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Ethnopharmacology and neurodegenerative disorders: Bridging traditional knowledge and modern medicine

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Abstract
The rising prevalence of neurodegenerative disorders (NDs) necessitates innovative therapeutic approaches, and ethnopharmacology provides a promising link between traditional medicine and modern drug discovery. This paper examines how ethnopharmacological wisdom can be integrated with contemporary scientific methods to treat NDs like Alzheimer's, Parkinson's, and Huntington's diseases. Traditional practices, emphasizing holistic health and the use of natural substances, offer both symptomatic relief and insights into sustainable medicinal plant use. Modern ethnopharmacology has led to significant drug developments, such as aspirin and digoxin, showcasing its potential against NDs. However, challenges include validating the safety and efficacy of natural substances through clinical trials and addressing the limitations of current computational drug discovery methods. The paper advocates for a combined approach that honors traditional knowledge while leveraging advanced science to create effective ND treatments.

Keywords: Ethnopharmacology, neurodegenerative disorders, traditional medicine, drug discovery, medicinal plants

1. Introduction
The field of medical research is constantly evolving, and the integration of traditional knowledge and modern science has gained wide attention. Ethnopharmacology, a discipline within this realm, explores the healing potential of conventional remedies [1]. By carefully studying the pharmacological effects of natural substances, ethnopharmacologists create a vital link between ancient healing practices and modern healthcare. This interdisciplinary field respects the rich cultural heritage of healing traditions and uncovers new avenues for drug development. Through rigorous scientific investigation, ethnopharmacology preserves the valuable insights passed down through generations and uses them to address contemporary health challenges [1]. By bridging the chasm between bygone eras and the present, ethnopharmacology offers a comprehensive approach to appreciating and harnessing nature's healing essence, blending the wisdom of the past with the advancements of today to pave the way for a healthier future.

Neurodegenerative disorders are a wide range of conditions where specific cells in the brain and spine slowly stop working and die off [2]. These disorders can lead to issues like trouble with movement, problems with thinking, and difficulties with talking and breathing [3]. Unfortunately, these diseases cannot be cured and can greatly impact a person's quality of life. As the world's population ages, the number of people affected by neurodegenerative disorders is on the rise. Some of the most well-known neurodegenerative disorders include Alzheimer's disease, Parkinson's disease, Huntington's disease, and amyotrophic lateral sclerosis (ALS) [2]. Most neurodegenerative disorders result from a mix of genetic and environmental influences, with age being the primary known risk factor.

The study of ethnopharmacology has been vital in the discovery of new drugs by offering guidance on how natural substances can be used for healing purposes [4]. Medicinal plants have been a source of inspiration for developing drugs like aspirin, artemisinin, colchicine, digoxin, and ephedrine, showcasing the promise of ethnopharmacology in drug discovery [5]. Despite its benefits, the shift from traditional ethnopharmacology to drug discovery has presented obstacles that must be addressed.

It is imperative to conduct both laboratory and animal testing to confirm the effectiveness and safety of potential new medications [5]. From ancient healing practices to high-tech drug development, the journey of discovering new medicinal compounds has been truly remarkable [5]. Traditional ethnopharmacology laid the groundwork for harnessing the healing powers of natural substances, which have been utilized by diverse cultures for centuries. This transition to modern drug discovery has been smooth, thanks to advancements in isolating and analysing compounds, the rise of computational capabilities, and the emergence of specialized cheminformatics techniques. Despite advancements in exploring natural product chemicals, there has been a lack of progress in developing new drugs, highlighting the need to address the limitations of current computer-based drug discovery methods [5].

Traditional Knowledge in Ethnopharmacology:

Ethnopharmacology is a diverse scientific field that delves into the traditional wisdom and customs related to utilizing medicinal plants, animals, and other natural ingredients for healing reasons [6, 7]. It involves various research methods such as ethnobotanical surveys, pharmacological research, phytochemical analysis, and anthropological inquiries [7]. This area plays a vital role in drug exploration, as it has contributed to the creation of numerous medications, a majority of which are derived from or influenced by natural compounds found in medicinal plants.

In many cultures around the world, traditional medicine is highly important for managing and treating neurodegenerative disorders like Alzheimer's disease, Parkinson's disease, and Huntington's disease. Indigenous healing methods, based on generations of observation and testing, provide valuable information on how to deal with these conditions. Local healers, who are respected in their communities, have a deep understanding of native plants, herbs, and treatments that are known for being good for the brain [8].

In various societies, traditional medicine embraces holistic methods for maintaining health. It views neurodegenerative conditions as signs of imbalances in the body, mind, and spirit. These healing techniques involve lifestyle changes, dietary adjustments, herbal remedies, and spiritual ceremonies to bring back harmony and boost overall wellness [9]. Traditional medicine not only aids cognitive abilities and eases symptoms but also enhances the well-being of those suffering from neurodegenerative disorders [5].

Ethnopharmacological research usually starts with a botanist, ethnobotanist, ethnopharmacologist, or plant ecologist who gathers and identifies plants of interest [5]. This approach combines botany, chemistry, and pharmacology, with contributions from other disciplines. The goals of ethnopharmacology include preserving cultural heritage, studying traditional remedies, and exploring new therapeutic agents. It is not just a historical science, but a dynamic field embracing modern methods [5]. The research focuses on how different chemicals work together and the testing of how well certain substances bind to receptors. Taking a holistic approach to drug development, especially using natural remedies like medicinal plants with proven benefits, may be more successful [5]. It is crucial to conduct clinical trials to show the effectiveness of herbal medicines for treating various conditions.

The process of discovering herbal drugs from Indian traditional medicine involves various stages such as observing plants in the field, documenting the use and benefits of traditional remedies, identifying plants botanically, investigating their chemical and pharmacological properties, and assessing their effectiveness through clinical trials. Traditional medicine plays a vital role in healthcare, especially in regions where indigenous communities are prevalent in developing countries [9]. It is crucial for national and state health policies to acknowledge and collaborate with traditional healers to address disparities and shortages in resources for achieving Universal Health Coverage (UHC) [9].

Neurodegenerative disorders

Neurons are crucial for the human brain to work properly as they are key for communication [10, 11]. While most neurons start in the brain, they can be found throughout the body [12]. In childhood, neural stem cells generate most of the neurons, but their numbers decrease significantly in adulthood [13]. Although neurons are not everlasting, the gradual loss of neurons and their functions, as well as changes in neuron structure, known as neurodegeneration, are at the core of many brain disorders and are a significant health issue [14]. Neurodegeneration, characterized by issues with synapses, neural networks, and abnormal protein deposits in the brain, is linked to various diseases such as Alzheimer's, Parkinson's, prion disease, ALS, motor neuron disease, Huntington's, SMA, and spinocerebellar ataxia[Fig 1] [15-18]. These diseases, collectively referred to as NDs are known for their hallmark feature of neurodegeneration.

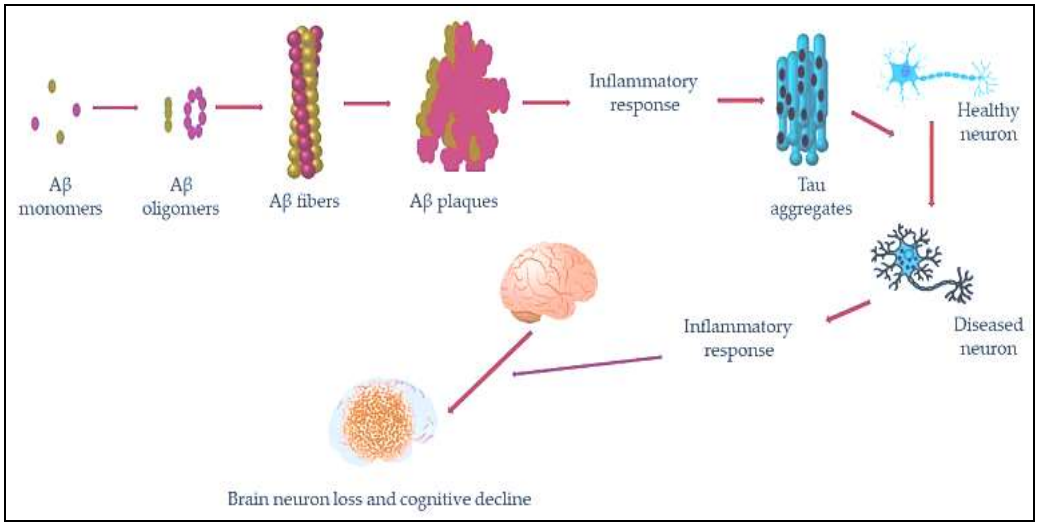

Fig 1: Path to cognitive decline in neurodegeneration. [19]

Neurodegenerative disorders impact numerous individuals around the world. While age is a significant risk factor for the development of these disorders, new research reveals that both genetics and environmental influences play a role in increasing the risk. Additionally, the progression and severity of neurodegeneration can be influenced by the individual's surroundings. Recent studies indicate that there may be multiple underlying pathologies associated with a single neurodegenerative disorder [20]. Thus, NDs have the potential to be extremely severe or, in some cases, life-threatening. The outcome is determined by the specific type and stage of the disease.

The brain has a significant impact on how the body functions, so neurodegenerative diseases can have a wide-ranging effect on human capabilities, making it difficult to perform simple tasks like speaking, moving, staying stable, and maintaining balance, as well as more complex activities such as controlling bladder and bowel functions, and cognitive skills. Many neurodegenerative diseases worsen over time without a break, although there are treatments available that aim to alleviate symptoms, reduce any pain that may be present, and restore balance and mobility. In the following sections, a brief overview of some common neurodegenerative diseases is discussed.

Alzheimer's disease (AD)

Alzheimer's disease is a degenerative brain condition that impairs memory, thought, and behavior. Recent research on Alzheimer's disease has revealed that the build-up of amyloid-beta (Aβ) and tau proteins plays a key role in the progression of the disease [21, 22]. The formation of Aβ-containing plaques in the brain, along with neurofibrillary tangles (NFTs) made up of hyperphosphorylated tau, is considered a hallmark of Alzheimer's disease [23]. These plaques disrupt the hippocampal circuitry, which in turn affects the conversion of short-term memories into long-term ones [24]. Alzheimer's disease (AD) causes significant neuronal loss, disrupted synaptic connections, and harm to neurotransmitter systems crucial for brain function and memory. Consequently, early-stage AD commonly presents as memory problems, particularly selective memory impairment. In addition, hippocampal and medial temporal lobe functions related to declarative episodic memory are frequently impacted. Executive function deficits, impaired judgment, and problem-solving difficulties are also common symptoms that typically emerge early on in the disease progression [19].

Parkinson's Disease (PD)

Parkinson's disease is a neurological disorder that progresses over time, resulting in tremors, muscle stiffness, an unsteady gait, and difficulties with balance and coordination. Both genetic and non-genetic factors can contribute to the development of Parkinson's disease. Aging is a major risk factor for the disease [25]. Other factors, including high caffeine consumption, smoking, and exposure to toxins, may also influence the risk of developing Parkinson's disease [26], although the exact mechanism is not fully understood. The pathophysiology of Parkinson's disease involves atrophy of the frontal cortex and enlargement of the ventricles. The most noticeable change in the brain of individuals with Parkinson's disease is the loss of pigmentation in specific regions like the locus coeruleus and substantia nigra pars compacta (SNpc). This loss is due to the death of dopaminergic (DA) neurons containing neuromelanin [27]. This cell loss disrupts the nigrostriatal pathway, leading to a decrease in dopamine levels in the striatum and resulting in the characteristic motor symptoms of Parkinson's disease [27]. Additionally, cell loss in various other brain regions contributes to the non-motor symptoms of Parkinson's disease, such as the nucleus basalis of Meynert, the raphe nuclei, the locus coeruleus, the pedunculopontine nucleus, the dorsal motor nucleus of the vagus nerve, the hypothalamus, and the olfactory bulb [28].

Researchers have discovered several factors that are important in the progression of Parkinson's disease, such as α-synuclein misfolding and clumping, issues with mitochondria, problems with clearing out proteins, the ubiquitin-proteasome and autophagy-lysosome systems, and inflammation in the brain [27, 29].

Huntington's disease (HD)

Huntington's disease (HD) is a genetic disorder that is passed down from one generation to the next. It is caused by the expansion of CAG repeats on chromosome 4p16.3 in the Huntingtin gene [30]. This condition is known for causing involuntary movements, cognitive issues, and a decline in motor function. HD is a progressive brain disorder that affects movement, mood, and cognitive abilities.

The gene responsible for Huntington's disease (HD) produces a protein known as huntingtin, the exact role of which is still not completely understood [31]. However, when this huntingtin protein is faulty, it triggers changes in the brain that result in involuntary movements, cognitive decline, and emotional disturbances like irritability, depression, and mood swings [31]. The main indicator of HD is uncontrollable movement in various parts of the body such as the arms, legs, head, face, and torso.

As of now, there is no known cure for Huntington's disease (HD). The focus of treatments is on enhancing the patient's quality of life and reducing complications. Treatment choices consist of using medications to address symptoms like movement issues, mental health issues, and cognitive decline. Additionally, physical therapy, occupational therapy, and speech therapy are beneficial in managing symptoms and enhancing the individual's functional capabilities.

Multiple Sclerosis (MS)

Multiple Sclerosis, also known as MS, is a long-term autoimmune condition that impacts the central nervous system and can result in various symptoms like tiredness, weakened muscles, and a decline in cognitive function [32, 33]. The disorder involves inflammation, loss of the protective covering of nerve fibers (demyelination), and damage to nerve cells in the central nervous system, potentially causing significant neurological issues [33].

Unfortunately, there is currently no cure for Multiple Sclerosis (MS). The focus of treatment is on controlling symptoms and halting the progression of the disease. The wide range of symptoms and the necessity of developing more specific treatments tailored to individuals based on genetic testing present major obstacles in the management of MS [32, 33].

Amyotrophic lateral sclerosis (ALS)

Amyotrophic Lateral Sclerosis (ALS) is a progressive neurological disorder that affects the nerve cells and spinal cord, resulting in muscle weakness and paralysis [34, 35]. In ALS, motor neurons gradually degenerate and die [36]. As these neurons become destroyed or die, signals that should be transmitted from the brain can no longer reach their target. While over 30 different genes have been associated with ALS,

mutations in just four main genes (C9orf72, TARDBP, SOD1, and FUS) are responsible for over 70% of ALS cases [36]. These genes encode proteins implicated centrally in motor neuron function, acting to maintain homeostasis, repair DNA, function within the mitochondria, and support glial cell function. Defects in each of these functions are proposed to combine in the decline of the motor neurons that characterize ALS. The other feature of ALS is the intracellular aggregation of proteins in neurons. The one commonly used to characterize ALS patients is the TAR DNA binding protein, though others include superoxide dismutase 1 and neurofilament that clump together [37]. It remains unclear, though, a question of which comes first: protein aggregates or complexes and neuronal damage, or vice versa.

Challenges in current treatment options

Neurodegenerative diseases represent types of disorders specifically affecting the central nervous system, characterized by progressive neuronal degenerations of choice origin, leading to loss of cognitive and motor functions. The major pathologies that have been observed in these diseases include oxidative damage, neuroinflammation, and mitochondrial dysfunction [38]. To date, there is no medication available to target neuroinflammation caused by ALS, but genetic research and technological advances are revolutionizing our understanding of neurodegenerative diseases and how we treat them. Genetic information can be gained from different kinds of genetic analysis, from the study of the whole genome down to the study of specific sequences. This search for genetic factors allows an in-depth understanding of neurological disorders that, in turn, may result in advanced treatments in the future, achieving better outcomes for patients [Table 1] [38].

Table 1: The current approachess for addressing neurodegenerative diseases. [19]

Neurological Disorder	Drug Class	Mechanism	Drugs
Alzheimer disease	Amyloid-directed antibody	Acts by targeting and removing amyloid-beta plaques	Aducanumab
	Cholinesterase Inhibitors	Prevent the knockdown of acetylcholine	Donepezil, rivastigmine, galantamine
	Glutamate regulators	Antagonize N-methyl-D-aspartate (NMDA) receptor to improve signal- to-noise ratio of glutamatergic transmission	Memantine
Parkinson disease	Dopamine supplements	Replenish the decreased dopamine levels	Levodopa
	Decarboxylase inhibitors	Prevent peripheral breakdown of levodopa	Carbidopa
	Dopamine agonist	Produces dopamine-like effects	Apomorphine hydrochloride, pergolide, pramipexole dihydrochloride, ropinirole hydrochloride, rotigotine
Amyotrophic Lateral Sclerosis	Glutamate-receptor antagonist	Inhibits glutamate receptors	Riluzole
	Free-radical scavenger	Scavanges free radicals	Edaravone

One major challenge in the development of treatments for neurodegenerative disorders is their complexity. Each disorder produces its typical symptoms and obscure disease processes, which remain poorly understood [39]. For example, Alzheimer's disease results from the buildup of beta-amyloid plaques and tau tangles within the brain, whereas Parkinson's disease emanates from the degeneration of dopamine-producing neurons in the substantia nigra of the CNS. Such complexity makes it challenging to converge onto the successful treatments targeting the root causes of neurodegeneration [40].

Treatment of neurodegenerative disorders is particularly challenging because their pathophysiology is still not well understood. Despite extensive research in this field, the causes of neurodegeneration are still largely unknown. For example, the causes of Alzheimer's disease or the selective neuronal death occurring in Parkinson's disease are yet not known. This ignorance significantly impedes the development of specific therapies to stop or slow down the progression of these diseases [40].

One major challenge in treating neurodegenerative disorders is the lack of dependable biomarkers for tracking disease progression. Biomarkers are key indicators that can help monitor how a disease is evolving and assess the success of treatments. Unfortunately, reliable biomarkers are still missing for most neurodegenerative disorders, making it tough to assess progression and treatment outcomes. This hurdle can slow down the advancement of effective therapies [40].

One of the main challenges in managing neurodegenerative disorders is the general lack of reliable disease progression biomarkers. Biomarkers are important indicators, which would give a clear perception about the course of a disease, and by inference, become an index for the eventual success of treatments. Unfortunately, reliable biomarkers remain relatively absent in most neurodegenerative disorders, and such assessment of progression and treatment outcomes remains challenging. This can be very retarding in credibly developing therapies [40].

One major challenge to treating neurodegenerative disorders is the very high cost of disease-modifying medications; regimens are beyond the reach of large numbers of patients. Many, unable to afford treatment, delay starting therapy and therefore have worse outcomes. In addition, the large cost to such medications places pressure on the health systems, reducing access to all patients [40].

Table 2: some of the challenges in current treatment options for neurodegenerative disorders

Challenges	Description
Limited Efficacy	Most treatments in use today have very minimal effectiveness to halt or reverse the progress of a neurodegenerative disease.
Disease Heterogeneity	This variability in the individual often results from different cases of neurodegenerative diseases, which complicate the possibility of a generalized treatment procedure.
Blood-Brain Barrier	This can complicate drug delivery into the brain for neurodegenerative conditions because of the restriction imposed by the blood-brain barrier.
Side Effects	Most medications that are used to treat neurodegenerative disorders have very significant side effects, which impinge on patient compliance and quality of life.
Disease Modification VS. Symptomatic Relief	It is difficult, however, to weigh treatments that alter the underlying disease process against those that alleviate symptoms.
Early Diagnosis	An early diagnosis is essential in effectual treatment but somewhere, many difficulties in the proper diagnosis of neurodegenerative diseases at an early stage.
Cost and Accessibility	Some treatments are too expensive, and in some cases and populations, the access to health care resources may be low.
Lack of Disease-Modifying Therapies	There is a high requirement for therapies that will change the course of a neurodegenerative disease and not just treat its symptoms.
Patient Variability	Responses to medication may be so variable that it becomes difficult to know how an individual shall react due to genetic, environmental, and other interacting causes, thus further straining treatment strategies.
Comorbidities and Complications	Comorbidities often interlink with neurodegenerative conditions and are thus complicated to treat, exacerbating their symptoms.

The challenges identified in Table 2, require constant research, innovation, and cooperation from the healthcare providers, patients, and the pharmaceutical industry. The researchers are exploring new ways of understanding the mechanisms of the diseases, defining markers of disease progression, and treatments that modify the course of the disease. Scientists are investigating various gene therapy, stem cell therapy, and other kinds of immunotherapy to treat neurodegenerative diseases. With regard to the development of effective treatments, there is a need for collaboration between healthcare professionals, patients, and the pharmaceutical industry.

Bridging traditional knowledge with modern medicine

Neurodegenerative diseases, like Alzheimer's and Parkinson's disease, are a significant factor in public health due to the fact that they involve the progressive loss of structure and function of neurons in the brain and spinal cord [41]. Original chemical diversity makes phytochemicals potentially very useful compounds for developing new neuroprotective drugs for the treatment of neurodegenerative diseases [41]. This article gives further examples of successful applications of traditional remedies in the treatment of neurodegenerative disorders and describes mechanisms in detail that underlie the neuroprotective effects of these herbal extracts.

Case Studies of Successful Integration

The *in vitro* study on *Centella asiatica* (L.) urban has proven its potential to be a modern medicine with neuroprotective properties. This herb used traditionally for medicine showed significant improvement in memory and learning in the animal models of AD [42]. The results show that the extracts from *Centella asiatica* may provide potential treatment for neurodegenerative diseases, mainly AD. This conventional remedy should, therefore, be utilized to improve cognitive functions and presumably delay neurodegenerative diseases.

The neuroprotective potential of *Centella asiatica*, Gotu Kola, has been utilized for centuries in folk medicine. Recent studies have shown that *Centella asiatica* extracts have the potential for improving memory and learning in several animal AD models, suggesting its possible therapeutic potential against neurodegenerative disorders [42]. Other mechanisms by which Centella asiatica extracts exert a positive effect on AD include the inhibition of the acetylcholinesterase enzyme responsible for degrading the neurotransmitter acetylcholine, consequently improving the cognitive function in AD [42]. Moreover, extracts from *Centella asiatica* have antioxidant activity and might scavenge free radicals that cause oxidative damage to neurons in neurodegenerative processes.

Another study, this time devoted to the health advantages of the iconic plants, like *Ginkgo polygonatum*, Chuanxiong, and the other Lycium species, found in traditional Chinese medicine, the one that has been traditionally used to treat Alzheimer's disease. The study showed that the mentioned herbs might relieve Alzheimer's disease because of the superior modules it creates in the resistor state of the two neurotransmitters (glutamatergic and cholinergic), removing plaques and neuron fibrils that stabilize memory functions in mice [41]. These results underscore the potential of traditional Chinese herbs in managing neurodegenerative disorders.

Ginkgo biloba also known as Maidenhair Tree, is an ancient Chinese remedy known for its neuroprotective properties. The study demonstrates that combining the Ginkgo biloba medicinal tablets with the use of aspirin can boost mental abilities in people with Alzheimer's disease [42]. Further, *Ginkgo biloba* extracts have been discovered to be helpful in cognitive function in the case of mild cognitive impairment [42]. *Lycium barbarum*, Goji Berry, is a classic neuroprotective Chinese herb. Extracts from *Lycium barbarum* have been shown to improve cognition in the animal models of AD and reduce Aβ and tau lesions while improving memory in animals [41].

Traditional Chinese herbs applied in treating neurodegenerative diseases have yielded encouraging results. These herbs demonstrated the promotion of glutamatergic and cholinergic neuron survival and functions, the clearance of Aβ and tau lesions, and the improvement of memory in animal models of AD [41]. Moreover, these herbs are strong antioxidants and anti-inflammatory chemicals that protect neurons against oxidative stress and inflammation, two major processes involved in neurodegenerative diseases [41].

Mechanistic insights into traditional remedies for neuroprotection

Centella asiatica, *Ginkgo polygonatum*, Chuanxiong, and *Lycium barbarum* are some of the traditional herbal remedies

that have proved to have neuroprotective effects through various mechanisms. *Centella asiatica*, or Gotu Kola, is a potential acetylcholinesterase inhibitor of the enzyme that breaks down acetylcholine, one of these neurotransmitters critical to cognitive function. By blocking this enzyme, extracts of *Centella asiatica* can improve cognitive function under several conditions, including in the neurodegenerative process of Alzheimer's disease [41]. Moreover, the significant antioxidant activity of *Centella asiatica* helps protect neurons against oxidative stress, which is one of the factors contributing to their death in neurodegenerative diseases [41].

On the other hand, traditional Chinese herbs like *Ginkgo polygonatum*, Chuanxiong, and *Lycium barbarum* have been found to have neuroprotective properties [43]. These herbs enhance the survival and function of crucial neurons responsible for cognitive function, such as glutamatergic and cholinergic neurons. By supporting the survival and function of these neurons, these herbs can potentially improve cognitive outcomes in neurodegenerative disorders like Alzheimer's disease (AD) [44]. Furthermore, studies have shown that these herbs can eliminate Aβ and tau lesions, which are key features of AD pathology, highlighting their potential in treating neurodegenerative diseases [44].

The use of traditional remedies such as *Centella asiatica*, *Ginkgo polygonatum*, Chuanxiong, and *Lycium barbarum* has been found to have multiple neuroprotective benefits. These remedies work through various mechanisms that help improve cognitive function, promote neuronal survival, and address the underlying causes of neurodegenerative disorders. By targeting important pathways related to brain health, these natural treatments provide a comprehensive approach to protecting the brain and potentially treating conditions like Alzheimer's disease.

The ability of *Centella asiatica* to block acetylcholinesterase is important in Alzheimer's disease (AD) because the reduction of acetylcholine causes cognitive decline. *Centella asiatica* extracts can help keep cognitive function intact and potentially delay the advancement of AD by maintaining acetylcholine levels. Additionally, *Centella asiatica*'s antioxidant characteristics are essential for shielding neurons from oxidative harm, a common occurrence in neurodegenerative disorders.

Herbs like *Ginkgo polygonatum*, Chuanxiong, and *Lycium barbarum* are important for supporting cognitive function by enhancing the survival and function of glutamatergic and cholinergic neurons. These herbs can improve cognitive outcomes in neurodegenerative disorders by eliminating Aβ and tau lesions, characteristic features of Alzheimer's disease. Their potential as therapeutic agents for neurodegenerative diseases are further highlighted by these effects.

In general, the scientific understanding of how traditional remedies such as *Centella asiatica*, *Ginkgo polygonatum*, Chuanxiong, and *Lycium barbarum* work indicates that they have beneficial effects on the brain by inhibiting acetylcholinesterase, acting as antioxidants, supporting important types of brain cells, and reducing key characteristics of neurodegenerative diseases. These discoveries underscore the promise of traditional remedies for offering comprehensive and multi-faceted strategies for protecting the brain and treating conditions like Alzheimer's disease. It is crucial to conduct more research on the molecular mechanisms and effectiveness of traditional remedies in order to fully utilize their therapeutic benefits for treating neurodegenerative disorders.

Future Perspectives and Challenges

The future perspectives and challenges in ethnopharmacology as well as Neurogenerative Disorders involve combining traditional knowledge with modern medicine. Moreover, since cases of neurodegeneration are on the rise notably; much emphasis needs to be put on coming up with more effective tools together with new therapeutic methodologies [40]. Although great hopes lie in traditional medicines and phytochemicals serving as rich sources to develop innovative drugs for neurodegenerative diseases, complex mixtures of their constituents, indeterminate molecular mechanisms and convoluted clinical benefits have been hindering research progress [41]. In speeding up drug discovery and mechanism elucidation, interdisciplinary actions have yielded significant success especially through complete employment of silico approaches and wet-lab assays [41].

There is potential usage of derived neuroprotective agents from plants and their bioactive compounds which are natural products in treating neurodegenerative disorders [45]. These natural products have been extensively studied and analyzed based on physiological processes, nutritional values as well as biomedical properties with an emphasis on health benefits as well as their medical uses. Nonetheless, the use of these substances in practice still triggers some concerns documented in the form of clinical questions mainly focusing on their effectiveness, safety, and lack of proof based on science [45].

Targeting a person's genetic profile and environmental effects makes personalized medicines a long-term aspiration for this sector and will be instrumental in the design of new clinical trials and pre-clinical laboratory studies [40]. In other words, combining anti-inflammatory drugs and tau-directed agents for Alzheimer's disease is also another area that needs more studies.

Stem cell treatments have shown promise for curing neurodegenerative diseases such as Alzheimer's and Parkinson's, particularly in the use of induced pluripotent stem cells (iPSCs). By taking skin biopsies from patients living with neurodegenerative illnesses so that they can get fibroblasts, researchers would be able to investigate the underlying mechanisms as well as the progression of diseases at the patient-specific level and then recommend individually customized therapies for change [40].

In order to truly understand how diseases work, it's critical to have good model systems. In spite of their usefulness, cell culture and computer simulations might not always approximate the intricacies of human disease [46]. Beyond that, among the most problematic obstacles in treating neurodegenerative diseases is the development of drug molecules that can pass through the blood-brain barrier, and nanosystems seem to offer a solution by enabling site-specific drug delivery to the brain while also improving pharmacokinetics for some classes of neuroactive agents [47].

Conclusion

Ethnopharmacology is one of the most promising perspectives on finding new ways to treat neurodegenerative diseases by joining ancient knowledge with modern scientific methods. In this respect, scientists have a possibility to find some bioactive compounds which may be beneficial for our nervous system, just due to the well-regulated examination of the indigenous medicative flora and non-traditional curative means. It is, therefore, the goal of ethnopharmacological studies to create treatments for such illnesses as Alzheimer's disease and Parkinson's that are at least as good as those

currently available but safer and more efficient by bringing together centuries-old treatment practices and innovations.

This multidisciplinary approach has quite potential value in dealing with the intricate etiology of neurodegenerative conditions. Many commonly used pharmacological agents for treating such disorders are composed of a variety of phytochemicals that exert diverse modes of action on neuronal processes, inflammation, and other oxidative stressors, as well as other pathways associated with the development and/or progression of neurodegeneration. Further, scientists would be able to obtain valuable knowledge on how different cultures use such plants medicinally by working together with local tribes, hence promoting ethics and sustainability in creating modern medicine.

If neurodegenerative research is to realize its potential, it needs to engage with a number of issues, including standardization and validation of efficacy, as well as intellectual property rights within ethnopharmacology. However, such integration of modern medicine with conventional knowledge gives hope for a better understanding and treatment of neurodegenerative illnesses by promising even better outcomes for patients in times ahead, notwithstanding such obstacles.

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