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# MEDICINAL PLANTS USED TO MANAGE CNS AND MEMORY-RELATED PROBLEMS BY INDIGENOUS COMMUNITIES OF JAMMU & KASHMIR (UT) AND LADAKH (UT), INDIA

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## Abstract

In the present review article, we have compiled and analysed ethnomedicinal knowledge on the plants used to manage CNS and memory-related problems by various indigenous communities of the two Union Territories of India viz., Jammu and Kashmir (J&K), and Ladakh. Ethnomedicinal studies conducted in J&K and Ladakh, India up till the year 2020, were searched from journals, edited books, and scientific databases such as Google Scholar, SciFinder, Scopus, CAB international, DOAJ, Science direct, PubMed and Web of Science. More than 100 ethnobotanical studies were reviewed during the present study. The reviewed studies covered various indigenous communities from the study area, such as Gujjar, Bakerwal, Amchis, Dard, Pathan, Gaddi, Pahari, and other local and ethnic communities. A total of 116 plants belonging to the 94 genera of 32 families were found to be used by different communities of the study area to manage CNS and memory-related problems. Some of the most used plant species were *Centella asiatica*, *Cannabis sativa*, *Datura stramonium, Valeriana jatamansi*, *Hyoscyamus niger*, *Hypericum perforatum*, *Heracleum candicans, Euphorbia wallichii, Potentilla multifida, Atropa acuminata,* and *Prunella vulgaris.* The maximum numbers of plant species used in the study area belonged to the family Asteraceae (15 spp.), followed by family Apiaceae (9 spp.), Lamiaceae (9 spp.), Solanaceae (6 spp.), Rosaceae (5 spp.), and so on. The whole plant of 34 plant species was used, followed by roots, leaves, seeds, fruits, and flowers for the treatment of CNS and memory-related ailments. The majority of the plants were used as a sedative or narcotic. Large numbers of plants were used to manage epilepsy, memory, or as a brain/nerve tonic. Further scientific validation studies are required to prove claimed neuroprotective uses of some of the highly used plant species in the region, such as *E. wallichii, P. multifida, A. acuminata, P. vulgaris, Malva neglecta, Plantago himalaica, Pedicularis pectinata,* and *Nepeta leucolaena.*

***Keywords***: Epilepsy, Dementia, Sedative, Narcotic, Nervousness, Ethnomedicine, Traditional Knowledge, Anxiety.

**List of abbreviations**: $AlCl_3$: Aluminium chloride, AP: Aerial part, Ba: Bark, Bu: Bulb, CAT: Catalase, CNS: Central nervous system, COVID-19: Novel Coronavirus Disease, DAXX: Death-associated protein, D-gal: D-galactose, DPPH: 2,2-diphenyl-1-picrylhydrazyl, Fl: Flower, Fr: Fruit, FST: Forced swim test, GABA: Gamma-Aminobutyric acid, GPX: Glutathione peroxidase, Gy: Gray, H: Herb, HO-1: Heme oxygenase-1, HT22: Hippocampal neuronal cell line, Ke: Kernel, L-DOPA: 3,4-dihydroxyphenylalanine, LPP: Lipid peroxidation products, Lv: Leaves, MES: Maximal Electroshock, MPP+: 1-methyl-4-phenylpyridinium, MPTP: 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine, NF-κB: Nuclear factor kappa-light-chain-enhancer of activated B cells, Nrf2: Nuclear factor erythroid 2-related factor, PC12: Adrenal phaeochromocytoma cell line, PTZ: Pentylenetetrazole, ROS: Reactive oxygen species, Rt: Root, Rz: Rhizome, S: Shrub, Sd: Seed, Sh: Shoot, SOD: Superoxide dismutase, St: Stem, STZ: Streptozotocin, T: Tree, TPCC: Total Protein Carbonyl Content, TST: Tail suspension test, Tu: Tuber, Tw: Twig, UT: Union Territory, VEGF: Vascular endothelial growth factor, Wp: Whole plant, δ-ALAD: Delta-Amino Levulinic Acid Dehydratase.

## Introduction

The Central Nervous System (CNS) consists of the brain and spinal cord and is linked to a number of major activities of the body. There are various diseases and medical conditions during which the brain and spinal cord get affected, imparting the mental and physical capabilities of the patient. The familiar symptoms of neurological diseases comprise restlessness, mood swing, impaired cognition, poor coordination, hopelessness, paralysis, seizures, the distress of sensation, muscle weakness, pain, and confusion (Hussain *et al.,* 2017). In a recent report by Feigin *et al.* (2019), migraine, meningitis, Alzheimer's, and other dementias have been stated to be the most frequent neurological disorders. Migraine headache occurs as periodical attacks and may be manifested by nausea, vomiting, photophobia, and phonophobia (Zencirsi, 2010).

In recent years, many chemotherapies and synthetic drugs have been developed for treating CNS and memory related issues, but the possible side effect of these therapies and drugs is the key concern. There are many claims that medicinal plant-based treatments have a therapeutic advantage and fewer side effects as compared to the synthetic drugs (Junior *et al.,* 2013), as a result of which a paradigm shift has been noticed among healthcare communities towards the exploration of herbal-based drugs. The medicinal plant resources have been used to cure various diseases by various indigenous communities since the advent of human civilization. A major chunk of the population in the developing countries still relies on herbal treatments for accomplishing their basic health needs. But, at the same time, people residing in developed countries also have started to seek complementary or alternative therapies involving medicinal plants (Saraf, 2012).

As per some estimates, globally, near about 500 million individuals go through anxiety disorder (Kaviani and Mousavi, 2008). Ample of historical evidence points towards the use of herbal therapies for treating convulsive seizures for many centuries (Schachter, 2009), and use of herbal therapies among the sufferers of anxiety and mood disorders is also followed since ancient times (Sewell and Rafieian-Kopaei, 2014; Kessler *et al.,* 2005). In India, more than 10 million individuals are estimated to have epilepsy (Dixit *et al.,* 2017), and near about 30 million people are suffering from neurological disorders (Gourie-Devi, 2014). As per the recent report of the National Mental Health Survey of India, about 150 million Indians require mental care service. Many studies in the region have shown that a large chunk of the population is suffering from CNS and memory related

problems. For example, in a house to house survey in Kuthar Valley of South Kashmir, J&K, Ganaie and Bashir (2014) detected 157 cases of epilepsy, of which 60.5% were males of age below 30 years. In another study in Hazratbal Community Block of Srinagar, Masoodi *et al.* (2016) did random sample analysis on 15,748 people, which revealed 47 cases of seizures with neuro-infection being the primary cause and encephalitis accounting for 12.63%.

Since medical resources in all the developing countries, including India, are not adequate to deal with such a high number of patients, people are looking towards medicinal plants-based remedies, which may give relief up to some extent. Besides, the drug discovery now a day is based on the reverse pharmacology of Traditional Systems of Medicine, in which bio-prospection is first done to identify the drug candidate based on its traditional medicinal utility and finally certification through clinical trials. India harbours rich medicinal plant diversity (Mukherjee and Wahile, 2006), and has approximately 9,500 medicinal plant species (Chowti *et al.,* 2018). Such a huge medicinal wealth, if tackled sustainably, can prove beneficial to India as well as for the entire humanity. In India, the plants are being used for medicinal purposes since antiquity, the earliest mention is found in Rigveda (4500-1600 BC) (Kapoor, 1990). As per Kumar (2006), more than 120 medicinal plants are being used for treating CNS related disorders in Asian countries. Jain and Verma (2016) have enlisted 159 medicinal plant species traditionally used for the treatment of epilepsy among various tribes found in India. Similarly, 24 medicinal plants from Uttarakhand have been reported to be used for curing epilepsy by Sharma *et al.* (2013a). Balkrishna and Misra (2017) enlisted 56 plants used for treating brain disorders. A total of 37 medicinal plant species have been documented for treating paralysis in India (Mikawlrawng *et al.,* 2018).

Western Himalayan Region in India is a rich storehouse of medicinal plants, and various researchers have reported use of these medicinal plants from the treatment of various ailments by indigenous communities of the region (Vishwakarma *et al.*, 2011; Sharma *et al.*, 2011, 2012, 2013a, 2013b, 2014; Rana *et al.*, 2013; Gairola *et al.*, 2013, 2014a, 2014b). Union Territories of Jammu and Kashmir (J&K) and Ladakh (Ladakh), India, are part of the Western Himalayas having rich biodiversity of medicinal plants. In a comprehensive review on medicinal plants used in the region, Gairola *et al.* (2014a) reported that a total of 948 plant taxa are used traditionally by the indigenous communities of J&K and Ladakh for treating various health ailments. Various ethnobotanical and ethnomedicinal studies have been conducted in J&K and Ladakh for the since past five decades (Bano *et al.*, 2017; Khanday *et al.,* 2018). During these studies in J&K and Ladakh, some important information on plants used for managing CNS and memory-related problems were collected. However, a systematic compilation of this information is lacking. The present study aimed A). To systematically review all the information collected by various researchers of the region on the medicinal plants used to manage CNS and memory-related problems by the indigenous communities of J&K and Ladakh, and B). To reveal the scientific gaps in current knowledge on these plants for suggesting the future course of research on development of drugs for CNS and memory-related problems.

## Materials and Methods

A comprehensive literature survey was done to review the knowledge on the plants traditionally used to manage CNS and memory-related problems by different indigenous communities of J&K and Ladakh, India. The articles related to ethnobotanical and ethnomedicinal studies from J&K and Ladakh on medicinal plants used by various indigenous communities were searched from journals, edited books, and scientific databases such as Google Scholar, SciFinder, Scopus, CAB international, DOAJ, Science direct, PubMed and Web of Science. The information on the medicinal plants, along with their valid scientific names, synonyms, families, plant parts used, ailment treated, mode of use, etc were collected and compiled. Valid botanical names of all the species compiled in the present study were verified from The Plant List Version 1.1 (TPL, 2013).

## Results and Discussion

More than 100 ethnobotanical studies were reviewed during the present study. The reviewed studies were performed at various localities of J&K and Ladakh. A total of 116 plants belonging to 94 genera of 32 families were found to be used by different communities of the study area for managing CNS and memory related problems (Table 1). The indigenous community from the study area included Gujjar-Bakerwal, Amchis, Dard, Pathan, Gaddi, Pahari, and other local and Ethnic communities. As shown in Fig. 1, the maximum number of plants of the family Asteraceae (15 spp., 12.9%) were used, followed by family Apiaceae (9 spp., 7.8%), Lamiaceae (9 spp., 7.8%), Solanaceae (6 spp., 5.2%), Rosaceae (5 spp., 4.3%), Leguminosae, Orchidaceae, Plantaginaceae, Ranunculaceae (4 spp., 3.4%) and so on. The highest use of family Asteraceae in the treatment of various ailments has also been observed in an earlier study in J&K by Bhardwaj *et al.* (2019). The members of the family Asteraceae harbor a wide variety of phytochemicals of economic importance like alkaloids, essential oil, tannins, terpenes (Akbar, 2020).

As shown in Fig. 2, whole plant of 43 plant species were used by various communities across the two union territories. In comparison, roots and leaves of 22 and 33 plant species, respectively were used, which were followed by use of seeds (14 spp.), flowers (9 spp.), fruits (8 spp.), and so on. The maximum number of plant parts used belonged to *H. niger*, which is one of the four plants used in Ayurveda to cure Parkinson's disease (Zhang *et al.,* 2012). Herbs were used in majority of the formulations. Out of the total 116 plant species reported, herbs accounted for 77% (89 spp.) of the total species followed by shrubs 15 % (18 spp.), trees 4%, (5 spp.), climber 3% (3 spp.) and runner 1% (1 sp.). The majority of the plants were used as a sedative, epileptic, memory enhancing, narcotic, brain tonic, and as a nerve tonic.

Of the total 116 plants species, 34 species were explicitly used in Jammu province of the Union territory of J&K. Some important species used were *C. asiatica, C. dactylon*, *B. monnieri*, *B. persicum*, *C. sativus*, *D. incarnate*, *D. cannabina*, *D. metel*, *D. purpurea*, *T. serpyllum*, *W. somnifera*, *V. negundo*, *C. pariera*, and *V. thapsus* (Table 1). In Kashmir province, 31 plant species were found to be used to manage CNS and memory related issues, and some important species were *C. sativum*, *E. wallichii*, *M. neglecta*, *V. album*, *A. chasmanthum*, *A. glauca*, *A. absinthium*, *A.*

*nilagirica*, *A. scoparia*, *C. maculatum*, *C. reflexa*, *L. angustifolia*, and *L. jacquemontiana* (Table 1).

In the Union Territory of Ladakh, 31 species were used. The most cited species from Ladakh were *H. niger*, *P. multifida*, and *P. vulgaris* with three citations each, followed by *M. officinalis*, *N. leucolaena*, *P. pectinata*, *P. himalaica*, *S. glacialis*, and *T. campylodes*. Plant species commonly used in both the division of J&K were *A. acminata*, *D. stramonium*, *H. candicans*, *O. corniculata*, *T. wallichiana*, *V. jatamansi*, and *V. officinalis*. The *D. hatagirea* was commonly used in both Kashmir and Ladakh, whereas *H. niger* was found to be used in Jammu & Kashmir, as well as Ladakh. The citation frequency was found to be high for the plant species namely *C. sativa* (9.5), *H. niger* (6.0), *D. stramonium* (5.2), *V. jatamansi* (4.3), *A. acuminata* (3.4), *H. candicans* (2.6), *C. asiatica* (2.6), *E. wallichii* (2.6), *P. multifida* (2.6), and *P. vulgaris* (2.6). The plant species used by indigenous communities of J&K and Ladakh, India, to manage various ailment or mental conditions related to the CNS and memory have been presented in Table 2. Some of these conditions were overlapping but to keep original information intact they are shown separately in the Table 2, which would give readers better view of the terminologies used by the local inhabitants to refer to the same problem. The present study revealed that the study area has a rich variety of medicinal plants, which are still commonly used for medicinal purposes by the local inhabitants.

The pharmacological properties of some of the important recorded plant species have been discussed in the following sections. There is a general understanding that reactive oxygen species (ROS) perform important roles in natural brain activity and pathology in the form of neurological diseases (Patel, 2016). Oxidative stress is a complex condition in which there is a discrepancy occurs between the production of ROS and the supply and operation of antioxidants (Du *et al.,* 2013). While evaluating the antioxidant potential of hydroalcoholic seed extract of *C. sativum* in a lead acetate (1,000 mg/L) induced stressed rat Velaga *et al.* (2014) found increased levels of ROS, total Protein Carbonyl Content (TPCC), lipid peroxidation products (LPP) and decreased activity of Delta-Amino Levulinic Acid Dehydratase (δ-ALAD) in the brain thereby showing its antioxidant potential. Emamghoreishi *et al.* (2006) evaluated the sedative-hypnotic potential of essential oil, hydroalcoholic and aqueous extract of coriander seeds (100, 200, 400, and 600 mg/kg) in pentobarbital-induce male albino mice. They found prolonged sleeping time at 200, 400, and 600 for aqueous extract, 400 and 600 mg/kg for hydroalcoholic while essential oil prolonged the sleeping time only at 600 mg/kg dose. Fresh leaves of *C. sativum* (5, 10, and 15% w/w of diet) have been reported to show a dose-dependent enhancement in memory scores of young as well as aged mice. Also, a successful reversal of the memory deficits was observed induced by diazepam (1 mg $kg^{-1}$, i.p.) and scopolamine (0.4 mg $kg^{-1}$, i.p.) (Mani *et al.,* 2009). Anticonvulsant and neuroprotective effects of *C. sativum* have been established in various studies (Hosseinzadeh and Madanifard, 2005; Rakhshandeh *et al.,* 2012; Karami *et al.,* 2015; Anaeigoudari *et al.,* 2016).

Cannabinoids are the important active principle in *C. sativa*. Bergamaschi (2011) reported the anxiety reduction by Cannabinidiol in a simulated public speaking task. A significant improvement in neuropathic pain at a dose of 1.29% and 3.53% of vaporized cannabis (delta-9-tetrahydrocannabinol) has been observed in a double-blind, placebo-controlled experiment (Wilsey *et al.,* 2013). In one more double-blind, placebo-controlled trial, a better efficacy of oral mucosal cannabinoid extract has been observed in treating the neuropathic pain than placebo (Lynch *et al.,* 2014). In a retrospective chart analysis of 121 people with migraines, who used prescription medicinal marijuana to cure migraines, the migraine incidence declined from 10.4 to 4.6 headaches per month. Most of the included participants took marijuana in more than one form on a regular basis for prevention. A reduced incidence of migraine headache was observed in 24 patients and abandoned migraine headache in 14 patients (Rhyne *et al.,* 2016). Various randomized trials showing positive effects of cannabidiol in treating epilepsy have been carried out (Hess *et al.,* 2016; Devinsky *et al.,* 2017, 2018; Schoedel *et al.,* 2018).

The aqueous methanol extract (containing 0.03% w/w of L-DOPA) of *H. niger* seeds have been shown to exhibit a significant effect on the striatal dopamine loss, and attenuation of motor disabilities (akinesia, catalepsy, and reduced swim score) in MPTP treated mice due to its hydroxyl radical scavenging capability and monoamine oxidase inhibitory potential (Sengupta *et al.,* 2011). A dose of 300 mg/kg ip of methanol extract of *H. niger* greatly postponed the initiation of picrotoxin-induced (12 mg/kg ip) seizures in mice that had shown its anticonvulsant function had been partially correlated with flavonoid rutin in the extract (Reza *et al.,* 2009). In the tail suspension test (TST) and forced swim test (FST) in Mice, Patil *et al.* (2013) reported an antidepressant-like action of ethanolic extract of *H. niger* in the dose range of 50-40 mg/kg. Khatri *et al.,* (2015) evaluated the neuroprotective potential of methanolic seeds extract of *H. niger* in stereotaxically induced rotenone model of Parkinson's disease in rats and found an increased level of GSH content and antioxidants enzymes activities (GPX, SOD, and CAT) therefore suggested it as a potential drug for treating physiological abnormalities, oxidative damage, and in neuroprotection.

Besides being used in the Indian system of medicine (Nayar *et al.,* 1988), *V. jatamansi* has also been used in Chinese Traditional Medicine for the treatment of insomnia, rheumatism, malaise and abdominal distention (Xu *et al.,* 2015). At an oral dose of 500 mg/capsule of valerian plant extract, twice every day after a meal to thirty-three Indian patients (20 males and 13 females; average age 34.2 years) substantially attenuated tension and anxiety, improved depression and more desirable willingness to adjust, without altering memory, focus or attention of the participants (Bhattacharyya *et al.,* 2007). Antidepressant-like results observed by Sah *et al.* (2011) for the essential oil of Indian valerian chemotypes were suggested to be mediated with NO pathway. Three iridoids namely Jatairidoid A, B, and C extracted from the roots of *V. jatamansii* at 30 μM concentrations have been shown to exhibit neuroprotective activity by increasing the cell viability to 77.2%, 78.9%, and 90.8% respectively in 1-methyl-4-phenylpyridinium (MPP+) induced cell death in SH-SY5Y cells (Xu *et al.,* 2012). The root extract at doses of 200 and 300 mg/kg improved sleep quality and modulates the amount of brain monoamine in rats (Sahu *et al.,* 2012). In a clinical study by Toolika *et al.* (2015) on 15 Indian patients, a significant improvement in the onset of sleep was observed after consuming 4 g of

valerian powder with milk thrice a day for one month, which was better than that achieved for *N. jatamansi*.

Various furocoumarins namely Canditririn C, Canditetrarin A, imperatorin, xanthotoxin, heraclenol, xanthotoxol, angelicin, phellopterin, heraclenin, candibirin have been isolated from *H. candicans* in different studies (Sharma *et al.,* 1964; Bandhopadhyay *et al.,* 1973; Doi *et al.,* 2004; Taniguch *et al.,* 2011). The furanocoumarins' imperatonin' had been shown to irreversibly inactivate the activity of gamma-aminobutyric acid (GABA)-transaminase, raising the level of GABA in the brain and the neuronal synaptic clefts (Choi *et al.,* 2005; Luszczki *et al.,* 2007). The neuroprotective potential of these plants like *E. wallichii, P. multifida, A. acuminata,* and *P. vulgaris* is still to be proved.

Oral administrations of *C. asiatica* extract at a dose of 20 mg/kg significantly revamp memory and cognitive deficiencies and improved neuronal damage in the dorsal hippocampus of rats (Thong-asa *et al.,* 2018). Asiatic acid, an active constituent of *C. asiatica,* has been shown to improved memory and cognitive ability at a dose of 30 mg/kg of in male Sprague-Dawley rats compared to scopolamine, baclofen, and saline (Nasir *et al.,* 2011). *C. asiatica* extract has been shown to have a neuroprotective impact on traumatic brain injury, through stimulation of the Krox-20 gene, thereby setting off the development of new phospholipids in nerve cells (Jazmi *et al.,* 2015). The potential of *C. asiatica* plant in alleviating the D-gal/$AlCl_3$ induced pathologies related to Alzheimer's disease has been demonstrated recently (Chiroma *et al.,* 2019). An herbal mixture containing *D. stramonium* as a constituent has been shown to possess antiseizure activity, therefore, suggested being helpful as an adjuvant in treating epilepsy (Peredery and Persinger, 2004). Bhalerao *et al.* (2011) reported potent nitric oxide and DPPH free radical scavenging capacity of the ethanolic aerial part extract of *C. dactylon*. The hydroalcoholic extract of *C. dactylon* at 0.25 g/kg and 1 g/kg dose has been shown to improve the cerebellar oxidative stress and the cognitive functions in gamma-irradiated (5 Gy) mice' Also, a significant increase in the glutathione level and decreased nitric oxide level and lipid peroxidation was observed compared to the control group (Poojary *et al.,* 2019).

The significant anxiolytic effect has been produced by the alcoholic extract of *M. officinalis* at a dose of 100 and 200 mg/kg compared to the standard diazepam hydrochloride (2 mg/kg) in albino mice (Kaur *et al.,* 2017). Bazazzadegan *et al.* (2017) investigated the effect of *M. officinalis* extract in Alzheimer disease in terms of its potential function as an antioxidant, anti-inflammatory agent and its influence on the expression of several genes including NFkB, VEGF and DAXX in the treatment of Alzheimer's disorder rat model relative to its standard streptozotocin (STZ). The findings revealed that the extract triggered a substantial decrease in the expression of NFkB, VEGF, and DAXX genes in the intermittent Alzheimer's disease rat model relative to STZ-induced rats. Furthermore, no major differences were found in the swim distance and time to reach the secret platform in the extract-treated community relative to the STZ-induced community. The sedative and anxiolytic effects of this plant have been evaluated (Hong *et al.,* 1983; Kaur *et al.,* 2017). Senthil and Raj (2010) screened the methanolic leaf extract of *O. corniculata* Linn. for its antiepileptic activity. They observed an antiepileptic effect against the Pentylenetetrazole (PTZ), and Maximal Electroshock (MES) induced convulsions in Albino Wistar rats at doses of 200 and 400 mg/kg.

The ethanolic extract of *T. campylodes* at 400 µg/mL concentration effectively reduced the cytotoxicity caused by ROS production and glutamate and in the HT22 cells in both ROS and cell viability and assays. Besides, the extract enhances the expression of HO-1 protein and which translocates the Nrf2 into the nucleus, thereby increasing the levels in the nucleus. Experiments with SnPP stipulated a positive association between the expressions of HO-1 with neuroprotective effects in the HT22 cells (Huang *et al.,* 2018). Crude aqueous methanolic extract of *V. officinalis* displayed dose-dependent (100–500 mg/kg) anticonvulsant activity in PTZ-induced seizures inAlbino mice while a dose range 50–300 mg/kg) exhibited the anxiolytic, and sedative activities in thiopental and diazepam induced models (Khan *et al.,* 2016). In the study carried out by Bekara *et al.* (2020), an oral administration of aqueous leaf extract of *V. officinalis* at a dose of 200 mg/kg portrayed an antidepressant action in an animal model of depression compared to that of fluoxetine (20 mg/kg). The ethanolic plant extract of the *V. album* displayed dose-dependent inhibition of PTZ induced convulsion and death and significantly slow down the onset and prolong the duration of sleep in pentobarbital induced sleep in mice (Timothy *et al.,* 2017). Sedative, antiepileptic and antipsychotic activities of leaf extract of *C. album* has been suggested to involve the GABAergic transmission and antidopaminergic potential of the extract (Gupta *et al.,* 2012).

Nisar *et al.* (2008) investigated the anticonvulsant effect of methanolic leaf extract of *T. wallichiana* at doses 50, 100, and 200 mg/ kg. They found a reduction in the myoclonic seizers induced by pentylenetetrazole in the rats. Besides, the extract dose of 100 and 200 mg/kg significantly delayed the onset of first clonus seizures, whereas, at 200 mg/kg dose, it impedes the tonous seizures. Hyperforin, an active compound of *H. perforatum***,** has been focused on as being principally responsible for the antidepressant activity (Biber *et al.,* 1998). A significant dose-dependent protective effect of the standardized extract of this plant on the $H_2O_2$ (200 µM) induced trauma of PC12 cells have been noticed within 24 h of treatment by Lu *et al.* (2004). Also, the extract at 10~100 µg/m concentration prevented the apoptosis in PC12, decreased the ROS both at intra- and extra-cellular levels, and blocked DNA fragmentation. In the study of Pochwat *et al.* (2018), a long-lasting antidepressant effect was evoked in both naive and chronic corticosterone-treated mice after a combined administration of hyperforin and lanicemine both *in vivo* and *in vitro* studies.

## Conclusion

A total of 116 plants belonging to 94 genera of 32 families were found to be used by different communities of the study area for managing CNS and memory related problems (Table 1). Irrespective of having a rich medicinal flora in both the Union Territories, the knowledge is mainly confined to the nomads and the local inhabitants. Also, the new generation generally shows no enthusiasm in inculcating this indigenous knowledge from their ancestors due to the carrier-oriented perspective for which they move out from their native place. Although the current market is loaded with medicines for CNS disorders including epilepsy, migraine, anxiety, depression, insomnia, neuralgia, but these are either

costly or may have severe side effects. In current scenario, a sudden epidemiological catastrophe like we are facing today, i.e., COVID-19, will effect psychological condition of large percentage of population. Therefore, the present documentation of the available ethnomedicinal knowledge on plants used to manage CNS and memory related problems will help scientists in searching for new herbal cures. Further scientific validation studies are required to prove claimed activites of the plant species compiled in the present study. Such studies may aid in isolation of novel CNS active compounds, and the use of 'omics' technology to help in elucidation of the mechanism responsible for their pharmacological action for development of effective herbal medicines.

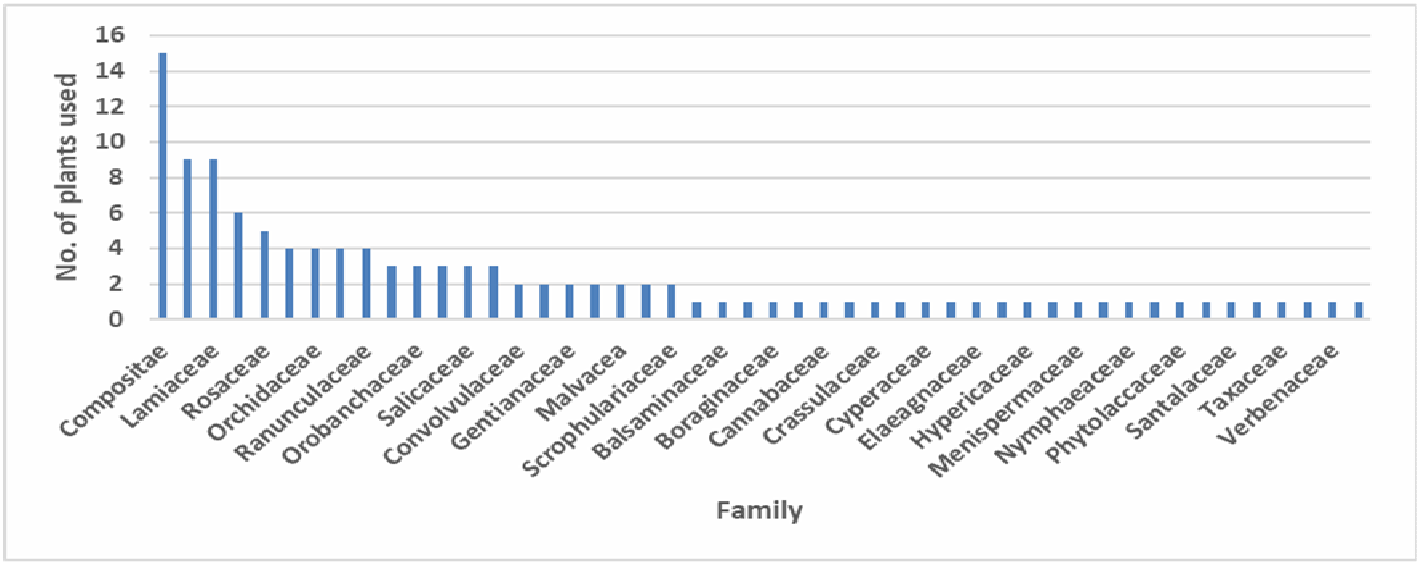


**Fig. 1:** Frequently used plant families for managing CNS, brain, and memory-related disorders by indigenous communities of J&K and Ladakh.

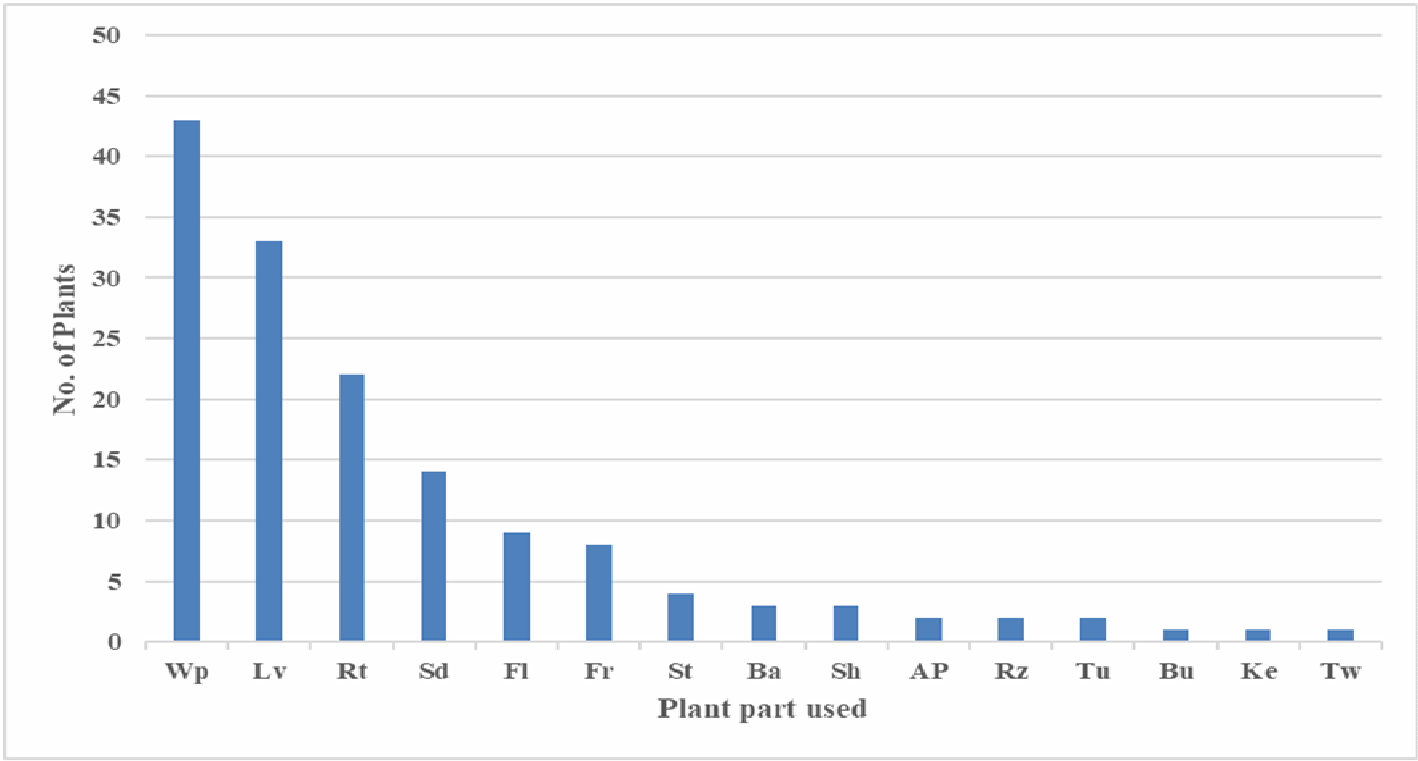


**Fig. 2:** Numbers of plant parts used in the formulations to manage CNS, brain, and memory-related disorders by indigenous communities of J&K and Ladakh.

**Table 1**: Medicinal plants used to manage CNS, brain, and memory-related ailments by indigenous communities of J&K and Ladakh, India

| S. No. | Botanical Name (*Synonym) Family] | Citation frequency | Growth form | Region (Community) | Ailment (Part used) | Source |
|---|---|---|---|---|---|---|
| 1. | *Abrus precatorius* L. [Fabaceae] | 0.9 | C | Trikuta Hills, Jammu, J&K (Gujjar community) | Nerve tonic (Lv, Sd) | Kumari *et al.* (2013) |
| 2. | *Abutilon indicum* (L.) Sweet [Malvaceae] | 0.9 | S | Rajouri District, Jammu, J&K (Gujjar-Bakerwal and other local communities) | Paralysis (Lv) | Bhandari (2015) |
| 3. | *Achillea millefolium* L. [Compositae] | 0.9 | H | Ladakh (Amchis) | Epilepsy (Wp) | Srivastava *et al.* (1981) |
| 4. | *Aconitum chasmanthum* Stapf ex Holmes [Ranunculaceae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiri Gujar, Pathan and Bakarwal communities) | Neuralgia (Rt) | Srivastava *et al.* (1984), Kapahi *et al* (1993) |
| 5. | *Acorus calamus* L. [Acoraceae] | 0.9 | H | Udhampur district, Jammu, J&K (Local community) | Memory enhancer (Rz | Bhatia *et al.* (2014) |
| 6. | *Actaea spicata* L. [Ranunculaceae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiri Gujar, Pathan and Bakarwal communities) | Nerve sedative (Wp) | Srivastava *et al.* (1984) |
| 7. | *Ageratum conyzoides* (L.) L. [Compositae] | 0.9 | H | Kathua district, Jammu, J&K (Local community) | Nerve tonic (Lv) | Kumar and Bhagat (2012) |
| 8. | *Anagallis arvensis* L. [Primulaceae] | 0.9 | H | Kathua district, Jammu, J&K (Local community) | Epilepsy (Wp) | Kumar and Bhagat (2012) |
| 9. | *Angelica glauca* Edgew. [Apiaceae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiri Gujars and Pathan communities) | Mental disorder (Wp) | Kapahi *et al.* (1993) |
| 10. | *Artemisia absinthium* L. [Compositae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiri Gujar, Pathan and Bakarwal communities) | Epilepsy (Wp) | Srivastava *et al.* (1984) Kapahi *et al.* (1993) |
| 11. | *Artemisia nilagirica* (C.B.Clarke) Pamp. [Compositae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiri Gujar, Pathan and Bakarwal communities) | Nervous disorder (Wp | Srivastava *et al.* (1984) |
| 12. | *Artemisia scoparia* Waldst. and Kit [Asteraceae] | 0.9 | H | Baramulla Tehsil, Baramulla, Kashmir, J&K (Local community) | Tranquilizer (Wp) | Wagay (2014) |
| 13. | *Atropa acuminata* Royle ex Lindl [Solanaceae] | 3.4 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiri Gujar, Pathan and Bakarwal communities) | Narcotic (Rt, Lv), Sedative (Rt, Lv) | Srivastava *et al.* (1984) |
| | | | | Jhelum valley, Kashmir, J&K (Local community) | Narcotic (Rt, Lv), Sedative (Rt, Lv), Neuralgia (Rt) | Naqshi *et al.* (1992) |
| | | | | Gurez valley, Kashmir, J&K (Dard, Kashmiris, Gujars and Pathans communities) | Sedative (Rt, Lv) | Kapahi *et al.* (1993) |
| | | | | Kishtwar district, Jammu, J&K (Gujjars and Bakerwal community) | Neuralgia (Rt) | Trak and Giri (2017) |
| 14. | *Atropa belladonna* L. [Solanaceae] | 0.9 | H | Pahalgam Valley, Kashmir, J&K (Local community) | Sedative (Wp) | Bhat and Gulfishan (2015) |
| 15. | *Avena sativa* L. [Poaceae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Sd) | Ballabh *et al.* (2008) |
| 16. | *Bacopa monnieri* (L.) Wettst. [Plantaginaceae] | 0.9 | H | Rajouri and Poonch districts, Jammu, J&K (Local community) | Nervous disorder (Wp | Azad and Bhat (2013) |
| 17. | *Berberis lycium* Royle [Berberidaceae] | 0.9 | S | Jammu, Kashmir, J&K (Traditional system of medicine) | Sedative and Hemicrania (Rt) | Rasool *et al.* (2016) |
| 18. | *Borago officinalis* L. [Boraginaceae] | 0.9 | H | Anantnag and Budgam districts, Kashmir, J&K (Ethnic communities) | Dementia (AP) | Bano *et al.* (2017) |
| 19. | *Bunium persicum* (Boiss.) B.Fedtsch. [Apiaceae] | 0.9 | H | Paddar Valley, Kishtwar district, Jammu, J&K (Local community) | Anxiety (Sd), Depression (Sd), Convulsions (Sd) | Gupta *et al.* (2013) |
| 20. | *Cannabis sativa* L. [Cannabaceae | 9.5 | H | Ganderbal district, Kashmir, J&K (Local community) | Narcotic (Lv) | Baba *et al.* (2012) |
| | | | | Baramulla and Kupwara district, Kashmir, J&K (Local herbalist) | Narcotic (Wp) | Malik *et al.* (2011) |
| | | | | Tanghmarg tehsil, Baramulla, Kashmir, J&K (Gujjars, Bakarwals and Paharis communities | Narcotic (Lv, Fl) | Yousuf *et al.* (2012) |
| | | | | Bandipora, Sonawari and Gurez tehsil of Bandipora district, Kashmir, J&K (Gujjars, Bakerwals and other local communities) | Narcotic (Lv) | Lone and Bhardwaj (2013b) |
| | | | | Baramulla Tehsil, Baramulla, Kashmir, J&K (Local community) | Narcotic (Lv) | Wagay (2014) |
| | | | | Kishtwar district, Jammu, J&K (Local community) | Sedative (Wp), Narcotic (Wp) | Kumar *et al.* (2009) |
| | | | | Kathua district, Jammu, J&K (Local community) | Sedative (Wp) | Kumar and Bhagat (2012) |
| | | | | Pahalgam Valley, Kashmir, J&K (Local community) | Hallucination (Fl, Lv) | Bhat and Gulfishan (2015) |
| | | | | North-West Himalaya, J&K (Gaddi community) | Sedative (Lv) | Dutt *et al.* (2015) |
| | | | | Kishtwar district, Jammu, J&K (Gujjars and Bakerwal communities) | Sedative (Lv) | Trak and Giri (2017) |
| | | | | Subdivision Mendhar, District Poonch, Jammu, J&K (Pahari community) | Narcotic (Wp) | Manzoor and Ali (2017) |

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| 21. | *Capparis spinosa* L. [Capparaceae] | 0.9 | S | Skuru watershed of Karakoram wildlife sanctuary, Ladakh (Traditional medicines system of Ladakh) | Paralysis (Lv, St) | Namtak and Sharma (2018) |
| 22. | *Centella asiatica* (L.) Urb. [Apiaceae] | 2.6 | H | Tehsil Billawar, Kathua district, Jammu, J&K (Local community) | Mental disorder (Lv) | Bhushan and Kumar (2013) |
| | | | | Kathua district, Jammu, J&K (Local community) | Brain tonic (Lv) | Rao *et al.* (2015) |
| | | | | Udhampur district, Jammu, J&K (Local community) | Memory enhancer (Lv | Bhatia *et al.* (2014) |
| 23. | *Cissampelos pariera* L. [Menispermaceae] | 0.9 | S | Jammu hills, Jammu, J&K (Local community | Sedative (Rt) | Sharma *et al.* (2015) |
| 24. | *Conium maculatum* L. [Apiaceae | 0.9 | H | Jhelum valley, Kashmir, J&K (Local community) | Sedative (Fr) | Naqshi *et al.* (1992) |
| 25. | *Coriandrum sativum* L. [Apiaceae] | 1.7 | H | Shopian district, Kashmir, J&K (Gujjar and Bakerwal communities) | Insomnia (Lv) | Bhat *et al.* (2012) |
| | | | | Langate area, Kupwara district, Kashmir, J&K (Local community) | Insomnia (NA) | Kanta *et al.* (2018) |
| 26. | *Cortia depressa* (D.Don) C.Norman [Apiaceae] | 0.9 | H | Ladakh (Amchis) | Sedative (Wp) | Srivastava *et al.* (1981) |
| 27. | *Cremanthodium decaisnei* C.B.Clarke [Compositae] | 0.9 | H | Leh, Chumathang, Nubra, Zanskar, Kargil an Drass, Ladakh (Amchis) | Sedative (Wp) | Gupta *et al.* (1981) |
| 28. | *Crocus sativus* L. [Iridaceae] | 0.9 | H | Kishtwar district, J&K (Local community) | Nerve sedative (Wp) | Kumar *et al.* (2009) |
| 29. | *Cuscuta reflexa* Roxb. [Convolvulaceae] | 0.9 | C | Bandipora, Sonawari and Gurez tehsil of Bandipora district, Kashmir, J&K (Gujjars, Bakerwals and other local communities) | Migraine (Wp) | Lone and Bhardwaj (2013b) |
| 30. | *Cynodon dactylon* (L.) Pers. [Poaceae] | 1.7 | H | Kathua district, Jammu, J&K (Local community) | Memory enhancer (Rt | Kumar and Bhagat (2012) |
| | | | | Subdivision Mendhar, District Poonch, Jammu, J&K (Pahari community) | Epilepsy (Wp, Rt) | Manzoor and Ali (2017) |
| 31. | *Cyperus glomeratus* L. [Cyperaceae] | 0.9 | H | Jammu, Kashmir, J&K (Local communities) | Nervous stimulant (Wp) | Kak (2007) |
| 32. | *Dactylorhiza hatagirea* (D.Don) Soo [Orchidaceae] | 1.7 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Tu) | Ballabh *et al.* (2008) |
| | | | | Kashmir, J&K (Local community) | The weakness of the nervous system (Tu) | Shapoo *et al.* (2013) |
| 33. | *Dactylorhiza incarnata* (L.) Soo (**Orchis latifolia* L.) [Orchidaceae] | 0.9 | H | Bhaderwah hills, Jammu, J&K (Gujjars, Bakerwal and Gaddhis communities) | Nervous disorder (Tu) | Kapur and Nanda (1992) |
| 34. | *Datisca cannabina* L. [Datiscaceae] | 0.9 | H | District Rajouri, Jammu, J&K (Gujjars and Bakerwals communities) | Sedative (Rt) | Rashid (2012) |
| 35. | *Datura metel* L. [Solanaceae] | 0.9 | H | Jammu hills in District Jammu, J&K (Local community) | Narcotic, sedative (Wp | Sharma *et al.* (2015) |
| 36. | *Datura stramonium* L. [Solanaceae] | 5.2 | H | Jhelum valley, Kashmir, J&K (Local community) | Narcotic (Lv, Sd) | Naqshi *et al.* (1992) |
| | | | | Baramulla and Kupwara district, Kashmir, J&K (Local herbalist) | Narcotic (Wp) | Malik *et al.* (2011) |
| | | | | PirPanjal range, Banihal, Jammu, J&K (Gujjar, Bakarwal and other local communities) | Narcotic (Wp) | Kumar and Naqshi (1990) |
| | | | | Baramulla Tehsil, Baramulla, Kashmir, J&K (Local community) | Hallucination (Sd) | Wagay (2014) |
| | | | | Pahalgam valley of Kashmir Himalayas, India J&K (Local community) | Narcotic (Lv, Sd) | Bhat and Gulfishan (2015) |
| | | | | Kashmir Himalaya, J&K (Local community) | Sedative (Sd) | Khanday *et al.* (2018) |
| 37. | *Delphinium denudatum* Wall. ex. H&T [Ranunculaceae] | 0.9 | H | J&K (Traditional System of Medicine) | Hemiplegia, Epilepsy (Rt) | Rasool *et al.* (2016) |
| 38. | *Digitalis purpurea* L. [Plantaginaceae] | 0.9 | H | Trikuta Hills, Jammu, J&K (Gujjar community) | Epilepsy (Lv) | Kumari *et al.* (2013) |
| 39. | *Elaeagnus rhamnoides* (L.) A.Nelson (* *Hippophae rhamnoides* L.) [Elaeagnaceae] | 0.9 | S | Suru, Wakha-chu and Lower Indus valleys, Western Ladakh (Amchis) | Memory enhancer (Fl Lv, St) | Angmo *et al.* (2012) |
| 40. | *Epipactis helleborine* (L.) Crantz [Orchidaceae] | 0.9 | H | Kashmir Himalaya, J&K (Local community) | Nerve tonic (Rh) | Shapoo *et al.* (2013) |
| 41. | *Erigeron multiradiatus* Benth. [Compositae] | 0.9 | H | Leh, Chumathang, Nubra, Zanskar, Kargil an Drass, Ladakh (Amchis) | Brain tonic (Wp) | Gupta *et al.* (1981) |
| 42. | *Euphorbia wallichii* Hook.f. [Euphorbiaceae] | 2.6 | H | Ganderbal district, Kashmir, J&K (Local community) | Nerve troubles (Lv, Sd | Baba *et al.* (2012) |
| | | | | Shopian district, Kashmir, J&K (Local community) | Nerve troubles (Wp) | Tantray *et al.* (2009) |
| | | | | Langate area, Kupwara district, Kashmir, J&K (Local community) | Nerve troubles (NA) | Kanta *et al.* (2018) |
| 43. | *Evolvulus alsinoides* L. [Convolvulaceae] | 0.9 | H | Kathua district, Jammu, J&K (Local community) | Brain tonic (Wp) | Rao *et al.* (2015) |
| 44. | *Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita [Rosaceae] | 0.9 | H | Rajouri district, Jammu, J&K (Gujjar community) | Memory enhancer (Wp) | Dangwal and Singh (2013) |

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| 45. | *Galium aparine* L. [Rubiaceae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Lv) | Ballabh *et al.* (2008 |
| 46. | *Galium rotundifolium* L. [Rubiaceae] | 0.9 | H | Bhaderwah hills, Jammu, J&K (Gujjars, Bakerwal and Gaddhi communities) | Epilepsy (Wp) | Kapur and Nanda (1992) |
| 47. | *Gentiana argentea* Royle. [Gentianaceae] | 0.9 | H | North-West Himalaya, J&K, India (Gaddi community) | Nervous distress (Rz) | Dutt *et al.* (2015) |
| 48. | *Gentiana squarrosa* Ledeb. [Gentianaceae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Rt) | Ballabh *et al.* (2008 |
| 49. | *Heracleum candicans* Wall. ex DC. [Apiaceae] | 2.6 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiris, Gujars, Pathans, Bakarwales communities) | Nerve tonic (Fr) | Srivastava *et al.* (1984) |
| | | | | Jhelum valley, Kashmir, J&K (Local community) | Nerve tonic (Wp) | Naqshi *et al.* (1992) |
| | | | | Bhaderwah hills, Jammu, J&K (Gujjars, Bakerwal and Gaddhis communities) | Nerve tonic (Fr) | Kapur and Nanda (1992) |
| 50. | *Heracleum pinnatum* C.B. Clarke [Apiaceae] | 0.9 | H | Skuru watershed of Karakoram wildlife sanctuary, Ladakh (Traditional medicines system of Ladakh) | Memory restoration (Rt, Sh) | Namtak and Sharma (2018) |
| 51. | *Herminium monorchis* (L.) R.Br. [Orchidaceae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Bu) | Ballabh *et al.* (2008 |
| 52. | *Hyoscyamus niger* L. [Solanaceae] | 6.0 | H | Leh, Chumathang, Nubra, Zanskar, Kargil an Drass, Ladakh (Amchis) | Sedative (Lv) | Gupta *et al.* (1981) |
| | | | | Ladakh (Amchis) | Sedative (Lv) | Srivastava and Gupt (1982) |
| | | | | Suru, Wakha-chu and Lower Indus valleys, Western Ladakh (Amchis) | Sedative (Lv, St) | Angmo *et al.* (2012) |
| | | | | Jhelum valley, Kashmir, J&K (Local community) | Sedative (Lv, FT), Narcotic (Lv, FT), | Naqshi *et al.* (1992) |
| | | | | Paddar Valley, Kishtwar district, Jammu, J&K (Local community) | Nervousness (Fl, Lv) | Gupta *et al.* (2013) |
| | | | | Bandipora, Sonawari and Gurez tehsil of Bandipora district, Kashmir, J&K (Gujjars, Bakerwals and other local communities) | Sedative (Lv) | Lone and Bhardwaj (2013b) |
| | | | | Kashmir, J&K | Sedative (Lf, Sd) | Khanday *et al.* (2018 |
| 53. | *Hypericum perforatum* L. [Hypericaceae] | 1.7 | H | North-West Himalaya, J&K (Gaddi community) | Mental depression (Lv | Dutt *et al.* (2015) |
| | | | | North-West Himalaya, J&K (Gaddi community) | Sedative (Wp) | Dutt *et al.* (2015) |
| 54. | *Impatiens glandulifera* Royle [Balsaminaceae] | 0.9 | H | Kishtwar district, Jammu, J&K (Local community) | Mental tension (Rt) | Kumar *et al.* (2009) |
| 55. | *Indigofera tinctoria* L. [Leguminosae] | 0.9 | S | Kathua district, Jammu, J&K (Local community) | Epilepsy (Wp), Nervous disorder (Wp | Kumar and Bhagat (2012) |
| 56. | *Iris hookeriana* Foster [Iridaceae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Wp) | Ballabh *et al.* (2008 |
| 57. | *Juniperus communis* var. *saxatilis* Pall. [Cupressaceae] | 0.9 | S | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Fr) | Ballabh *et al.* (2008 |
| 58. | *Lavandula angustifolia* Mill. (**Lavendulla officinalis* Chaix) [Lamiaceae] | 0.9 | H | Anantnag and Budgam districts of Kashmir division, J&K (Ethnic communities) | Dementia and neuropathy (Fl) | Bano *et al.* (2017) |
| 59. | *Ligularia jacquemontiana* (Decne.) M.A.Rau (**Senecio jacquemontianus* (Decne.) Benth. ex Hook.f.) [Compositae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiris, Gujars, Pathans, Bakarwals communities) | Nerve tonic (Rt) | Srivastava *et al.* (1984) |
| 60. | *Malva neglecta* Wallr. [Malvaceae] | 1.7 | H | Ganderbal district, Kashmir, J&K (Local community) | Nerve tonic (Lv) | Baba *et al.* (2012) |
| | | | | Baramulla and Kupwara district, Kashmir, J&K (Local herbalist) | Nerve tonic (Lv) | Malik *et al.* (2011) |
| 61. | *Meconopsis aculeata* Royle [Papaveraceae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiris, Gujars, Pathans, Bakarwals communities) | Narcotic (Rt) | Srivastava *et al.* (1984) |
| 62. | *Melilotus officinalis* (L.) Pall. [Fabaceae] | 1.7 | H | Skuru watershed of Karakoram wildlife sanctuary, Ladakh (Traditional medicines system of Ladakh,) | Nervous tension, Insomnia (Wp) | Namtak and Sharma (2018) |
| | | | | Kanji Wildlife Sanctuary, Kargil, Ladakh | Nervous tension, Insomnia (Wp) | Hamid and Raina (2014) |
| 63. | *Melissa officinalis* L. [Lamiaceae | 0.9 | H | Anantnag and Budgam districts of Kashmir division, J&K (Ethnic communities) | Nervous complaints (AP) | Bano *et al.* (2017) |
| 64. | *Mentha arvensis* L. [Lamiaceae] | 0.9 | H | Budgam district, Kashmir, J&K (Local community) | Memory enhancer (Lv | Hassan *et al.* (2013) |
| 65. | *Mucuna pruriens* (L.) DC. (**Mucuna prurita* (L.) Hook.) [Leguminoseae] | 0.9 | H | Rajouri and Poonch districts, Jammu, J&K (Local community) | Nerve tonic (Rt) | Azad and Bhat (2013) |
| 66. | *Nepeta leucolaena* Benth. ex Hook.f. (**Nepeta salviifolia* Royle ex Benth.) [Lamiaceae] | 1.7 | H | Leh, Chumathang, Nubra, Zanskar, Kargil an Drass, Ladakh (Amchis) | Cerebral tonic (Wp) | Gupta *et al.* (1981) |
| | | | | Ladakh (Amchis) | Cerebral tonic (Wp) | Srivastava and Gupt (1982) |

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| 67. | *Nymphaea nouchali* Burm.f. (**Nymphaea stellata* Willd.) [Nymphaeaceae] | 0.9 | H | Anantnag and Budgam districts of Kashmir division, J&K (Ethnic communities) | Migraine (Fl, Sd) | Bano *et al.* (2017) |
| 68. | *Oxalis corniculata* L. [Oxalidaceae] | 1.7 | H | Rajouri district, Jammu, J&K (Gujjar community) | Migraine (Wp) | Dangwal and Singh (2013) |
| | | | | Pir Panjal Range of Shopian District, Kashmi J&K (Gujjar and Bakerwal Tribes) | Convulsions (Lv) | Bhat *et al.* (2012) |
| 69. | *Papaver dubium* L. [Papaveraceae] | 0.9 | H | Bandipora district, Kashmir, J&K (Gujjar, Bakarwal and other local communities) | Memory enhancer (Fl | Lone and Bhardwaj (2013a) |
| 70. | *Papaver somniferum* L. [Papaveraceae] | 0.9 | H | Shopian district, Kashmir, J&K (Gujjar and Bakerwal communities) | Memory enhancer (Sd | Bhat *et al.* (2012) |
| 71. | *Pedicularis longiflora* Rudolph [Orobanchaceae] | 0.9 | H | Suru, Wakha-chu and Lower Indus valleys, Western Ladakh (Amchis) | Vertigo (Lv, St) | Angmo *et al.* (2012) |
| 72. | *Pedicularis oederi* Vahl [Orobanchaceae] | 0.9 | H | Suru, Wakha-chu and Lower Indus valleys, Western Ladakh (Amchis) | Sedative (Wp) | Angmo *et al.* (2012) |
| 73. | *Pedicularis pectinata* Wall. ex Benn. [Orobanchaceae] | 1.7 | H | Leh, Chumathang, Nubra, Zanskar, Kargil an Drass, Ladakh (Amchis) | Sedative (Wp) | Gupta *et al.* (1980) |
| | | | | Ladakh (Amchis) | Sedative (Wp) | Srivastava and Gupt (1982) |
| 74. | *Peganum harmala* L. [Nitrariaceae] | 0.9 | H | Anantnag and Budgam districts of Kashmir division, J&K (Ethnic communities) | Nerve weakness (Sd) | Bano *et al.* (2017) |
| 75. | *Phytolacca acinosa* Roxb. [Phytolaccaceae] | 0.9 | H | Kishtwar district, Jammu, J&K (Local community) | Sedative (Lv) | Kumar *et al.* (2009) |
| 76. | *Plantago himalaica* Pilg. [Plantaginaceae] | 1.7 | H | Ladakh (Amchis) | Sedative (Wp) | Srivastava and Gupt (1982) |
| | | | | Leh district, Ladakh (Local community) | Sedative (Wp) | Khan *et al.* (2018) |
| 77. | *Plantago major* L. [Plantaginaceae] | 0.9 | H | Shopian District, Kashmir, J&K (Local community) | Insomnia (Lv) | Khanday and Singh (2017) |
| 78. | *Potentilla multifida* L. [Rosaceae | 2.6 | H | Ladakh (Amchis) | Insomnia (Sd) | Srivastava *et al.* (1981) |
| | | | | Ladakh (Amchis) | Insomnia (Sd) | Srivastava and Gupt (1982) |
| | | | | Suru, Wakha-chu and Lower Indus valleys, Western Ladakh (Amchis) | Insomnia (Sd) | Angmo *et al.* (2012) |
| 79. | *Prunella vulgaris* L. [Lamiaceae] | 2.6 | H | Leh, Chumathang, Nubra, Zanskar, Kargil an Drass, Ladakh (Amchis) | Cerebral disorders (Fl Lv), Brain disorders (Fl, Lv) | Gupta *et al.* (1980) |
| | | | | Ladakh (Amchis) | Brain disorder (Wp) | Srivastava *et al.* (1981) |
| | | | | Ladakh (Amchis) | Cerebral disorders (Fl Lv), Brain disorders (Fl, Lv) | Srivastava and Gupt (1982) |
| 80. | *Punica granatum* L. [Lythraceae] | 0.9 | S | Shopian district, Kashmir, J&K (Gujjar and Bakerwal communities) | Insomnia (Sd) | Bhat *et al.* (2012) |
| 81. | *Randia tetrasperma* (Wall. ex Roxb.). T.Yamaz. (**Himalrandia tetrasperma* (Wall. ex Roxb.) T.Yamaz.) [Rubiaceae] | 0.9 | S | Jammu hills in District Jammu, J&K (Local community) | Sedative (Ba) | Sharma *et al.* (2015) |
| 82. | *Ranunculus arvensis* L. [Ranunculaceae] | 0.9 | H | Kanji Wildlife Sanctuary, Kargil, Ladakh (Local community) | Hallucination (Fr mixed with Br of Juniper plant) | Hamid and Raina (2014) |
| 83. | *Rhodiola tibetica* (Hook. F. & Thoms.) Fu [Crassulaceae] | 0.9 | H | Skuru watershed of Karakoram wildlife sanctuary, Ladakh (Traditional medicines system of Ladakh) | Stress, memory loss (Lv, Sh) | Namtak and Sharma (2018) |
| 84. | *Rosa webbiana* Wall. ex Royle [Rosaceae] | 0.9 | S | Kathua district, Jammu, J&K (Local community) | Brain tonic (Fl, Rt) | Rao *et al.* (2015) |
| 85. | *Salix alba* L. [Salicaceae] | 0.9 | T | Kathua, Udhampur, Poonch, Rajouri, Doda districts, Jammu, J&K (Gujjar, Bakerwals an other local communities) | Nerve tonic (Fl) | Mahajan *et al.* (2012 |
| 86. | *Salix caprea* L. [Salicaceae] | 0.9 | S | J&K (Traditional system of medicine) | Brain tonic and sedative (Lv, Ba) | Rasool *et al.* (2016) |
| 87. | *Salix denticulata* Andersson [Salicaceae] | 0.9 | S | Subdivision Mendhar, District Poonch, Jammu, J&K (Pahari community) | Paralysis (Ba) | Manzoor and Ali (2017) |
| 88. | *Sapindus mukorossi* Gaertn. [Sapindaceae] | 0.9 | T | Kathua district, Jammu, J&K (Local community) | Epilepsy (Fr) | Kumar and Bhagat (2012) |
| 89. | *Sarcococca pruniformis* Lindl. (**Sarcococca saligna* Mull.Arg.) [Buxaceae] | 0.9 | S | Rajouri district, Jammu, J&K (Gujjar community) | Anxiety (Rt) | Dangwal and Singh (2013) |
| 90. | *Saussurea bracteata* Decne. [Compositae] | 0.9 | H | Ladakh (Amchis) | Mental disorders (Wp | Uniyal and Issar (1988) |
| 91. | *Saussurea costus* (Falc.) Lipsch. [Asteraceae] | 0.9 | H | Anantnag and Budgam districts of Kashmir division, J&K (Ethnic communities) | Paralysis (Rt) | Bano *et al.* (2017) |
| 92. | *Saussurea glacialis* Herder [Compositae] | 1.7 | H | Suru valley, Ladakh (Amchis) | Mental disorders (Lv, Fl) | Uniyal (1981) |

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| | | | | Ladakh (Amchis) | Mental disorders (Wp | Uniyal and Issar (1988) |
| 93. | *Saussurea simpsoniana* (Fielding & Gardner) Lipsch. (*Saussurea sacra* Edgew.) [Asteraceae] | 0.9 | H | Kashmir Himalaya, J&K (Local community) | Nervine debility (Wp) | Khanday *et al.* (2018 |
| 94. | *Scrophularia koelzii* Pennell. [Scrophulariaceae] | 0.9 | H | Leh district, Ladakh (Local community) | Sciatic pain (Sd) | Khan *et al.* (2018) |
| 95. | *Selinum vaginatum* Clarke. [Apiaceae] | 0.9 | H | North-West Himalaya, J&K (Gaddi community) | Nervine sedative (Rt) | Dutt *et al.* (2015) |
| 96. | *Senecio tibeticus* Hook.f. [Compositae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Lv) | Ballabh *et al.* (2008 |
| 97. | *Senna tora* (L.) Roxb. (**Cassia tora* L.) [Leguminosae] | 0.9 | H | Budhal area, Jammu region, J&K (Gujjar and Bakarwal communities) | Neuralgia (Sd) | Kumar *et al.* (1993) |
| 98. | *Spiraea canescens* D. Don. [Rosaceae] | 0.9 | S | North-West Himalaya, J&K (Gaddi community) | Nervous system disorders (Lf) | Dutt *et al.* (2015) |
| 99. | *Sorbaria tomentosa* (Lindl.) Rehder (*Spirea sorbifolia* Hook.f ) [Rosaceae] | 0.9 | S | North-West Himalaya, J&K (Gaddi community) | Nervous system disorders (Wp) | Dutt *et al.* (2015) |
| 100. | *Stachys sericea* Wall. Ex Benth. [Lamiaceae] | 0.9 | H | North-West Himalaya, J&K (Gaddi community) | Epilepsy (Wp) | Dutt *et al.* (2015) |
| 101. | *Stachys tibetica* Vatke. [Lamiaceae] | 0.9 | H | Leh district, Ladakh (Local community) | Psychosomatic effect, epilepsy (Wp) | Khan *et al.* (2018) |
| 102. | *Taraxacum campylodes* G.E.Haglund (**Taraxacum officinale* (L.) Weber ex F.H.Wigg) [Compositae] | 1.7 | H | Ladakh (Amchis) | Vertigo (Rt) | Srivastava *et al.* (1981) |
| | | | | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Rt) | Ballabh *et al.* (2008 |
| 103. | *Taraxacum sikkimense* Hand.-Mazz. [Compositae] | 0.9 | H | Leh and Kargil districts, Ladakh (Amchis) | Sedative (Rt) | Ballabh *et al.* (2008 |
| 104. | *Taxus wallichiana* Zucc. [Taxaceae] | 1.7 | T | Gurez valley, Kashmir, J&K (Dard, Kashmiris, Gujars, Pathans, Bakarwales communities) | Epilepsy (Lv) | Srivastava *et al.* (1984) |
| | | | | Poonch district, Jammu, J&K (Local community) | Sedative (Fr) | Kirn *et al.* (1999) |
| 105. | *Thymus serpyllum* L. [Lamiaceae | 0.9 | H | Paddar Valley, Kishtwar district, Jammu, J&K (Local community) | Epilepsy (Wp) | Gupta *et al.* (2013) |
| 106. | *Trifolium repens* L. [Leguminosae] | 0.9 | H | Rajouri district, Jammu, J&K (Gujjar community) | Memory enhancer (Wp) | Dangwal and Singh (2013) |
| 107. | *Urtica dioica* L. [Urticaceae] | 0.9 | H | Skuru watershed of Karakoram wildlife sanctuary, Ladakh (Traditional medicines system of Ladakh) | Paralysis of limbs (Sh | Namtak and Sharma (2018) |
| 108. | *Valeriana hardwickii* Wall. [Caprifoliaceae] | 0.9 | H | Gurez valley, Kashmir, J&K (Dard, Kashmiris, Gujars, Pathans, Bakarwales communities) | Epilepsy (Rt) | Srivastava *et al.* (1984), Kapahi *et al* (1993) |
| 109. | *Valeriana pyrolifolia* Decne. [Caprifoliaceae] | 0.9 | H | Pir Panjal Range of Shopian District, Kashmi J&K (Gujjar and Bakerwal communities) | Insomnia (Rt) and Migraine (Lv) | Bhat *et al.* (2012) |
| 110. | *Valeriana jatamansi* Jones (**Valeriana wallichii* DC.) [Caprifoliaceae] | 4.3 | H | Lolab valley, Kashmir, J&K (Local community) | Nerve tonic (Rt) | Singh (2002) |
| | | | | Paddar Valley, Kishtwar district, Jammu, J&K (Local community) | Sedative (Rt) | Gupta *et al.* (2013) |
| | | | | Kathua district, Jammu, J&K (Local community) | Nervous disorder (Rt) | Kumar and Bhagat (2012) |
| | | | | Trikuta Hills, Jammu, J&K (Gujjar community) | Epilepsy (Rt), Sedativ (Rt) | Kumari *et al.* (2013 |
| | | | | Kashmir Himalaya, J&K (Local community) | Tranquillizer (Wp) | Khanday *et al.* (2018 |
| 111. | *Verbascum thapsus* L. [Scrophulariaceae] | 0.9 | H | Kishtwar district, Jammu, J&K (Local community) | Mental relaxation (Lv | Kumar *et al.* (2009) |
| 112. | *Verbena officinalis* L. [Verbenaceae] | 1.7 | H | Baramulla and Kupwara district, Kashmir, J&K (Local herbalist) | Nervous disorder (Wp | Malik *et al.* (2011) |
| | | | | Trikuta Hills, Jammu, J&K (Gujjar community) | Nervous disorder (Lv | Kumari *et al.* (2013 |
| 113. | *Viscum album* L. [Santalaceae] | 1.7 | S | Shopian district, Kashmir, J&K (Gujjar and Bakerwal communities) | Migraine (Lv), Epilepsy (Fr) | Bhat *et al.* (2012) |
| | | | | Langate area, Kupwara district, Kashmir, J&K (Local community) | Migraine, epilepsy (NA) | Kanta *et al.* (2018) |
| 114. | *Vitex negundo* L. [Lamiaceae] | 0.9 | S | Jammu hills in District Jammu, J&K (Local community) | Sedative (Ke) | Sharma *et al.* (2015 |
| 115. | *Vitis vinifera* L. [Vitaceae] | 0.9 | S | Bandipora district, Kashmir, J&K (Gujjar, Bakarwal and local communities) | Memory enhancer (Tw | Lone and Bhardwaj (2013b) |
| 116. | *Withania somnifera* (L.) Dunal [Solanaceae] | 0.9 | H | Udhampur district, Jammu, J&K (Local community) | Memory enhancer (Lv | Bhatia *et al.* (2014) |

**Abbreviations**: AP: Aerial part, Ba: Bark, Bu: Bulb, Fl: Flower, Fr: Fruit, H: Herb, Ke: Kernel, Lv: Leaves, Rt: Root, Rz: Rhizome, S: Shrub, Sd: Seed, Sh: Shoot, St: Stem, T: Tree, Tu: Tuber, Tw: Twig, Wp: Whole plant.

**Table 2**: Plant species used by indigenous communities of J&K and Ladakh, India, to manage various ailment or mental conditions related to the CNS, brain, and memory (some of these conditions are overlapping but to keep original information intact they are shown separately).

| Ailment/ Mental condition | Plant species used |
|---|---|
| Anxiety | *B. persicum, S. pruniformis* |
| Brain disorders | *P. vulgaris* |
| Brain tonic | *C. asiatica, E. multiradiatus, E. alsinoide, R. webbiana, S. caprea* |
| Cerebral disorders | *P. vulgaris* |
| Cerebral tonic | *N. leucolaena* |
| Convulsions | *O. corniculata, B. persicum* |
| Dementia | *B. officinalis, L. angustifolia* |
| Depression | *H. perforatum, B. persicum* |
| Epilepsy | *A. millefolium, A. arvensis, A. absinthium, C. dactylon, D. purpurea, G. rotundifolium, I. tinctoria, S. mukorossi, S. sericea, S. tibetica, T. wallichiana, T. serpyllum, V. hardwickii, V. jatamansi, V. album* |
| Hallucination | *C. sativa, D. stramonium, R. arvensis* |
| Hemicrania | *B. lycium* |
| Hemiplegia | *D. denudatum* |
| Insomnia | *C. sativum, M. officinalis, P. major, P. multifida, P. granatum, V. pyrolifolia* |
| Memory enhancer | *A. calamus, C. asiatica, C. dactylon, E. rhamnoides, F. nubicola, M. arvensis, P. dubium, P. somniferum, T. repens, V. vinifera, W. somnifera* |
| Memory loss | *R. tibetica* |
| Memory restoration | *H. pinnatum* |
| Mental depression | *H. perforatum* |
| Mental disorder | *A. glauca, C. asiatica, S. bracteata, S. glacialis* |
| Mental relaxation | *V. thapsus* |
| Mental tension | *I. glandulifera* |
| Migraine | *V. pyrolifolia* |
| Narcotic | *A. acuminata, C. sativa, D. metel, D. stramonium, H. niger, M. aculeata* |
| Nerve debility | *S. simpsoniana* |
| Nerve sedative | *C. sativus, A. spicata* |
| Nerve tonic | *A. precatorius, A. conyzoides, E. helleborine, H. candicans, L. jacquemontiana, M. neglecta, M. pruriens, S. alba, V. jatamansi* |
| Nerve troubles | *E. wallichii* |
| Nerve weakness | *P. harmala* |
| Nervous complaints | *M. officinalis* |
| Nervous disorders | *A. nilagirica, B. monnieri, D. incarnata, I. tinctoria, V. jatamansi, V. officinalis* |
| Nervous distress | *G. argentea* |
| Nervous stimulant | *C. glomeratus* |
| Nervous tension | *M. officinalis* |
| Nervousness | *H. niger* |
| Neuralgia | *A. chasmanthum, A. acuminata, S. tora* |
| Neuropathy | *L. angustifolia* |
| Paralysis | *S. denticulata, S. costus, U. dioica, A. indicum, C. spinosa* |
| Psychosomatic effect | *S. tibetica* |
| Sciatic pain | *S. koelzii* |
| Sedative | *A. spicata, A. acuminata, A. belladonna, A. sativa, B. lycium, C. sativa, C. pariera, C. maculatum, C. depressa, C. decaisnei, C. sativus, D. hatagirea, D. cannabina, D. metel, D. stramonium, G. aparine, G. squarrosa, H. monorchis, H. niger, H. perforatum, I. hookeriana, J. communis* var. *saxatilis, P. oederi, P. pectinata, P. acinosa, P. himalaica, R. tetrasperma, S. caprea, S. vaginatum, S. tibeticus, T. campylodes, T. sikkimense, T. wallichiana, V. jatamansi, V. negundo* |
| Tranquilizer | *V. jatamansi* |
| Vertigo | *T. campylodes, P. longiflora* |
| Weakness of the nervous system | *D. hatagirea* |

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**Conflicts of Interest**

The authors declare no conflict of interest.

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