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Medicinal Plants as Neuroprotective Agents in Neurodegenerative Disorders

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Abstract

Neurodegenerative diseases, including Alzheimer's disease (AD), Parkinson's disease (PD), and Huntington's disease (HD), present significant global health issues, with existing treatments primarily providing limited symptom relief. Consequently, there is an increasing scientific focus on the neuroprotective capabilities of medicinal plants that have been utilized in various traditional healing practices. This review examines the therapeutic properties of *Ginkgo biloba, Crocus sativus* (saffron), *Curcuma longa* (turmeric), *Mucuna pruriens*, and *Withania somnifera* (Ashwagandha) plants that are abundant in bioactive compounds such as flavonoids, alkaloids, terpenoids, and polyphenols. These phytochemicals possess strong antioxidant, anti-inflammatory, and anti-apoptotic effects, which aid in combating oxidative stress, diminishing protein aggregation, and modulating neurotransmitter levels. Furthermore, plants like *Centella asiatica* (Gotu Kola) and *Bacopa monnieri* (Brahmi) have demonstrated potential in improving cognitive function and maintaining neuronal health. Mechanistic investigations reveal that the modulation of acetylcholinesterase activity and the reduction of reactive oxygen species are significant neuropharmacological mechanisms. Although these results highlight the potential of medicinal plants as neuroprotective agents, additional clinical studies are necessary to confirm their safety and effectiveness as either standalone or complementary treatments for neurodegenerative disorders.

Keywords: Neurodegeneration, Alzheimer's, Parkinson's, neuroprotection, Phytochemicals, Neuroinflammation, *Curcuma longa, Bacopa monnieri, Withania somnifera, Ginkgo biloba*

Introduction

Neurodegenerative disorders are mainly defined by the gradual loss of neurons, resulting in the slow decline of cognitive and motor abilities. Among these disorders, Alzheimer's disease (AD) and Parkinson's disease (PD) are the most common, having a significant effect on aging populations globally. Current pharmacological interventions primarily aim to alleviate symptoms rather than prevent disease progression. This limited effectiveness is largely due to the blood-brain barrier (BBB), which hinders the passage of therapeutic agents into the central nervous system. Additionally, the pathophysiological processes associated with many neurodegenerative diseases are still not well understood. As a result, researchers have begun to investigate environmental factors such as exposure to heavy metals, pesticides, and air pollutants as possible contributors to neurodegeneration (Dehaghi *et al*., 2022; Oran *et al*., 2022).

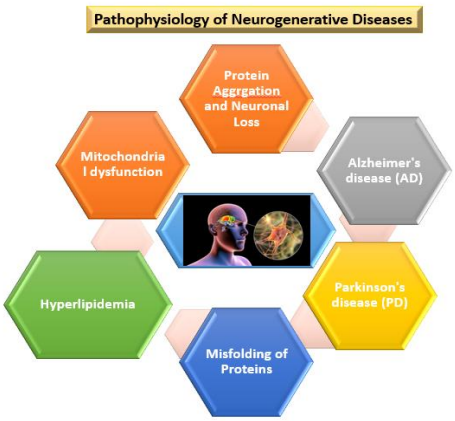

Figure 1. Pathophysiology of Neurodegenerative Diseases: Alzheimer's and Parkinson's disease

Epidemiological studies indicate a possible connection between environmental factors and an elevated risk of conditions such as amyotrophic lateral sclerosis (ALS), progressive supranuclear palsy (PSP), multiple system atrophy (MSA), Alzheimer's disease (AD), and Parkinson's disease (PD). However, these correlations are frequently inconsistent across various studies, attributed to differences in exposure assessment, population demographics, and diagnostic precision. Neurodegenerative diseases often exhibit overlapping symptoms, which complicates clinical differentiation, especially in instances of Parkinson-plus syndromes (e.g., MSA and PSP). Furthermore, coexisting vascular conditions such as stroke and coronary heart disease can further complicate the diagnostic process. As diagnostic criteria continue to evolve, achieving accurate classification remains a significant challenge, highlighting the necessity for early detection methods and

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biomarkers that can facilitate differential diagnosis prior to the onset of irreversible brain damage (Brown *et al*., 2005; Ashkevari & Ghasemi, 2023; Tural & Şahan, 2023; Ha & Hang, 2024) **(Figure 1)**.

Recent advancements in neuroimaging and neuropsychological assessments have enhanced early diagnostic capabilities, although these techniques still necessitate further refinement. Current studies underscore the significance of incorporating genetic, environmental, and lifestyle factors to gain a deeper understanding of disease origins. There is a growing agreement that extensive longitudinal research is vital for identifying causative elements and enhancing diagnostic accuracy. The rising prevalence of neurodegenerative diseases in the United States and worldwide underscores the pressing need for more effective environmental health policies and focused prevention initiatives (Scheltens *et al*., 2021; Hoang *et al*., 2022; Tam *et al*., 2022; Son *et al*., 2023). Ultimately, a multidisciplinary strategy that integrates environmental science, neurology, and molecular biology will be essential in tackling these intricate disorders.

The Genetic Basis and Clinical Manifestations of Neurodegenerative Disorders

Neurodegenerative disorders exhibit significant genetic foundations, acting as both inherited characteristics and risk factors in sporadic instances. The identification of genes associated with these diseases and their risk loci has led to significant advancements in medicine, illuminating critical pathways and mechanisms of the diseases. Progress in molecular biology, genomics, and innovative research methodologies has enhanced our comprehension of the genetics underlying neurodegenerative conditions. For instance, the analysis of restriction fragment-length polymorphism facilitated the discovery of a marker on chromosome 4 related to disease manifestation. In the 1990s, scientists identified causative genes: the APP gene on chromosome 21 was linked to familial Alzheimer's disease (AD), while the SNCA gene on chromosome 4 was associated with Parkinson's disease (PD). These discoveries validated that both conditions can exhibit Mendelian inheritance patterns in certain families, whereas others may be affected by environmental influences and random (stochastic) factors (Pihlstrøm *et al*., 2018; Gondo & Haryanti, 2024; Linh *et al*., 2024; Saliev *et al*., 2024; Zharashueva *et al*., 2024; Abbas *et al*., 2025).

Genetic Symptoms in Neurodegenerative Diseases

- Alzheimer's Disease (AD)
- Loss of memory (connected to APP and other genes such as PSEN1, PSEN2)
- Decline in cognitive function
- Alterations in mood
- Challenges in performing tasks
- Parkinson's Disease (PD)
- Tremors (linked to SNCA mutations)
- Stiffness
- Bradykinesia (sluggishness in movement)
- Imbalance
- Challenges with speech and facial expressions

These symptoms, influenced by genetics, frequently intersect, and grasping their genetic origins is vital for timely diagnosis and possible treatment options **(Figure 2)**.

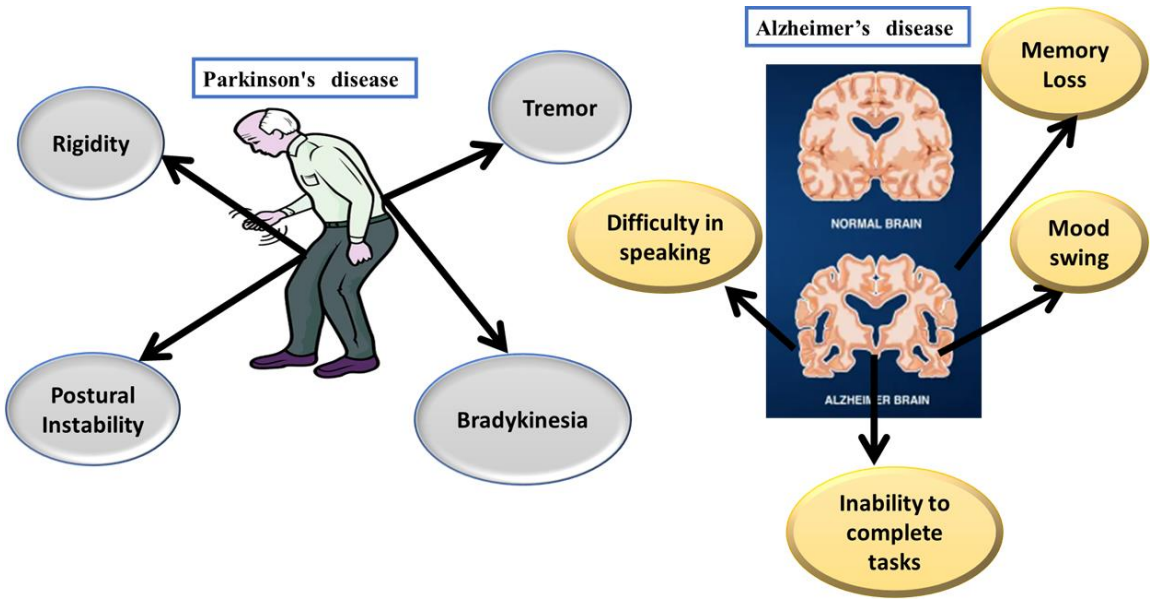

Figure 2. A comparative analysis of the symptoms and neurological alterations associated with Parkinson's disease and Alzheimer's disease. Parkinson's primarily impacts motor functions, such as tremors and rigidity, whereas Alzheimer's primarily affects cognitive abilities, including memory impairment and mood fluctuations.

Nerve Growth Factors

NGF enables its effects through three fundamental cell types: structural fibroblasts, smooth muscle cells, hepatocytes, endothelium, and epithelial cells, in addition to auxiliary Müller cells and astrocytes, and immunological cells, including eosinophils, granulocytes, lymphocytes, mast cells, and antigen-presenting cells. The combination of soluble factors that includes cytokines, neuropeptides, and growth factors enables NGF to induce cell activation and differentiation, along with proliferation, migration, and survival promotion in these cell types. NGF shows great potential in the treatment of numerous human illnesses. This substance functions as a possible therapeutic choice because it affects neuronal growth and survival, along with neuronal activation. Two receptors comprise the biological activity of the insulin-like molecule NGF: p75NTR, as the transmembrane glycoprotein also called "high-affinity receptor", and the tropomyosin receptor kinase with tyrosine kinase activity. The p75NTR receptor interacts with all neurotrophic factors, yet binds Trk receptors differently because NGF engages TrkA, whereas NT-3 connects to TrkC, and BDNF binds to TrkB. Upon receptor binding of the ligand, this family of receptors activates their tyrosine kinase domain, which promotes substrate phosphorylation to enable diverse biological responses such as immune cell development and survival, healing processes, and maintenance functions for neurons. The distribution pattern of these receptors on cellular surfaces establishes the effect of NGF (Abdel-Hadi & Abdel-Fattah, 2022; Akbari, 2022; Perwitasari *et al*., 2023; Gavioli *et al*., 2024; Levochkina *et al*., 2024; Molas-Tuneu *et al*., 2024). Neurotrophin proteins (NGF, BDNF, NT3, and NT4) exert their effects through both CNS development and aging with normal or pathologic conditions using four mechanisms: Trk receptors, PI3K/Akt-prosurvival gene transcription, MAPK/ERK-differentiation promoting substrate activation, and IP3-DAG-induced calcium release. Prior to their maturation process, proneurotrophins have low binding affinity to the tumour necrosis factor receptor p75NTR and induce cellular death in both neuronal and non-neuronal cells upon receptor activation. Research shows that the growth factor glial-derived neurotrophic factor (GDNF) protects cell cultures of dopaminergic neurones through its membership in the transforming growth factor β (TGFβ) superfamily (Enciu *et al*., 2011; Özatik *et al*., 2022; Asar *et al*., 2023; Petronis *et al*., 2023).

Role of Oxidative Stress and Inflammation in Neurobiology

Inflammation

The blood-brain barrier (BBB) function forces scientists to consider the brain as an immunologically privileged organ, thus minimizing the analysis of neuro-immune interactions. Research data from preclinical and clinical studies demonstrates that neural-immune communication occurs in two directions through essential neural–immune connections. Medical science experts classify inflammatory processes as weapons that cut both ways. The inflammatory process operates as a protective defense mechanism until it develops into dangerous chronic inflammation, thus becoming a crucial factor in neuropathological events. Neuroinflammation occurs prior to psychotic symptoms; therefore, scientists consider it significant in understanding psychosis development. Mental disorders display an inflammatory response that produces elevated levels of pro-inflammatory cytokines to define their condition. Clinical research on peripheral pro-inflammatory cytokines in patients with first-episode schizophrenia produced findings of substantial correlations between cytokine levels and disease symptoms. Long-term methamphetamine utilization creates an inflammatory imbalance that results in higher amounts of pro-inflammatory cytokines. The constant activation of the immune system disrupts neurochemical processes that transmit signals due to higher levels of these pro-inflammatory proteins. Comprehensive research on immunological dysfunction in schizophrenia was analyzed by Miller and Goldsmith. The authors analyzed the inconsistent findings from schizophrenia treatment using immunomodulatory therapies and recommended monoclonal antibody immunotherapy with adjunctive effects as potential future strategies. Clinical research on peripheral pro-inflammatory cytokines in patients with first-episode schizophrenia produced findings of substantial correlations between cytokine levels and disease symptoms. Long-term methamphetamine utilization creates an inflammatory imbalance that results in higher amounts of pro-inflammatory cytokines. The constant activation of the immune system disrupts neurochemical processes that transmit signals due to higher levels of these pro-inflammatory proteins. Comprehensive research on immunological dysfunction in schizophrenia was analyzed by Miller and Goldsmith. The authors analyzed the inconsistent findings from schizophrenia treatment using immunomodulatory therapies and recommended monoclonal antibody immunotherapy with adjunctive effects as potential future strategies (Abozor & Abduljawad, 2022; Mickevičius *et al*., 2023; Alqara *et al*., 2024; Rawani *et al*., 2024; Soman *et al*., 2024).

Oxidative Stress

Scientists define oxidative stress as a condition appearing when the body cannot eliminate reactive products or free radicals or create reactive species. Neurotoxicity and cellular malfunction, together with molecular damage and necrotic and apoptotic cell-death pathways, result from the excessive production of these reactive species. The nitroxyl anion, alongside other nitrogen oxides, belongs to the reactive oxygen species group (such as hydrogen peroxide and superoxide free radicals) that oxidant stress literature mainly focuses on. Mitochondrial production of ATP leads to the generation of ROS. Regular health situations allow the body to maintain redox balance, the state of equilibrium between tissue oxidation and reduction. The medical literature defines oxidative stress as a situation that arises from conflicts between reactive product detoxification capability and reactive species production rates within the human body.

Neurotoxicity and cellular malfunction with subsequent molecular damage alongside necrotic and apoptotic cell-death signaling become possible when reactive species are present in high amounts. RNS such as the nitroxyl anion, alongside other nitrogen oxides, function as ROS, which includes hydrogen peroxide and superoxide free radicals that occupy the majority of reports on oxidative stress in the literature. ROS are generated by the mitochondrial ATP production. Without an abnormality, the body

maintains the redox balance that represents the state of equal oxidation and reduction in tissues. Oxidative stress interacts with a variety of physiological processes in both directions, affecting neurotransmission, neuroinflammation, and homeostatic networks, including the HPA axis. We have discussed the potential role of oxidative stress in theories of psychosis that involve the immune system, dopamine, glutamate, and impaired brain connections. Compared blood indicators of oxidative stress and inflammation in first-episode psychosis (FEP) patients and healthy controls in a comprehensive analysis of cross-sectional studies.

The blood data showed FEP patients had elevated homocysteine and IL-6 and TNF-α concentrations when compared to controls, but they simultaneously presented diminished docosahexaenoic acid and total antioxidant status. Research findings showed that patients with first-episode psychosis demonstrated both elevated pro-inflammatory conditions and decreased antioxidant protection. The DATs that regulate dopamine breakdown become dysfunctional as ROS affects them (Bahamid *et al*., 2022; Sindhu *et al*., 2023; Belfiore *et al*., 2024; Odeh *et al*., 2024; Upchezhokov *et al*., 2024; Zangiabadi *et al*., 2025). Experimental rodent research showed that diminished drug reuptake causes dopaminergic increases in synaptic cleft levels in the nucleus accumbens. Dopamine excess causes auto-oxidation in the brain cells, thus becoming a primary trigger of brain oxidative stress. Dopamine intensifies oxidative stress harm through its reduction of how well antioxidants function. The hippocampus and PFC areas affected by synaptic dopamine participate in dopaminergic effects that lead to cellular pro-oxidation. Research through positron emission tomography imaging demonstrates that higher levels of dopaminergic neurotransmission lead to unhealthy conditions by amplifying the production of reactive oxygen species (ROS). The ability of protective antioxidant enzymes becomes impaired by psychostimulant use. Reactive astrocytes and microglia maintain a cyclic process that results in ROS production and sustained inflammation while killing cells and enhancing the production of pro-inflammatory cytokines. The immune response appears to underlie oxidative stress, especially among psychotic patients. Oxidative stress serves as an example of a bidirectional psychosis mechanism because it triggers neuroinflammation. Research has established that elevated oxidative stress levels function as a mediator of psychosis development in immunological activation conditions. ROS, alongside pro-inflammatory cytokines produced by reactive microglia, can damage the BBB according to scientific evidence. The detection of oxidative stress and neuroinflammatory processes of the immune system during pathological events suggests that this stress behavior both initiates and results from neuroinflammation (Liu *et al*., 2022; Makhoahle & Gaseitsiwe, 2022; Teleanu *et al*., 2022; Graefen *et al*., 2023; İlaslan *et al*., 2023; Thazha *et al*., 2023).

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Importance of Medicinal Plants in Neurodegenerative Diseases

American Alzheimer's, Parkinson's disease, and Huntington's disease make up the neurodegenerative diseases that occur more frequently due to humans living longer. Plant extracts have consistently been employed in human history to treat numerous diseases because they possess several therapeutic properties. Scientific researchers now study the neuroprotective effects, along with the biological activities of medicinal plants. Research using animal subjects illustrates that the plant's fruit and root bark possess all three effects, including hypotensive property and hypoglycaemic and antipyretic action. Traditional medicine practitioners in China, along with Japan and Korea, prescribe Lycium chinense Miller for treatment purposes. The plant serves medical purposes for treating neurological conditions and shows effects that reduce aging symptoms. The protective properties of various plant materials against neural cell damage have been extensively researched. Two individual studies proved that extracts from Camellia sinensis and Erigeron breviscapus protected PC12 cells from hydrogen peroxide damage, along with a neuroprotective action demonstrated from Smilacis chinensis plant rhizome in N-methyl-d-aspartate-induced neurotoxicity models. The research showed parallel results when tested on animals with focal cerebral ischaemia (Uddin *et al*., 2013; AlYousef *et al*., 2022; Najjar, 2023; Padma *et al*., 2023).

Plant-Based Interventions in Alzheimer's Disease

Crocus Sativus

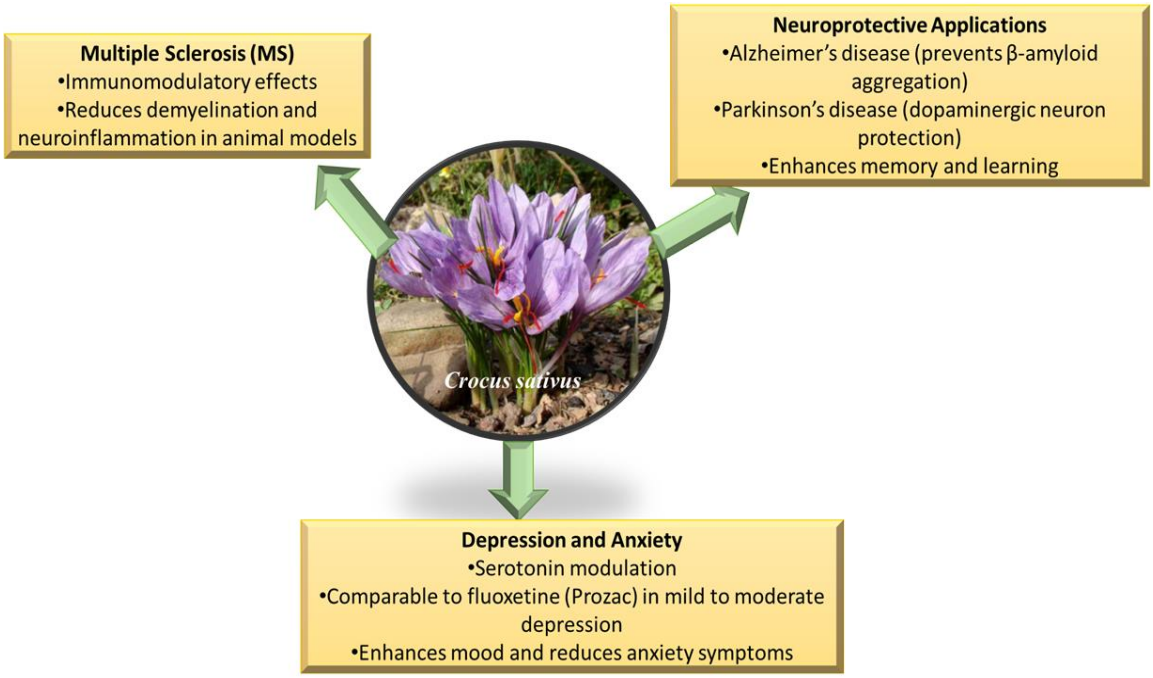

Figure 3. *Crocus sativus* and its neuroprotective functions against neurodegenerative diseases

Crocus sativus L. stands out among therapeutic plants because of its increasing popularity. Crocus sativus L. belongs to the Iridaceae family and grows throughout Greece, Italy, Spain, Israel, Morocco, Turkey, Iran, India, China, Egypt, Mexico, and other regions. The purpose of this research focuses on the neuroprotective functions of Crocus sativus L., especially in treating Parkinson's disease and Alzheimer's disease. The metabolic redox reactions in cells generate unavoidable byproducts known as reactive oxygen-nitrogen species, and together they are designated as reactive oxygen-nitrogen species. These species are produced during phagocytosis, oxidative phosphorylation in the respiratory chain of mitochondria, eicosanoid synthesis, and redox reactions that involve metals with variable valence and biotransformation reactions of exogenous and endogenous substrata in endoplasmic reticulum cells (D'Onofrio *et al*., 2021; Aruta *et al*., 2023; Gurubasajar *et al*., 2023; Bergeron *et al*., 2024; Naseri *et al*., 2024). Saffron or *Crocus sativus* has existed as a color and flavoring agent and medicinal herb since the beginning of human civilization. Scientists continue to identify emerging research that demonstrates the pharmacological benefits of saffron alongside its key compounds for CNS therapy applications. *Crocus sativus* L. has neuroprotective effects on Alzheimer's disease (AD) patients' cognitive impairment. Reviewing the data and mechanisms underlying saffron-induced therapeutic effects and quantifiable cognitive advantages in AD is the aim of this study. Studies that were preclinical and clinical were found. These criteria were used to choose preclinical in vitro and in vivo studies: 1) creation of the pharmacological profile of saffron on biological or biophysical endpoints; 2) assessment of saffron effectiveness using animal screens as an AD model; and 3) studies lasting at least three months that show that crocin seems to be able to control glutamate levels, lower oxidative stress, and modify tau and Aβ proteins. Research investigates how saffron functions as a neuroprotective agent in age-related macular degeneration (AMD) cases (D'Onofrio *et al*., 2021; Al Hemaidi, 2024). Medical evidence from pharmacological studies demonstrates that saffron supplementation therapy protects the brain through various scientific investigations that link its therapeutic properties to crocins, crocetin, picrocrocin, and safranal compounds. Studies indicate that saffron carotenoids serve as the primary source of antioxidant properties based on the evidence throughout most research. The capacity of saffron metabolites enables them to bind to biomolecules that protect them against free radical damage **(Figure 3)**.

Ginko Bibloba

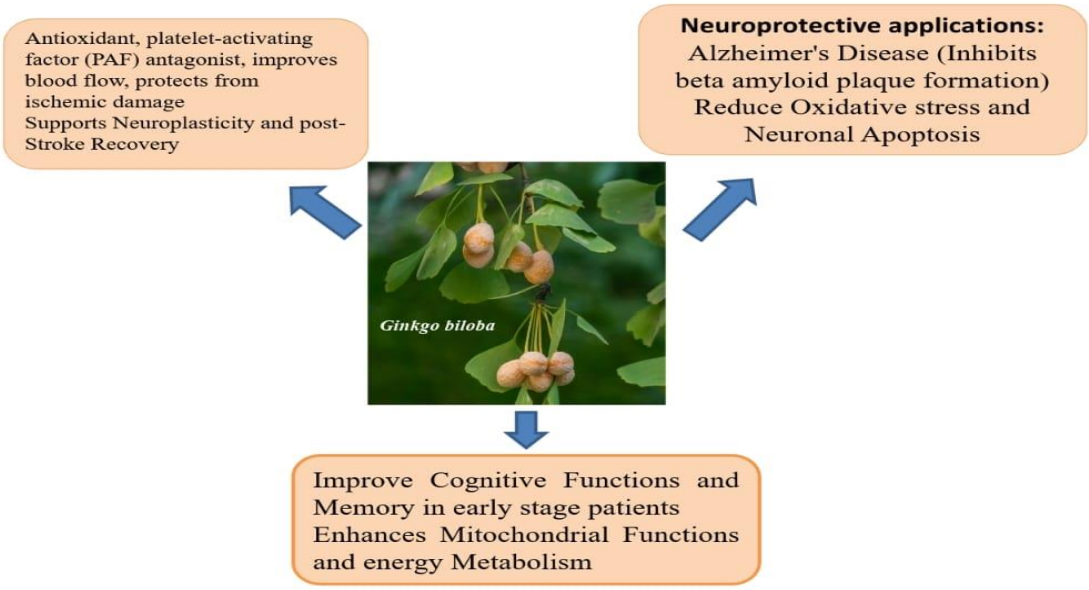

Figure 4. *Ginko bibloba* and its neuroprotective functions against neurodegenerative diseases

The medical usage of standardised *ginkgo* extracts contains 6% terpenoids and 24% *ginkgo*-flavone glycosides. Bilobalide belongs to the group of terpenoids, which also includes ginkgolides A, B, C, M, and J that serve as a group of 20-carbon cage molecules with six 5-membered rings. Ginkgolides function as platelet-activating factor (PAF) antagonists through multiple biological mechanisms. 1 Activating and aggregating platelets, increasing vessel permeability, and causing powerful stomach ulcers and smooth muscle contraction, including bronchial muscle, are additional effects of PAF. Platelet-activating factor directly influences neuronal activity alongside long-term potentiations. Its preventive effects protect brain neurones from peroxidation-induced oxidative damage and reduce both subchronic cold stress effects on receptor desensitisation and neuronal damage from ischemic or electroconvulsive shock situations (Oken, *et al*., 1998). The anti-ischaemia and anti-hypoxia effects of Ginkgo support better brain metabolic functions. One of the multiple conditions treated with ginkgo biloba extract includes heart disease, alongside its variant known as coronary heart disease **(Figure 4)**.

Research through meta-analysis confirmed that *ginkgo biloba* extract leads to improved cognitive performance in patients with vascular cognitive impairment, although researchers could not determine its effectiveness in the treatment of Alzheimer's Disease patients treatment. Both donepezil medication and ginkgo preparations work toward treating Alzheimer's disease, although they belong to different treatment classes (Li *et al*., 2023). Medical effects of *Ginkgo* result from two main active metabolite groups, which include Ginkgo flavones (with quercetin, kaempferol, and iso-rhamnetin glycosides as the principal flavonoids plus biflavonoids ginkgetin/isoginkgetin) and terpene lactones (ginkgolides A, B, C, and J and bilobalide). Pharmacologically active standardized *ginkgo* leaf extracts are commercially available in the market. The medicinal effects of ginkgo leaf extracts depend on the combined antioxidant capabilities of ginkgolides and the ability of flavonoids and terpenoids to scavenge radicals and suppress platelet-activating factors, and improve blood flow while decreasing platelet aggregation. Scientific evidence suggests that flavonoids protect against the damaging effects of oxidation on lipid membrane structure (Bosch-Morell *et al*., 2020).

Curcuma Longa

Figure 5. *Curcuma longa* and its neuroprotective functions against neurodegenerative diseases

Traditional Asian communities have been using *curcumin* as both food and a medicinal substance since ancient times. Research has proven that *curcumin* demonstrates three beneficial properties in different studies, which include anticancer effects and anti-inflammatory qualities, together with antioxidant properties. *Curcumin* stands as the most promising treatment material being considered to develop AD therapies because this ancient Indian plant is commonly used in India for curry powder preparation. Modern and Indian medical research demonstrates that this substance effectively addresses a broad spectrum of diseases, including arthritis, liver diseases, colon cancer, breast cancer, haemorrhoids, gastric ulcers, atherosclerosis, and cystic fibrosis. Nerve cell inflammation proves to be an essential cause of Alzheimer's disease, according to recent medical research (Mishra *et al*., 2008). Medical scientists view *curcumin* from Indian curry spices as one of the best candidates to create effective treatments for Alzheimer's disease. Studies both in traditional and contemporary medical contexts show extensive usage of *curcumin* as an ancient Indian herb to treat several diseases, such as arthritis and conditions involving liver diseases and cancer, along with breast cancer, haemorrhoids, gastric ulcers, atherosclerosis, and cystic fibrosis. Proof shows that chronic nerve cell inflammation functions as a leading cause in the development of Alzheimer's disease.

Medical research studies have examined how *curcumin* affects cancer because scientists have confirmed its cancer-influencing properties in tumors. Researchers present evidence that *curcumin* has the potential to treat the development of Alzheimer's disease (AD). Research reveals that curcumin inhibits the activity of Aβ aggregation together with Aβ-induced inflammation and β-secretase, as well as acetylcholinesterase, in in vitro tests. The administration of *curcumin* through the mouth resulted in positive behavioral results during in vivo experiments and inhibited brain tau phosphorylation and Aβ oligomeric aggregation, as well as reduced Aβ brain deposition in AD patients (Hamaguchi *et al*., 2010). During amyloid-β (Aβ) peptide accumulation, the brain experiences associated inflammatory changes, which cause microgliosis and astrocytosis and lead to the formation of pro-inflammatory substances. Evidence shows that individuals who regularly take several nonsteroidal anti-inflammatory drugs, including ibuprofen, develop decreased risks of AD symptomatic presentation. Over an extended period of time, NSAIDs have poisonous effects on three essential body organs: the kidneys, liver, and gastrointestinal tract. Therapeutic results from *curcumin* consumption toward inflammatory processes are robust. Different anti-inflammatory qualities of the treatment make it potentially advantageous for AD management. Adherence of Egr-1 protein and DNA-binding functionalities to THP-1 monocytic cells remains decreased when exposed to *curcumin* combined with Aβ. Research shows that the amyloid peptide triggers monocyte cytochemokine gene expression through the protein Egr-1. *Curcumin* prevents the DNA-binding ability of the Egr-1 protein **(Figure 5)**.

Plant-based Interventions in Parkinson's Diseases

Mucuna Pruriens

M. pruriens exists as a climbing legume that originates from eastern India and southern China. Scientists note that various nations have relied on *M. pruriens* as a food source that ethnic groups have employed historically. Members of distinct ethnic groups across different nations use *M. pruriens* as a medicinal and nutraceutical product to treat cancer and PD, as well as diarrhoea and helminthiasis, in addition to ulcer management and treatment of infertility, elephantiasis, snake and scorpion stings, and malaria. The plant gains its high nutritional value from its supply of amino acids, which contain arginine, serine, lysine, histidine,

phenylalanine, proline, tyrosine, threonine, and tryptophan. This food source contains an ample variety of minerals, along with fiber components, both at high levels and fatty acids and vitamins. Scientific studies have established the biological strength of L-3,4-dihydroxyphenylalanine (L-DOPA) and two other bioactive components, named ursolic acid and betulinic acid, from the plant. Several other compounds in the plant consist of (Z, E)-7,11-hexadecadien-1-yl acetate, n-hexadecanoic acid (palmitic acid), 9,12-octadecadienoic acid, octadecanoic acid, hexadecanoic acid, 2-hydroxy-1-(palmitoylglycerol), and 2-methyl butanal. Different animal research models confirm how certain bioactive substances generate antidepressant results.

Studies demonstrate that decreased dopamine (DA) signaling throughout different brain locations forming mesocortical and mesolimbic pathways keeps a close relationship to physiological processes which bring about depressive behavior. The plant contains L-3,4-dihydroxyphenylalanine (L-DOPA) and two other vital components, which are ursolic acid and betulinic acid; scientific studies prove their powerful biological effects. The plant contains several substances, including (Z E)-7 11-hexadecadien 1-yl acetate, n-hexadecanoic acid (palmitic acid), 9 12-octadecadienoic acid, octadecanoic acid, and hexadecanoic acid 2-hydroxy-1-(palmitoylglycerol) and 2-methyl butanal. Scientists have demonstrated specific bioactive chemicals to have antidepressant properties using different animal study models. Scientific investigations show that depressive behavior develops alongside a decrease in dopamine signaling throughout the brain regions which form the mesocortical and mesolimbic pathways (Mata-Bermudez *et al*., 2024). Scientists have discovered both neuroprotective properties and supportive effects for levodopa anti-PD actions in the individual components of *Mucuna* seeds such as genistein and gallic acid along with unsaturated acids and nicotine and bufotenin and harmin alkaloids and lecithin. The paper details various components present in *Mucuna pruriens* seeds regarding their medical potential for Parkinson's disease treatment. A standardized *Mucuna* seed extract holds great promise to reduce medical expenses while minimizing PD progression because the current treatment combination of levodopa with other medications is very expensive. *Mucuna* seeds exist in the market at favorable prices as well as easy accessibility. *Mucuna pruriens* provides effective treatment for Parkinson's disease according to the review due to Ayurveda's full treatment methodology (Kasture *et al*., 2013).

Withania Somnifera

Figure 6: *Withania somnifera* and its neuroprotective functions against neurodegenerative diseases

Historically, Ayurveda has adopted ashwagandha, which has the botanical *name Withania somnifera (L.)* Dunal provides various medical advantages. A wide range of active components in this plant show their anti-inflammatory, anti-diabetic, anticancer, anti-microbial, and neurotherapeutic effects through research involving chemically-treated mice in lab experiments. Researchers use genetically modified Drosophila models to study genetic pathways alongside cellular events happening in situ for various neurodegenerative diseases, including Parkinson's and Alzheimer's. The development of drugs in vitro environments fails to produce effective treatments in clinical trials due to variations in human genetics and physiological conditions (Murthy *et al*., 2024) **(Figure 6, Table 1)**.

According to Vrindamadhava from 900 AD, this marks the first Ayurvedic treatise to present ashwagandha as medication against diverse neurological diseases, such as Medhya for memory improvement, Kampavatha for Parkinson's patients, and chinta for anxiety, and Nidranasa for sleep disturbances, etc. Studies have shown that different regions of ashwagandha contain over 50 chemical components, and its main biological action originates from withanolide lactones and steroidal alkaloids, which compose

the various pathological symptoms of Parkinson's disease. The combination of ubisol-Q10 with ethanolic ashwagandha extract (ASH) represents two simple, harmless nutraceutical compounds that provide supportive treatment for the multiple biochemical causes found in Parkinson's disease. The combined action of these medications provided better results in medical treatment efforts to stop the progressive neurodegenerative process of Parkinson's disease compared to using them separately. Our research utilized lower doses of the known neuroprotectant ASH by combining separate drugs that target distinct Parkinson's disease pathologies, rather than previous studies about ASH use alone. The strategies addressed through Ubisol-Q10 treatment did not reach all possible PD mechanisms, but the therapy implemented targeted vital mechanisms. Parkinson's disease exists as a multi-process disease, so neurodegeneration stoppage demands intervention in numerous processes simultaneously (Vegh *et al*., 2021).

Table 1. Neuroprotective Medicinal Plants and Their Mechanisms of Action in Neurodegenerative Diseases

Medicinal Plant	Scientific Name	Neurodegenerative Target	Key Bioactive Compounds	Mechanisms of Neuroprotection
Turmeric	*Curcuma longa*	Alzheimer's Disease	Curcumin	Antioxidant, anti-inflammatory, inhibits Aβ aggregation and acetylcholinesterase, reduces tau phosphorylation.
Brahmi	*Bacopa monnieri*	Alzheimer's Disease	Bacosides	Enhances synaptic transmission, antioxidant effects, improves memory and cognition.
Ashwagandha	*Withania somnifera*	Parkinson's Disease	Withanolides, steroidal alkaloids	Antioxidant, anti-apoptotic, improves dopaminergic neuron survival, reduces oxidative stress.
Velvet Bean	*Mucuna pruriens*	Parkinson's Disease	Levodopa (L-DOPA), ursolic acid, betulinic acid	Natural dopamine source, antioxidant, supports neurotransmission, and has antidepressant effects.
Ginkgo	*Ginkgo biloba*	Alzheimer's & Vascular Dementia	Ginkgolides, bilobalide, flavone glycosides	Antioxidant, platelet-activating factor (PAF) antagonist, improves blood flow, protects from ischemic damage.
Gotu Kola	*Centella asiatica*	Cognitive Decline	Asiaticoside, madecassoside	Neuroregenerative, antioxidant, enhances synaptic plasticity and cognitive performance.
Goji Berry	*Lycium chinense*	Aging-related degeneration	Polysaccharides, carotenoids	Anti-aging reduces neuronal damage.

Applications

Neurodegenerative Disorders and The Role of Medicinal Herbs

A distinct feature of the neurodegenerative diseases Parkinson's disease and Alzheimer's disease includes progressive deterioration of neurons that leads to their ultimate death. Many neurodegenerative disorders have origins that healthcare professionals are unable to establish correctly. Neurodegenerative disorders are mainly caused by six different classes of environmental influences, including environmental variables, mitochondrial abnormalities, oxidative stress, inflammation, protein degradation, genetic factors, and protein accumulation in neurones. Neurodegenerative illnesses tend to advance significantly with age as a determining factor. Medical research has employed wolfberry together with *ginkgo biloba*, resveratrol, and ginseng alongside *curcumin, Baccopa monnieri,* and *Withania somnifera* (ashwagandha) as medicinal plants for treating and preventing neurological diseases and their symptoms. When properly processed, natural substances retain their original activity levels suitable for use as therapeutic nanoparticles.

The specific delivery of cells and tissues becomes possible through nanodrug delivery systems, which increase drug bioavailability. A drug delivery system using nanoparticles together with polymeric nanomicelles, as well as complex polymer nanocrystals and nanofibres, transports medicinal plants for neurological illness treatments. The preventive power of therapeutic herbs operates against neurodegenerative illnesses. These diseases are known as neurodegenerative diseases because they lead to significant neuron reduction along physical and functional lines. People nowadays prefer non-traditional treatment options because various adverse effects increase from contemporary medical approaches combined with disease progression. Medicinal plants demonstrate various cellular and molecular pathways that facilitate their advantageous use in these medical situations. Several neuroprotective capabilities occur in traditional plants, which work by reducing inflammation while improving antioxidative mechanisms and inhibiting the pro-inflammatory functions of tumor cytokines.

The protection of plants from diseases depends mainly on different transcription and transduction pathways (Ratheesh *et al*., 2017). The healthcare systems around the world face immense costs from the three important neurodegenerative diseases called Alzheimer's disease, Parkinson's disease, and Huntington's disease. These diseases will become more severe when life expectancies continue to increase during the upcoming decades. Medical science lacks any treatment that can cure these illnesses despite offering symptomatic treatments through prescription medications. Medical research proves that oxidative stress functions as either the source or product of other downstream factors leading to neurodegeneration in patients. Proof exists that the application of antioxidants to fight oxidative cellular stress might serve as a

potential therapy for neurological diseases in the nervous system. Scientists have dedicated their research to studying natural antioxidants for their potential as oxidative stress fighters over these past ten years. The outcomes from clinical trials did not lead to effective treatments for neurological issues. Studies on natural extracts for nerve disease prevention or treatment after scientists found these substances have antioxidant properties, along with other helpful biological attributes, demonstrate their worth. The review encompasses expert analysis of both clinical trials and in vitro, along with in vivo investigations, together with the analysis of natural antioxidant potential (Ratheesh *et al*., 2017).

Limitations

Neurodegenerative disorders (NDDs) represent multiple diseases that damage neurons to produce mental and motor impairment. Many experts now study NDDs because of their complex origin factors, together with multifaceted symptoms, which result in significant social and economic consequences. The observed cell death of brain cells mainly stems from metabolic alterations, which lead to elevated oxidase enzyme activity, together with increased free radicals, mitochondrial dysfunctions, and neuroinflammation. The detection of numerous NDD issues from their initial stages through development has improved through modern diagnostic procedures. Research in NDD focuses on enhancing cellular defense mechanisms and especially on oxidoreductases because scientists aim to discover effective treatments (Zaky *et al*., 2025).

Challenges and Future Perspective

The application spectrum of plant-derived natural compounds and plant extracts with antioxidant properties extends to in vitro and in vivo studies. The increasing lifespan of people will lead to escalating health problems from these diseases in the future decades. The association between neurodegeneration and oxidative stress exists as both a result and an underlying cause of different pathological events. Medical experts recommend that antioxidants might function as remedies for neurological diseases that help reduce oxidative stress inside nerve cells. The application spectrum of plant-derived natural compounds and plant extracts with antioxidant properties extends to in vitro and in vivo studies. The increasing lifespan of people will lead to escalating health problems from these diseases in the future decades. The association between neurodegeneration and oxidative stress exists as both a result and an underlying cause of different pathological events. Medical experts recommend that antioxidants might function as remedies for neurological diseases that help reduce oxidative stress inside nerve cells. The application of nanotechnology represents a key approach to handling multiple limitations in medical conditions, whereas neurodegenerative disorders stand among the set of diseases it avoids. Nanotechnology represents an important technology that has transformed human life in multiple directions. Multiple nanostructures that include Carbon nanotubes (CNTs) with polymer and lipid nanoparticles and nanoliposomes and nano-micelles combined with vehicle systems based on lactoferrin alongside polylactic-co-glycollic acid and polybutylcyanoacrylate improve medication PK, stability, and drug properties and toxicity profiles. NDs join the millions of people who experience numerous debilitating diseases. The power of nanotechnology assists medical science in breaking through barriers that exist in numerous disease treatments, especially those affecting neurodegenerative disorders (NDs). This progressive strategy has modified human existence through multiple revolutionary changes. A combination of carbon nanotubes (CNTs), polymer nanoparticles, lipid nanoparticles, nanoliposomes, and nano-micelles with vehicle systems that include lactoferrin, polylactic-co-glycollic acid, and polybutylcyanoacrylate improves the therapeutic qualities of many medications. The medical condition experienced by NDs affects millions of people with multiple chronic debilitating diseases (Ratheesh *et al*., 2017; Moradi *et al*., 2020; Puri *et al*., 2022).

Conclusion

The underlying factors contributing to numerous neurodegenerative diseases remain largely unknown, which has led to an ongoing exploration of herbal medicine as a viable treatment option. Phytochemicals derived from medicinal plants exhibit encouraging therapeutic properties, primarily due to their capacity to mitigate inflammation, counteract oxidative stress, and inhibit acetylcholinesterase activity—critical elements in the process of neurodegeneration. Conditions such as Alzheimer's disease (AD), Parkinson's disease (PD), and Huntington's disease exhibit shared cellular and molecular pathways, including inflammatory damage, necroptosis, and apoptosis. Nevertheless, the practical use of herbal medicine is frequently hindered by inadequate pharmacokinetic characteristics. Recent innovations in drug delivery systems, especially nanoencapsulation, have enhanced the accuracy and effectiveness of natural compounds by improving target specificity, minimizing toxicity, and decreasing required dosages. New research into electrospinning and electrospraying technologies is broadening the development of fibers and nanoparticles aimed at treating age-related neurodegenerative conditions. Traditional Persian medicinal plants, abundant in bioactive phytochemicals, are among those being studied for their potential to augment standard therapies. Although these compounds demonstrate significant neuroprotective potential, additional clinical investigations are necessary to validate their safety and efficacy. In summary, medicinal plants offer a valuable and diverse strategy for addressing neurodegenerative diseases, providing natural alternatives with reduced side effects and the ability to influence multiple disease pathways.

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References

Abbas, I. K., Hareeja, M. M., Jaber, S. A., Qader, A. B., Mahal, R. K., Salih, O. S., & Hussein, A. A. (2025). Impact of

preparation techniques on formulation and characterization of captopril effervescent granules. *Journal of Advanced Pharmacy Education and Research, 15*(2), 51–56. doi:10.51847/8aO2P1Lp5P

Abdel-Hadi, B., & Abdel-Fattah, S. R. (2022). Clinical pharmacist intervention in appendectomy—Dexmedetomidine as an adjunct therapy. *Journal of Advanced Pharmacy Education and Research, 12*(2), 1–5. doi:10.51847/AYOZXtLMrj

Abozor, B. M., & Abduljawad, A. A. (2022). Obesity and demographics influence on periapical lesions, dental caries, and oral health in adults. *Annals of Dental Specialty, 10*(3), 31–38. doi:10.51847/85ojmUYR3S

Akbari, M. (2022). Is there an alternative therapy for refractory vernal keratoconjunctivitis? *Journal of Advanced Pharmacy Education and Research, 12*(3), 54–58. doi:10.51847/LGMe2jFqWh

Al Hemaidi, S. S. (2024). Effectiveness of botulinum toxin (botox) for treatment of nystagmus: a review. *World Journal of Environmental Biosciences, 13*(4), 14–17. doi:10.51847/kqbONHsU0o

Alqara, M. H., Alqara, A. H., & AlKhathlan, A. (2024). Recent advances in minimally invasive dentistry: a narrative review of the literature. *Annals of Dental Specialty, 12*(3), 28–33. doi:10.51847/GdquefIPmp

AlYousef, R. A., Abualnaja, A. A., AlNojaidi, J. H., AlDosari, Y. N., AlKhalaf, S. A., AlQahtani, N. J., AlDosari, D. A., AlKhalaf, A. A., & Alharbi, M. S. (2022). Lower back pain in athletes and non-athletes: a group comparison of risk factors and pain management. *World Journal of Environmental Biosciences, 11*(3), 36–44. doi:10.51847/kVriSL1OCS

Aruta, R. S., & Durotan, R. (2023). Profiling and mitigation practices of inhabitants in disaster-prone communities: inputs for climate-resiliency strategies. *World Journal of Environmental Biosciences, 12*(2), 13–18. doi:10.51847/l0EZH9VOfD

Asar, M. E., Saleh, E., & Ghaneapur, M. (2023). Innovative and motivational SDT-based approach to promote Iranian women's physical activity. *Journal of Advanced Pharmacy Education and Research, 13*(1), 62–65. doi:10.51847/gcrJpRS1SU

Ashkevari, S. B., & Ghasemi, B. (2023). The impact of strategic leadership on organizational performance with regard to the role of organizational innovation. *Journal of Organizational Behavior Research, 8*(2), 40–53. doi:10.51847/vSDdNm6S8t

Bahamid, A. A., AlHudaithi, F. S., Aldawsari, A. N., Eyyd, A. K., Alsadhan, N. Y., & Alshahrani, F. A. M. (2022). Success of orthodontic space closure vs. implant in the management of missing first molar: systematic review. *Annals of Dental Specialty, 10*(4), 9–14. doi:10.51847/jDPeo7jLvg

Belfiore, C. I., Galofaro, V., Cotroneo, D., Lopis, A., Tringali, I., Denaro, V., & Casu, M. (2024). Studying the effect of mindfulness, dissociative experiences, and feelings of loneliness in predicting the tendency to use substances in nurses. *Journal of Integrative Nursing and Palliative Care, 5*, 1–7. doi:10.51847/LASijYayRi

Bergeron, S., Boopathy, R., Nathaniel, R., Corbin, A., & LaFleur, G. (2024). A review of the reasons for increasing the presence of antibiotic-resistant bacteria in drinking water. *World Journal of Environmental Biosciences, 13*(2), 6–12. doi:10.51847/xXkJ6gfNwB

Bosch-Morell, F., Villagrasa, V., Ortega, T., Acero, N., Muñoz-Mingarro, D., González-Rosende, M. E., Castillo, E., Sanahuja, M. A., Soriano, P., & Martínez-Solís, I. (2020). Medicinal plants and natural products as neuroprotective agents in age-related macular degeneration. *Neural Regeneration Research, 15*(12), 2207–2216. doi:10.4103/1673-5374.284978

Brown, R. C., Lockwood, A. H., & Sonawane, B. R. (2005). Neurodegenerative diseases: an overview of environmental risk factors. *Environmental Health Perspectives, 113*(9), 1250–1256. doi:10.1289/ehp.7567

D'Onofrio, G., Nabavi, S. M., Sancarlo, D., Greco, A., & Pieretti, S. (2021). Crocus sativus L. (saffron) in Alzheimer's disease treatment: bioactive effects on cognitive impairment. *Current Neuropharmacology, 19*(9), 1606–1616. doi:10.2174/1570159X19666210113144703

Dehaghi, A. A., Dolatshahi, B., Taremian, F., Pourshahbaz, A., & Ansari, H. (2022). Acceptance and commitment therapy with Islamic aspects as a treatment for scrupulosity in a case study. *Journal of Organizational Behavior Research, 7*(2), 95–108. doi:10.51847/Fa3ED8HrzB

Enciu, A. M., Nicolescu, M. I., Manole, C. G., Mureşanu, D. F., Popescu, L. M., & Popescu, B. O. (2011). Neuroregeneration in neurodegenerative disorders. *BMC Neurology, 11*(1), 1–7. https://pubmed.ncbi.nlm.nih.gov/26921134/

Figueroa-Valverde, L., Marcela, R., Alvarez-Ramirez, M., Lopez-Ramos, M., Mateu-Armand, V., & Emilio, A. (2024). Statistical data from 1979 to 2022 on prostate cancer in populations of Northern and Central Mexico. *Bulletin of Pioneering Researches of Medical and Clinical Science, 3*(1), 24–30. doi:10.51847/snclnafVdg

Firdous, S. M., Khan, S. A., & Maity, A. (2024). Oxidative stress–mediated neuroinflammation in Alzheimer's disease. *Naunyn-Schmiedeberg's Archives of Pharmacology, 397*(11), 8189–8209.

Gavioli, E., Mantelli, F., Cesta, M. C., Sacchetti, M., & Allegretti, M. (2024). The history of nerve growth factor: from molecule to drug. *Biomolecules, 14*(6), 635. doi:10.3390/biom14060635

Gondo, H. K., & Haryanti, E. (2024). Higher placental activin-A (ACV-A) and inhibin-A (INH-A) in the placenta of a preeclampsia mother compared to a diabetic mother. *Journal of Advanced Pharmacy Education and Research, 14*(3), 15–17. doi:10.51847/QVCQHO6GxQ

Graefen, B., Hasanli, S., & Fazal, N. (2023). Behind the white coat: The prevalence of burnout among obstetrics and gynecology residents in Azerbaijan. *Bulletin of Pioneering Researches of Medical and Clinical Science, 2*(2), 1–7. doi:10.51847/vIIhM1UG2l

Gurubasajar, N., Subhakar, A., Dadayya, M., Veeranna, S. H., & Basaiah, T. (2023). Isolation, characterization, and quantification of polyhydroxybutyrate-producing bacteria Achromobacter xylosoxidans KUMBNGBT-63 from

different agroresidues. *World Journal of Environmental Biosciences, 12*(2), 35–42. doi:10.51847/YmLaQtfbzH

Ha, H. D., & Hang, H. T. T. (2024). The impact of transformational leadership on employee performance in the Vietnamese banking industry. *Journal of Organizational Behavior Research, 9*(2), 12–27. doi:10.51847/8COZGxs9s6

Hamaguchi, T., Ono, K., & Yamada, M. (2010). Curcumin and Alzheimer's disease. *CNS Neuroscience & Therapeutics, 16*(5), 285–297. doi:10.1111/j.1755-5949.2010.00147.x

Hoang, T. T. V., Nguyen, T. H., Nguyen, T. T. T., Hoang, L. P. T., Ho, T. T. T., Nguyen, T. H. T., & Nguyen, T. T. M. (2022). Research factors affecting students' academic results in learning project subjects oriented CDIO at Vinh University. *Journal of Organizational Behavior Research, 7*(1), 14–28. doi:10.51847/SntPtYuASo

İlaslan, E., Adıbelli, D., Teskereci, G., & Cura, Ş. Ü. (2023). Studying the impact of clinical decision-making and critical thinking on the quality of nursing care. *Journal of Integrative Nursing and Palliative Care, 4*, 23–29. doi:10.51847/fsTLiDadY3

Kasture, S., Mohan, M., & Kasture, V. (2013). *Mucuna pruriens* seeds in treatment of Parkinson's disease: pharmacological review. *Oriental Pharmacy and Experimental Medicine, 13*(3), 165–174.

Kwatra, D., Venugopal, A., & Anant, S. (2024). Studying the efficacy of tolmetin radiosensitizing effect in radiotherapy treatment on human clonal cancer cells. *Bulletin of Pioneering Researches of Medical and Clinical Science, 3*(2), 22–28. doi:10.51847/Uuhjk0fMC8

Levochkina, E. D., Belyaev, N. G., Tkach, A. I., Menadzhiev, A. S., Volkova, M. N., Akifeva, N. M., Zemcev, D. A., & Korotchenko, E. A. (2024). Data analysis of autoimmune bioindicators in the context of predicting cardiomyocyte damage. *Journal of Advanced Pharmacy Education and Research, 14*(3), 62–69. doi:10.51847/ilO1LTBQLt

Li, D., Ma, J., Wei, B., Gao, S., Lang, Y., & Wan, X. (2023). Effectiveness and safety of Ginkgo biloba preparations in the treatment of Alzheimer's disease: a systematic review and meta-analysis. *Frontiers in Aging Neuroscience, 15*, 1124710. doi:10.3389/fnagi.2023.1124710

Linh, D. H., Hoa, T. T. V., Dan, N. K., Anh, T. T. P., Ngoc, D. H., & Hoang, P. N. (2024). The impact of green credit on a sustainable economy: an empirical study in Vietnam. *Journal of Organizational Behavior Research, 9*(2), 164–178. doi:10.51847/euzEogd4CX

Liu, M., Tang, Q., Wang, Q., Xie, W., Fan, J., Tang, S., Liu, W., Zhou, Y., & Deng, X. (2022). Studying the sleep quality of first-time pregnant women in the third trimester of pregnancy and some factors related to it. *Journal of Integrative Nursing and Palliative Care, 3*, 1–6. doi:10.51847/K1PUWsJ24H

Makhoahle, P., & Gaseitsiwe, T. (2022). Efficacy of disinfectants on common laboratory surface microorganisms at R.S Mangaliso Hospital, NHLS Laboratory, South Africa. *Bulletin of Pioneering Researches of Medical and Clinical Science, 1*(1), 1–12. doi:10.51847/d5bXpXAtcI

Mata-Bermudez, A., Diaz-Ruiz, A., Silva-García, L. R., Gines-Francisco, E. M., Noriega-Navarro, R., Rios, C., Romero-Sánchez, H. A., Arroyo, D., Landa, A., & Navarro, L. (2024). *Mucuna pruriens*, a possible treatment for depressive disorders. *Neurology International, 16*(6), 1509–1527. https://www.mdpi.com/2035-8377/16/6/112

Mickevičius, I., Astramskaitė, E., & Janužis, G. (2023). Implant survival rate after immediate implantation in infected sockets: a systematic literature review. *Annals of Dental Specialty, 11*(2), 46–56. doi:10.51847/H2f8RrgSWB

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

Molas-Tuneu, M., Briones-Buixassa, L., Díaz, L., Pérez, H., Berrocoso, S., Naudó-Molist, J., Escribà-Salvans, A., Peraile, M. A., Barbero-Jambrina, S., & Lladó-Jordan, G. (2024). Perception of care and emotional impact of perinatal women during COVID-19: a multicenter study. *Journal of Advanced Pharmacy Education and Research, 14*(2), 1–10. doi:10.51847/AQbgFnHjf3

Moradi, S. Z., Momtaz, S., Bayrami, Z., Farzaei, M. H., & Abdollahi, M. (2020). Nanoformulations of herbal extracts in the treatment of neurodegenerative disorders. *Frontiers in Bioengineering and Biotechnology, 8*, 238. doi:10.3389/fbioe.2020.00238

Murthy, M. N., & Shyamala, B. V. (2024). *Ashwagandha–Withania somnifera* (L.) Dunal as a multipotent neuroprotective remedy for genetically induced motor dysfunction and cellular toxicity in human neurodegenerative disease models of Drosophila. *Journal of Ethnopharmacology, 318*, 116897. doi:10.1016/j.jep.2023.116897

Najjar, A. A. (2023). Managing major foodborne mycotoxins: A therapeutic approach for safety and health. *World Journal of Environmental Biosciences, 12*(4), 46–53. doi:10.51847/fhNKVgnWUR

Naseri, B., & Sasani, S. (2024). Stem rust, planting date, wheat maturity and genetic resistance, weather and productivity. *World Journal of Environmental Biosciences, 13*(4), 1–6. doi:10.51847/2njt2p8YQ0

Odeh, L. G. H., Jammal, L. E., Alenazi, A. A., & Ansari, S. H. (2024). Factors affecting the prognosis of dental implants: a systematic review. *Annals of Dental Specialty, 12*(2), 39–46. doi:10.51847/w0q1mO1V2r

Oken, B. S., Storzbach, D. M., & Kaye, J. A. (1998). The efficacy of Ginkgo biloba on cognitive function in Alzheimer's disease. *Archives of Neurology, 55*(11), 1409–1415. doi:10.1001/archneur.55.11.1409

Oran, İ. B., Ayboğa, M. H., Erol, M., & Yildiz, G. (2022). The necessity of transition from Industry 4.0 to Industry 5.0: SWOT analysis of Turkey's SCM strategy. *Journal of Organizational Behavior Research, 7*(2), 1–17. doi:10.51847/vrFR9HDvbh

Özatik, Ş., Saygılı, S., Sülün, T., & Alan, C. B. (2022). Semi-digital workflow of removable partial denture fabrication for scleroderma-induced microstomia patients: two clinical reports. *Annals of Dental Specialty, 10*(3), 1–6. doi:10.51847/CF2JBPvHvL

Padma, K. R., Don, K. R., Anjum, M. R., Sindhu, G. S., & Sankari, M. (2023). Application of green energy technology for environmental sustainability. *World Journal of Environmental Biosciences, 12*(4), 1–7. doi:10.51847/bAMKAPPZGe

Perwitasari, D. A., Candradewi, S. F., Purba, F. D., & Septiantoro, B. P. (2023). Mapping functions of cancer patients' quality of life in Indonesia: from EORTC-QlQ-C-30 to EQ-5D-5L. *Journal of Advanced Pharmacy Education and Research, 13*(3), 19–22. doi:10.51847/avg60W3aR5

Petronis, Z., Golubevas, R., Rokicki, J. P., Guzeviciene, V., Sakavicius, D., & Lukosiunas, A. (2023). Analysis of trigeminal neuralgia associated with neurovascular compression utilizing MRI: a systematic review and meta-analysis. *Annals of Dental Specialty, 11*(4), 1–8. doi:10.51847/rDJGquURHA

Pihlstrøm, L., Wiethoff, S., & Houlden, H. (2018). Genetics of neurodegenerative diseases: an overview. *Handbook of Clinical Neurology, 145*, 309–323. doi:10.1016/B978-0-12-802395-2.00022-5

Puri, V., Kanojia, N., Sharma, A., Huanbutta, K., Dheer, D., & Sangnim, T. (2022). Natural product-based pharmacological studies for neurological disorders. *Frontiers in Pharmacology, 13*, 1011740. doi:10.3389/fphar.2022.1011740

Ranjel, E. S. M., Moreno, P. M. N., Córdova, M. G. D. G., Castillo, C. G. G., Flores, V. J. A., Conesa, J. G., & García, J. A. L. (2025). Bee propolis (Apis mellifera) as a growth promoter in tilapia (Oreochromis niloticus). *World Journal of Environmental Biosciences, 14*(2), 13–19. doi:10.51847/uDczvYfi37

Ratheesh, G., Tian, L., Venugopal, J. R., Ezhilarasu, H., Sadiq, A., Fan, T. P., & Ramakrishna, S. (2017). Role of medicinal plants in neurodegenerative diseases. *Biomanufacturing Reviews, 2*, 1–16.

Rawani, N. S., Chan, A. W., Dursun, S. M., & Baker, G. B. (2024). The underlying neurobiological mechanisms of psychosis: Focus on neurotransmission dysregulation, neuroinflammation, oxidative stress, and mitochondrial dysfunction. *Antioxidants, 13*(6), 709. doi:10.3390/antiox13060709

Roy, S., Laha, I., Ray, D., & Choudhury, L. (2022). Influence of climate change & environmental toxicants on epigenetic modifications. *World Journal of Environmental Biosciences, 11*(3), 21–29. doi:10.51847/jku3EDOAkt

Saliev, T., Tanabayeva, S., Ussebayeva, N., Izmailova, S., Umbayev, B., Akhanov, G., Akhmad, N., & Fakhradiyev, I. (2024). In vitro cytotoxicity and antiviral activity of aminocaproic acid against SARS-CoV-2. *Journal of Advanced Pharmacy Education and Research, 14*(3), 1–8. doi:10.51847/ueSpVWAvbT

Scheltens, P., De Strooper, B., Kivipelto, M., Holstege, H., Chételat, G., Teunissen, C. E., Cummings, J., & van der Flier, W. M. (2021). Alzheimer's disease. *The Lancet, 397*(10284), 1577–1590. doi:10.1016/S0140-6736(20)32205-4

Sindhu, S., Maiti, S., & Nallaswamy, D. (2023). Factors affecting the accuracy of intraoral scanners: a systematic review. *Annals of Dental Specialty, 11*(1), 40–52. doi:10.51847/izu17ACVUd

Soman, C., Hawzah, A. A. A. A., Alsomali, M. A., Alghamdi, S. A. K., & AlOsaimi, M. M. (2024). Salivary specimen in COVID-19 testing for dental settings: a meta-analysis comparing saliva, nasopharyngeal, and serum specimens. *Annals of Dental Specialty, 12*(1), 33–47. doi:10.51847/LNn8bSwowj

Son, V. T., Ha, B. T., Anh, N. Q., Mai, N. P., Trang, D. T., Lu, L. D., Anh, N. T. N., & Tam, L. T. (2023). Impact of enterprise risk management on firm value during the instability context: Case of Vietnam. *Journal of Organizational Behavior Research, 8*(2), 236–250. doi:10.51847/x9nE6PL4i8

Tam, L. T., An, H. T. T., Linh, T. K., Nhung, L. T. H., Ha, T. N. V., Huy, P. Q., & Luc, P. T. (2022). Value co-creation activities of students on the COVID-19 pandemic: empirical evidence from economics students in Vietnam. *Journal of Organizational Behavior Research, 7*(2), 214–228. doi:10.51847/Nofw4ZK2wd

Teleanu, D. M., Niculescu, A. G., Lungu, I. I., Radu, C. I., Vladâcenco, O., Roza, E., Costăchescu, B., Grumezescu, A. M., & Teleanu, R. I. (2022). An overview of oxidative stress, neuroinflammation, and neurodegenerative diseases. *International Journal of Molecular Sciences, 23*(11), 5938. doi:10.3390/ijms23115938

Thazha, S. K., Cruz, J. P., Alquwez, N., Scaria, B., Rengan, S. S., & Almazan, J. U. (2023). Studying the attitude and knowledge of nursing students towards the physical restraint use in patients. *Journal of Integrative Nursing and Palliative Care, 4*, 1–5. doi:10.51847/cFz2ew4AK8

Tural, A., & Şahan, G. (2023). Awareness towards human rights and democracy education: a mixed-method research. *Journal of Organizational Behavior Research, 8*(2), 107–128. doi:10.51847/odg5gU1i7S

Uddin, R., Kim, H. H., Lee, J. H., & Park, S. U. (2013). Neuroprotective effects of medicinal plants. *EXCLI Journal, 12*, 541.

Upchezhokov, M. A., Avagyan, A. T., Bagomedova, D. M., Kurbanov, A. E., Kadyrov, E. R., Bremov, I. M., Agabekov, A. A., & Shidakova, L. Z. (2024). The impact of weather and climatic conditions on the dental health of military personnel. *Annals of Dental Specialty, 12*(4), 39–46. doi:10.51847/JBHRQlFtfR

Vegh, C., Wear, D., Okaj, I., Huggard, R., Culmone, L., Eren, S., Cohen, J., Rishi, A. K., & Pandey, S. (2021). Combined ubisol-Q10 and ashwagandha root extract targets multiple biochemical mechanisms and reduces neurodegeneration in a paraquat-induced rat model of Parkinson's disease. *Antioxidants, 10*(4), 563. doi:10.3390/antiox10040563

Zaky, M. Y., Mohamed, E. E., & Ahmed, O. M. (2025). Neurodegenerative disorders: available therapies and their limitations. In *Nanocarriers in neurodegenerative disorders* (pp. 29–46). CRC Press. doi:10.1201/9781003383376

Zangiabadi, I., Askaripour, M., Rajizadeh, M. A., Badreh, F., Bagheri, M. M., Jafari, E., Shamsara, A., Shafiei, G., & Rajabi, S. (2025). Conditioned medium from human adipose-derived mesenchymal stem cells attenuates cardiac

injury induced by Movento in male rats: role of oxidative stress and inflammation. *BMC Pharmacology and Toxicology, 26*(1), 13. doi:10.1016/j.neuroscience.2024.12.057

Zharashueva, E. B., Mirzayeva, A. K., Iakovleva, A. N., Dyshnieva, N. A., Dudurgova, A. T., Utovka, O. V., Strelchuk, S. V., & Dekkusheva, R. M. (2024). Sanitary and hygienic assessment of the dressing material modified with silver nanoparticles. *Journal of Advanced Pharmacy Education and Research, 14*(3), 9–14. doi:10.51847/J10C8y3UWQ