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REVIEW ARTICLE

ETHNOMEDICINAL PLANTS IN THE TREATMENT OF NEURODEGENERATIVE DISEASES: A NARRATIVE REVIEW

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ABSTRACT

A plethora of diseases are associated with our nervous system. Neurodegenerative diseases include Parkinson's disease, epilepsy, Alzheimer's disease, Huntington's disease, schizophrenia and depression. Many plants are known to be beneficial against certain neurodegenerative disorders. This study provides an overview of such thirty-five plants whose part, from roots to seeds or their bio-chemicals extract are used for the treatment of multiple neurodegenerative disorders in Pakistan and beyond.

KEYWORDS: Parkinson's Disease; Epilepsy; Alzheimer's Disease; Huntington's Disease; Schizophrenia; Depression; Neurodenegerative Diseases; Ethnomedicine; Ethnomedicinal Plants; Plant Extracts.

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1. INTRODUCTION

Human body consists of nervous system which contains sensory organs and brain.[1] The brain is made up of nerve cells through which all activities of the body are regulated.[2] The brain is made of one hundred trillion neurons. These neurons perform many tasks such as memory, thinking, smelling, hearing and seeing. These neurons connect all organs to the brain and function in accordance with the signals that the brain receive.[3] The gradual deterioration of the neurological system is called neurodegeneration. This may occur in motor, emotional, cognitive and sensory functions owing to the age or to varied environmental variables. Acute neurodegenerative disorders can be treated, however, the chronic diseases progress over the period of time. Neurodegenerative disorders are the second biggest cause of mortality worldwide, according to the global burden of diseases.[3] Every year, around 6.9 million deaths from aforementioned diseases are reported.[1,4]

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The treatment involves related processes and maneuvers to help combat damaged neurons caused by neurodegenerative diseases. Phytochemicals have an extensive application in neuroprotection for this aim.[5] Investigators across the globe are identifying bioactive phytochemicals from traditional medicines, such as the Chinese medicinal system, Korean medicinal system, Indian Ayurvedic medicinal system, and the Mediterranean medicine system.[6]

2. METHODOLOGY

This narrative review was conducted in School of Pharmacy & School of Medicine, Changzhou University, Jiangsu, China from October 2020 to December 2020. In order to assess the ethnomedicinal properties of plants in the treatment of neurodegenerative, this narrative review analyzed all articles published for the period from 2003 to 2021 in both local and foreign journals. The main question of this paper was to analyze the ethnomedicinal properties of certain plants to treat neurodegenerative diseases. To answer this question, different keywords; Parkinson's Disease, epilepsy, Alzheimer's disease, Huntington's disease, schizophrenia, depression, neurodenegerative diseases, ethnomedicine, ethnomedicinal plants and plant extracts were separately and in combination searched in different electronic databases such as CINAHL, PubMed, Scopus, Web of Science, HEC digital library, and eMedicine. The article's inclusion criteria were based on the ethnomedicinal properties

and applications of plants. Articles with copyright, irrelevant information and lacking the full text were excluded. A total of 143 articles were selected for this study, out of which in screening step, 68 articles after review of abstract, according to criteria and duplicates were removed. In last step, 75 articles were selected for the final analysis. The medium of language of all these articles was English.

3. DISCUSSION

3.1 NEURODEGENERATIVE DISORDERS

3.1.1 Parkinson's Disease (PD)

It is caused by motor neuron dysfunction. Substantia nigra is compromised in this illness. Motor neurons play a prominent role in movement of body. Because of Parkinson's disease, body segments which are involved in activities are affected. Trembling of the legs, hands, faces, arms and limbs and poor coordination[7] are the main signs of PD. The prevalence of this disease is assumed to be around 20/100,000 population.[8]

3.1.2 Epilepsy

The irregular occurrence of febrile episodes is defined by epilepsy. Convulsions are caused by unnecessary discharge of grey cerebral neurons.[9] In epilepsy, disrupted neurotransmission of the calcium and sodium channels by excess glutamate may initiate an event flow that leads to apoptosis. Worldwide, over 51 million people experience epilepsy.[10]

3.1.3 Alzheimer's Disease (AD)

Alzheimer is named after Aloes Alzheimer, a German physician. Alzheimer is a chronic illness causing brain dysfunction. It's also a kind of dementia.[11] The effect is mostly on the elderly. With time this illness progresses. It is anticipated that its increase rate in individuals aged between 65 and 74 is around 3.0 percent and in those aged 85 it is 47.2 percent.[12] Astrogliosis, neurofibrillary clot, amyloid-beta plaques that lead to chronic illness are formed during AD. The symptoms of Alzheimer's include cognitive impairment, sleeplessness, disturbance, memory loss, disorientation and reduced speech function.[12]

3.1.4 Huntington's Disease (HD)

It is a chromosomal disorder-related brain disorder. This is due to the impact of chromosome 4 that leads to nerve cell alterations.[9] Involuntary leg movement, bracelet and head, weakened thinking, sadness and unpleasant temperament include HD symptoms. It is prevalent mostly in persons between 30 and 40 years of age. Approximately 12/100,000 people are affected.[13]

3.1.5 Schizophrenia

It is a condition in which the patient does not know what is around him or what he or she is. In this disorder, nervous system up regulates neurotransmitters including dopamine, 5-HT, acetylcholine and nor-epinephrine.[14] This disorder has two distinct types depending upon its symptoms. Negative symptoms; there are no social contacts and the emotional reactions are flattened. Positive symptoms; these symptoms comprise misunderstanding, hallucinations, behavioral disturbances and thought processes abnormalities.[14,15]

3.1.6 Depression

Depression is despair. It might vary from mild realism to agony. Both environmental and biological variables determine this state. The consequences of depression lead to decreased cortical and hippocampus, 5-HT abnormalities and HPA axis dysfunctions.[16] According to the World Health Organization (WHO), over 460 million individuals suffer from depression.

3.2 PHYTOCHEMICALS USED IN TREATMENT OF NEURODEGENERATIVE DISORDERS

3.2.1 Alkaloids

Alkaloids impair the autonomous nerves which control breathing, heartbeat and blood circulation. The central nervous system is also affected by alkaloids. The serotonin activity in the brain is hampered by indole alkaloids which contain an indole carbon nitrogen ring.[17] Tropane alkaloids which are extracted from Datura, directly affects central nervous system (CNS) and peripheral nervous system (PNS) of humans.[18]

3.2.2 Isoprenoids

Plants contain neuroprotective compounds such as isoprenoids which are efficacious. For instance, *Valerian officinalis*, a rhizome includes sesquiterpenes and valepotriates that influence inhibition of GABA uptake and binding ability of GABA (B) receptors in mice synaptosomes. Similarly, *Centella Asiatica*, another rhizome contains triterpenoids, α-terpinene, and β-terpinene, which are efficient to strengthen and energize neurological functions.[19]

3.2.3 Polyphenols

The secondary metabolites present in plants are polyphenols. There are more than one phenolic group linked with the benzene ring. Studies demonstrated a beneficial impact of flavanols on brain and its activities. Catechin offers protection from Parkinson's disease brain damage. Inflammation of the neurons is likewise suppressed by catechin.[20]

3.2.4 Fatty acids

The structural organization of neurons is maintained by fatty acid.[21] Human and animal mental deterioration is stalled by unsaturated fatty acids. The neuroprotective action of Omega-6 and Omega-3 acids is high. The fatty acid composition decreases over age. Likewise, trans unsaturated fatty acids help directly to signal neurons and neuroprotection to operate.[20]

3.3 SOURCES OF NEUROPROTECTIVE AGENTS

3.3.1 Resveratrol

Resveratrol is an antioxidant which is present in red

grapes. It is highly effective against ischemic injury. It also protects neurons from oxidative stress caused by nitrous oxide (NO).[22] It is also effective with amyloid β-peptide for the conservation of neuronal cells.

3.3.2 *Allium* and *Allicin*

Allium and Allicin are organosulfur composites present in *Allium sativum* (garlic) and *Allium cepa*. Allicin and allium are useful compounds for neuroprotection, as these play role in scavenging free radicals present in neuronal cells. Allyl-containing sulfides can trigger neuroprotection-related pathways that cause mitochondrial uncoupling proteins to be initiated.[23]

3.3.3 Curcumin

In *Curcuma longa*, *curcumin* is discovered. It is used to prevent neurodegenerative age-related diseases. It also reveres stress produced by impaired hippocampal neurogenesis. The BDNF (neurotrophic factor) has also been increased.[24] It also inhibits glutamate excitotoxicity in rodent cells.[24,25]

3.3.4 Sulforaphane

The Brussels sprouts, broccoli and other Cruciferaceae members contain sulforaphane. It is an isothiocyanate. It decreases the edema of the brain and protects the retinal pigment named dopaminergic neurons against mitochondrial toxicity.[26]

3.4 BIOCHEMICAL ACTIVITIES OF NEUROPROTECTIVE PLANTS

In neuroprotection, several plants are employed. Chemicals from various sections of the plants can be collected, and occasionally the entire plant is utilized to extract biochemical products required for nervous system safety**.**

3.4.1 *Centella asiatica*

Brahmoside, isothankunoside, brahminoside, asiaticoside, and thankunoside as active ingredients are present in the *Centella asiatica*.[21] Its leaf is intended to enhance and revitalize nerve function and memory. It is also used for preventing and restoring dementia.[22] The disease inhibits beta-amyloid death, utilized in Alzheimer's disease and beta-amyloid toxicity prevention. Depression, mental weakness and epilepsy are also cured by the extract of this plant .[27]

3.4.2 *Bacopa monniera*

This plant is usually referred to as Brahmi. It is intended to stimulate memory, relieve tension during learning and anxiety. It contains stigmastanol, bacopa saponin, betulinic acid and active bacosides. It is used for healing of damaged neurons, restoration of synaptic activity, conductive nerve impulses and kinase activity.[28] It also prevents cholinergic deterioration and increases cognition in rodents.[28,29]

3.4.3 *Picrorhiza scrophulariiflora*

The roots of plants contain terpenoids, phenolic glycosides, terpenoids, phenylethanoid glycosides and iridoid glycosides. Its rhizome is utilized in Southeast Asia as a neuroprotective agent. Neuritis development in PC12D cells in Picrosides I and II is shown via signaling pathway reliant on cellular mitogen activated protein kinase.[30]

3.4.4 *Ginkgo biloba*

It is used to enhance memory by removing free radicals and improving the availability of oxygen. This product is therefore utilized to treat alpha beta nitric oxide-related toxicity and Alzheimer's disease. It contains isorhamnetin and quercetin as flavonoids, sitosterols and stigmasterol as steroids, sesquiterpene lactones ginkgolides A, B, C, J & M, sesquiterpene lactones and diterpenic lactones.[31]

3.4.5 *Bertholettia excels*

Its common name is Brazil Nuts. It is high in choline-based lecithin.[32] Choline is an acetylcholine fundamental unit. In Alzheimer's disease patients, these basic units enhance the levels of acetylcholine.[33]

3.4.6 *Cyperus rotundus*

Its common name is Sedge. It includes a small quantity of essential oils such as pinene, film and terpenes. It has got Anti-AChE activity of ethanol which is extracted from sedge. Its adherents have enhanced spatial learning and memory in mouse with damaged nucleus basalis of meynert after treatment with 2 dosages of extracts.[34]

3.4.7 *Lavandula officinalis*

It is commonly known as ***lavender. Oils of these p***lants are used in cosmetics and aromas. Lavender juice contains linalyl acetate, geraniol, ursolic acid, borneol, linalool, luteolin flavonoids, butyric acid, flaskin, camphor and valerianic acid.[35] These chemicals increase the plant impact in limbic system, which causes GABA receptors to soothe and relax. In rodents which undergo reperfusion or ischemia, lavender oil reduces neurological impairment, malondialdehyde (MDA) level, strokes, carbonyl species, and reactive oxygen species. The impact is strongly neuroprotective.[36]

3.4.8 *Rosmarinus officinalis*

Rosemary possesses antioxidants and anti-inflammatory chemicals. The antioxidants are carnosic acid and ferulic acid, with a higher antioxidant potential than butylated hydroxyl toluene (BHT) and butylated hydroxyl anisole (BHA).[31] It also contains the inhibitors of COX-2 oleanolic acid, carvacrol, ursolic acid and eugenol. The inhibitors of COX-2 are Alzheimer's preventative.[37]

3.4.9 *Hypericum perforatum*

The flowers of this plant contain ***tannins, essential oils, choline,*** hayperpyron and hayperciyn. It affects anxiety, depression, injury and neurological conditions positively.[37] ***The extract of this plant also*** contaisn ***quercetin and*** quercitrine, which are useful in free radicals scavenging. Before injecting sco-

polamine, pretreatment with hypericum showed antioxidant action. It affects glutathione peroxidase activity, glutathione level and brain MDA.[38]

3.4.10 *Glycyrrhiza glabra*

Alzheimer's disease is because of neuronal loss and the development of senile plaques. These plaques include amyloid-β peptide as their fundamental component. Glycyrrhizene is an active molecule of *glycyrrhiza glabra* which contains glycyrrhizene, glycyrrhetine and glycyrrhizin acid.[34] This has a beneficial effect on the apoptotic death of Aβ fragments in nerve cells. The root extract works for brain disorders such as dementia, Alzheimer's disease and Huntington's disease.[39]

3.4.11 *Melissa officinalis L.*

Melissa officinalis L. is commonly known as Lemon balm. It contains rhamnocitrin, rosmarinic acid, luteolin-7-O-glucoside, methyl carnosoates and ferulic acid. It sharpens memory and enhances patient mood. The Alzheimer's disease may be treated quite efficiently because acetylcholinesterase and its antioxidant effects can be prevented.[40]

3.4.12 *Curcuma longa*

This rhizome is commonly known as turmeric. It is used in cooking. It is utilized as an anti-inflammatory and antioxidant source of curcumin; that primarily treat Alzheimer's disease. It keeps the equilibrium of mind. In rats it works as antidepressant.[41]

3.4.13 *Matricaria recutita*

It is commonly known as chamomile. It soothes the nerves, assists with digestion, aids immune system, counteracts sleeplessness, boost the brain, dissipates fatigue, and relives anxiety.[42]

3.4.14 *Cassia obtusifolia*

The plant has active ingredients rubrofusarin and isorubrofusarin. It protects substantianigra and neuronal degeneration of dapaminergic models among mice who are induced by 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP). *Cassia obtusifolia* supplementation in 6- OHDA pc12 driven cells mitigates cell damage and mitochondrial membrane depolarization.[43]

3.4.15 *Coffea Arabica*

It contains caffeine. It increases motor function, decrease apomorphine-induced rotation and reverse motor deficiency in Parkinson's disease-mice.[44]

3.4.16 *Panax ginseng*

Ginseng is a medicinal herb from China and Korea. This herb is highly effective against plethora of disorders such as neurodegenerative disorders, cancer, hypocholesteremia, diabetes and high blood pressure.[51] It impedes nigral iron levels, reduces divalent metal transporter 1 (DMT1) expression, and increases ferroportin 1 (FP1) expression in the Parkinson's disease.[45]

3.4.17 *Terminalia chebula*

The active ingredients of this plant are chebulinic acid, arjungenin, chebulosides I and II, punicalagin, gallic acid and punicalagin. The mature fruit triggers sharp memory.[54] The NMDA and GABA receptors are discovered to be binding with a methanol extract. However, there is no evidence of the inhibition of cholinesterase.[46]

3.4.18 *Clitoria ternatea*

It is commonly called as butterfly-pea, contains kaempferol-3-rutinoside (sitosterol).[47] This rhizome is used as brain toner in AM. It triggers memory and intellectual abilities.[53] Ethanolic rhizome extract also improves memory. This impact is attributed to higher Ach and ChAT levels. The watery extract also improves Ach level in rat's hippocampus.[48,49]

3.4.19 *Commiphora whighitti*

C. whighitti is also called as Guggulu. This plant contains guggulipid, which is a guggulsterone. It has a storage effect to improve memory impairments caused by scopolamine. The acetyltransferase level in the hippocampus is decreased as well. This plant is effective against dementia and memory loss.[50]

3.4.20 *Convolvulus pluricaulis*

The plant is usually referred to as shahkpushpi. It contains convolidine, confoline, kaempferol and steroids.[51] It is utilized in the treatment of neurological disorders by ayurvedic specialists. [52] It is also utilized to slow the process of ageing. Plant extract and milk cure scrofula, syphilis, memory loss and fever effectively.[53]

3.4.21 *Withania somnifera*

This plant contains withanone *and* withasomniferin A, B, C. Its roots are generally referred to as ashwagandha and are specifically utilized in AM for intellectual and memory increase.[60] The standardized root extract helps alleviate cognitive impairment.[54] Hydroalcoholic extract enhances in vivo neuroprotection. It has antioxidant and inflammatory properties as well.[59]

3.4.22 *Commiphora mukul*

The active components of this plant include sesquiterpenoids, terpenes, cuminic aldehyde, eugenol, guggulsterone I, II, Z-and-E-guggulsterone. and ketone steroids.[55] It significantly reduces brain and flip neuronal cholesterol levels and inhibits the amyloidogenic route of beta-amyloid formation, likely through action against acetylcholinesterase (AChE).[56,61]

3.4.23 *Crocus sativus*

This plant is commonly known as saffron. It contains α- and β-carotenes acids, gallic acids, picrocrocin, safranal and lycopene.[57] *Crocus sativus's* pistil alcoholic extract is beneficial for behavioral impairments in mouse models. The disruption of hippocampal synaptic plasticity can be achieved by blocking this.[58,59] Saffron suppresses the deposition, aggregation and short-term memory disorders of

the amyloid β of the human brain. It is used for the treatment of Alzheimer's disease.[60,61]

3.4.24 *Celastrus paniculatus*

This plant is known as black oil tree and malkangni and is available in entire South-East Asia, especially India. It possesses active components such as diacylglycerol, triacylglycerol, sterol and monoacylglycerol.[51] Indians are using it as an enhancer of intellect. The seed oil is utilized to boost the memory.[62] The oil lowers the concentrations of noradrenaline, 5-hydroxytryptamine and dopamine. In mentally challenged youngsters, it also increases IQ. Extract of methanol has an anti-inflammatory effect linked to the treatment of Alzheimer's disease.[63]

3.4.25 *Evolvulus alsinoides*

It is commonly found in India. Betain and β-sitosterol are active components of this plant, which work for stress, epilepsy, nerve retardants and insensitivity.[64]

3.4.26 *Petasites japonicus*

This plant is herbaceous. It is present in Hubei, Shanxi and Sichuan provinces of China. *P. japonicus* contains 19 sesquiterpenoids which are efficient as anti-allergic, antioxidants, anti-inflammatory and neuroprotective agents. Sesquiterpenoids encourage development of neurites.[65,66]

3.4.27 *Sida cordifolia*

This plant comprises the asparagine and ephedrine as its active ingredients.[46] It is used to treat sciatica and Bell's palsy. The plant extract has powerful anti-inflammatory, analgesic and hypoglycemic effects. Plant roots and milk cure Parkinson's disease effectively.[67]

3.4.28 *Huperzia serrate*

In China, this herb is popularly referred as 'qianceng ta.' This herb is used for memory enhancement in Traditional Chinese Medicinal System (TCM). Its component, 'Lycopodium alkaloids', is a powerful and reversible AChE inhibitor. It is used to treat Alzheimer's disease by reducing free radicals in the brain. Amnesia produced by scopolamine is also overturned by it, indicating its efficacy in Alzheimer's disease for cognitive issues.[68,69]

3.4.29 *Tinospora cordifolia*

It is commonly known as guduchi. It improves memory and learning in animals. It increases acetylcholine levels and improves cognitive function.[70]

3.4.30 *Rhaponticum carthamoides*

This plant is widespread in China. It is used to treat hypertension, anepithymia and nervous prostration as a medication in China. Neurotrophic chemicals are commonly utilized for ecdysterone derived from the plant.[71] The ecdysterone increases the neuronal damage caused by glutamate.[59]

3.4.31 *Urtica dioica*

It is commonly known as stinging nettle. It contains *histamine, acetylcholine, proteins, and tryptamine 5-hydroxy.*[37] It is used to treat hay fever and other symptoms of allergies. It contains biological anti-inflammatory ingredients. It includes boron that improves the body's estrogen level, which is good for short-term memory. In Alzheimer's sufferers, it increases mood.[72]

3.4.32 *Acorus calamus* L.

It is commonly known as sweet flag. Its hydroethanolic and ethanolic rhizomes extracts possess sedative and neuroprotective effects.[49] The α- and β-asarone is included in the product. This plant has memory-enhancing, anti-inflammatory, cytoprotective, antispasmodic, and antidiarrheal effects.[73]

3.4.33 *Galanthus nivalis* L.

Galanthamine is the principal component of *galanthus nivalis*. It contains isoquinoline alkaloid which is galanthamine. It is long acting AChEase inhibitor. It increases cholinergic nicotine neurotransmission by allosterically modifying the Alzheimer's disease-effective nicotine receptors.[74]

3.4.34 *Salix alba*

This plant has active ingredients such as salicine, populin, salicortin, fragiline, salicyl alcohol, tremulacine, saligenin, vanillin and salidroside. Salicin is an inhibitor for COX-1 and COX-2 and an anti-inflammatory substance by its activity to limit the production of prostaglandin.[75,64]

3.4.35 *Rheum glabricaule*

This plant contains N-hexacosnic acid, daucosterol, palmitic acid, crystal 8-Me, glucopyranoside chrysophane, rhapontigenin, and citreorosein. These neuroprotective agents are utilised to treat Parkinson's disease. Moreover, the functioning of mitochondria with amyloid-beta (1-42) neurosis is protected by rhapontigenin which is a part of this plant.[75]

Table 1 gives the summary of above mentioned 35 ethnomedicinal plants.

Table 1 Summary of Ethnomedicinal plants to treat Neurodegenerative disorders

S. No.	***Scientific name***	Common Name	Family Name	Phytochemical Constituents	Plant used For	Citation
1	***Centella asiatica***	Gotu kola	Apiaceae/ Umbelliferae	Asiatic acid, isothankunoside &	Depression and epilepsy	21, 27
2	***Bacopa monniera***	Brahmisak	Scrophulariaceae	Bacopasaponins, Stigmastanol, and bacosides	Boosts memory, Decreases nervousness,	28, 29

3	***Picrorhiza scrophulariiflora***	Hu Huang Lian	Scrophulariaceae	phenolic glycosides and terpenoids,	Picrosides I and II shows neurite, growth in PC12D cells	30
4	***Ginkgo biloba***	Maiden hair tree	Ginkgoaceae	Quercetin, sesquiterpenictrilactone, and ginkgolides A, B, C, J	Neuroprotective, Prevention for AD.	31
5	***Bertholettia excels***	Brazil Nuts	Lecythidaceae	Lecithin,	Alzheimer's disease	32, 33
6	***Cyperus rotundus***	Sedge	Cyperaceae	essential oils such as terpenes and pinene	Improves spatial learning in Rats.	34
7	***Lavandula officinalis***	Lavender	Lamiaceae	Geraniol, ursolicacid, linalool and camphor	Decreases neurologic deficit and ROS	35, 36
8	***Rosmarinus officinalis***	Rosemary	Lamiaceae	ferulic acid, and eugenol	Alzheimer's disease	31, 37
9	***Hypericum perforatum***	Bulhsana	Hypericaceae	Quercitrin,hayperciyn and quercetin	Alzheimer disease	38
10	***Glycyrrhiza glabra***	Liquorice	Fabaceae	Glycyrrhizin and glycyrrhetinic acid	Alzheimer's disease	34, 39
11	***Melissa officinalis L.***	Lemon balm	Lamiaceae	luteolin-7-O- glucoside	Alzheimer's disease	40
12	***Curcuma longa***	Turmeric	Zingiberaceae	Curcumin	Treats AD	41
13	***Matricaria recutita***	Babonaj	Asteraceae	α-bisobolol, chamazulene, sesquiterpenes,	Insomnia and anxiety	42
14	***Cassia obtusifolia***	Senna	Fabaceae.	Isorubrofusarin and Rubrofusarin	Reduces ROS generation	43
15	***Coffea Arabica***	Arabian coffee	Rubiaceae	Caffeine	Reverses motor deficit in Parkinson's mice Model	44
16	***Panax ginseng***	Ginseng	Araliaceae	Ginsenosides	Neurodegenerative disorders	45, 51
17	***Terminalia chebula***	Myrobalan	Combretaceae	Chebulinic acid, chebulosides I and II	Enhances memory	46, 54
18	***Clitoria ternatea***	Butterfly-pea	Fabaceae	sitosterol, kaempferol-3- rutinoside	Treats AD, increases memory	47, 48
19	***Commiphora whighitti***	Guggul, Mukul	Burseraceae	Guggulipid and guggulsterone	dementia preventer	50
20	***Convolvulus pluricaulis***	Shahkpushpi	Convolvulaceae	convolidine, confoline, and kaemperfol	memory loss and syphilis	51, 52, 53
21	***Withania somnifera***	Ashwagandha	Solanaceae	withasomniferin A, B, C and withanone	Intellect and memory enhancer	54, 59
22	***Commiphora mukul***	Gugal	Burseraceae,	Terpenes, eugenol, cuminic aldehyde, sesquiterpenoids	Decrease neuronal cholesterol level	55, 60
23	***Crocus sativus***	Saffron	Iridaceae	Gallic acids, safranal, crocin, and α- and β carotenes	Corrects impaired behavior and learning	60, 61
24	***Celastrus paniculatus***	Black-oil tree	Celastraceae	Triacylglycerol and esterified sterols	Memory enhancer Anti-stress,	62, 63
25	***Evolvulus alsinoides***	Sankha-holi	Convolvulaceae	betaine, β-sitosterol	Anti-stress	64
26	***Petasites japonicas***	butterbur, giant	Asteraceae	Sesquiterpenoids	Neuroprotection	65, 66

27	***Sida cordifolia***	Beej band	Malvaceae	asparagine, ephedrine	Sciatica, Parkinson's disease	46, 67
28	***Huperzia serrate***	QianCeng, Ta	Lycopodiaceae	Lycopodium alkaloids	Alzheimer's disease	68, 69
29	***Tinospora cordifolia***	Guduchi	Menispermaceae	alkaloids, terpenoids	Improves cognitive function	70
30	***Rhaponticum carthamoides***	Maral root	Asteraceae	Ecdysterone	Treats Hypertension	59, 71
31	***Urtica dioica***	Stinging Nettle	Clusiaceae	Acetylcholine, and 5-hydroxytryptamine	Short term memory	37, 72
32	***Acorus calamus***	Sweet flag,Vacha	Araceae	α-asarone and β-asarone	Memory enhancer	49, 73
33	***Galanthus nivalis***	Snowdrop	Amaryllidaceae	Galanthamine	Alzheimer's disease	74
34	***Salix alba***	White willow	Salicaceae.	Salicin and saligenin	Inhibits COX-1 and COX-2	64, 75
35	***Rheum glabricaule***	Samuelsson	Polygonaceae	n-hexacosnic acid and citreorosein	Mitochondrial protection against amyloid-beta neurotoxicity	75

4. CONCLUSIONS & FUTURE PROSPECTS

Ethnomedicinal herbs have been utilized to cure neurogenerative illnesses for ages. In this study, thirty-five plants are studied, and it is determined that biochemicals derived from these plants are beneficial in the treatment of several neurodegenerative disorders. Depending on the plant or ailment, various parts of plant such as bark, root, stem, leaves, flowers, seeds, and fruits are utilized to extract biochemicals or administered intact to cure such disorders. In certain situations, though, the entire plant is used for this purpose. In today's era, the trend from allopathic medicines is changing gradually towards herbal medicines, as some allopathic medicine are considered to have serious side-effects. These natural plants are major stakeholders in this regard. There is so much to be discovered about the treatment of plethora of other neurodegenerative disorders such as progressive supranuclear palsy, multiple system atrophy, motor neuron disease etc. These biocompatible plant products are opening new horizon of research.

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CONFLICT OF INTEREST
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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

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Acquisition, Analysis or Interpretation of Data:	TH, XH, SS, MH, SN, SS
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All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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