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## Review Article

# Herbal Medicine for the Mind: Traditionally Used Medicinal Plants for Memory Loss from the Indian Subcontinent

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## Abstract

Memory loss is a symptom of several neurological disorders, including dementia and Alzheimer's disease (AD). It can significantly impact individuals, their loved ones, and society as a whole. Current pharmaceutical interventions have shown some improvement in individuals' quality of life, but more needs to be done to reduce the burden of memory loss and AD. This paper investigates herbal remedies for memory loss, with a particular focus on the mechanisms underlying their effects. By consulting several South Asian printed books, numerous traditionally used medicinal plants with memory-enhancing properties were identified. A review of published studies showed that many of these plants have reported properties related to memory enhancement and the treatment of AD. Some of the relevant mechanistic actions reported for these plants include acetylcholinesterase inhibition, anti-inflammatory activity, antioxidant effects, and neuroprotective properties. There is also evidence that some plants exhibit a combination of different mechanisms, making them especially promising as therapeutic agents for memory loss. Our review shows the existence and potential of medicinal plants in addressing memory loss. Additionally, some reports provide a scientific basis for the use of these plants in conditions characterized by memory decline, such as AD. This study underscores the importance of further research to evaluate the efficacy of traditionally used medicinal plants in the management of memory loss.

## Introduction

Human life expectancy has been steadily increasing.[1] With this rise in lifespan, the prevalence of chronic illnesses has also grown.[2,3] Chronic diseases such as Alzheimer's disease (AD), dementia, diabetes, cancer, and heart disease are now more common than ever before.[4,5] The prevalence of these conditions is expected to continue increasing over the next decade.[6] Neurocognitive disorders such as AD and dementia are projected to affect 152 million people worldwide by 2050.[7] These disorders are characterized by cognitive decline and memory loss. They impact not only the patients but also their loved ones and society at large.[8] Numerous mechanisms can contribute to neurocognitive and memory disorders, including chronic inflammation,[9] oxidative stress,[10] and vascular insufficiency,[11] all of which can lead to neuronal cell death.[12] While certain pharmacological treatments exist for these disorders,[13] they are often limited by issues of affordability, accessibility, efficacy, and tolerability.[14] Consequently, there is a growing interest in holistic and herbal alternatives that may offer comparable efficacy to pharmaceuticals, while potentially reducing costs and adverse effects.[15]

Traditional herbal medicine has long been a mainstay of treatment throughout human history, especially in Asia and the Indian Subcontinent.[16,17] Recently, traditional medicine practices have gained popularity in other parts of the world, especially among individuals seeking alternatives to conventional pharmaceuticals.[18] This paper sought to identify plants traditionally used in the Indian Subcontinent to manage memory impairment and to evaluate whether any of these plants have been experimentally studied for this purpose. Memory loss is a symptom seen in several different conditions, including dementia. Common symptoms of dementia include memory loss as well as problems with judgment, language, and reasoning. Dementia itself can result from a variety of underlying conditions, including Alzheimer's disease, Lewy body dementia, and vascular dementia.

The first phase of this study involved surveying South Asian medicinal plant books to identify as many plants as possible believed to have beneficial effects on memory loss. Several local books and sources were consulted.[19–34]

The second phase of the study involved a literature search using

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**Table 1. List of plants traditionally used for their memory-enhancing effects in South Asia**

| Botanical name | Family | Local name (Hindi) | English name | Part used | References |
|---|---|---|---|---|---|
| *Acacia nilotica* | Mimosoideae | Babul, kikar | Gum Arabic tree | Gum | 27 |
| *Acorus calamus* | Aracaceae | Waj, bach | Sweetflag | Roots | 33 |
| *Anacardium occidentale* | Anacardiaceae | Kaju, kaja | Cashew nut | Nuts | 33 |
| *Boswellia glabra* | Burceraceae | Kundar, Salai loban | Indian olibanum | Gum, resin | 33 |
| *Celastrus paniculatus* | Celastraceae | Malakanguni | Staff tree | Seed, leaf, oil | 23 |
| *Centaurea behen* | Compositae | Safed bahman | Behen, centaurea | Roots | 33 |
| *Coriandrum sativum* | Umbelliferae | Dhania | Coriander | Fruit, leaf | 23 |
| *Evolvulus alsinoides* | Convulvulaceae | Shankapushpi | Dwarf morning-glory | Whole herb | 23,24 |
| *Hydrocotyle asiatica* | Umbelliferae | Khulakudi | Indian pennywort | Whole plant, leaf | 23 |
| *Panax ginseng* | Araliaceae | Jenseng, tapmari | Ginseng | Roots, tea of leaf | 33 |
| *Salvia officinalis* | Labiatea | Salbia sefakuss | Common sage, garden sage | Leaves (dried) | 20 |
| *Withania somnifera* | Solanaceae | Asgandh, ashvagandha | Winter cherry, withania | Roots | 33 |
| *Zingiber officinale* | Zingiberaceae | Adrak, zinjibeel, sonth | Ginger | Rhizomes | 25,33 |

The search was performed using several South Asian books.

databases such as PubMed and Google Scholar to determine whether any of the identified plants have been scientifically shown to possess memory-enhancing properties. Given the various pathways and mechanisms contributing to memory loss, additional reported properties—such as anti-inflammatory, antioxidant, neuroprotective effects, and impacts on cerebral blood flow—were also recorded.[35]

## Memory-enhancing medicinal plants

A total of 13 traditionally used plants from local South Asian texts were identified as having memory-enhancing properties (Table 1).[20,23-25,27,33] As stated, all these texts are local books from South Asia (India and Pakistan). The terms we searched for in the plant descriptions within these books were "memory" and "forgetfulness." This led to the identification of these plants, which are traditionally known in local customs as those that can help individuals with memory issues. Table 1 also shows the plant families they belong to, their local names (usually in Hindi or Urdu), their English names, and the parts of the plants used for this specific memory-enhancing effect. The books did not provide further details on the manner of use or any mechanisms behind these plants' effects. These books are not research- or science-based but instead present a collection of information based on folk knowledge and culture. The only information provided was the indication that the plants listed in Table 1 have traditionally been used to benefit people with memory loss. These plants belong to different plant families, although two of them are members of the Umbelliferae family (Fig. 1). Several studies have shown that plants from this family have beneficial effects on memory.[36–38] The most commonly used parts of these plants for this benefit are the leaves and roots (Fig. 2).

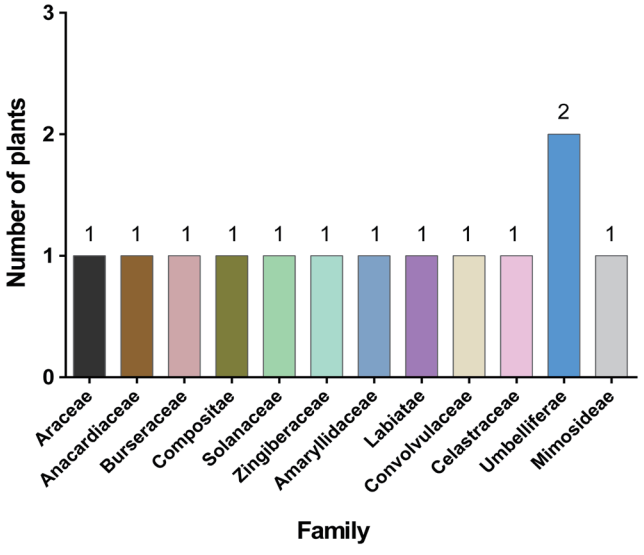


**Fig. 1. Graph showing the different plant families represented by the memory-enhancing plants.**

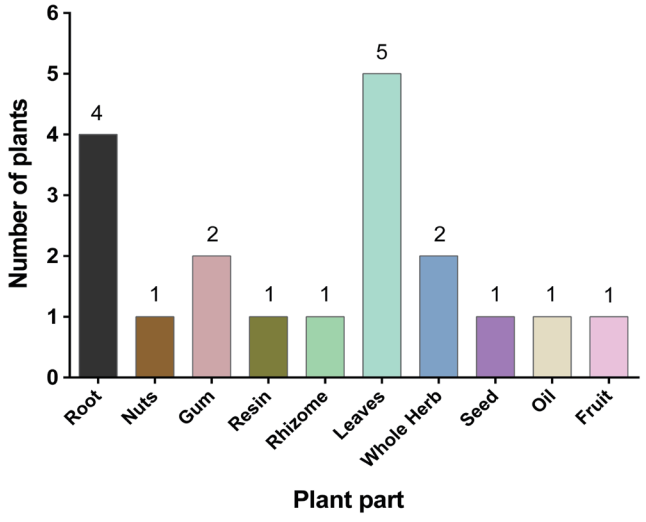


**Fig. 2. Graph showing the different plant parts traditionally used for enhancing memory from the discussed medicinal plants.**

After reviewing the published studies, we found that the roots and leaves of many different plants have been scientifically proven to be effective against memory loss.[39,40]

## Scientific evidence to back these plants

The second phase of the study involved investigating whether the plants listed in Table 1 have any scientific evidence supporting their memory-enhancing effects. This was done through a literature review of these plants on databases such as PubMed and Google Scholar. Several plants from Table 1, when searched through these databases, were found to have been reported with evidence supporting their memory-enhancing effects (Table 2).[41–126] Of the 13 plants, only *Boswellia glabra*, *Centaurea behen*, and *Hydrocotyle asiatica* were not found to have any published data on this aspect of their pharmacology. While searching the databases, we used the following terms to help find relevant information: memory, dementia, Alzheimer's disease, and cholinesterase (ChE), one of the main mechanisms through which chemicals can benefit memory deficits.

## Mechanism of action involving acetylcholinesterase inhibition

Table 2 shows all the plants with reported activities on memory enhancement. The table also details the primary mechanisms proposed in those studies for their memory-enhancing effects, the experimental models used, and the potential chemicals in the plants responsible for these activities. For all the plants listed in Table 2, the predominant mechanism proposed for their memory-enhancing effects is the inhibition of ChE enzymes, namely acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE). The exact pathogenesis of AD is not clearly defined, but there is a consensus on the role of acetylcholine (ACh) and its excitatory contribution to nerve conduction.[127] Conversely, the central hydrolyzing enzyme AChE can break down ACh, leading to a deficit in ACh levels. This is why most clinically used AD drugs (donepezil, rivastigmine, and galantamine) are AChE inhibitors, which can inhibit the AChE enzyme and increase ACh levels in the brain,[128] helping with the memory symptoms of AD. The AChE inhibitory activity of these plants has been investigated using both *in vitro* and *in vivo* methods. This points to the abundance of natural chemicals that could contribute to drug discovery in this area via the pathway of AChE inhibition. As all the plants in Table 2 have shown ChE inhibitory activities, there is a need for more advanced studies to investigate these plants and their components further to develop them into clinically useful medications for patients with memory loss due to AD.

## Mechanism of action involving N-methyl-D-aspartate (NMDA) antagonism

In addition to AChE inhibitor drugs, memantine is another drug clinically used in AD that works through a separate pathway by blocking NMDA receptors. This receptor plays a key role in the central nervous system, particularly in cases where abnormal NMDA receptor function or expression levels are associated with several neurodegenerative diseases, including AD.[129] Table 2 shows that several plants have activities reported in modulating NMDA receptor function, specifically plants like *Celastrus paniculata*, *Withania somnifera*, and *Zingiber officinale*. This suggests that plants could also be a valuable source for new NMDA receptor ligands, in addition to ChE ligands.[130] Memantine was approved by the U.S. Food and Drug Administration over 20 years ago. More research should be focused on this area, and additional NMDA antagonists need to be approved for use in AD. Plants present a viable option for discovery in this area of interest.

## Additional mechanisms for memory enhancement

The studies listed in Table 2 also show that anti-inflammatory and antioxidant mechanisms are common among these plants used for memory loss in AD.[131] Neuroinflammation is not typically linked to the onset of AD, but it can exacerbate the disease by elevating abnormalities caused by amyloid-beta (Aβ) and tau proteins. When immune cells release inflammatory cytokines, it further triggers the immune system and increases inflammation levels.[132] In people with AD, immune cells are often overly active, which leads to an increased buildup of Aβ and tau proteins. This excessive activity can also result in the loss of synapses, damage to the blood-brain barrier, and overall brain degeneration.[133] Similarly, there is a risk of imbalance between the production and breakdown of Aβ. This imbalance causes elevated levels of Aβ to accumulate in the brain.[134] Aβ can create oxidative stress, which in turn can further increase Aβ production. Neurons are particularly vulnerable to oxidative stress because they have low levels of antioxidants, and their membranes are rich in fatty acids that are easily damaged.[135] This highlights the importance of these mechanisms and their relevance in drug discovery for AD research. Much has been published in this regard, as evident from Table 2, and further efforts are needed to bring this to fruition in terms of developing newer AD drugs.

From the findings of this review, it is also evident that some plants exhibit not only one mechanism of action but multiple mechanisms contributing to their efficacy in addressing memory loss in AD. For instance, *Acorus calamus*, *Anacardium occidentale*, and *Salvia officinalis* are reported to have AChE inhibitory, cholinomimetic, and antioxidant properties[47,52,54–57,102,112]; *Celastrus paniculatus* has AChE inhibitory, antioxidant, and NMDA antagonist activities[69,70]; *Coriandrum sativum*, *Evolvulus alsinoides*, and *Withania somnifera* exhibit antioxidant, anti-inflammatory, and AChE inhibitory effects[113–115]; while *Zingiber officinale* exhibits cholinomimetic, antioxidant, BuChE inhibitory, and $Ca^{2+}$ antagonist activities.[121,122] Among the pure compounds, 6-gingerol, a known constituent of ginger rhizome, is recognized for having multiple properties, including $Ca^{2+}$ antagonist and BuChE inhibitory effects. This suggests that 6-gingerol could potentially target AD from multiple angles, much like the ginger rhizome from which it is isolated.[121] The potential of plants and their pure compounds to benefit disease conditions and target different pathways is promising for discovering and designing new therapeutic entities for AD.

Integrative medicine is a healthcare approach that combines conventional medicine with complementary and alternative therapies.[136] This collaboration involves the use of traditional therapies, including medicinal plants. As demonstrated in this study, there is a wide range of age-old medicinal plants with potential benefits for memory loss and other cognitive issues. The scientific literature reveals the diverse mechanisms within these plants that support brain health. By merging folk knowledge with contemporary medical science, a more holistic approach can be offered to patients, thereby improving patient care and outcomes in the field of cognitive health.

## Data from clinical trials in humans

Human clinical trials are pivotal in the drug discovery process, including for drugs derived from plant sources. While experiments

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**Table 2. Published data related to memory improvement and potential use in Alzheimer's disease for plants traditionally used for their memory-enhancing effects in South Asia**

| Plant name | Proposed mechanism | Experimental model | Chemical responsible | References |
|---|---|---|---|---|
| *Acacia nilotica* | AChEi, BuChEi, anti-inflammatory | *In vitro* | | 41 |
| | AChEi | *In vitro* | Heptacosane, niloticane | 42,43 |
| *Acorus calamus* | Prevention of mitochondrial damage in hippocampus | Mice | | 44 |
| | AChEi | Rats | α-Asarone | 45 |
| | Low memory deficit via antioxidant & anti-inflammatory effect | Rats | | 46 |
| | Antioxidant, AChEi | Rats | α-Asarone | 47 |
| | Antioxidant, ↓ Na-K-ATPase | Rats | | 48 |
| | AChEi | *In vitro* | | 49–51 |
| | ↑ Cholinergic system, antioxidant | Mice | | 52 |
| | Antioxidant, ↓ cell death | *In vitro* | α-Asarone | 53 |
| *Anacardium occidentale* | Antioxidant, anti-inflammatory | Rats | Triterpenoid (ursolic acid, oleanolic acid, lupane); polyphenols (catechin, quercetin, kaempferol) | 54 |
| | Prevention of oxidative stress, neuroinflammation & neurobehavioral changes | Rats | | 55 |
| | Antioxidant, effects on Cholinergic & GABAergic system | Rats | | 56 |
| | AChEi | *In vitro* | Anacardic acid, Phenolic lipids, cardanol, cadol | 57–62 |
| *Celastrus paniculatus* | ↑ Behavioral outcomes, AChEi, ↓ neuroinflammation, ↑ synaptic plasticity, ↑ cognitive functions | Rats | | 63 |
| | Improved behavior, ↓ oxidative stress, AChEi | Mice | | 64 |
| | Improved behavior, oxidative stress | Rats | | 65 |
| | Improved cognitive functions | Rats | | 66 |
| | Memory enhancement seen on elevated plus maze and passive avoidance tests | Mice | | 67 |
| | AChEi | Rat | | 68 |
| | Antioxidant, AChE independent effect | Rat | | 69 |
| | NMDAi, antioxidant | Rat | | 70 |
| | Antioxidant | Rat | | 71 |
| | Reversed scopolamine-induced task performance deficit | Rat | | 72 |
| | Involvement of aminergic system | Rat | | 73 |
| | Aluminum induced neurodegeneration and oxidative stress | Rat | | 74 |

*(continued)*

**Table 2.** *(continued)*

| Plant name | Proposed mechanism | Experimental model | Chemical responsible | References |
|---|---|---|---|---|
| *Coriandrum sativum* | ↓ Oxidative stress, AChEi | Zebrafish | | 75 |
| | Neuritogenesis and synaptogenesis | *In vitro* | | 76 |
| | Barnes maze test performance | Mice | | 77 |
| | Oxidative stress | Rat | | 78 |
| | Antioxidant | Rat | | 78 |
| | AChEi | Mice | | 80 |
| | AChEi | *In vitro* | Linalool, γ-terpinene, α-pinene | 81 |
| | ↓ Oxidative stress via protecting cell death, ↓ ROS production, preventing cell apoptosis, modulating sirtuin longevity | *In vitro* | Linalool, linalyl acetate, geranyl acetate | 82 |
| | Antioxidant, anti-inflammatory, ERK inhibitory | Drosophila | | 83 |
| *Evolvulus alsinoides* | Antioxidant, AChEi | *In vitro* | Tannins, flavonoids, phenols | 84 |
| | Antioxidant, anti-inflammatory, AChEi, memory enhancing | *In vitro*, rat | Steroid (stigmasterol, betulinic acid); coumarin (scopoletin); flavonoid (β-carotene, chlorogenic acid) | 85 |
| | ↓ Streptozotocin induced cognitive impairment by ↓ oxidative stress, ↑ cholinergic function, ↓ rho kinase expression | Rat | | 86 |
| | Antioxidant | *In vitro* | | 87 |
| | Prevention against scopolamine induced amnesia | Mice | | 88–91 |
| | Improvement against radial arm maze task and Barnes maze test | Rat | | 92 |
| | Effect on elevated plus-maze | Rat | | 93,94 |
| *Panax ginseng* | Improved memory | Humans | | 95 |
| | ↓ β-amyloid production via ↑ capacitative $Ca^{2+}$ entry | Mice | Ginsenoside | 96 |
| | Different memory tests | Rat | | 97 |
| | ↑ Neurogenesis and synaptogenesis through the CREB/BDNF signaling pathway | Mice | Ginsenoside | 98 |
| | ↓ Neuroinflammation and inhibits neurotoxicity of Aβ deposition and Tau phosphorylation | Rat | Ginsenoside | 99 |
| | AChEi | *In vitro* | Homopanaxynol, homopanaxydol | 100 |
| *Salvia officinalis* | AChEi, BuChEi, antioxidant, ↓ amyloid-beta Aβ | *In vitro*; Nematode (Globodera pallida) | | 101 |

*(continued)*

**Table 2.** *(continued)*

| Plant name | Proposed mechanism | Experimental model | Chemical responsible | References |
|---|---|---|---|---|
| | ↓ β-amyloid deposition, ↓ oxidative stress, AChEi | Rat | Methyl carnosate, carnosic acid, carnosol, rosmanol, salvianolic acids | 102 |
| | Improved perceived exertion, working memory, and reaction time | Humans | | 103–107 |
| | Modulation of Brain-derived Neurotrophic Factor | *In vitro* | benzyl 6-O-β-D-apiofuranosyl-β-D-glucoside | 108 |
| | Effect on Morris water maze via CaM kinase II protein expression | Mice | | 109 |
| | Antioxidant | Rat | | 110 |
| | AChEi | Mice | | 111 |
| | Activation of cholinergic system | Rat | | 112 |
| *Withania somnifera* | ↑ Cognitive function and mood | Humans | | 113 |
| | Anti-inflammatory | Rat | | 114 |
| | Antioxidant | *In vitro* | | 115 |
| | Protection from glutamate induced neurotoxicity | Rat | | 116 |
| | Protection from neurotoxicity and neuroinflammation | mice | | 117 |
| | ↑ executive function, attention, short-term/working memory | Humans | | 118 |
| | ↑ memory and focus, psychological well-being, sleep quality, ↓ stress levels, | Humans | | 119 |
| | AChEi, BuChEi, $Ca^{2+}$ antagonist | *In vitro*, rabbit | Withanolides | 120 |
| *Zingiber officinale* | Muscarinic agonist, $Ca^{2+}$ antagonist, BuChEi | Rodent, *in vitro* | 6-Gingerol | 121 |
| | Antioxidant | Mice | | 122 |
| | ↓ cognitive deficits via blocking PERK/CHOP-dependent ER stress pathway and apoptosis | *In vitro* | Zerumbone | 123 |
| | ↓ ethanol-induced cognitive impairment via modulation of expression of NMDA and GABA receptors, ↓ oxidative damage | Rat | | 124 |
| | ↑ Memory and behavior post lipopolysaccharide exposure | Rat | 6-shogaol | 125 |
| | ↓ Oxidative stress | Rat | | 126 |

AChEi, acetylcholinesterase inhibition; AD, Alzheimer's disease; BDNF, brain-derived neurotrophic factor; BuChEi, butyrylcholinesterase inhibition; CHOP, CCAAT-enhancer-binding protein homologous protein; CREB, cAMP response element binding; ERK, extracellular signal-regulated kinase; GABA, gamma-aminobutyric acid; NMDA, N-methyl-D-aspartate; NMDAi, N-methyl-D-aspartate receptor inhibition; PERK, protein kinase RNA-like ER kinase; ROS, reactive oxygen species.

done on animals provide critical starting data on safety, efficacy, and biological effects, human trials confirm these findings and ensure that a drug works safely and effectively in people. Human trials also provide important information regarding dosage, adverse effects, and how the human body processes the drugs. This is especially important because plants contain hundreds of active chemicals, and the response observed in lab animals may not always extrapolate directly to humans. Additionally, genetics and individual response variations among humans make clinical trials necessary to fully understand the biological effects of the drugs and to help with the approval of the drug for widespread human consumption.

With this in mind, we examined the data in Table 2 and observed that three of the plants mentioned have been the subject of human trials: *Panax ginseng*, *Salvia officinalis*, and *Withania somnifera*. For *Panax ginseng*, the referenced study tested a ginseng extract called ThinkGIN™ to assess its potential for improving memory in older adults with subjective memory impairment.[95] A 12-week clinical trial was conducted with 80 participants aged 55 to 75. Half of the participants took ThinkGIN™ daily, while the other half took a placebo. After 12 weeks, the ThinkGIN™ group showed significant improvements in memory and cognitive function compared to the placebo group. Safety tests showed no serious side effects.

Multiple human trials have been performed on *Salvia officinalis* (sage). One crossover, randomized, double-blind trial with 26 volunteers assessed the effects of sage supplementation two hours before a fatiguing cycling task.[103] Results showed that sage improved cognitive functions, including perceived exertion, working memory, and reaction time in the athletes. In another randomized, double-blind trial,[104] sage was administered to 94 healthy individuals over a 29-day period. The study consistently showed significant benefits in working memory and accuracy in task outcomes. The study suggested that terpenes and phenolics in the herb were responsible for these benefits. Additionally, a double-blind, randomized pilot study involving 44 healthy human volunteers demonstrated that a combination extract containing sage improved delayed word recall in volunteers under 63 years of age.[105] A terpenoid-containing sage extract tested in 36 healthy volunteers showed improved performance on secondary memory and attention tasks, reduced mental fatigue, and increased alertness following oral administration.[106] Lastly, a randomized, placebo-controlled, double-blind, balanced, five-period crossover study involving 20 healthy older adults showed enhancement in secondary memory performance and improved accuracy in attention tasks.[107] The authors identified the ChE inhibitory mechanism of the extract as responsible for these beneficial effects.

Finally, *Withania somnifera* (ashwagandha) has also been studied in human volunteers. In one randomized, double-blind study,[113] 59 healthy young human volunteers received an ashwagandha extract. Results showed improvements in multiple parameters of cognitive function, mood, and markers of health and safety. In another double-blind, placebo-controlled, crossover study,[118] 13 healthy volunteers were administered an ashwagandha extract. The extract benefited executive function, improved attention, and enhanced short-term/working memory. Finally, a double-blind, randomized, placebo-controlled clinical trial examined the effect of a root extract of ashwagandha in 130 healthy adults.[119] Over 90 days of testing, the extract not only improved memory and focus, psychological well-being, and sleep quality but also reduced stress levels. The administration of the extract was safe for the volunteers, and no adverse effects were noted.

The results from these human trials demonstrate the effectiveness of these medicinal herbs in improving cognition and memory.

## Limitations

This review presents various South Asian medicinal plants traditionally used for memory loss. Although several plants have been identified and shown to have a scientific basis for use in memory loss, there are still a few limitations to this study:

Only a limited number of books were searched for this review article. Additional local books and printed literature might have yielded more plants traditionally used for memory loss.

This review and study could have been further strengthened if an in-person survey of local herbalists and traditional healers had been conducted. This would have provided actual, real-time data about the practical clinical use of medicinal plants by traditional healers in South Asia for patients with memory loss. This could be the next step in this direction.

Talking to actual patients about how they use these plants in real life would have also been more effective. Currently, the books used to reference the use of these plants only describe the plant parts used for medicinal benefit. Conversations with healers and patients would have provided more information on the process of preparing these plants for use in treating memory loss.

This study is just a review of plants traditionally used in South Asia. A broader study involving other cultures and nations would provide a much larger list of plants with this benefit. In the future, such an effort could be undertaken.

This review did not delve deeply into the medicinal chemistry aspect. A detailed exploration of the chemicals in plants with memory-enhancing benefits could provide more insights into drug design and discovery.

## Conclusions

The initial effort to identify South Asian plants traditionally used for memory-enhancing effects yielded a list of medicinal plants. Most of these plants have been reported in the literature to have activity in improving memory, particularly memory loss associated with AD. Several mechanisms have been reported, such as AChE inhibition, modulation of NMDA receptors, and antioxidant and anti-inflammatory effects. Most of the studies cited tested these plants on animals. Our study highlights the existence of plants and chemicals that can target memory loss through multiple pathways simultaneously, emphasizing the need for more research in this area. Currently, only AChE inhibitors and NMDA receptor antagonists are available for clinical use in memory loss and AD. If extracts or chemicals with the ability to target disease via multiple pathways simultaneously were introduced, it could potentially be a medical breakthrough. There is also a need to gather data from human studies to assess safety, efficacy, and pharmacokinetics, so that more agents can be made available for clinical use.

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## Conflict of interest

MNG has been an editorial board member of *Future Integrative Medicine* since February 2023. The authors declare that there is no other conflict of interest.

## Author contributions

Conceptualization, investigation, data curation, writing—original draft, and writing—review & editing (FAS, AG, ZU, MNG). All authors have made significant contributions to this study and have approved the final manuscript.

## References


[1] O'Neil-Pirozzi TM, Cappon DB, Pascual-Leone A. Adherence to cognitive and physical exercise engagement: a challenge to successful dementia risk reduction and prevention efforts. Front Dement 2023;2:1254986. doi:10.3389/frdem.2023.1254986, PMID:39081974.

[2] Fasouli ES, Katsantoni E. Age-associated myeloid malignancies - the role of STAT3 and STAT5 in myelodysplastic syndrome and acute myeloid leukemia. FEBS Lett 2024;598(22):2809–2828. doi:10.1002/1873-3468.14985, PMID:39048534.

[3] Ozceylan O, Sezgin-Bayindir Z. Current Overview on the Use of Nanosized Drug Delivery Systems in the Treatment of Neurodegenerative Diseases. ACS Omega 2024;9(33):35223–35242. doi:10.1021/acsomega.4c01774, PMID:39184484.

[4] Ibrahim N, Nadian I, Noor DR, Fadilah F. Prediction of Translational Regulation by Network Interaction in Synaptic Plasticity Induced with Centella asiatica. ScientificWorldJournal 2023;2023:4199614. doi:10.1155/2023/4199614, PMID:37440991.

[5] Voglhuber J, Ljubojevic-Holzer S, Abdellatif M, Sedej S. Targeting Cardiovascular Risk Factors Through Dietary Adaptations and Caloric Restriction Mimetics. Front Nutr 2021;8:758058. doi:10.3389/fnut.2021.758058, PMID:34660673.

[6] Ung CY, Correia C, Li H, Adams CM, Westendorf JJ, Zhu S. Multiorgan locked-state model of chronic diseases and systems pharmacology opportunities. Drug Discov Today 2024;29(1):103825. doi:10.1016/j.drudis.2023.103825, PMID:37967790.

[7] Almeaqli MT, Alaidaa Y, Alnajjar FM, Al Shararh AS, Alharbi DS, Almslmani YI, *et al*. Therapeutic Effects of Arctiin on Alzheimer's Disease-like Model in Rats by Reducing Oxidative Stress, Inflammasomes and Fibrosis. Curr Alzheimer Res 2024;21(4):276–288. doi:10.2174/0115672050333388240801043509, PMID:39136502.

[8] Knight F, Ridge D, Loveday C, Weidner W, Roeser J, Halton C, *et al*. A Role-Needs Framework: Rethinking Support for Informal Caregivers for Alzheimer's Across the Global South and Global North. Int J Geriatr Psychiatry 2024;39(9):e6141. doi:10.1002/gps.6141, PMID:39289861.

[9] Pehlivanlar E, Çakir DA, Sanajou S, Tezel Yalçin H, Baydar T, Erkekoğlu P, *et al*. Synthesis and characterization of new hexahydroquinoline derivatives and evaluation of their cytotoxicity, intracellular ROS production, and inhibitory effects on inflammatory mediators. Turk J Chem 2024;48(4):659–675. doi:10.55730/1300-0527.3686, PMID:39296790.

[10] Tayarani-Najaran Z, Dehghanpour Farashah M, Emami SA, Ramazani E, Shahraki N, Hadipour E. Protective effects of betanin, a novel acetylcholinesterase inhibitor, against H(2)O(2)-induced apoptosis in PC12 cells. Mol Biol Rep 2024;51(1):986. doi:10.1007/s11033-024-09923-6, PMID:39283367.

[11] Hong CT, Lee HH, Chung CC, Chiu WT, Lee TY, Chen DY, *et al*. Post-stroke Cognitive Impairment: A Longitudinal Follow-Up and Pre/Post-stroke Mini-Mental State Examination Comparison. Curr Alzheimer Res 2022;19(10):716–723. doi:10.2174/1567205019666220802151945, PMID:35927922.

[12] Sivasinprasasn S, Tocharus J, Mahatheeranont S, Nakrat S, Tocharus C. Anthocyanin-Rich Fraction of Black Rice Bran Extract Protects against Amyloid β-Induced Oxidative Stress, Endoplasmic Reticulum Stress, and Neuronal Apoptosis in SK-N-SH Cells. Pharmaceuticals (Basel) 2024;17(8):1039. doi:10.3390/ph17081039, PMID:39204144.

[13] Pathak C, Kabra UD. A comprehensive review of multi-target directed ligands in the treatment of Alzheimer's disease. Bioorg Chem 2024;144:107152. doi:10.1016/j.bioorg.2024.107152, PMID:38290187.

[14] A P, Agrawal M, Dethe MR, Ahmed H, Yadav A, Gupta U, *et al*. Nose-to-brain drug delivery for the treatment of Alzheimer's disease: current advancements and challenges. Expert Opin Drug Deliv 2022;19(1):87–102. doi:10.1080/17425247.2022.2029845, PMID:35040728.

[15] Mohamed IE, Osman EE, Saeed A, Ming LC, Goh KW, Razi P, *et al*. Plant extracts as emerging modulators of neuroinflammation and immune receptors in Alzheimer's pathogenesis. Heliyon 2024;10(16):e35943. doi:10.1016/j.heliyon.2024.e35943, PMID:39229544.

[16] Ghayur MN. Traditional Chinese medicine research and education in Canada. J Altern Complement Med 2009;15(6):689–694. doi:10.1089/acm.2008.0552, PMID:19500004.

[17] Ghayur MN, Janssen LJ. A natural way to cardiovascular health. Nat Rev Cardiol 2010;7(3):1–2. doi:10.1038/nrcardio.2009.131-c1, PMID:20213930.

[18] Ghayur MN. Natural products breaking through. Pharmacog Mag 2006;2(5):1–2.

[19] Azhar I, Usmanghani K. Essential Oils. Karachi: Research Institute of Indusyunic Medicine; 2002.

[20] Azhar I, Mazhar F. Spices as Medicine. Karachi: Research Institute of Indusyunic Medicine; 2003.

[21] Baqar SR. Medicinal and Poisonous Plants of Pakistan. Karachi: Printas; 1989.

[22] Gilani AH. Constipation and its treatment with natural drugs used in Pakistan. In: Capasso F, Mascolo N (eds). Natural Drugs and the Digestive Tract. Roma: EMSI; 1992:117–121.

[23] Kapoor LD. Handbook of Ayurvedic Medicinal Plants. Boca Raton: CRC Press; 1990.

[24] Memon MIA, Shahani NM. Survey and domestication of wild medicinal plants distribution in Sindh Province of Pakistan, Annual Research Report, Department of Plant Breeding and Genetics. Tandojam: Sindh Agriculture University Press; 1986.

[25] Nadkarni KM. Indian Materia Medica. Bombay: Popular Prakashan; 1976.

[26] Pakistan Forest Institute (PFI). A Note on the Plants of Medicinal Value in Pakistan. Islamabad: Printing Corporation of Pakistan Press; 1984.

[27] Rahman A, Said HM, Ahmad VU. Pakistan Encyclopedia Planta Medica Vol 1. Karachi: Hamdard Foundation Press; 1986.

[28] Said HM. Hamdard Pharmacopoeia of Eastern Medicine. 2nd ed. Karachi: Hamdard Foundation of Pakistan; 1970.

[29] Said HM. Diseases of the liver: Greco-Arab Concepts. Karachi: Hamdard Foundation Press; 1982.

[30] Said HM, Ahmad VU, Rahman A. Pakistan Encyclopedia Planta Medica Vol 2. Karachi: Hamdard Foundation Press; 1986.

[31] Said HM. Medicinal Herbal Vol 1. Karachi: Hamdard Foundation Pakistan; 1996.

[32] Shinwari ZK, Khan AA, Nakaike T. Medicinal and Other Useful Plants of District Swat Pakistan. Peshawar: Al-Aziz Communications; 2003.

[33] Usmanghani K, Saeed A, Alam MT. Indusyunic medicine. Karachi: B.C.C. & T. Press; 1997.

[34] Zaman MB, Khan MS. Hundred Drug Plants of West Pakistan/ Islamabad: Printing Corporation of Pakistan Press; 1970.

[35] Naskar R, Ghosh A, Bhattacharya R, Chakraborty S. A critical appraisal of geroprotective activities of flavonoids in terms of their bio-accessibility and polypharmacology. Neurochem Int 2024;180:105859. doi:10.1016/j.neuint.2024.105859, PMID:39265701.

[36] Zhu H, Liu J, Zhou J, Jin Y, Zhao Q, Jiang X, *et al*. Notopterygium incisum roots extract (NRE) alleviates neuroinflammation pathology in Alzheimer's disease through TLR4-NF-κB pathway. J Ethnopharmacol 2024;335:118651. doi:10.1016/j.jep.2024.118651, PMID:39094757.

[37] Li XX, Yang P, Zhang YH, Song W, Wang XM, Li J. Research progress on mechanisms of ligustilide in treatment of nervous system diseases. Zhongguo Zhong Yao Za Zhi 2024;49(9):2290–2298. doi:10.19540/j.cnki.cjcmm.20240221.601, PMID:38812129.

[38] Tan TYC, Lim XY, Norahmad NA, Chanthira Kumar H, Teh BP, Lai NM, *et al*. Neurological Applications of Celery (Apium graveolens): A Scoping Review. Molecules 2023;28(15):5824. doi:10.3390/mol-

ecules28155824, PMID:37570794.
[39] Zhang JN, Pei ZD, Wang WY, Zhao MY, Pei WH, Zhang H, *et al*. Integration of High-Resolution LC-Q-TOF Mass Spectrometry and Multidimensional Chemical-Biological Analysis to Detect Nanomolar-Level Acetylcholinesterase Inhibitors from Different Parts of Zanthoxylum nitidum. J Agric Food Chem 2024;72(31):17328–17342. doi:10.1021/acs.jafc.4c00866, PMID:39045647.
[40] Guo J, Liu S, Guo Y, Bai L, Ho CT, Bai N. Chemical characterization, multivariate analysis and comparison of biological activities of different parts of Fraxinus mandshurica. Biomed Chromatogr 2024;38(6):e5861. doi:10.1002/bmc.5861, PMID:38501361.
[41] Rauf A, Ibrahim M, Alomar TS, AlMasoud N, Khalil AA, Khan M, *et al*. Hypoglycemic, anti-inflammatory, and neuroprotective potentials of crude methanolic extract from Acacia nilotica L. - results of an in vitro study. Food Sci Nutr 2024;12(5):3483–3491. doi:10.1002/fsn3.4017, PMID:38726429.
[42] Vivekanandhan P, Alharbi SA, Ansari MJ. Toxicity, biochemical and molecular docking studies of Acacia nilotica L., essential oils against insect pests. Toxicon 2024;243:107737. doi:10.1016/j.toxicon.2024.107737, PMID:38677379.
[43] Eldeen IM, Van Heerden FR, Van Staden J. In vitro biological activities of niloticane, a new bioactive cassane diterpene from the bark of Acacia nilotica subsp. kraussiana. J Ethnopharmacol 2010;128(3):555–560. doi:10.1016/j.jep.2010.01.057, PMID:20138134.
[44] Cao Y, Li M, Gu L, Zhao X, Zhou A, Miao Y, *et al*. Chinese traditional formula Kaixin San suppressed ferroptosis of hippocampal neurons and cardiomyocytes in mice with paradoxical sleep deprivation. J Ethnopharmacol 2023;304:116034. doi:10.1016/j.jep.2022.116034, PMID:36529245.
[45] Venkatesan K. Author Correction: Anti-amnesic and anti-cholinesterase activities of α-asarone against scopolamine-induced memory impairments in rats. Eur Rev Med Pharmacol Sci 2023;27(8):3218. doi:10.26355/eurrev_202304_32182, PMID:37140272.
[46] Esfandiari E, Ghanadian M, Rashidi B, Mokhtarian A, Vatankhah AM. The Effects of Acorus calamus L. in Preventing Memory Loss, Anxiety, and Oxidative Stress on Lipopolysaccharide-induced Neuroinflammation Rat Models. Int J Prev Med 2018;9:85. doi:10.4103/ijpvm.IJPVM_75_18, PMID:30450168.
[47] Sundaramahalingam M, Ramasundaram S, Rathinasamy SD, Natarajan RP, Somasundaram T. Role of Acorus calamus and alpha-asarone on hippocampal dependent memory in noise stress exposed rats. Pak J Biol Sci 2013;16(16):770–778. doi:10.3923/pjbs.2013.770.778, PMID:24498829.
[48] Reddy S, Rao G, Shetty B, Hn G. Effects of Acorus calamus Rhizome Extract on the Neuromodulatory System in Restraint Stress Male Rats. Turk Neurosurg 2015;25(3):425–431. doi:10.5137/1019-5149.JTN.11405-14.1, PMID:26037183.
[49] Oh MH, Houghton PJ, Whang WK, Cho JH. Screening of Korean herbal medicines used to improve cognitive function for anti-cholinesterase activity. Phytomedicine 2004;11(6):544–548. doi:10.1016/j.phymed.2004.03.001, PMID:15500267.
[50] Pradeep S, Jain AS, Dharmashekara C, Prasad SK, Akshatha N, Pruthvish R, *et al*. Synthesis, Computational Pharmacokinetics Report, Conceptual DFT-Based Calculations and Anti-Acetylcholinesterase Activity of Hydroxyapatite Nanoparticles Derived From Acorus Calamus Plant Extract. Front Chem 2021;9:741037. doi:10.3389/fchem.2021.741037, PMID:34692640.
[51] Mukherjee PK, Kumar V, Mal M, Houghton PJ. In vitro acetylcholinesterase inhibitory activity of the essential oil from Acorus calamus and its main constituents. Planta Med 2007;73(3):283–285. doi:10.1055/s-2007-967114, PMID:17286241.
[52] Malik R, Kalra S, Pooja, Singh G, Meenu, Gahlot V, *et al*. Antioxidative and neuroprotective potential of *Acorus calamus* linn. and *Cordia dichotoma* G. Forst. In Alzheimer's type dementia in rodent. Brain Res 2024;1822:148616. doi:10.1016/j.brainres.2023.148616, PMID:37793605.
[53] Mikami M, Takuya O, Yoshino Y, Nakamura S, Ito K, Kojima H, *et al*. Acorus calamus extract and its component α-asarone attenuate murine hippocampal neuronal cell death induced by l-glutamate and tunicamycin. Biosci Biotechnol Biochem 2021;85(3):493–501. doi:10.1093/bbb/zbaa071, PMID:33589895.
[54] Désiré GNS, Simplice FH, Guillaume CW, Kamal FZ, Parfait B, Hermann TDS, *et al*. Cashew (Anacardium occidentale) Extract: Possible Effects on Hypothalamic-Pituitary-Adrenal (HPA) Axis in Modulating Chronic Stress. Brain Sci 2023;13(11):1561. doi:10.3390/brainsci13111561, PMID:38002521.
[55] Oyagbemi AA, Adebayo AK, Adebiyi OE, Adigun KO, Folarin OR, Esan OO, *et al*. Leaf extract of Anacardium occidentale ameliorates biomarkers of neuroinflammation, memory loss, and neurobehavioral deficit in N(ω)-nitro-L-arginine methyl ester (L-NAME) treated rats. Biomarkers 2023;28(3):263–272. doi:10.1080/1354750X.2022.2164354, PMID:36632742.
[56] Srichomphu P, Wattanathorn J, Thukham-Mee W, Muchimapura S. Anxiety, Insomnia, and Memory Impairment in Metabolic Syndrome Rats Are Alleviated by the Novel Functional Ingredients from Anacardium occidentale. Antioxidants (Basel) 2022;11(11):2203. doi:10.3390/antiox11112203, PMID:36358575.
[57] Bini KKN, Kobenan KC, Kouakou M, Kouadio IS, Zengin G, Jekő J, *et al*. Phytochemical profiling, antioxidant activities, enzymatic activities and insecticidal potential of aqueous extracts of four plants on the larvae of Helicoverpa armigera (Lepidoptera: Noctuidae), the main pest of cotton plant in Ivory Coast. Arch Insect Biochem Physiol 2023;113(3):e22017. doi:10.1002/arch.22017, PMID:37185885.
[58] Morais SM, Silva KA, Araujo H, Vieira IG, Alves DR, Fontenelle RO, *et al*. Anacardic Acid Constituents from Cashew Nut Shell Liquid: NMR Characterization and the Effect of Unsaturation on Its Biological Activities. Pharmaceuticals (Basel) 2017;10(1):31. doi:10.3390/ph10010031, PMID:28300791.
[59] Stasiuk M, Janiszewska A, Kozubek A. Phenolic lipids affect the activity and conformation of acetylcholinesterase from Electrophorus electricus (Electric eel). Nutrients 2014;6(5):1823–1831. doi:10.3390/nu6051823, PMID:24787269.
[60] de Paula AA, Martins JB, dos Santos ML, Nascente Lde C, Romeiro LA, Areas TF, *et al*. New potential AChE inhibitor candidates. Eur J Med Chem 2009;44(9):3754–3759. doi:10.1016/j.ejmech.2009.03.045, PMID:19446931.
[61] De Lima SG, Feitosa CM, Citó AM, Moita Neto JM, Lopes JA, Leite AS, *et al*. Effects of immature cashew nut-shell liquid (Anacardium occidentale) against oxidative damage in Saccharomyces cerevisiae and inhibition of acetylcholinesterase activity. Genet Mol Res 2008;7(3):806–818. doi:10.4238/vol7-3gmr473, PMID:18949700.
[62] Stasiuk M, Bartosiewicz D, Kozubek A. Inhibitory effect of some natural and semisynthetic phenolic lipids upon acetylcholinesterase activity. Food Chem 2008;108(3):996–1001. doi:10.1016/j.foodchem.2007.12.011, PMID:26065763.
[63] Faldu KG, Patel SS, Shah JS. Celastrus paniculatus oil ameliorates NF-KB mediated neuroinflammation and synaptic plasticity in the scopolamine-induced cognitive impairment rat model. Metab Brain Dis 2023;38(4):1405–1419. doi:10.1007/s11011-023-01186-7, PMID:36809523.
[64] Arya A, Kaushik D, Almeer R, Bungau SG, Sayed AA, Abdel-Daim MM, *et al*. Application of Green Technologies in Design-Based Extraction of Celastrus paniculatus (Jyotishmati) Seeds, SEM, GC-MS Analysis, and Evaluation for Memory Enhancing Potential. Front Nutr 2022;9:871183. doi:10.3389/fnut.2022.871183, PMID:35662919.
[65] Malik J, Karan M, Dogra R. Ameliorating effect of Celastrus paniculatus standardized extract and its fractions on 3-nitropropionic acid induced neuronal damage in rats: possible antioxidant mechanism. Pharm Biol 2017;55(1):980–990. doi:10.1080/13880209.2017.1285945, PMID:28164735.
[66] Bhagya V, Christofer T, Shankaranarayana Rao BS. Neuroprotective effect of Celastrus paniculatus on chronic stress-induced cognitive impairment. Indian J Pharmacol 2016;48(6):687–693. doi:10.4103/0253-7613.194853, PMID:28066108.
[67] Raut SB, Parekar RR, Jadhav KS, Marathe PA, Rege NN. Effect of *Jyotiṣmatī* seed oil on spatial and fear memory using scopolamine induced amnesia in mice. Anc Sci Life 2015;34(3):130–133. doi:10.4103/0257-7941.157149, PMID:26120226.
[68] Bhanumathy M, Harish MS, Shivaprasad HN, Sushma G. Nootropic activity of Celastrus paniculatus seed. Pharm Biol 2010;48(3):324–327. doi:10.3109/13880200903127391, PMID:20645820.
[69] Godkar PB, Gordon RK, Ravindran A, Doctor BP. Celastrus pan-

iculatus seed oil and organic extracts attenuate hydrogen peroxide- and glutamate-induced injury in embryonic rat forebrain neuronal cells. Phytomedicine 2006;13(1-2):29–36. doi:10.1016/j.phymed.2003.11.011, PMID:16360930.
[70] Godkar PB, Gordon RK, Ravindran A, Doctor BP. Celastrus paniculatus seed water soluble extracts protect against glutamate toxicity in neuronal cultures from rat forebrain. J Ethnopharmacol 2004;93(2-3):213–219. doi:10.1016/j.jep.2004.03.051, PMID:15234755.
[71] Kumar MH, Gupta YK. Antioxidant property of Celastrus paniculatus willd.: a possible mechanism in enhancing cognition. Phytomedicine 2002;9(4):302–311. doi:10.1078/0944-7113-00136, PMID:12120811.
[72] Gattu M, Boss KL, Terry AV Jr, Buccafusco JJ. Reversal of scopolamine-induced deficits in navigational memory performance by the seed oil of Celastrus paniculatus. Pharmacol Biochem Behav 1997;57(4):793–799. doi:10.1016/s0091-3057(96)00391-7, PMID:9259008.
[73] Nalini K, Karanth KS, Rao A, Aroor AR. Effects of Celastrus paniculatus on passive avoidance performance and biogenic amine turnover in albino rats. J Ethnopharmacol 1995;47(2):101–108. doi:10.1016/0378-8741(95)01264-e, PMID:7500635.
[74] Chakrabarty M, Bhat P, Kumari S, D'Souza A, Bairy KL, Chaturvedi A, *et al*. Cortico-hippocampal salvage in chronic aluminium induced neurodegeneration by Celastrus paniculatus seed oil: Neurobehavioural, biochemical, histological study. J Pharmacol Pharmacother 2012;3(2):161–171. doi:10.4103/0976-500X.95520, PMID:22629092.
[75] Brinza I, Boiangiu RS, Cioanca O, Hancianu M, Dumitru G, Hritcu L, *et al*. Direct Evidence for Using Coriandrum sativum var. microcarpum Essential Oil to Ameliorate Scopolamine-Induced Memory Impairment and Brain Oxidative Stress in the Zebrafish Model. Antioxidants (Basel) 2023;12(8):1534. doi:10.3390/antiox12081534, PMID:37627529.
[76] Munni YA, Dash R, Mitra S, Dash N, Shima M, Moon IS. Mechanistic study of Coriandrum sativum on neuritogenesis and synaptogenesis based on computationally guided in vitro analyses. J Ethnopharmacol 2023;306:116165. doi:10.1016/j.jep.2023.116165, PMID:36641106.
[77] Mima Y, Izumo N, Chen JR, Yang SC, Furukawa M, Watanabe Y. Effects of Coriandrum sativum Seed Extract on Aging-Induced Memory Impairment in Samp8 Mice. Nutrients 2020;12(2):455. doi:10.3390/nu12020455, PMID:32054079.
[78] Velaga MK, Yallapragada PR, Williams D, Rajanna S, Bettaiya R. Hydroalcoholic seed extract of Coriandrum sativum (Coriander) alleviates lead-induced oxidative stress in different regions of rat brain. Biol Trace Elem Res 2014;159(1-3):351–363. doi:10.1007/s12011-014-9989-4, PMID:24793421.
[79] Cioanca O, Hritcu L, Mihasan M, Hancianu M. Cognitive-enhancing and antioxidant activities of inhaled coriander volatile oil in amyloid β(1-42) rat model of Alzheimer's disease. Physiol Behav 2013;120:193–202. doi:10.1016/j.physbeh.2013.08.006, PMID:23958472.
[80] Mani V, Parle M, Ramasamy K, Abdul Majeed AB. Reversal of memory deficits by Coriandrum sativum leaves in mice. J Sci Food Agric 2011;91(1):186–192. doi:10.1002/jsfa.4171, PMID:20848667.
[81] Hajlaoui H, Arraouadi S, Noumi E, Aouadi K, Adnan M, Khan MA, *et al*. Antimicrobial, Antioxidant, Anti-Acetylcholinesterase, Antidiabetic, and Pharmacokinetic Properties of Carum carvi L. and Coriandrum sativum L. Essential Oils Alone and in Combination. Molecules 2021;26(12):3625. doi:10.3390/molecules26123625, PMID:34199316.
[82] Jongwachirachai P, Ruankham W, Apiraksattayakul S, Intharakham S, Prachayasittikul V, Suwanjang W, *et al*. Neuroprotective Properties of Coriander-Derived Compounds on Neuronal Cell Damage under Oxidative Stress-Induced SH-SY5Y Neuroblastoma and in Silico ADMET Analysis. Neurochem Res 2024;49(12):3308–3325. doi:10.1007/s11064-024-04239-0, PMID:39298035.
[83] Liu QF, Jeong H, Lee JH, Hong YK, Oh Y, Kim YM, *et al*. Coriandrum sativum Suppresses Aβ42-Induced ROS Increases, Glial Cell Proliferation, and ERK Activation. Am J Chin Med 2016;44(7):1325–1347. doi:10.1142/S0192415X16500749, PMID:27776428.
[84] Pavithra Mettupalayam Kaliyannan Sundaramoorthy, Kilavan Packiam K. In vitro enzyme inhibitory and cytotoxic studies with Evolvulus alsinoides (Linn.) Linn. Leaf extract: a plant from Ayurveda recognized as Dasapushpam for the management of Alzheimer's disease and diabetes mellitus. BMC Complement Med Ther 2020;20(1):129. doi:10.1186/s12906-020-02922-7, PMID:32345272.
[85] Sethiya NK, Nahata A, Singh PK, Mishra SH. Neuropharmacological evaluation on four traditional herbs used as nervine tonic and commonly available as Shankhpushpi in India. J Ayurveda Integr Med 2019;10(1):25–31. doi:10.1016/j.jaim.2017.08.012, PMID:29530454.
[86] Mehla J, Pahuja M, Dethe SM, Agarwal A, Gupta YK. Amelioration of intracerebroventricular streptozotocin induced cognitive impairment by Evolvulus alsinoides in rats: in vitro and in vivo evidence. Neurochem Int 2012;61(7):1052–1064. doi:10.1016/j.neuint.2012.07.022, PMID:22892278.
[87] Auddy B, Ferreira M, Blasina F, Lafon L, Arredondo F, Dajas F, *et al*. Screening of antioxidant activity of three Indian medicinal plants, traditionally used for the management of neurodegenerative diseases. J Ethnopharmacol 2003;84(2-3):131–138. doi:10.1016/s0378-8741(02)00322-7, PMID:12648805.
[88] Nithya K, Siddaraman R, Sheelajoice PP, Rajarathinam M, Chandra VB. Nootropic activity of methanolic extract from Evolvulus alsinoides Linn. in mice with scopolamine-induced amnesia. Bioinformation 2023;19(12):1212–1216. doi:10.6026/973206300191212, PMID:38250536.
[89] Yadav MK, Singh SK, Singh M, Mishra SS, Singh AK, Tripathi JS, *et al*. Neuroprotective Activity of Evolvulus alsinoides & Centella asiatica Ethanolic Extracts in Scopolamine-Induced Amnesia in Swiss Albino Mice. Open Access Maced J Med Sci 2019;7(7):1059–1066. doi:10.3889/oamjms.2019.247, PMID:31049081.
[90] Nahata A, Patil UK, Dixit VK. Effect of Evolvulus alsinoides Linn. on learning behavior and memory enhancement activity in rodents. Phytother Res 2010;24(4):486–493. doi:10.1002/ptr.2932, PMID:19610035.
[91] Siripurapu KB, Gupta P, Bhatia G, Maurya R, Nath C, Palit G. Adaptogenic and anti-amnesic properties of Evolvulus alsinoides in rodents. Pharmacol Biochem Behav 2005;81(3):424–432. doi:10.1016/j.pbb.2005.03.003, PMID:15899513.
[92] Gupta A, Raj H, Karchuli MS, Upmanyu N. Comparative evaluation of ethanolic extracts of Bacopa monnieri, Evolvulus alsinoides, Tinospora cordifolia and their combinations on cognitive functions in rats. Curr Aging Sci 2013;6(3):239–243. doi:10.2174/1874609811205999 0036, PMID:23866011.
[93] Malik J, Karan M, Vasisht K. Nootropic, anxiolytic and CNS-depressant studies on different plant sources of shankhpushpi. Pharm Biol 2011;49(12):1234–1242. doi:10.3109/13880209.2011.584539, PMID:21846173.
[94] Shah J, Goyal R. Investigation of neuropsychopharmacological effects of a polyherbal formulation on the learning and memory process in rats. J Young Pharm 2011;3(2):119–124. doi:10.4103/0975-1483.80296, PMID:21731356.
[95] Baek HI, Ha KC, Park YK, Kim TY, Park SJ. Efficacy and Safety of Panax ginseng Sprout Extract in Subjective Memory Impairment: A Randomized, Double-Blind, Placebo-Controlled Clinical Trial. Nutrients 2024;16(12):1952. doi:10.3390/nu16121952, PMID:38931306.
[96] Cho YY, Park JH, Lee JH, Chung S. Ginsenosides Decrease β-Amyloid Production via Potentiating Capacitative Calcium Entry. Biomol Ther (Seoul) 2024;32(3):301–308. doi:10.4062/biomolther.2023.172, PMID:38586949.
[97] Afshan H, Khatoon H, Aziz A, Arefa M, Khaliq SA, Alam N. Memory and cognition enhancing effects of combination of Melissa officinalis and Panax ginseng. Pak J Pharm Sci 2023;36(5 Special):1609–1618. PMID:38008959.
[98] She L, Tang H, Zeng Y, Li L, Xiong L, Sun J, *et al*. Ginsenoside RK3 promotes neurogenesis in Alzheimer's disease through activation of the CREB/BDNF pathway. J Ethnopharmacol 2024;321:117462. doi:10.1016/j.jep.2023.117462, PMID:37981117.
[99] Wang X, Shi YJ, Niu TY, Chen TT, Li HB, Wu SH, *et al*. Neuroprotective effect of 20 (S) - Protopanaxadiol (PPD) attenuates NLRP3 inflammasome-mediated microglial pyroptosis in vascular dementia rats. Neurosci Lett 2023;814:137439. doi:10.1016/j.neulet.2023.137439, PMID:37579868.
[100] Murata K, Iida D, Ueno Y, Samukawa K, Ishizaka T, Kotake T, *et al*. Novel polyacetylene derivatives and their inhibitory activities on acetylcholinesterase obtained from Panax ginseng roots. J Nat Med 2017;71(1):114–122. doi:10.1007/s11418-016-1036-7, PMID:27568312.
[101] Althobaiti NA, Menaa F, Dalzell JJ, Albalawi AE, Ismail H, Alghuthay-

mi MA, *et al*. Ethnomedicinal Plants with Protective Effects against Beta-Amyloid Peptide (Aβ)1-42 Indicate Therapeutic Potential in a New In Vivo Model of Alzheimer's Disease. Antioxidants (Basel) 2022;11(10):1865. doi:10.3390/antiox11101865, PMID:36290588.

[102] Ayoub IM, George MY, Menze ET, Mahmoud M, Botros M, Essam M, *et al*. Insights into the neuroprotective effects of Salvia officinalis L. and Salvia microphylla Kunth in the memory impairment rat model. Food Funct 2022;13(4):2253–2268. doi:10.1039/d1fo02988f, PMID:35137748.

[103] Babault N, Noureddine A, Amiez N, Guillemet D, Cometti C. Acute Effects of Salvia Supplementation on Cognitive Function in Athletes During a Fatiguing Cycling Exercise: A Randomized Cross-Over, Placebo-Controlled, and Double-Blind Study. Front Nutr 2021;8:771518. doi:10.3389/fnut.2021.771518, PMID:34926550.

[104] Wightman EL, Jackson PA, Spittlehouse B, Heffernan T, Guillemet D, Kennedy DO. The Acute and Chronic Cognitive Effects of a Sage Extract: A Randomized, Placebo Controlled Study in Healthy Humans. Nutrients 2021;13(1):218. doi:10.3390/nu13010218, PMID:33466627.

[105] Perry NSL, Menzies R, Hodgson F, Wedgewood P, Howes MR, Brooker HJ, *et al*. A randomised double-blind placebo-controlled pilot trial of a combined extract of sage, rosemary and melissa, traditional herbal medicines, on the enhancement of memory in normal healthy subjects, including influence of age. Phytomedicine 2018;39:42–48. doi:10.1016/j.phymed.2017.08.015, PMID:29433682.

[106] Kennedy DO, Dodd FL, Robertson BC, Okello EJ, Reay JL, Scholey AB, *et al*. Monoterpenoid extract of sage (Salvia lavandulaefolia) with cholinesterase inhibiting properties improves cognitive performance and mood in healthy adults. J Psychopharmacol 2011;25(8):1088–1100. doi:10.1177/0269881110385594, PMID:20937617.

[107] Scholey AB, Tildesley NT, Ballard CG, Wesnes KA, Tasker A, Perry EK, *et al*. An extract of Salvia (sage) with anticholinesterase properties improves memory and attention in healthy older volunteers. Psychopharmacology (Berl) 2008;198(1):127–139. doi:10.1007/s00213-008-1101-3, PMID:18350281.

[108] Chiang N, Ray S, Lomax J, Goertzen S, Komarnytsky S, Ho CT, *et al*. Modulation of Brain-Derived Neurotrophic Factor (BDNF) Signaling Pathway by Culinary Sage (Salvia officinalis L.). Int J Mol Sci 2021;22(14):7382. doi:10.3390/ijms22147382, PMID:34299002.

[109] Dinel AL, Lucas C, Guillemet D, Layé S, Pallet V, Joffre C. Chronic Supplementation with a Mix of Salvia officinalis and Salvia lavandulaefolia Improves Morris Water Maze Learning in Normal Adult C57Bl/6J Mice. Nutrients 2020;12(6):1777. doi:10.3390/nu12061777, PMID:32549250.

[110] Hasanein P, Felehgari Z, Emamjomeh A. Preventive effects of Salvia officinalis L. against learning and memory deficit induced by diabetes in rats: Possible hypoglycaemic and antioxidant mechanisms. Neurosci Lett 2016;622:72–77. doi:10.1016/j.neulet.2016.04.045, PMID:27113201.

[111] Smach MA, Hafsa J, Charfeddine B, Dridi H, Limem K. Effects of sage extract on memory performance in mice and acetylcholinesterase activity. Ann Pharm Fr 2015;73(4):281–288. doi:10.1016/j.pharma.2015.03.005, PMID:25934446.

[112] Eidi M, Eidi A, Bahar M. Effects of Salvia officinalis L. (sage) leaves on memory retention and its interaction with the cholinergic system in rats. Nutrition 2006;22(3):321–326. doi:10.1016/j.nut.2005.06.010, PMID:16500558.

[113] Leonard M, Dickerson B, Estes L, Gonzalez DE, Jenkins V, Johnson S, *et al*. Acute and Repeated Ashwagandha Supplementation Improves Markers of Cognitive Function and Mood. Nutrients 2024;16(12):1813. doi:10.3390/nu16121813, PMID:38931168.

[114] Abomosallam M, Hendam BM, Abdallah AA, Refaat R, El-Hak HNG. Neuroprotective effect of Withania somnifera leaves extract nanoemulsion against penconazole-induced neurotoxicity in albino rats via modulating TGF-β1/Smad2 signaling pathway. Inflammopharmacology 2024;32(3):1903–1928. doi:10.1007/s10787-024-01461-8, PMID:38630361.

[115] Borgonetti V, Galeotti N. Novel Combination of Choline with Withania somnifera (L.) Dunal, and Bacopa monnieri (L.) Wetts Reduced Oxidative Stress in Microglia Cells, Promoting Neuroprotection. Int J Mol Sci 2023;24(18):14038. doi:10.3390/ijms241814038, PMID:37762339.

[116] Al-Dmour RH, Al-Tawarah NM, Mwafi N, Alkhataybeh BM, Khleifat KM, Tarawneh A, *et al*. Enhancement of hippocampal-dependent spatial memory by Ashwagandha (Withania somnifera) characterized by activation of NMDA receptors against monosodium glutamate-induced neurotoxicity in rats. Int J Neurosci 2024;134(11):1220–1228. doi:10.1080/00207454.2023.2255372, PMID:37659008.

[117] Costa G, Serra M, Maccioni R, Casu MA, Kasture SB, Acquas E, *et al*. Withania somnifera influences MDMA-induced hyperthermic, cognitive, neurotoxic and neuroinflammatory effects in mice. Biomed Pharmacother 2023;161:114475. doi:10.1016/j.biopha.2023.114475, PMID:36905810.

[118] Xing D, Yoo C, Gonzalez D, Jenkins V, Nottingham K, Dickerson B, *et al*. Effects of Acute Ashwagandha Ingestion on Cognitive Function. Int J Environ Res Public Health 2022;19(19):11852. doi:10.3390/ijerph191911852, PMID:36231152.

[119] Gopukumar K, Thanawala S, Somepalli V, Rao TSS, Thamatam VB, Chauhan S. Efficacy and Safety of Ashwagandha Root Extract on Cognitive Functions in Healthy, Stressed Adults: A Randomized, Double-Blind, Placebo-Controlled Study. Evid Based Complement Alternat Med 2021;2021:8254344. doi:10.1155/2021/8254344, PMID:34858513.

[120] Choudhary MI, Nawaz SA, ul-Haq Z, Lodhi MA, Ghayur MN, Jalil S, *et al*. Withanolides, a new class of natural cholinesterase inhibitors with calcium antagonistic properties. Biochem Biophys Res Commun 2005;334(1):276–287. doi:10.1016/j.bbrc.2005.06.086, PMID:16108094.

[121] Ghayur MN, Gilani AH, Ahmed T, Khalid A, Nawaz SA, Agbedahunsi JM, *et al*. Muscarinic, Ca(++) antagonist and specific butyrylcholinesterase inhibitory activity of dried ginger extract might explain its use in dementia. J Pharm Pharmacol 2008;60(10):1375–1383. doi:10.1211/jpp/60.10.0014, PMID:18812031.

[122] Luciano TF, Teodoro de Souza C, de Oliveira J, Muller AP. Reversal of high-fat diet-induced cognitive impairment and oxidative stress in the brain through Zingiber officinale supplementation. Metab Brain Dis 2024;39(8):1495–1503. doi:10.1007/s11011-024-01406-8, PMID:39120852.

[123] Yang C, Zhao M, Chen Y, Song J, Wang D, Zou M, *et al*. Dietary bitter ginger-derived zerumbone improved memory performance during aging through inhibition of the PERK/CHOP-dependent endoplasmic reticulum stress pathway. Food Funct 2024;15(18):9070–9084. doi:10.1039/d4fo00402g, PMID:39078275.

[124] Wang J, Akbari A, Chardahcherik M, Wu J. Ginger (Zingiber Officinale Roscoe) ameliorates ethanol-induced cognitive impairment by modulating NMDA and GABA-A receptors in rat hippocampus. Metab Brain Dis 2024;39(1):67–76. doi:10.1007/s11011-023-01301-8, PMID:37966694.

[125] da Rosa N, de Medeiros FD, de Oliveira J, Laurentino AOM, Peretti EM, Machado RS, *et al*. 6-Shogaol improves behavior and memory in Wistar rats prenatally exposed to lipopolysaccharide. Int J Dev Neurosci 2022;82(1):39–49. doi:10.1002/jdn.10157, PMID:34755374.

[126] Marefati N, Abdi T, Beheshti F, Vafaee F, Mahmoudabady M, Hosseini M. Zingiber officinale (Ginger) hydroalcoholic extract improved avoidance memory in rat model of streptozotocin-induced diabetes by regulating brain oxidative stress. Horm Mol Biol Clin Investig 2021;43(1):15–26. doi:10.1515/hmbci-2021-0033, PMID:34679261.

[127] Zhao X, Hu Q, Wang X, Li C, Chen X, Zhao D, *et al*. Dual-target inhibitors based on acetylcholinesterase: Novel agents for Alzheimer's disease. Eur J Med Chem 2024;279:116810. doi:10.1016/j.ejmech.2024.116810, PMID:39243456.

[128] Jaqua EE, Tran MN, Hanna M. Alzheimer Disease: Treatment of Cognitive and Functional Symptoms. Am Fam Physician 2024;110(3):281–293. PMID:39283851.

[129] Rafe MR, Saha P, Bello ST. Targeting NMDA receptors with an antagonist is a promising therapeutic strategy for treating neurological disorders. Behav Brain Res 2024;472:115173. doi:10.1016/j.bbr.2024.115173, PMID:39097148.

[130] Thakral S, Yadav A, Singh V, Kumar M, Kumar P, Narang R, *et al*. Alzheimer's disease: Molecular aspects and treatment opportunities using herbal drugs. Ageing Res Rev 2023;88:101960. doi:10.1016/j.arr.2023.101960, PMID:37224884.

[131] Daraban BS, Popa AS, Stan MS. Latest Perspectives on Alzheimer's

Disease Treatment: The Role of Blood-Brain Barrier and Antioxidant-Based Drug Delivery Systems. Molecules 2024;29(17):4056. doi:10.3390/molecules29174056, PMID:39274904.
[132] Chitnis T, Weiner HL. CNS inflammation and neurodegeneration. J Clin Invest 2017;127(10):3577–3587. doi:10.1172/JCI90609, PMID:28872464.
[133] Leng F, Edison P. Neuroinflammation and microglial activation in Alzheimer disease: where do we go from here? Nat Rev Neurol 2021;17(3):157–172. doi:10.1038/s41582-020-00435-y, PMID:33318676.
[134] Tofighi N, Asle-Rousta M, Rahnema M, Amini R. Protective effect of alpha-linoleic acid on Aβ-induced oxidative stress, neuroinflammation, and memory impairment by alteration of α7 nAChR and NMDAR gene expression in the hippocampus of rats. Neurotoxicology 2021;85:245–253. doi:10.1016/j.neuro.2021.06.002, PMID:34111468.
[135] Miller VM, Lawrence DA, Mondal TK, Seegal RF. Reduced glutathione is highly expressed in white matter and neurons in the unperturbed mouse brain—implications for oxidative stress associated with neurodegeneration. Brain Res 2009;1276:22–30. doi:10.1016/j.brainres.2009.04.029, PMID:19393633.
[136] Locke A. Using the Values of Integrative Medicine to Create the Future of Healthcare. Glob Adv Integr Med Health 2024;13:27536130241253607. doi:10.1177/27536130241253607, PMID:38751850.