J Biochem Technol (2025) 16(2): 105-112
https://doi.org/10.51847/4xc3jpX3U5
ISSN: 0974-2328

Phytotherapy in Dementia: Multi-Targeted Approaches to Neuroprotection and Cognitive Preservation

Bagepalli Srinivas Ashok Kumar*, Disha Nanjundiya Sadashiva

Received: 03 May 2025 / Received in revised form: 16 July 2025, Accepted: 17 July 2025, Published online: 25 July 2025

Abstract

Dementia is a progressive neurodegenerative disorder marked by a decline in cognitive function, with Alzheimer's disease being the most prevalent form. Current pharmacological treatments offer only limited symptomatic relief, prompting increasing interest in alternative strategies. Emerging evidence suggests that the plant-derived compounds may play a role as potential adjuncts in the management of dementia. This review explores the neuroprotective properties of selected medicinal plants, including *Ginkgo biloba* (enhancing cerebral blood flow and mitochondrial activity), *Curcuma longa* (inhibiting amyloid-beta aggregation), *Glycyrrhiza glabra* (improving cholinergic transmission), *Panax ginseng* (modulating oxidative stress and amyloid toxicity), and *Camellia sinensis* (reducing oxidative damage and supporting cognitive function). By synthesizing findings from preclinical and clinical studies retrieved from PubMed, Scopus, and Web of Science, this review highlights how these botanicals act on multiple pathological pathways associated with dementia, including oxidative stress, neuroinflammation, amyloid deposition, and cholinergic dysfunction. Although clinical outcomes remain inconsistent due to variations in study design, dosage, and extract standardization, these plants exhibit promising therapeutic potential with favourable safety profiles. The review emphasizes the need for standardized formulations, well-designed clinical trials, and personalized treatment protocols to establish their efficacy and integrate them effectively into dementia care.

Keywords: Dementia, Alzheimer's disease, Neuroprotective, *Ginkgo biloba, Panax ginseng, Curcuma longa*

Introduction

Dementia is a general term for a range of progressive neurological disorders that significantly affect memory, cognition, behaviour, and the ability to perform daily activities. According to the World Health Organization, dementia is not a single disease but an umbrella term for various conditions, including Alzheimer's disease (AD), frontotemporal dementia (FTD), Lewy body dementia, and vascular dementia (VD). While aging is the most significant risk factor, dementia is not a normal consequence of aging (Anonymous, 2019; Arvanitakis *et al.,* 2019). The U.S. National Institute of Neurological Disorders and Stroke highlights that dementia is characterized by severe impairment in at least two cognitive domains, such as memory, language, or reasoning, that interfere with day-to-day life (Sheet, 2018).

Historically, the concept of dementia predates the modern medical era. Though the diseases that cause dementia have likely existed since the dawn of humanity, it was only in 1906 that Alois Alzheimer described the condition that now bears his name. Prior to this, cognitive decline in old age was often dismissed as 'senility.' Early medical texts and literary works made vague references to memory loss and behavioural changes in the older peoples, but these were not understood in clinical terms. The early 20th century witnessed breakthroughs in neuropathology that clarified the nature of degenerative dementias, laying the foundation for modern dementia research (Berrios, 1990; Vatanabe *et al*., 2020). The prevalence of dementia has increased significantly in recent decades, primarily due to longer life expectancies. In 2017, approximately 50 million people worldwide were living with dementia a sharp rise from 35.6 million in 2010 (Sathianathan & Kantipudi, 2018; Gogoi *et al*., 2023). Projections indicate that this number will grow to 82 million by 2030 and 152 million by 2050, with the greatest burden expected in low- and middle-income countries. Alzheimer's disease is the most common form, followed by vascular and mixed dementias. About 10% of cases involve mixed dementia, often a combination of AD and VD or FTD (Karantzoulis & Galvin, 2011; Prince *et al.,* 2015).

Epidemiological studies have shown that dementia is one of the top five causes of death globally. In 2013 alone, dementia was responsible for 1.7 million deaths, a significant increase from 0.8 million in 1990. Life expectancy after diagnosis varies, typically ranging from 3 to 12 years, depending on age at onset, type of dementia, and other comorbidities. For instance, vascular dementia generally carries a poorer prognosis than Alzheimer's disease (Duthey, 2013; Aburas, 2022; Li *et al.,* 2024b).

Despite advances in diagnosis and symptomatic treatment, dementia remains incurable. Current therapies may temporarily alleviate symptoms or slow disease progression but cannot reverse

Bagepalli Srinivas Ashok Kumar*
Department of Pharmacognosy R.L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research (A Deemed to be University), Tamaka, Kolar, Karnataka, India.

Disha Nanjundiya Sadashiva
Department of Pharmaceutical Chemistry, R.L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research (A Deemed to be University), Tamaka, Kolar, Karnataka, India.

***E-mail:** ashok4vani@gmail.com

brain damage. The absence of curative treatments underscores the urgent need for further research into the biological, genetic, and environmental factors underlying this devastating condition.

In recent years, there has been growing interest in the use of medicinal plants for the management of dementia, particularly AD, due to their multifaceted pharmacological properties and favourable safety profiles (Gregory *et al.*, 2021; Carpio-Vargas *et al*., 2023; Mounir *et al*., 2023). Several traditional medicinal systems, including Ayurveda and Traditional Chinese Medicine, have long utilized plant-based therapies to enhance memory and cognitive function. Notable plants that have been investigated for their neuroprotective effects include *Ginkgo biloba*, *Panax ginseng*, *Curcuma longa, Glycyrrhiza glabra, Camellia sinensis* (Mantle *et al*., 2000; Chen *et al*., 2021; Shahzan *et al*., 2022; Bulovina *et al*., 2024; Kadiri & Tiwari, 2025).

These plants exhibit various mechanisms of action relevant to dementia therapy, such as antioxidant, anti-inflammatory, and anticholinesterase activities, as well as modulation of neurotransmitter systems. For instance, *Ginkgo biloba* extract has demonstrated efficacy in slowing cognitive decline and improving memory (Howes & Perry 2011; Singh *et al*., 2022; Villegas *et al.,* 2022; Tripathi *et al*., 2024). Likewise, *Panax ginseng*, *Curcuma longa*, *Glycyrrhiza glabra*, and *Camellia sinensis* have shown cognitive-enhancing potential through various neuropharmacological pathways (Lopresti, 2017; Jakaria *et al*., 2018; Jo, 2018; Cachón-Rodríguez *et al*., 2024; Nguyen *et al*., 2024).

These ethnomedicinal plants, used individually or in polyherbal formulations, provide a natural and potentially safer alternative or adjunct to conventional therapies. Their diverse bioactive compounds provide a promising foundation for the development of novel therapeutics targeting the complex pathophysiology of dementia. Therefore, exploring plant-derived compounds remains a vital area of research in the search for more effective, accessible, and holistic treatment options for dementia.

Materials and Methods

Data Collection

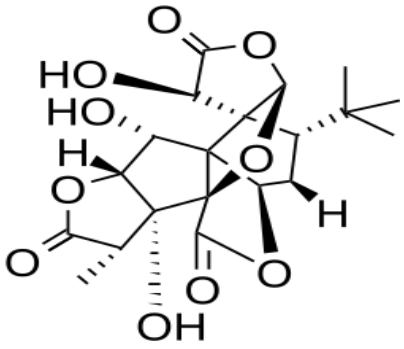
The literature for this article was collected through a comprehensive search using major scientific databases, including Google Scholar, PubMed, Scopus, and Web of Science. These search engines were employed to retrieve peer-reviewed articles, clinical studies, reviews, and ethnopharmacological reports related to dementia and the use of medicinal plants. Keywords used in the search included: “dementia,” “Alzheimer’s disease,” “medicinal plants,” “neuroprotection,” “cholinesterase inhibitors,” “antioxidants,” “anti-inflammatory agents,” “*Ginkgo biloba*,” “*Panax ginseng*,” “*Curcuma longa,” “Glycyrrhiza glabra,” “Camellia sinensis”.*

Role of Herbs in the Management of DEMENTIA

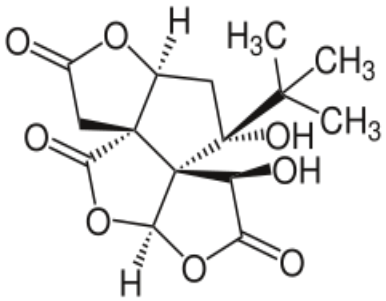
Ginkgo Biloba

Ginkgo biloba, often regarded as a “living fossil,” is one of the oldest surviving tree species, with its origin dating back over 200 million years. It is the sole extant member of the Ginkgoaceae family and has been widely cultivated in China for centuries due to its medicinal value (Jacobs & Browner, 2000; Crane, 2019; Yilmaz *et al*., 2023). Traditionally, Ginkgo extracts have been used to manage ailments like poor circulation, vertigo, fatigue, and tinnitus (Cybulska-Heinrich *et al*., 2012). In recent decades, it has gained global recognition for its neuroprotective potential, particularly in age-related cognitive decline and dementia (Çakar *et al*., 2022; Noor-E-Tabassum *et al.,* 2022).

Phytochemical studies reveal that *G. biloba* contains two major groups of active constituents responsible for its therapeutic properties: flavonoids and terpene lactones. Flavonoids, including kaempferol, quercetin, meletin, and isorhamnetin, exert antioxidant effects and modulate signaling pathways involved in memory and learning (Nakagawa & Yamashita, 2022; Karim *et al*., 2024; Gamal *et al*., 2025). Terpene lactones such as ginkgolides A, B, C, and bilobalide **(Figure 1)** exhibit neuroprotective activity by antagonizing platelet-activating factor (PAF) receptors and preserving mitochondrial integrity. Additionally, minor constituents like ginkgotoxin and bilobol have specific biological effects, including neurotoxicity and antibacterial action, respectively (Biernacka *et al*., 2023; Yahyaeva *et al*., 2023; Gamal *et al.,* 2025).



a)



b)

Figure 1. Ginkgolide and Bilobalide

Pharmacologically, *G. biloba* exhibits antioxidant, anti-inflammatory, vasoregulatory, and antiplatelet properties (Gamal *et al.,* 2025). These effects collectively contribute to improved cerebral blood flow, reduced oxidative stress, and enhanced synaptic plasticity, all of which are vital for maintaining cognitive health (Duman & Eken, 2022). The standardized extract EGb 761, containing 24% flavonoids and 6% terpene lactones, is the most

widely studied formulation. It has shown promise in preclinical and clinical studies for preserving cognitive function, protecting neurons from ischemic and toxic damage, and enhancing behavioural outcomes in both AD and VD (Farooqui, 2012). Due to its multifaceted mechanisms and favourable safety profile, *G. biloba* remains one of the few phytomedicines internationally recommended for the management dementia. However further standardized trials are needed to confirm its long-term efficacy.

Curcuma Longa

Curcuma longa L., commonly known as turmeric, is a perennial herb from the Zingiberaceae family. Widely used as a culinary spice and traditional remedy across Asia, particularly in Ayurvedic and Chinese medicine, turmeric has been applied for centuries to treat various ailments, including inflammation, digestive issues, liver disorders, and wound healing. Recent research has focused on its neuroprotective potential, particularly in dementia and AD (Mishra & Palanivelu, 2008; Farooqui, 2018; Tian *et al*., 2025).

The primary bioactive constituents of turmeric are curcuminoids, including curcumin **(Figure 2)**, demethoxycurcumin, and bisdemethoxycurcumin (Sharma & Sharma, 2022). Curcumin (diferuloylmethane) is the major and most studied compound, responsible for turmeric's bright yellow color. It possesses a symmetrical structure with two ferulic acid residues joined by a seven-carbon chain containing a β-diketone moiety. Curcumin also exists in keto and enol tautomeric forms depending on environmental pH. Additionally, turmeric contains essential oils such as turmerone, atlantone, and zingiberene (Oliveira Filho *et al.,* 2021).

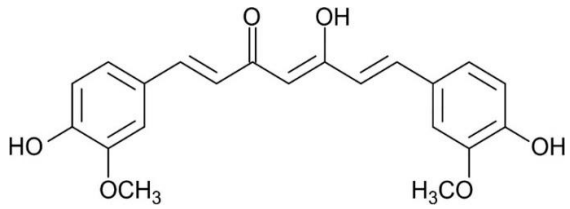


Figure 2. Curcumin

Curcumin exhibits a wide range of pharmacological effects including antioxidant, anti-inflammatory, antimicrobial, anticancer, and anti-amyloidogenic activities (Jyotirmayee *et al.,* 2023; Islam *et al.,* 2024). Its antioxidant properties stem from its phenolic groups and β-diketone moiety, which scavenge free radicals and modulate oxidative stress pathways. It also inhibits key inflammatory mediators such as TNF-α, IL-1β, and NF-κB, contributing to its neuroprotective profile (Azzini *et al.,* 2024; Genchi *et al.,* 2024).

Preclinical studies show that curcumin can reduce β-amyloid (Aβ) accumulation, inhibit tau hyperphosphorylation, modulate synaptic plasticity, and protect mitochondria. It crosses the blood-brain barrier (BBB), binds to Aβ plaques, and enhances their clearance via phagocytosis. Curcumin also improves memory and reduces oxidative and inflammatory damage in animal models of AD. While clinical data remain limited and inconclusive, curcumin demonstrates potential as an adjunctive therapeutic for managing dementia, especially AD. Improved formulations enhancing bioavailability are under investigation to support future clinical applications (Chen *et al.,* 2018; Shrifi-Rad *et al.,* 2020).

Glycyrrhiza Glabra

Glycyrrhiza glabra, commonly known as licorice, is a valued medicinal plant from the Fabaceae family, long revered in traditional healing systems such as Ayurveda and Traditional Chinese Medicine. Historically, the roots of *G. glabra* have been used to treat respiratory ailments, digestive disorders, and chronic inflammatory conditions (Batiha *et al.,* 2020; Wahab *et al*., 2021). More recently, scientific investigations have focused on its neuroprotective potential, particularly in relation to neurodegenerative diseases such as dementia and Alzheimer's disease (Paudel *et al*., 2020; Sarkar *et al*., 2023; Verma *et al*., 2024). The therapeutic efficacy of *G. glabra* is largely attributed to its rich array of bioactive compounds, including glycyrrhizin, glycyrrhetinic acid, glabridin, liquiritin, and isoliquiritigenin (Kaur *et al.,* 2013). These phytochemicals possess robust antioxidant, anti-inflammatory, and anti-apoptotic properties that directly counteract key pathological features of dementia.

Among its constituents, glycyrrhizin **(Figure 3)** has shown notable potential in protecting the brain against vascular dementia and other neurodegenerative insults. It exerts neuroprotective effects by reducing oxidative stress, inhibiting lipid peroxidation, and preserving neuronal structure in key brain areas, such as the hippocampus, which plays a crucial role in learning and memory (Guo *et al*., 2016; Li *et al*., 2024a). Glycyrrhizin also supports cognitive health by attenuating neuroinflammatory responses, notably by modulating the expression of pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β (Song *et al.,* 2025).

Furthermore, it has been observed to protect neuronal cells from glutamate-induced toxicity, a key contributor to excitotoxicity in neurodegeneration, by enhancing cell viability and regulating apoptosis-related genes, such as Bcl-2 and Bax (Yang *et al*., 2013). Additionally, other flavonoids, such as glabridin, have demonstrated the ability to cross the blood-brain barrier and protect neurons from amyloid-beta toxicity, a hallmark of Alzheimer's pathology.

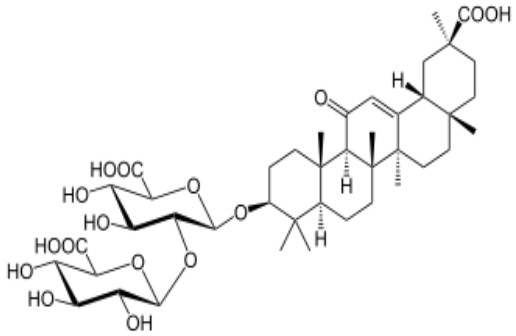


Figure 3. Glycyrrhizin

Animal model studies further suggest that *G. glabra* extract can enhance memory and learning by improving cholinergic transmission and inhibiting acetylcholinesterase activity (Dhingra *et al.,* 2004). Although more extensive clinical studies are needed,

current preclinical evidence and centuries of traditional usage collectively highlight *G. glabra* as a promising natural candidate for dementia management. Its multitargeted action, safety profile, and accessibility support its inclusion in the ongoing exploration of plant-based interventions for neurodegenerative disorders.

Panax Ginseng

Panax ginseng, commonly known as ginseng, is a perennial medicinal plant traditionally used in East Asia, particularly in China and Korea, as a general tonic to enhance vitality and promote longevity (Potenza *et al.,* 2023). Among its various species, *Panax ginseng* C.A. Meyer has received the most attention for its pharmacological properties, especially in relation to cognitive health. Ginseng contains several bioactive constituents including ginsenosides (notably Rg1, Rg2, Rg3), gintonin, polysaccharides, and amino acids, many of which have demonstrated neuroprotective and cognition-enhancing effects in both preclinical and clinical settings (Huang *et al.,* 2019; Liu *et al*., 2023).

Ginsenosides **(Figure 4)**, the primary active compounds, are known to influence multiple pathological pathways relevant to dementia. Ginsenoside Rg3 has been shown to reduce amyloid-beta (Aβ) accumulation and improve cognitive function by modulating oxidative stress, neuroinflammation, and apoptosis (Yang *et al.,* 2021; Hwang *et al.,* 2025). Rg1, another well-studied ginsenoside, is believed to protect neurons from Aβ-induced neurotoxicity and oxidative damage, partly through regulation of the p38 MAPK signaling pathway. Both Rg1 and Rg3 also affect cholinergic neurotransmission by modulating acetylcholine receptor activity and inhibiting acetylcholinesterase, mechanisms closely associated with memory and learning (Kim *et al.,* 2018; Jiang *et al*., 2025).

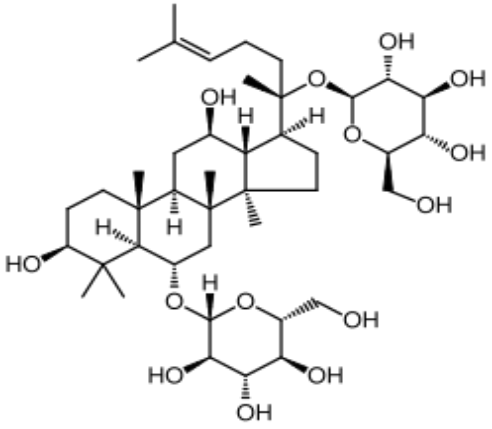


Figure 4. Ginsenoside

Emerging evidence suggests that ginseng extracts improve cognitive performance in individuals with subjective memory impairment (SMI), mild cognitive impairment (MCI), and early AD (58). Ginseng has also demonstrated benefits in VD models by enhancing cerebral blood flow, reducing glial activation, and regulating apoptotic proteins such as Bcl-2 and Bax (Kim *et al.,* 2013). Moreover, gintonin, a recently identified component of ginseng, contributes to neuroprotection through the activation of lysophosphatidic acid (LPA) receptors, which influences synaptic plasticity.

Although clinical trials evaluating the efficacy of ginseng in AD have produced mixed results, often due to small sample sizes and methodological limitations, its multi-targeted actions make it a promising candidate for integrative dementia therapy. The broad spectrum of neuroprotective activities, coupled with its traditional use and favourable safety profile, supports the continued exploration of *Panax ginseng* as a complementary approach in dementia management.

Camellia Sinensis

Camellia sinensis Kuntze, commonly known as green tea, is among the most widely consumed beverages worldwide and has been recognized for its diverse health-promoting properties, including its neuroprotective potential. Rich in bioactive compounds, particularly polyphenols such as epigallocatechin-3-gallate (EGCG) **(Figure 5)**, green tea exhibits potent antioxidant, anti-inflammatory, and anti-apoptotic activities that contribute to cognitive preservation and modulation of neurodegenerative diseases (Aboulwafa *et al.,* 2019; Prasanth *et al*., 2019).

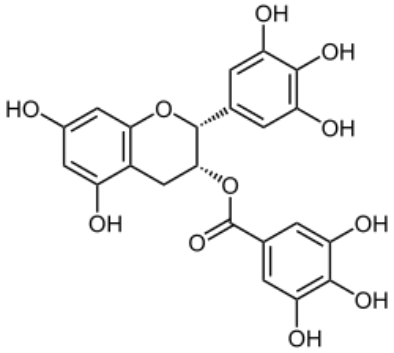


Figure 5. Epigallocatechin-3-gallate

Several studies highlight the role of green tea and its constituents in counteracting key pathological processes involved in dementia, including oxidative stress, amyloid-beta (Aβ) toxicity, and cholinergic dysfunction. EGCG and other catechins regulate ROS production, restore mitochondrial membrane potential, and enhance superoxide dismutase activity. L-theanine, a unique amino acid found in green tea, provides neuroprotection by inhibiting ERK/p38 and nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) signaling, thereby reducing Aβ42-induced memory loss and neuronal death. Additionally, green tea extract improves cognitive function by enhancing the expression of membrane metalloendopeptidase (MME), which facilitates Aβ degradation (Doganoglu & Erbas, 2021; Afzal *et al*., 2022).

Experimental models demonstrate that green tea ameliorates cognitive impairments in AD, VD, and diabetes-induced cognitive decline. Intrahippocampal and systemic administration of green tea constituents improved learning and memory in rats and protected hippocampal neurons from AlCl3 and ischemia-induced injury. Furthermore, green tea extract inhibits acetylcholinesterase and beta-secretase two critical enzymes implicated in AD pathology

suggesting a dual-action mechanism that enhances cholinergic signaling while impeding Aβ plaque formation.

Clinical and epidemiological studies also support the cognitive benefits of green tea. While some studies show a strong association between green tea intake and a reduced dementia risk, the results remain partially inconclusive, indicating the need for larger, well-controlled human trials. Nevertheless, green tea's affordability, accessibility, and safety profile make it a viable candidate for dietary interventions aimed at preventing age-related cognitive decline.

C. sinensis shows promise as a multifunctional neuroprotective agent with potential applications in dementia prevention and therapy. Its capacity to modulate multiple molecular targets central to neurodegeneration justifies further exploration in both experimental and clinical settings.

Conclusion

Medicinal plants such as Ginkgo biloba, turmeric, and ginseng exhibit promising neuroprotective effects against dementia through various mechanisms. While preclinical evidence is compelling, clinical applications require standardized extracts and rigorous trials. Their multi-target action and safety profile make them ideal complementary therapies. Future research should focus on optimal formulations and personalized treatment approaches. Integrating these botanicals with conventional care could provide a more comprehensive approach to dementia management. Ultimately, plant-based therapies may bridge current gaps in neurodegenerative disease treatment.

Acknowledgments: The authors are thankful to the Management of RL Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research, Tamaka, Kolar, Karnataka, India for providing facilities to carry out this work.

Conflict of interest: None

Financial support: None

Ethics statement: None

References

Aboulwafa, M. M., Youssef, F. S., Gad, H. A., Altyar, A. E., Al-Azizi, M. M., & Ashour, M. L. (2019). A comprehensive insight into the health benefits and phytoconstituents of *Camellia sinensis* and recent approaches for its quality control. *Antioxidants, 8*(10), 455. doi:10.3390/antiox8100455

Aburas, M. (2022). Characterization and identification of *Pantoea calida* from contaminated soil and its biocontrol by *Streptomyces coeruleorubidus*. *World Journal of Environmental Biosciences, 11*(3), 50–56. doi:10.51847/JxVBFGWSn1

Afzal, O., Dalhat, M. H., Altamimi, A. S., Rasool, R., Alzarea, S. I., Almalki, W. H., Murtaza, B. N., Iftikhar, S., Nadeem, S., Nadeem, M. S., et al. (2022). Green tea catechins attenuate neurodegenerative diseases and cognitive deficits. *Molecules, 27*(21), 7604. doi:10.3390/molecules27217604

Anonymous, World Health Organization. (2019). *Risk reduction of cognitive decline and dementia: WHO guidelines* (pp. 96–96). World Health Organization.

Arvanitakis, Z., Shah, R. C., & Bennett, D. A. (2019). Diagnosis and management of dementia. *JAMA, 322*(16), 1589–1599. doi:10.1001/jama.2019.4782

Azzini, E., Peña-Corona, S. I., Hernández-Parra, H., Chandran, D., Saleena, L. A., Sawikr, Y., Peluso, I., Dhumal, S., Kumar, M., Leyva-Gómez, G., et al. (2024). Neuroprotective and anti-inflammatory effects of curcumin in Alzheimer's disease: targeting neuroinflammation strategies. *Phytotherapy Research, 38*(6), 3169–3189. doi:10.1002/ptr.8200

Batiha, G. E., Beshbishy, A. M., El-Mleeh, A., Abdel-Daim, M. M., & Devkota, H. P. (2020). Traditional uses, bioactive chemical constituents, and pharmacological and toxicological activities of *Glycyrrhiza glabra* L. (Fabaceae). *Biomolecules, 10*(3), 352. doi:10.3390/biom10030352

Berrios, G. E. (1990). Alzheimer's disease: a conceptual history. *International Journal of Geriatric Psychiatry, 5*(6), 355–365.

Biernacka, P., Adamska, I., & Felisiak, K. (2023). The potential of *Ginkgo biloba* as a source of biologically active compounds: a review of the recent literature and patents. *Molecules, 28*(10), 3993. doi:10.3390/molecules28103993

Bulovina, M., Derevyankina, A., Khadzhibekova, A., Khoshbekyan, A., Babayan, M., Bochkarev, M., Balayan, B., & Shchamkhalov, S. (2024). Optimization of chitosan-based scaffold technology in tissue engineering: a review. *Journal of Advanced Pharmaceutical Education & Research, 14*(3), 18–25. doi:10.51847/WKRwRsIEaB

Cachón-Rodríguez, G., Blanco-González, A., Prado-Román, C., & Del-Castillo-Feito, C. (2024). Studying the pattern of employee loyalty based on social capital and sustainable human resource management. *Journal of Organizational Behavior Research, 9*(2), 1–11. doi:10.51847/fN33v3jKBU

Çakar, S., Özyer, K., & Azizoğlu, O. (2022). The mediating role of emotional labor in the impact of organizational climate on burnout. *Journal of Organizational Behavior Research, 7*(1), 1–13. doi:10.51847/oKRklsMVyv

Carpio-Vargas, E. E., Ibarra-Cabrera, E. M., Ibarra, M. J., Choquejahua-Acero, R., Calderon-Vilca, H. D., & Torres-Cruz, F. (2023). Categorical stress predictors in higher education students amidst remote learning in COVID-19 pandemic. *Journal of Advanced Pharmaceutical Education & Research, 13*(2), 131–139. doi:10.51847/ImofrnDDZg

Chen, M., Du, Z. Y., Zheng, X., Li, D. L., Zhou, R. P., & Zhang, K. (2018). Use of curcumin in the diagnosis, prevention, and treatment of Alzheimer's disease. *Neural Regeneration Research, 13*(4), 742–752. doi:10.4103/1673-5374.230303

Chen, X., Drew, J., Berney, W., & Lei, W. (2021). Neuroprotective natural products for Alzheimer's disease. *Cells, 10*(6), 1309. doi:10.3390/cells10061309

Crane, P. R. (2019). An evolutionary and cultural biography of ginkgo. *Plants, People, Planet, 1*(1), 32–37.

Cybulska-Heinrich, A. K., Mozaffarieh, M., & Flammer, J. (2012).

Ginkgo biloba: an adjuvant therapy for progressive normal and high tension glaucoma. *Molecular Vision, 18*, 390.

de Oliveira Filho, J. G., de Almeida, M. J., Sousa, T. L., dos Santos, D. C., & Egea, M. B. (2021). Bioactive compounds of turmeric (*Curcuma longa* L.). In *Bioactive Compounds in Underutilized Vegetables and Legumes* (pp. 297–318). Springer International Publishing.

Dhingra, D., Parle, M., & Kulkarni, S. K. (2004). Memory-enhancing activity of *Glycyrrhiza glabra* in mice. *Journal of Ethnopharmacology, 91*(2–3), 361–365. doi:10.1016/j.jep.2004.01.016

Doğanoğlu, A., & Erbaş, O. (2021). Effects of green tea polyphenols and oxidative stress on Alzheimer's and Parkinson's diseases. *Journal of Experimental and Basic Medical Sciences, 2*(1), 001–006.

Duman, İ., & Eken, Ç. G. (2022). Therapeutic effects of *Ginkgo biloba* extract in neuropsychiatric disorders. *Current Research in Health Sciences*, 170–188.

Duthey, B. (2013). Background paper 6.11: Alzheimer's disease and other dementias. *A public health approach to innovation, 6*, 1–74.

Farooqui, A. A. (2012). Beneficial effects of *Ginkgo biloba* in neurological disorders. In *Phytochemicals, Signal Transduction, and Neurological Disorders* (pp. 237–270). Springer, New York, NY.

Farooqui, A. A., Farooqui, T., Madan, A., Ong, J. H., & Ong, W. Y. (2018). Ayurvedic medicine for the treatment of dementia: Mechanistic aspects. *Evidence-Based Complementary and Alternative Medicine, 2018*(1), 2481076. doi:10.1155/2018/2481076

Gamal, S., Ibrahim, N., Ashour, A., & Ayoub, I. M. (2025). *Ginkgo biloba*: a review on its phytoconstituents and pharmacological activities. *Archives of Pharmaceutical Sciences Ain Shams University, 9*(1), 152–176.

Genchi, G., Lauria, G., Catalano, A., Carocci, A., & Sinicropi, M. S. (2024). Neuroprotective effects of curcumin in neurodegenerative diseases. *Foods, 13*(11), 1774. doi:10.3390/foods13111774

Gogoi, P., Kamle, M., & Kumar, P. (2023). Endophytic bacteria associated with rice: role in biotic and abiotic stress protection and plant growth promotions. *World Journal of Environmental Biosciences, 12*(1), 1–9. doi:10.51847/ELxLUdbokK

Gregory, J., Vengalasetti, Y. V., Bredesen, D. E., & Rao, R. V. (2021). Neuroprotective herbs for the management of Alzheimer's disease. *Biomolecules, 11*(4), 543. doi:10.3390/biom11040543

Guo, J., Yang, C., Yang, J., & Yao, Y. (2016). Glycyrrhizic acid ameliorates cognitive impairment in a rat model of vascular dementia associated with oxidative damage and inhibition of voltage-gated sodium channels. *CNS & Neurological Disorders - Drug Targets, 15*(8), 1001–1008. doi:10.2174/1871527315666160527163526

Howes, M. J., & Perry, E. (2011). The role of phytochemicals in the treatment and prevention of dementia. *Drugs & Aging, 28*(6), 439–468. doi:10.2165/11591310-000000000-00000

Huang, X., Li, N., Pu, Y., Zhang, T., & Wang, B. (2019). Neuroprotective effects of ginseng phytochemicals: recent perspectives. *Molecules, 24*(16), 2939. doi:10.3390/molecules24162939

Hwang, J., Keum, M., Choe, Y. M., Suh, G. H., Choi, H. J., Lee, B. C., Kim, S. G., Kim, H. S., Yi, D., & Kim, J. W. (2025). *Panax ginseng*: a modulator of amyloid, tau pathology, and cognitive function in Alzheimer's disease. *Journal of Ginseng Research, 49*(4), 348–355. doi:10.1016/j.jgr.2025.03.011

Islam, M. R., Rauf, A., Akash, S., Trisha, S. I., Nasim, A. H., Akter, M., Dhar, P. S., Ogaly, H. A., Hemeg, H. A., Wilairatana, P., et al. (2024). Targeted therapies of curcumin focus on its therapeutic benefits in cancers and human health: molecular signaling pathway-based approaches and future perspectives. *Biomedicine and Pharmacotherapy, 170*, 116034. doi:10.1016/j.biopha.2023.116034

Jacobs, B. P., & Browner, W. S. (2000). *Ginkgo biloba*: a living fossil. *The American Journal of Medicine, 108*(4), 341–342. doi:10.1016/s0002-9343(00)00290-4

Jakaria, M., Haque, M. E., Kim, J., Cho, D. Y., Kim, I. S., & Choi, D. K. (2018). Active ginseng components in cognitive impairment: therapeutic potential and prospects for delivery and clinical study. *Oncotarget, 9*(71), 33601. doi:10.18632/oncotarget.26035

Jiang, M., Chi, J., Qiao, Y., Wang, J., Zhang, Z., Liu, J., Sheng, X., & Yuan, L. (2025). Ginsenosides Rg1, Rb1, and rare ginsenosides: promising candidate agents for Parkinson's disease and Alzheimer's disease and network pharmacology analysis. *Pharmacological Research, 107578*. doi:10.1016/j.phrs.2025.107578

Jo, N. Y. (2018). Analysis of papers on *Curcuma longa* rhizoma for the possibility evaluation of therapeutic against dementia. *The Journal of the Society of Korean Medicine Diagnostics, 22*(1), 11–18.

Jyotirmayee, B., Nayak, S. S., Mohapatra, N., Sahoo, S., Mishra, M., & Mahalik, G. (2023). Bioactive compounds and biological activities of turmeric (*Curcuma longa* L.). In *Bioactive Compounds in the Storage Organs of Plants* (pp. 1–29). Springer Nature Switzerland.

Kadiri, S. K., & Tiwari, P. (2025). Integrating traditional medicine with network pharmacology for Alzheimer's treatment. *Health Sciences Review, 100223*.

Karantzoulis, S., & Galvin, J. E. (2011). Distinguishing Alzheimer's disease from other major forms of dementia. *Expert Review of Neurotherapeutics, 11*(11), 1579–1591. doi:10.1586/ern.11.155

Karim, S., Kutbi, D., Alkreathy, H., Alharthy, B., Alsieni, M., Daghistani, H., Shakroun, O. H., Bazuhair, M., Barasheed, M. O., & Ali, A. S. (2024). Amlodipine protects against methotrexate nephrotoxicity by modulating inflammation, oxidative stress, and apoptosis through NF-κB/PPAR-β/caspase 3 pathways. *Journal of Advanced Pharmaceutical Education and Research, 14*(4), 7–17. doi:10.51847/niC6BprrEv

Kaur, R., Kaur, H., & Dhindsa, A. S. (2013). *Glycyrrhiza glabra*: a phytopharmacological review. *International Journal of Pharmaceutical Sciences and Research, 4*(7), 2470.

Kim, H. J., Kim, P., & Shin, C. Y. (2013). A comprehensive review of the therapeutic and pharmacological effects of ginseng and ginsenosides on the central nervous system. *Journal of Ginseng Research, 37*(1), 8–29. doi:10.5142/jgr.2013.37.8

Kim, K. H., Lee, D., Lee, H. L., Kim, C. E., Jung, K., & Kang, K. S. (2018). Beneficial effects of *Panax ginseng* for the treatment and prevention of neurodegenerative diseases: past findings and future directions. *Journal of Ginseng Research, 42*(3), 239–247. doi:10.1016/j.jgr.2017.03.011

Li, Y., Wu, J., Du, F., Tang, T., Lim, J. C., Karuppiah, T., Liu, J., & Sun, Z. (2024a). Neuroprotective potential of glycyrrhizic acid in ischemic stroke: mechanisms and therapeutic prospects. *Pharmaceuticals, 17*(11), 1493. doi:10.3390/ph17111493

Li, Z., Yang, N., He, L., Wang, J., Yang, Y., Ping, F., Xu, L., Zhang, H., Li, W., & Li, Y. (2024b). Global burden of dementia death from 1990 to 2019, with projections to 2050: an analysis of the 2019 global burden of disease study. *The Journal of Prevention of Alzheimer's Disease, 11*(4), 1013–1021. doi:10.14283/jpad.2024.21

Liu, S., Chen, W., Zhao, Y., Zong, Y., Li, J., & He, Z. (2023). Research progress on the effects of ginsenoside Rg2 and Rh1 on the nervous system and related mechanisms. *Molecules, 28*(23), 7935. doi:10.3390/molecules28237935

Lopresti, A. L. (2017). *Salvia* (Sage): a review of its potential cognitive-enhancing and protective effects. *Drugs R D, 17*(1), 53–64. doi:10.1007/s40268-016-0157-5

Mantle, D., Pickering, A. T., & Perry, E. K. (2000). Medicinal plant extracts for the treatment of dementia: a review of their pharmacology, efficacy and tolerability. *CNS Drugs, 13*(3), 201–213.

Mishra, S., & Palanivelu, K. (2008). The effect of curcumin (turmeric) on Alzheimer's disease: an overview. *Annals of Indian Academy of Neurology, 11*(1), 13–19. doi:10.4103/0972-2327.40220

Mounir, M. M. F., Alharthi, A., Jamaluddinsyed, J., & Alkeheli, M. (2023). Recombinant amelogenin protein alone regenerates lost tissues in immature teeth with pulp necrosis and preapical periodontitis. *Annals of Dental Specialty, 11*(4), 9–15. doi:10.51847/zPEhEt763f

Nakagawa, N., & Yamashita, T. (2022). Comparative study of traditional face-to-face teaching, audience response system, and a flipped classroom plus audience response. *Journal of Advanced Pharmaceutical Education and Research, 12*(1), 9–16. doi:10.51847/ODLhsGztZ9

Nguyen, T. V., Quang, M. T., Nguyen, T. A. H., Ta, T. T. T., & Pham, T. P. T. (2024). Childhood storytelling experiences and positive mental health among Vietnamese university students: a cross-sectional study. *Journal of Advanced Pharmaceutical Education and Research, 14*(3), 78–83. doi:10.51847/pXvvRN5SJK

Noor-E-Tabassum, Das, R., Lami, M. S., Chakraborty, A. J., Mitra, S., Tallei, T. E., Idroes, R., Mohamed, A. A., Hossain, M. J., Dhama, K., et al. (2022). *Ginkgo biloba*: a treasure of functional phytochemicals with multimedicinal applications. *Evidence-Based Complementary and Alternative Medicine, 2022*, 8288818. doi:10.1155/2022/8288818

Paudel, Y. N., Angelopoulou, E., Semple, B., Piperi, C., Othman, I., & Shaikh, M. F. (2020). Potential neuroprotective effect of the HMGB1 inhibitor glycyrrhizin in neurological disorders. *ACS Chemical Neuroscience, 11*(4), 485–500. doi:10.1021/acschemneuro.9b00640

Potenza, M. A., Montagnani, M., Santacroce, L., Charitos, I. A., & Bottalico, L. (2023). Ancient herbal therapy: a brief history of *Panax ginseng*. *Journal of Ginseng Research, 47*(3), 359–365. doi:10.1016/j.jgr.2022.03.004

Prasanth, M. I., Sivamaruthi, B. S., Chaiyasut, C., & Tencomnao, T. (2019). A review of the role of green tea (*Camellia sinensis*) in antiphotaging, stress resistance, neuroprotection, and autophagy. *Nutrients, 11*(2), 474. doi:10.3390/nu11020474

Prince, M., Wimo, A., Guerchet, M., Ali, G. C., Wu, Y. T., & Prina, M. (2015). *World Alzheimer Report 2015: the global impact of dementia - an analysis of prevalence, incidence, cost and trends*. Alzheimer's Disease International (ADI), London. https://www.alzint.org/u/WorldAlzheimerReport2015.pdf

Sarkar, S., Shaw, P., Singh, P., & Chowdhury, A. A. (2023). Emerging neuroprotective potential of liquorice: mechanistic insights for neurological disorders. *South African Journal of Botany, 154*, 149–158.

Sathianathan, R., & Kantipudi, S. J. (2018). The dementia epidemic: impact, prevention, and challenges for India. *Indian Journal of Psychiatry, 60*(2), 165–170. doi:10.4103/psychiatry.indianjpsychiatry_261_18

Shahzan, S., Paulraj, J., & Maiti, S. (2022). Assessment of anxiety levels in children receiving dental treatment using rubber dam: a randomized control trial. *Annals of Dental Specialty, 10*(4), 15–21. doi:10.51847/Ang4hblnjK

Sharma, V., & Sharma, H. D. (2022). Bioactive compounds in turmeric. In *Spice Bioactive Compounds* (pp. 71–92). CRC Press.

Sheet, L. B. (2018). National institute of neurological disorders and stroke. NINDS. https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Narcolepsy-Fact-Sheet

Singh, G. P., Attavar, S. H., & Kavuri, S. (2022). Application of cone-beam computed tomography in diagnosis and treatment of multiple canals: a case report. *Annals of Dental Specialty, 10*(2), 15–18. doi:10.51847/vgeNZYRIRH

Song, X., Wang, X., Gao, Y., Xu, G., Yan, X., Chen, Z., & Song, G. (2025). Exploring the therapeutic potential of *Glycyrrhiza* compounds in Alzheimer's disease: a comprehensive review. *Current Topics in Medicinal Chemistry, 25*(3), 286–310. doi:10.2174/0115680266322320240911194626

Tian, W. W., Liu, L., Chen, P., Yu, D. M., Li, Q. M., Hua, H., & Zhao, J. N. (2025). *Curcuma longa* (turmeric): from traditional applications to modern plant medicine research hotspots. *Chinese Medicine, 20*(1), 76. doi:10.1186/s13020-025-01115-z

Tripathi, P. N., Lodhi, A., Rai, S. N., Nandi, N. K., Dumoga, S., Yadav, P., Tiwari, A. K., Singh, S. K., El-Shorbagi, A. A., & Chaudhary, S. (2024). Review of pharmacotherapeutic targets in Alzheimer's disease and its management using

traditional medicinal plants. *Degenerative Neurology and Neuromuscular Disease, 14*, 47–74. doi:10.2147/dnnd.s452009

Vatanabe, I. P., Manzine, P. R., & Cominetti, M. R. (2020). Historic concepts of dementia and Alzheimer's disease: from ancient times to the present. *Revue Neurologique, 176*(3), 140–147. doi:10.1016/j.neurol.2019.03.004

Verma, M., Usman, M., & Singh, N. K. (2024). Neuroactive phytoconstituents of *Glycyrrhiza glabra* for the treatment of Alzheimer's disease. *Current Topics in Medicinal Chemistry.* Advance online publication.

Villegas, C., Perez, R., Petiz, L. L., Glaser, T., Ulrich, H., & Paz, C. (2022). Ginkgolides and Huperzine a for complementary treatment of Alzheimer's disease. *IUBMB Life, 74*(8), 763–779.

Wahab, S., Annadurai, S., Abullais, S. S., Das, G., Ahmad, W., Ahmad, M. F., Kandasamy, G., Vasudevan, R., Ali, M. S., & Amir, M. (2021). *Glycyrrhiza glabra* (licorice): a comprehensive review on its phytochemistry, biological activities, clinical evidence and toxicology. *Plants, 10*(12), 2751. doi:10.3390/plants10122751

Yahyaeva, A. H., Aslanovna, M. M., Yariyeva, K. A., Pogosov, A. O., Ilyasova, N. A., & Kokova, D. R. (2023). Study of blood-ocular barrier permeability by fluoroquinolone group drugs. *Journal of Advanced Pharmaceutical Education & Research, 13*(2), 35–42. doi:10.51847/TkUByTPhAq

Yang, E. J., Park, G. H., & Song, K. S. (2013). Neuroprotective effects of liquiritigenin isolated from licorice roots on glutamate-induced apoptosis in hippocampal neuronal cells. *Neurotoxicology, 39*, 114–123. doi:10.1016/j.neuro.2013.08.012

Yang, X., Chu, S. F., Wang, Z. Z., Li, F. F., Yuan, Y. H., & Chen, N. H. (2021). Ginsenoside Rg1 exerts neuroprotective effects in 3-nitropropionic acid-induced mouse model of Huntington's disease via suppressing MAPKs and NF-κB pathways in the striatum. *Acta Pharmacologica Sinica, 42*(9), 1409–1421. doi:10.1038/s41401-020-00558-4

Yilmaz, S., Ertürk, M., Soydemir, A., Erciyas, A., & Oran, İ. B. (2023). Military implications of artificial intelligence - Case of the Republic of Turkey. *Journal of Organizational Behavior Research, 8*(2), 1–14. doi:10.51847/Tal2sc1FFp