins, lignans, neolignans, alkaloids and steroids form the major components of the non-volatile extracts<sup>32,33,34,35</sup>. Sesquiterpene was eventually found in abundance in both the categories and found to accumulate in higher levels. Valeranone (jatamansone) is a sesquiterpene found to be present at up to 0.7%. Other sesquiterpenes include nardin, nardal, nardol, valeranal, jatamnsic acid, b- maline and patchouli alcohol<sup>36</sup>.

Chatterjee *et al.* undertook the chemical examination of the rhizomes in detail leading to the isolation of a new terpenoid ester, nardostachysin<sup>37</sup>. Again in 2005, Chatterjee *et al.* carried out an investigation on the chemical constituents of *N. jatamansi* which resulted in the isolation of a new sesquiterpene acid, nardin (Figure 2a) and a new pyranocoumarin: 2', 2'-dimethyl-3'-methoxy-3', 4'-dihydropyranocoumarin (Figure 2b). Besides these two, several coumarins were already known<sup>9</sup>.

Sesquiterpenes and coumarins are present in considerable amount in the roots of *jatamansi* plant mainly responsible for its essential oil<sup>9</sup>. Figure 2c represents the principal sesquiterpene of this plant named jatamansone or valeranone<sup>38,39</sup>. Various other sesquiterpenes known are nardostachone (Figure 2d), dihydro *jatamansin*, *jatamansinol*, *jatamansic acid*<sup>40</sup>, *jatamansinone*, *jatamansinol*, oroseolol, oroselone, seselin, valeranal, nardostachysin<sup>5</sup>, nardosinone, spirojatamol<sup>41</sup>, jatamol A and B<sup>42</sup>, calareno<sup>43</sup>, seychellene, seychelane, coumarin: *jatamansin* or xanthogalin<sup>44,45</sup>. An alkaloid named actinidine has also been reported (Figure 2e). Nardal has been reported to be an active component by Venkateshwara (Figure 2f)<sup>46</sup>.



**Figure 2. Structural representation of (a) Nardin, (b) Pyranocoumarin, (c) Jatamansone (d) Nardostachone, (e) Actinidine and (f) Nardal.**

**6.1 Jatamansone (valeranone):** Anti-oestrogenic, anti-arrhythmic, antihypertensive, anticonvulsant, sedative and tranquilizing activities have been reported of jatamansone through animal studies<sup>47,48,49,50</sup>. Jatamansone does not have neuroleptic characteristics, still exhibits anticonvulsive effect against electric shock and gastro protective actions. Toxicological investigation on rats and mice were carried out showing an oral LD<sub>50</sub> greater than 3160 mg/kg, thus suggesting the chances of developing a therapeutically useful dose ratio<sup>38</sup>. Additionally,



tranquillizer experiments exhibit jatamansone ability to prolong barbiturate hypnosis, impair rota rod performance and potentiate the body-temperature lowering activity of reserpine.

Pharmacological effects of jatamansone also includes in its activity towards reduction in aggressiveness, restlessness, stubbornness and insomnia. Jatamansone, D-amphetamine and chlorpromazine were compared in a study which was conducted on hyperkinetic children for its efficacy. The behavior of these children was significantly improved by jatamansone and amphetamine with amphetamine reducing aggressiveness and restlessness to a greater extent. Jatamansone shows less side effects as compared to D-amphetamine and chlorpromazine<sup>51</sup>.

**6.2 Jatamansin:** Jatamansin is a coumarin known to be effective in internal treatment of varicose veins<sup>52</sup>.

## 7. Biological activities

**7.1 Antioxidant activity:** *N. jatamansi* induces a state of resistance against stress in organisms. In experimental medicine, restraint stress (RS) is known as one of the most popular stressors<sup>53</sup>. Lyle *et al.* investigated *N. jatamansi* for its effect on RS-induced changes in different parameters and the role exhibited by its antioxidant property. Ethanolic extracts of *N. jatamansi* (NJE) were administered in Wistar rats in two doses followed by immobilization stress on the 5<sup>th</sup> day. Rats that received different doses of NJE did not show clinical signs of toxicity and in vitro study showed free radical scavenging activity of NJE, as evidenced by low IC<sub>50</sub> value. Pre-treatment with NJE-200 and 500 mg/kg significantly decreased lipid peroxidation (LPO) and nitrite level and increased the catalase activity in the brain. Presence of flavonoids and polyphenols is responsible for the antioxidant property of NJE and may also be responsible for its anti-stress effect<sup>54</sup>.

The antioxidant and anti-cataleptic effects of the aqueous extract of *Nardostachys jatamansi* roots was studied. Male albino rats were administered with haloperidol (1 mg/kg, ip) to induce catalepsy. Though a significant ( $P < 0.01$ ) reduction was observed in the cataleptic scores of all the drug-treated groups as compared to the haloperidol-treated group, maximum reduction was observed in the group treated with *Nardostachys jatamansi* (250 and 500 mg/kg body weight). Among the biochemical parameters, generation of thio-barbituric acid reactive substances (TBARS) increased while

glutathione (GSH) reduced significantly as a result of haloperidol administration. However, after their treatment with *Nardostachys jatamansi*, the substances were restored to near normal level. Haloperidol administration reduced the levels of catalase and superoxide dismutase (SOD) significantly which were restored to their normal level by *Nardostachys jatamansi* treatment. Thus *Nardostachys jatamansi* reverses the haloperidol-induced catalepsy in rats and reduces oxidative stress<sup>55</sup>.

**7.2 Nootropic:** Three doses of the ethanolic extract of *N. jatamansi* (NJE) were administered in both young and aged mice. The 200 mg/kg dose of the extract improved learning and memory effectively in young mice and reversed age related amnesia in older mice. The reversal of scopolamine-induced amnesia by NJE may be because of facilitation of cholinergic transmission in the brain. Hence, *N. jatamansi* could be a useful agent in restoring memory in case of dementia seen in elderly persons<sup>56</sup>.

The administration of the ethanolic extract of *N. jatamansi* (NJE) for 21 days elevated acetylcholinesterase (AChE) activity levels in the frontal cortex thereby suggesting a possible mechanism for a nootropic effect of *N. jatamansi*<sup>57</sup>.

**7.3 Anticonvulsant activity:** Rao *et al.* investigated the ethanol extract of the roots of *N. jatamansi* alone as well as in combination with phenytoin for its anticonvulsant activity and neurotoxicity in rats. The result shows a decrease in the extension/flexion ratio which indicates a significant increase in the seizure threshold by *N. jatamansi* root extract against maximal electroshock seizure model and exhibited minimal neurotoxicity against rota rod test. When given in combination with 50mg/kg of *N. jatamansi* root extract, an increase in the protective index of phenytoin was recorded. Thus the effect of phenytoin alone and in combination with *N. jatamansi* extract is clearly demonstrated<sup>15</sup>.

**7.4 Hepatoprotective activity:** Ali *et al.* investigated the pretreatment of rats with 800 mg/kg body wt of the 50% ethanolic extract of *N. jatamansi*. The study showed major hepatoprotective activity against thioacetamide induced hepato-toxicity and reduced the levels of serum transaminase and alkaline phosphatase significantly. An increase in the survival rates in rats intoxicated with LD<sub>50</sub> dose of the hepatotoxic drug was highly observable after pretreatment of the animals with the extract<sup>58</sup>.

**7.5 Cardio protective and hypolipidemic activity:** Ethanolic extract of *N. jatamansi* was investigated in Wistar albino rats for cardio protective activity against doxorubicin induced myocardial injury. Doxorubicin is an inhibitor of fatty oxidation in the heart which leads to cardio toxicity. An increase in serum and cardiac lipids (cholesterol, triglycerides, free fatty acids and phospholipids) as well as increase in low density serum lipoproteins, very low density lipoproteins and drop in high density lipoproteins levels were reported in rats treated with a single dose of doxorubicin (15 mg/kg) intraperitoneally. These resulted in the changes of serum and cardiac lipid metabolizing enzymes<sup>59</sup>.

Pretreatment of doxorubicin induced rats with an extract of *N. jatamansi* (500 mg/kg) given orally for seven days. This resulted in prevention in the lipid status with the activities of the lipid metabolizing enzymes to a large extent. Also the histopathological observations were found in correlation with the biochemical parameters. The protective and hypolipidemic effect of *N. jatamansi* against myocardial injury induced by doxorubicin in rats could be mediated through its anti-lipid peroxidative properties as suggested by the above observations<sup>59</sup>.

A 50% ethanolic extract of *Curcuma longa* (tuber) and *N. jatamansi* (whole plant) showed elevation in the HDL-cholesterol/total cholesterol ratio in triton-induced hyperlipidemic rats, a study by Dixit *et al.* Also a reduction in the ratio of total cholesterol/phospholipids was observed<sup>60</sup>.

**7.6 Nervous system:** The inhibitory activity of acetyl cholinesterase of methanolic and successive water extracts of *N. jatamansi* (rhizome) were investigated by Vinutha for *in vitro* acetyl cholinesterase inhibitory activity. Methanolic extracts were reported to be more active than water extracts. For methanolic and successive water extracts of *N. jatamansi*, the IC<sub>50</sub> value recorded was 47.21 mg/ml. The traditional use of *N. jatamansi* for improving cognition is partly validated by these results<sup>61</sup>.

**7.7 Antidepressant activity:** Prabhu *et al.* treated male albino Wistar rats with alcoholic extract of the roots of *N. jatamansi* DC acutely and subchronically in order to demonstrate its effect on nor-epinephrine (NE), dopamine (DA), serotonin (5-HT), 5-hydroxyindoleacetic acid (5-HIAA), gamma-aminobutyric acid (GABA), and taurine. The level of NE and DA remained unchanged by acute oral administration but increased the level of 5-HT and 5-HIAA considerably. As compared to the controls, the level of GABA and taurine increased

significantly in the drug-treated groups. A significant increase in the levels of NE, DA, 5-HT, 5-HIAA, and GABA was reported in a 15-day treatment<sup>62</sup>.

**7.8 Antiparkinson's activity:** Ahmad *et al.* administered rats with 200, 400, and 600 mg/kg body weight of *N. jatamansi* roots for 3 weeks. The right striatum was infused with 2 µl of 6-OHDA (12 µg in 0.01% in ascorbic acid-saline) on day 21, while 2 µl of vehicle was infused in the sham-operated group. The neuro behavioural activity in the rats were tested after three weeks of 6-OHDA injection which were then sacrificed after 6 weeks in order to evaluate lipidperoxidation, reduced glutathione content, the activities of glutathione-S-transferase, glutathione reductase, glutathione peroxidase, superoxide dismutase and catalase, quantification of catecholamines, dopaminergic D2 receptor binding and tyrosinehydroxylase expression. The alterations caused by 6-OHDA injections such as increase in drug-induced rotations and deficits in locomotor activity and muscular coordination were extensively and dose-dependently restored by *N. jatamansi*. Thus attenuation of Parkinsonism might be enhanced using the extract of *N. jatamansi* as indicated by this study<sup>63</sup>.

**7.9 Anti-alzheimer's activity:** A strong linkage between Insomnia and Alzheimer's disease (AD) has been hypothesized. With age, sleep disturbances and dementia increases as per statistical data and chances of developing AD and depression in young and middle-aged adults suffering from insomnia is 11 times more likely in their later life. The effect of methanolic extract of *Nardostachys jatamansi* DC. (MENJ) rhizome was investigated on sleep deprived (SD) amnesic mice in order to assess anti- amnesic activity. Pretreatment of animals with MENJ and Piracetamas standard drug for 14 days was followed by 5 days sleep deprivation using multiple platform method. Groups that were treated with MENJ doses showed considerable improvement in learning and cognition parameters in behavioral tests. The loss of memory and cognitive deficits due to sleep deprivation could be protected by MENJ as suggested by the above study<sup>64</sup>.

Rahman *et al.* investigated the anti-amnesic activity of methanolic extract of rhizome of *Nardostachys jatamansi* DC. (MENJ) on sleep deprived (SD) amnesic mice. Pretreatment of animals with MENJ and Piracetam for 14 days was followed by sleep deprivation using multiple platform method for 5 days. The mice brain was

evaluated for Acetylcholinesterase (AChE) activity, glutamate, antioxidants enzymes Superoxide dismutase (SOD), Catalase (CAT), Glutathione reductase (GRD), Glutathione peroxidase (GPx), Lipid peroxidase assay (LPO) and ascorbic acid (Vit.C) on the 19<sup>th</sup> day. Significant inhibition of AChE activity and improved antioxidants enzyme levels in sleep deprived amnesic mice was reported after treating the groups with MENJ doses. The protective effect of MENJ against loss of memory and cognitive deficits due to its inhibition of AChE as well as protection from oxidative damage due to sleep deprivation is demonstrated by the above findings<sup>65</sup>.

Alzheimer is known to be an incurable, degenerative, and terminal disease, which is associated with mutations in Amyloid Precursor Protein (APP), Presenilin 1 (PS1), Presenilin 2 (PS2), or Apolipoprotein E (APOE). Using Homology Modeling, Gore *et al.* generated 3D structures of the above 4 proteins. Keeping in regard the memory enhancement ability, the active compounds of medicinal herbs- *Canscora decussate*, *Nardostachys jatamansi* and *Mucuna pruriens* were selected. The combination of the active components of *Canscora decussate*-*Nardostachys jatamansi* -*Mucuna pruriens*'s were docked successfully with the four proteins. APP, APOE, PS1 and PS2 were successfully docked with nardal, ergotamine & xanthone combination, thereby suggesting the effective treatment of Alzheimer's disease<sup>66</sup>.

**7.9 Neuroprotective activity:** Salim *et al.* studied the pretreatment of rats with an alcoholic extract of *N. jatamansi* at 250 mg/kg dose for 15 days which protected them against focal ischemia caused by middle cerebral artery occlusion. The improvement in glutathione content, inhibition of lipid peroxidation, and activity on the Na<sup>+</sup>/K<sup>+</sup>-ATPase and catalase enzyme systems might be related to the protective effect mentioned above<sup>67</sup>.

**7.10 Antifungal activity:** Sarbhoy *et al.* investigated the *jatamansi* oil for its efficiency against *Aspergillus flavus*, *A. fumigatus*, *A. sulphureus*, *Mucor fragilis*, and *Rhizopus stolonifer*. Depending upon the concentrations, the *jatamansi* oil was reported to be fungistatic or fungicidal to one or the other molds<sup>68</sup>.

## 8. Conclusion

*N. jatamansi* is an essential herb with multiple remedies. This Himalayan herb is now on the verge of extinction and immense conservation strategies need not only be considered but as well as developed. The rhizome of the herb is used in

various Ayurvedic formulations and has a history of use as an essential oil known to be effective for insomnia, stress and tension. It is used in various Tibetan healing incenses. As its demand in the market increases, the chances of its variation increases. Also *N. jatamansi* could engender new cures for degenerative diseases such as Alzheimer's disease (AD) and Parkinson's disease. The researchers must therefore select genuine raw materials from the market. Its antitoxic activity could be explored in more details thereby increasing the possibility of developing new drugs.

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