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An In-Depth Examination of the Pharmacological Effects of Plants in the Therapeutic Management of Alzheimer's Disease.

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KEYWORDS

Alzheimer disease, History, Plants, Senility.

ABSTRACT:

Alzheimer's disease is a progressive neurological condition caused by changes in the brain, leading to memory loss, confusion, emotional instability, and cognitive decline. This neurodegenerative disease begins gradually and worsens over time. Initially, damage occurs in the hippocampus and entorhinal cortex, which are crucial areas for memory, resulting in a decrease in brain size. Currently, medical experts, researchers, and scientists are facing challenges in identifying significant brain changes during the early stages of Alzheimer's and as the disease progresses. There is growing global interest in natural remedies, dietary supplements, and functional foods marketed as memory enhancers that may help prevent Alzheimer's and other forms of cognitive decline. However, the claims regarding the safety and effectiveness of these products are largely based on limited testimonials, traditional knowledge, and minimal scientific research. Historically, natural compounds were among the first treatments used for Alzheimer's disease. Comprehensive studies are still needed to fully understand the mechanisms of herbal formulations and to establish appropriate dosages and treatment regimens. The optimal compliance framework consists of five key points: (1) it addresses multiple objectives; (2) it maximizes the impact on each goal; (3) it prevents adverse interactions with other drugs; (4) it has lasting effects and avoids tolerance; and (5) it operates within reasonable limits. We are continuously exploring new herbal formulations within this optimal compliance framework to address complex conditions such as Alzheimer's disease. This article provides a thorough review of Alzheimer's disease and the plants used in its treatment.

1. Introduction

Alzheimer's disease is a degenerative nerve illness caused by brain changes that lead to "memory loss, confusion, emotional instability, and progressive loss of mental capacity." This neurodegenerative disease begins slowly and gradually worsens (Figure 1 Patterns of Brain Aging).

As the disease progresses, the issue is with changes in oral and transient temperament, loss of anxiety, always self-care, and social markers. In the previous study, no specific diagnostic test was to determine "Alzheimer's dementia" for patient examination. Dementia is a broad term that Alzheimer's disease can also contribute. Damage to this disease initially occurs in the "hippocampus and entorhinal cortex", and other portions of the intellect are required for memory and decrease in size. Medical experts, researchers, and scientists cannot uncover significant brain changes in the early attack and succession of AD. A neurologist can diagnose the patient by assessing the signs and symptoms and performing medical evaluations of the patient. It occurs rapidly in

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60–70% of cases of dementia [1]. World Alzheimer's Day, on September 21, is a facility to focus on raising universal attention about Alzheimer's dementia and its effect on family units [2].

"In 1906, a German psychiatrist and neurologist, Dr. Alois Alzheimer, first diagnosed a disease known as Alzheimer's disease. He noticed changes in the brain tissue of a woman who died of an unusual mental illness. Her symptoms include memory loss, language problems, and unexpected behavior. After her death, he examined her brain and several abnormal lesions (now called *amyloid plaques*) and tangled bundle fibers (now called *neurofibrillary tangles or tau*)".[3] Now, the advancement of high-resolution brain imaging techniques allows doctors and researchers to examine the extent of unusual "amyloid and tau proteins" in the living brain, along with changes in brain morphology and action without invasive neurosurgery. "Aβ-amyloid hypothesis, oligomer hypothesis, presenilin hypothesis, Ca2+ dysregulation hypothesis, locosome hypothesis, tau hypothesis, genetic mutations, intermediate neurons, and network abnormalities and many hypotheses of Alzheimer's disease". In the previous research reports, the amyloid assumptions provide a broad framework for explaining the production of AD pathogens. It is accepted that the hereditary risks of AD are inherited from a person's mother and father with many features [4].

Other factors are the background identified by head injuries, grief, and hypertension. Worldwide increasing attention on "natural remedies, dietary supplements, and medical foods" is being promoted as a memory enhancer or to prevent Alzheimer's disorder and other dementias. However, claims that these products are harmless and effective are primarily based on the small body of testimonials, tradition, and scientific research. Natural compounds were the first molecule used as a remedial agent in Alzheimer's disease [5]. Since ancient times, plants have been exemplary sources of medicine. "

Among them, some plants such as Ashwagandha, Turmeric, Brahmi, Shankhpushpi, Guggulu, Gotu kola, Jyotishmati, Jatamansi, Liquorice, Maiden-hair tree, Rosemary, Lemon balm, Common snowdrop, Toothed firmoss, Asian ginseng, Moringa, Sage, Maca, Giloy, Self-heal herb, Jujube claimed to have phytoconstituents like Withanamide A, curcumin, Bacoside A, Asiaticoside, Ginkgolide B, Apigenin, galanthamine, Huperzine A, Ginsenoside RG1, Ascorbic acid that possess medicinal properties against Alzheimer's disease". These compounds have many antioxidant properties, which help against the free radicals developing in the body by reducing the body's ability to create natural defense mechanisms. Researchers hope to find particular treatments that focus on the "genetic, molecular, and cellular" process to prevent the fundamental origin of the disease. [

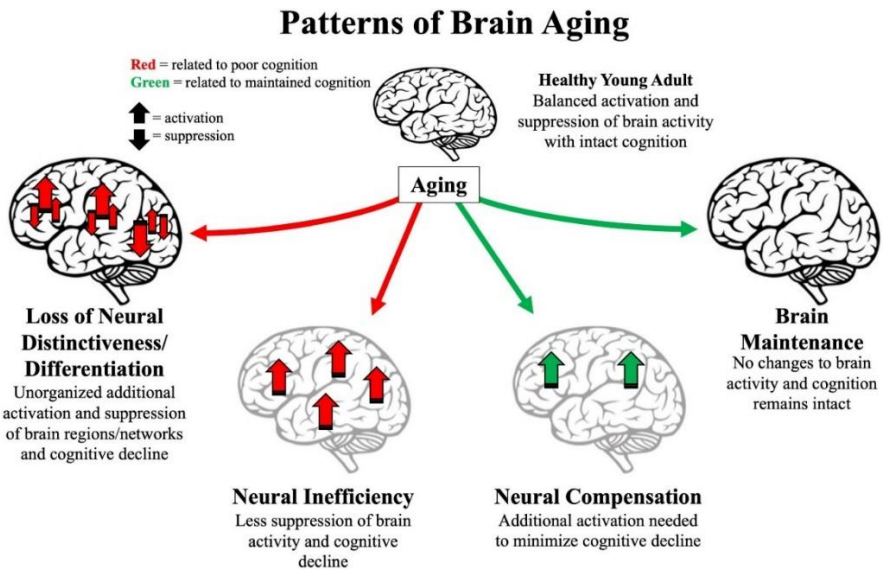

Figure 1 Patterns of Brain Aging [7]

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Stages Of Alzheimer's Disease [7-9]:

Alzheimer's disease progression is frequently slow. However, each person's progression through the disease is distinct. Understanding these stages enables healthcare practitioners and family members to make educated decisions regarding the care of Alzheimer's patients. Dr. Barry Reisberg devised the seven Clinical Stages of Alzheimer's disease, sometimes known as the Global Deterioration Scale (GDS).*(Figure 2 Clinical Stages of Alzheimer's disease):*

PHASE 1: NO EFFECT: At no effect position, AD is undetectable, and no symptoms of memory problems or dementia are present.

PHASE 2: VERY MILD DECLINE: Seniors may also have inconsiderable memorizing complications or missing items around the home, not even thinking about the loss of memory associated with normal mind age. The situation is easily unusual. The person is still poorly performing the skill test; therefore, the person or doctors who played it are not likely to be diagnosed with the disease. [10]

PHASE 3: MILD DECLINE: At this phase, the circle of relatives and friends may also start to thought cognitive problems. People in the "Mild Decline" phase face trouble in many areas, such as finding, organizing, and planning appropriate words at some point in the conversation and recalling the names of recent contacts. People with Alzheimer's disease often misplace valuable items, such as personal belongings. [11]

PHASE 4: MODERATE DECLINE In the stage of Alzheimer's disease, the symptoms of the condition become more apparent. Individuals in Stage 4 may struggle with basic arithmetic, experience poor short-term memory (such as not remembering what they had for breakfast), face financial difficulties, and may find it hard to manage their bills and daily responsibilities. [9]

PHASE 5: MODERATELY SEVERE During the moderately severe decline or fifth phase of Alzheimer's, individuals often seek assistance with daily activities. People in this stage may have trouble recalling simple details such as their phone numbers, become confused about their surroundings, and struggle with dressing appropriately. Despite these challenges, they generally retain knowledge of their relationships and memories from their past, particularly from childhood. [12]

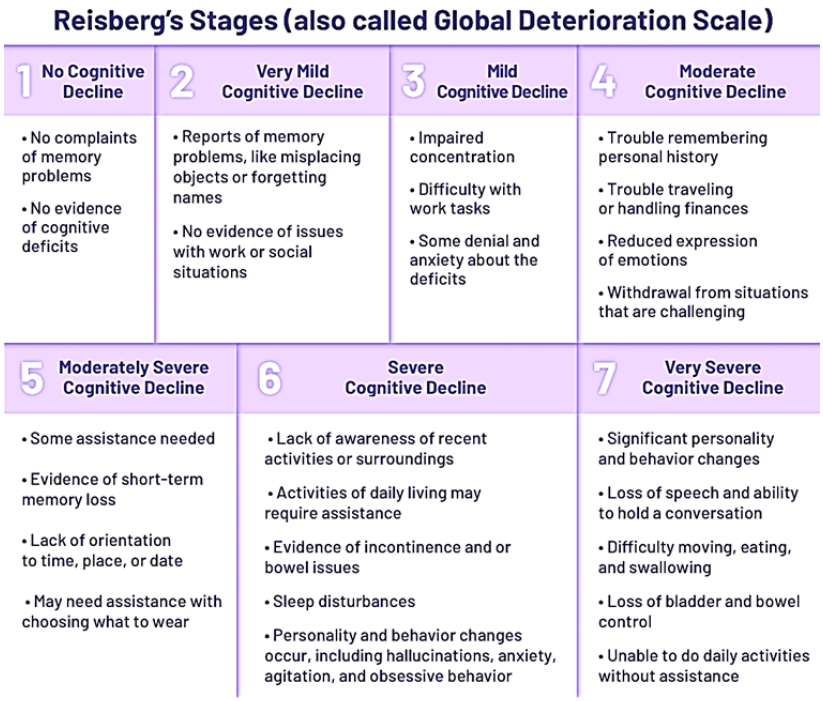

Figure 2 Clinical Stages of Alzheimer's Disease. [11]

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PHASE 6: SEVERE DECLINE Those in the sixth phase require constant supervision and professional care. They may exhibit confusion or discomfort in familiar environments, fail to recognize anyone beyond close friends or family, and lose track of their personal history. Other symptoms may include loss of bladder and bowel control, significant personality changes, and difficulty performing activities of daily living (ADLs) such as toileting, bathing, and walking. [13]

PHASE 7: VERY SEVERE DECLINE The seventh phase of Alzheimer's is characterized by very severe decline and often indicates that the disease is nearing its final stages. At this point, individuals may lose the ability to speak or respond to their surroundings. They may also lose the capacity to eat and require extensive care and support. [14]

Symptoms of Alzheimer's: [4,7,11,15]

1. Loss of memory can disrupt everyday life
2. Challenges in project outlining
3. Struggling in finalized known job
4. Confusion with moment or location
5. A new complication with phrases in, verbal or recorded on paper
6. Reducing the efficiency of cases
7. Negative judgment
8. Pull back from pictures or communal gathering
9. Change in temperament and identity

History: Over the past 50 years, neuropsychologists have faced significant challenges in understanding cognitive dementia and its underlying brain pathology. Historically, Hellenic and Augustan thinkers and practitioners coupled aging with dementia. However, it was not until German therapist and neurologist Dr. Alois Alzheimer identified what is now known as "Alzheimer's disease" in a 55-year-old woman that the condition gained wider recognition. Dr. Alzheimer meticulously observed and documented her condition until she passed away in 1906, providing a detailed description of the disease. Initially, Emile Kraepelin categorized Alzheimer's disease as a distinct condition, highlighting its unique medical and pathological symptoms, such as confusion and hallucinations. [7,16] A key neuropsychological feature of the disease is severe memory impairment. The patient could recognize objects placed in front of her but would quickly forget them. During cognitive tests, she struggled to read lines coherently and often misinterpreted words or phrases, rendering them meaningless. In her writing, she repeatedly used certain words, omitted others, and eventually stopped writing altogether. Additionally, she had difficulty understanding some questions and could not remember how to use particular objects. After the death of the patient, Auguste Deter, Dr. Alzheimer employed a new silver-staining histological method to microscopically examine her brain. This analysis led to the identification of "neuritic plaques, neurofibrillary tangles, and amyloid angiopathy," which have since become defining features of Alzheimer's disease. [17]

By 1911, Alzheimer's disease was recognized within the medical community as a diagnostic term for patients in both Europe and the United States. In the early 20th century, the diagnosis was primarily applied to individuals aged 45 to 60 who displayed symptoms of dementia. However, this terminology evolved after a 1977 symposium on AD, which resolved that the quantifiable and diagnostic appearances of early-onset and late-onset dementia were nearly identical. The session also acknowledged that certain specific causes could not be entirely excluded.[18]

In 1990s, a new criteria for Alzheimer's disease adopted in the 1980s upgraded the consistency of the clinical diagnosis and acceptable group studies of mildly Alzheimer's disease patients to be carried out with a reasonable degree of accuracy. Many of these studies applied the theories and methods of cognitive psychology to study the mental consequences of Alzheimer's disease. Numerous studies at this time exposed that episodic memory loss (i.e., amnesia) is usually the earliest and most salient aspect of Alzheimer's disease syndrome. [19]

These findings were consistent with neuropathologic studies that showed extensive AD pathology occurs earliest in medial temporal lobe (MTL) structures (e.g., hippocampus, entorhinal cortex) important for episodic memory. Lack of memory reflects a failure to translate efficiently and to store new information because most early Alzheimer's disease patients are mainly impaired in delayed recall (i.e., irregular) early memory, demonstrating an abnormal systemic effect of deficiency. [20] Initial effects (i.e., recall of words from the beginning of the list) and reduced demand for recovery by identity tests were also impaired. Semantic

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programming is less effective in improving the topical memory performance of Alzheimer's disease patients compared to typical elderly characters. Patients with Alzheimer's disease are more accustomed to oral and non-verbal memory tests, which undoubtedly increase compassion for interventions and/or less inhibitory mechanisms. This pattern of memory impairment fluctuates from the patterns exhibited by patients with subclinical dementia, who have struggled to learn new information but are well-educated and in recovery aids (e.g., queuing or identity formats).[5,21]

Patients had high sequelae of individual items that they missed on various semantic memory tests, either using the duplicate entry and output mode or in a single trial in a series of evaluations. Numerous studies have shown that ophthalmic deficiency is present in Alzheimer's patients, but this decrease is less relevant than other cognitive deficits in the early stages of general illness. The delicate visual visuospatial work of early Alzheimer's often extends not only to the optical and anatomical aspects of the concert but also to theoretical knowledge. Events to explain Alzheimer 's-related neuropsychological impairment have had a significant impact on the ability to make an accurate diagnosis in the early stages of the disease. [22]

This clinical helpfulness was confirmed in a study involving multiple complex measures of learning, memory, administrative abilities, language, and ophthalmology separately between mild Alzheimer's and matched general regulatory subjects. The results showed excellent insight and specificity for learning from the California Verbal Learning Test (CVLT) and delayed recall actions. Semantic encoding is less effective in improving the periodic memory performance of patients with Alzheimer's than in normal mature individuals. Besides, disturbances often occur in verbal and non-verbal memory tests in Alzheimer's patients, possibly due to increased sensitivity to interference and/or inhibitory processes. A series of memory disorders fluctuate from patterns shown in patients with subcortical dementia who have difficulty learning new information but are well-known and have recovery aids. (E.g., identity or identity formats) with improved performance. Results suggest that the differential roles of the MTL and the fronto-striatal brain in constructing memory function". [7, 23]

Pathological process of AD:

Several suppositions explain AD pathological processes, such as the "Aβ-amyloid hypothesis, the Aβ-amyloid oligomer hypothesis, the presenilin hypothesis, the Ca2+ dysregulation hypothesis, the lysosome hypothesis, tau hypothesis, Genetic Mutation, Intermediate Neurons and Network Abnormalities, Synaptic Damages, Chemokines, MicroRNA-137, Neuroinflammation, Cell Autophagy, Endoplasmic Reticulum Stress Function" [9, 24]. According to previous research, the amyloid hypothesis provides an extensive framework for explaining AD pathogenesis. β-amyloid is chemically "adhesive" when cutting into APP. It accumulates in the subtle amyloid plaques that are considered the trademark of the mind of Alzheimer's sufferers. The fragments are from small groups called oligomers first, then chains of groups called fibrils, then beta-sheets. According to the amyloid hypothesis, this "beta-amyloid" accumulation level disrupts "cell-to-cell" interaction and sets immune cells. These immune cells cause inflammation. Eventually, the brain cells are destroyed. Although many anti-β-amyloid drugs have not previously been successful, a test was posted in September 2016, which showed that anti-amyloid antibody brings down beta-amyloid quantity in the brain and impaired cognitive function in humans. However, not all scientists are satisfied that the first motive for Alzheimer's is β-amyloid. Researchers around the world are looking at very different triggers for the devastating events that eventually kill brain cells. [25-29]

Plants used to treat Alzheimer disease:

Herbal medicine has emerged as a promising complementary approach for managing Alzheimer's disease (AD), a progressive neurodegenerative disorder characterized by memory loss, cognitive decline, and the accumulation of amyloid-beta plaques and neurofibrillary tangles. Various herbs and their bioactive compounds have been studied for their potential to address the complex pathology of AD. [1, 30]

1. Ashwagandha (*Withania somnifera*, *Solanaceae*): In traditional medicine, ashwagandha is a "nerve tonic, aphrodisiac, and 'adaptogen,' aiding the body's adaptation to stress." It is classified as a chemical that can promote "antioxidant activity, a calming effect on the central nervous system, free radical discovery activity, and a healthy immune system." Withanamides component

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removes free radicals and amyloid plaques that cause Alzheimer's and neurological cell death. Winter cherry's aqueous extract boost cholinergic activity in mice, with acetylcholine content and progressive evidence of choline acetyltransferase activity, and explains the benefits of improving comparative sensation and memory.[10].

Turmeric (*Curcuma longa*, *Zingiberaceae*): Turmeric rhizome is used as a spice, in traditional Indian medicine for its anti-inflammatory, and antibacterial qualities. Turmeric's "non-steroidal and anti-inflammatory" qualities lessen the incidence of AD and in transgenic mice it reversed amyloid pathology. [11].

3. Brahmi (*Bacopa monnieri*, *Plantaginaceae*) : Bacopa is a sour- plant found in saline and sludge conditions, historically used as a nerve tonic, diuretic, and cardiotonic. Bacosides A and B are linked to memory enhancement. In an AD rat model, BM increases protein kinase activity in the hippocampus and corrects the cholinergic neuron problem. [12]

4. Shankhpushpi (Convolvulus pluricaulis, Convolvulaceae): Shankapushpi are utilized as a brain tonic in a variety of methods to improve memory and cognitive performance. Shankhpushpi extracts in ethanol, ethyl acetate, and aqueous form stimulated learning and memorizing in rats. (13, 14)

5. Guggulu (Commiphora wightii, Burseraceae):*Guggulu* is an oleogum substance use treats "arthritis, irritation, obesity, and lipid metabolism syndromes." Its "cholesterol-lowering, antioxidant, and anti-acetylcholine esterase activity" may be related. These findings support Gugulip as a potential treatment for dementia.[15].

6. Gotu kola (*Centella asiatica*, Apiaceae)

Gotu Kola enhance "intelligence, durability, and memory." Asiaticoside products, containing reduce oxidative stress which activates "cell death, lower free radical concentrations, and prevent the death of beta-amyloid cells". [16].

7. Jyotishmati (Celastrus paniculatus, Celastraceae):Jyotishmati is a valuable therapeutic herb to "sharpen memory, improve concentration and cognitive function" in Ayurveda. The aqueous extracts of jyotishmati seeds have "sensory and antioxidant" properties. Its extract can induce antioxidant enzymes, preserves neuronal cells and reduce lipid peroxidation [17-31].

8. Jatamansi (Nardostachys jatamansi, Caprifoliaceae): Nordostachys jatamansi improved all signs of chronic fatigue disorder (CFS) in rats. Similarly, the alcoholic extract of this plant increase learning and memory in rats indicating that the compound in this plant may be useful in restoring memory in the patients with dementia [32].

9. Liquorice (Glycyrrhiza glabra, Fabaceae): Glycyrrhiza glabra is used in gastric ulcer, lung congestion, numbness, and sore throat". Memory improving the action of Glycyrrhiza glabra has been described in scopolamine, which promotes Alzheimer's disease . The natural product 2,2′,4′-trihydroxychalcone (TDC) from this plant work against β-site amyloid precursor protein-cleaving enzyme 1 (BACE1).(33)

10. Maidenhair tree (Ginkgo Biloba L., Ginkgoaceae) :Ginkgo biloba is the first choice for Alzheimer's disease mamagment. The remarkable chemical component gingkolides helps AD management with neuroprotective and cholinergic activities.. Studies have shown that ginkgo production improves mental health problems such as depression or hallucinations. Ginkgo biloba is satisfactory for its ability to flow systematically.[34] It is directly related to vasorelaxant action to increase blood flow, reduce blood pressure, and prevent platelets from accumulating.

11.Rosemary (*Rosmarinus officinalis*, Lamiaceae): The leaf of Rosmarinus officinalis L. is used as food and as a remedy for the obstacle and cure of dementia (symptoms of Alzheimer's disease). Preclinical studies have been shown that the hippocampus and frontal cortex are involved in the behavioral and cognitive responses associated with AChE and butyrylcholinesterase activities and mRNA expression levels of rats after oral administration of plant extract (RE) (200mg / kg, p.o.). Rosemary contains natural COX-II inhibitors such as thymol, apigenin, carvacrol, oleanolic acid, eugenol, and uricolic acid. It contains a wide variety of strongest antioxidants on synthetic antioxidants such as carnosic acid and ferulic acid butylhydroxytoluene (BHT) and butylated hydroxyanisole (BHA). [35]

12. Lemon balm (Melissa officinalis L. , Lamiaceae): Melissa officinalis is soothing and has carminative

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effects, including anxiolytic and hypnotic functions. Historically, It is believed to increase memory. Evaluation of efficacy and safety of *M officinalis* extract in double-blind patients with Alzheimer's disease at four-month intervals at a dose (60 drops/day). A blinded, randomized, placebo-controlled trial design concluded that mild to moderate AD is valuable in management and has a positive impact on mobility in such patients. [32]

13. Common snowdrop (Galanthus niralus L., Amaryllidaceae) Historically, galantamine has been used for the curing of myasthenia gravis and. Many trials have confirmed the efficacy of galantamine (32 mg/day) in the treatment of cognitive symptoms in AD as determined by the ADAS score and other endpoints. Galantamine is also a nicotinic receptor stimulator, and there is evidence that such an effect is important for AD. [37]

14 Toothed firmoss (*Huperzia serrata*, *Lycopodiaceae*) Huperzia Serrata has multifaceted pharmacological effects like the protective outcome on Aβ induced reactive oxygen species injury and mitochondrial dysfunctioning on neurons even antagonists of growth factor of nerve and N-methyl-di-aspirate receptors. [31]

15 Jujube (*Zizyphus jujube*, Rhamnaceae) *Jujube* fruit has calming and anti-inflammatory properties. Increased acetylcholine levels in cholinergic terminals improve AD symptoms and motor deficits can be managed by jujube extracts. *Jujube* restores the effects caused by the Meynert nucleus lesion (loss of neurons) in AD at the base of the frontal lobe of the rat CNS. [19]

16 Asian ginseng (*Panax Ginseng*, Araliaceae): Extract of *Panax ginseng* improves AD symptoms and two major constituents of ginseng help to treat AD. The first is Ginsenosides and the second is Gintonin. Ginsenosides have different neuroprotective effects related to AD. Ginsenosides inhibit AChE activity and Aβ-induced neurotoxicity by preventing secretase (γ and β) action or by operate the nonamyloidogenic of amyloid β-protein and also prevent Aβ induced oxidative impairment and neuroinflammatory responses. Gintonin (p.o) increases amyloid plaque clearance in the CNS, increases hippocampus neurogenesis and, cholinergic systems thereby reducing memory impairment and enhance cognitive action in AD patients. Ginsenosides and Gintonin are involved in the neuropathology of AD through several pathways. [33]

17 Moringa *(Moringa oleifera*, *Moringaceae):* Moringa extract helps in the enhancement of memory via nootropics activity. It is a rich source of antioxidants such as vitamin C and E, contributing to combat oxidative stress in AD. Neurological parameters such as norepinephrine, dopamine, and serotonin level also found to be altered by *M. oleifera* leaf extracts and cure memory loss. [32]

18. Sage (*Salvia officinalis*, Lamiaceae): *S. officinalis* extract was found to increases memory retention of rodents in passive avoidance.. Many clinical trials were also conducted to confirm the cognitive performance *of S. officinalis* in both healthy volunteers and cognitive impairment patients. Further, *S. officinalis* was found to inhibit acetylcholinesterase activity. All these results suggested that *S. officinalis* could be a future herbal drug treatment of Alzheimer's disease. [34]

19. Maca (*Lepidium meyenii*, *Brassicaceae*): It exhibited memory-enhancing activity by increasing the acetylcholine level by acetylcholinesterase inhibitory and antioxidant effects. [1]

20. Giloy (*Tinospora cordifolia, Menispermaceae*): *T. cordifolia* possess memory and cognition-enhancing properties in pre-clinical studies. It acts by increasing acetylcholine synthesis and cognition by immune-stimulation, which act as supplementation for cognitive function.[30]

21. Self-heal herb (*Prunella vulgaris*, *Lamiaceae*): Traditionally Prunella has been used to treat dizziness, headache, inflammation and eye pain. Recently, it has been found to possess anti-Alzheimer's property as the extract of P. Vulgaris at the dose of 25 and 50 mg, ameliorated scopolamine-induced impairments in rodent This anti-Alzheimer's action found to be results of imitation of acetylcholine effect, indirect effect on cholinergic and methyl-d-aspartate receptor signaling in the brain as this extract didn't inhibit AChE activity. [32]

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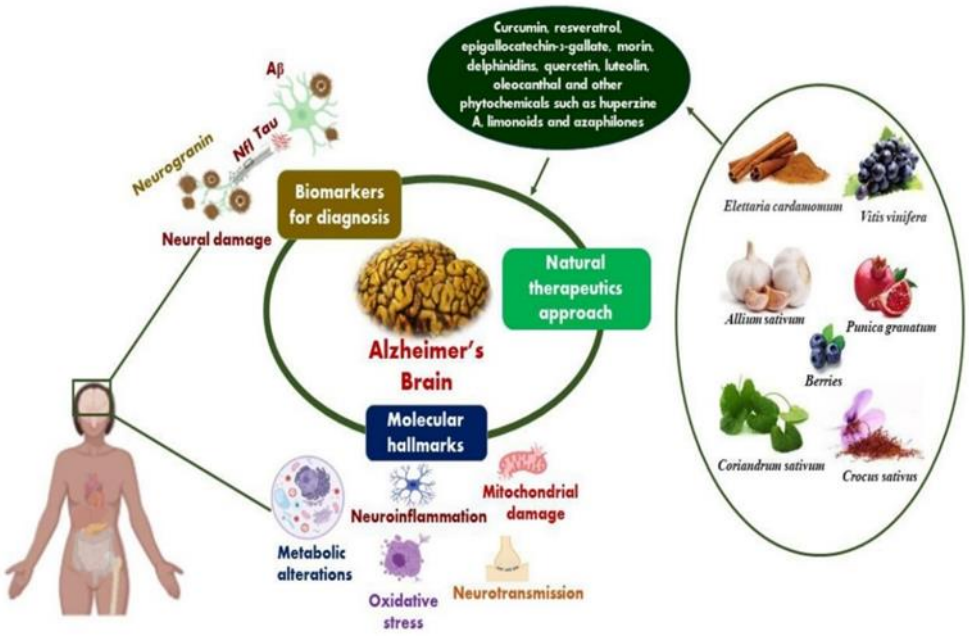

Figure 3 Herbal molecules and their role in AD

Herbal Modulation Mechanisms In Alzheimer's:

Amyloidogenic Processing. Ginkgo biloba terpene lactones (ginkgolides, bilobalide) stop the formation of amyloid-beta by raising the activity of α-secretase through the PKC and MAPK pathways. Salvia miltiorrhiza diterpenes stop BACE1 from working by controlling all of its parts. This lowers the amounts of amyloid-beta40/42 in transgenic mouse models. Withania somnifera (ashwagandha) withanolides increases neprilysin expression, which promotes amyloid-beta breakdown.[20]

Tau Pathology Mitigation Green tea epigallocatechin-3-gallate (EGCG) attaches to tau's microtubule-binding region, stopping the formation of filaments and making it easier for proteasomes to get rid of highly phosphorylated proteins. Turmeric ar-turmerone derivatives phosphorylate Ser9 residues, inhibiting GSK-3β and restoring tau's microtubule-stabilizing activity. [21]

Antioxidant and anti-inflammatory effects: Ginsenosides, which come from Panax ginseng, remove hydroxyl radicals and turn on Nrf2, which raises glutathione production in astrocytic networks. Rosmarinic acid from *Rosmarinus officinalis* stops the activation of the NLRP3 inflammasome by chelating the copper ions needed for the ASC speck to oligomerize. [18]

2. Conclusion

study found that numerous natural plant medications are promise for treating Alzheimer's disease. Bacopa monnieri phytochemicals, including bacoside A3 and stigmasterol, prevent amyloid-beta (Aβ) cytotoxicity and plaque development, whereas Camellia sinensis contains polyphenols that significantly suppress Aβ aggregation. Phytochemicals from Moringa oleifera, Ginkgo biloba, and Bacopa monnieri enhance cognitive performance and provide neuroprotection. Botanicals like Rosmarinus officinalis and Tinospora cordifolia improve neurotransmitter levels, learning, and memory in animal studies. Cissampelos pareira and Ficus racemosa extracts improve cognitive performance by increasing antioxidants and acetylcholine levels. [10] Furthermore, oleuropein and ginsenoside Rg1 have been shown to significantly reduce amyloid plaque formation and neuroinflammation, highlighting their therapeutic potential. These natural chemicals' several mechanisms of action, which include acetylcholinesterase inhibition, antioxidant activity, and neuroinflammatory pathway alteration, underline their potential as AD adjunctive therapy. [30] The findings show that these natural

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compounds and extracts might offer a holistic approach for treating Alzheimer's disease by targeting many disease pathways. More research and clinical studies, however, are required to demonstrate their efficacy and safety, which will ultimately pave the way for their inclusion in comprehensive AD treatment strategies. Furthermore, considering the limits of previous research in this area, we advocate speeding future studies to improve the safety and efficacy of herbal treatment for Alzheimer's disease. As a consequence, treatments will be safer and more effective. [31]

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