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SHORT REVIEW

Exploring the Neuroprotective Potential of Functional Mushrooms: A Comprehensive Review

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Abstract

Neurodegenerative diseases such as Alzheimer's, Parkinson's, and stroke continue to challenge global healthcare with limited therapeutic options. Functional mushrooms, especially *Hericium erinaceus* (Lion's Mane), *Ganoderma lucidum* (Reishi), *Cordyceps sinensis*, and *Inonotus obliquus* (Chaga), have shown promising neuroprotective properties. These benefits are linked to their antioxidant, anti-inflammatory, and neurotrophic effects and their support of mitochondrial health and gut-brain axis regulation. Evidence from preclinical studies highlights their ability to reduce oxidative stress, modulate microglial activity, and support synaptic function. Emerging clinical data also suggest improvements in cognition. However, issues like poor bioavailability, lack of standardised formulations, and limited large-scale trials remain barriers. Future research, including nanotechnology-based delivery and synergistic formulations, may unlock their full potential in neurodegenerative therapy and drug development.

Major Findings: Functional mushrooms like Lion's Mane, Reishi, Cordyceps, and Chaga exhibit neuroprotective effects through antioxidant, anti-inflammatory, and neurotrophic actions targeting cellular pathways such as Nrf2/ARE and microglial modulation. Advanced delivery systems and synergistic use with compounds like curcumin and resveratrol enhance their therapeutic potential.

Keywords: Alzheimer's Disease, Functional Mushrooms, Multiple Cognitive Enhancement, Neurodegenerative Disorders, Neuroprotection, Parkinson's Disease

1. Introduction

Neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's disease pose a growing global health challenge. The conditions feature neuron structure and functional decline that develop into cognitive and motor function deficits. Available treatments provide only mild relief to patients since they focus mainly on symptom control instead of attacking the source of neurodegeneration. As a result, there has been increasing interest in exploring natural compounds with neuroprotective properties, aiming to develop safer and more effective therapies. Functional mushrooms have emerged as promising candidates due to their rich composition of bioactive compounds and centuries-long use in traditional medicine[1].

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In recent years, the search for natural neuroprotective agents has intensified, driven by the growing awareness of the limitations and side effects associated with conventional pharmaceuticals. Neurodegeneration treatment now focuses on natural compounds obtained from plants and fungi because these compounds attack several targets at once. The scientific community directs its search into identifying bioactive compounds which hold the capacity to control oxidative stress and decrease inflammation rates, and keep neurons alive. Among these natural agents, functional mushrooms have garnered attention for their unique chemical composition, which holds potential for preventing and slowing the progression of neurodegenerative disorders[2].

Functional mushrooms refer to species that provide health benefits beyond basic nutrition, thanks to their diverse array of bioactive compounds. Key mushrooms of interest in neuroprotection include Lion's Mane (*Hericium erinaceus*), Reishi (*Ganoderma lucidum*), Cordyceps (*Cordyceps sinensis*), and Chaga (*Inonotus obliquus*). The mushrooms contain polysaccharides together with triterpenoids and ergothioneine, and antioxidants that display capabilities for diminishing neuroinflammation while facilitating nerve regeneration and protecting brain cells from oxidative stress. Lion's Mane mushroom stimulates the synthesis of Nerve Growth Factor (NGF), which plays an essential role in the growth and survival of neurons. Meanwhile, Reishi's triterpenoids exhibit anti-inflammatory and antioxidant properties, making it a strong candidate for combating neurodegenerative processes[3].

Neurodegenerative diseases share several pathological mechanisms, including protein misfolding, mitochondrial dysfunction, excitotoxicity, and neuroinflammation. One of the primary drivers of neuronal damage is oxidative stress, where an imbalance between free radicals and antioxidants leads to cellular injury. Neurons exist under ongoing metabolic pressure because they possess inadequate antioxidant defences, which leaves these brain cells at risk from oxidative damage. The damaging effect of oxidative stress amplifies inflammatory responses while promoting poisonous protein aggregation that speeds up brain deterioration. Functional mushrooms, with their rich antioxidant profile, hold promise in mitigating these damaging processes by scavenging free radicals, modulating inflammatory responses, and promoting cellular repair mechanisms[4].

2. Molecular Mechanisms of Neuroprotection in Functional Mushrooms

2.1 Antioxidant Pathways

Functional mushrooms are rich in polyphenols, flavonoids, and terpenoids, which play crucial roles in neutralising free radicals and reducing oxidative stress. One key pathway involved is the Nrf2/ARE signalling pathway. Nrf2 (Nuclear factor erythroid 2-related factor 2) severs its binding with the inhibitor because of oxidative stress, then goes into the nucleus to activate response elements known as Antioxidant Response Elements (AREs). When activated under oxidative stress conditions both Superoxide Dismutase (SOD) and glutathione peroxidase enzymes become expressed to defend neurons from oxidative damage[5].

2.2 Anti-Inflammatory Mechanisms

Neuroinflammation is a hallmark of neurodegenerative diseases. Functional mushrooms modulate microglial activation, shifting the balance from the pro-inflammatory M1 phenotype to the anti-inflammatory M2 phenotype. Neuroinflammation and neural damage are reduced when communities activate these cytokines to stop the release of TNF-α, IL-6 and IL-1β[6].

2.3 Neurotrophic Support and Synaptic Plasticity

Compounds in mushrooms, particularly hericenones and erinacines from Lion's Mane, stimulate the production of NGF and Brain-Derived Neurotrophic Factor (BDNF). Neurotrophic substances enable both neural repair processes and cell survival functions, and growth operations. Neurotrophins lead to synaptogenesis, which powers the development of synaptic plasticity and strengthens learning as well as memory processes[7].

2.4 Mitochondrial Function and Bioenergetics

Mitochondria are vital for energy production and cellular health. Functional mushrooms enhance Adenosine Triphosphate (ATP) production and

Table 1. Key molecular mechanisms of neuroprotection in functional mushrooms

Mechanism	Key Processes	Main Compounds	Neuroprotective Effects
Antioxidant Pathways	Reduces oxidative stress by scavenging free radicals and activating Nrf2/ARE signalling.	Polyphenols, Flavonoids, Terpenoids	Protects cells from oxidative damage.
Anti-Inflammatory Mechanisms	Lowers inflammation by modulating microglia and reducing cytokines like TNF-α, IL-6, and IL-1β.	Triterpenes, Polysaccharides, β-glucans	Reduces neuroinflammation and prevents cell damage.
Neurotrophic Support	Boosts NGF and BDNF, enhancing neuron growth and synaptic connections.	Erinacines, Hericenones	Promotes brain plasticity, learning, and memory.
Mitochondrial Function	Improves energy production and reduces mitochondrial dysfunction.	Cordycepin, Adenosine	Supports energy metabolism and protects mitochondria.
Gut-Brain Axis Modulation	Balances gut microbiota, reducing gut-driven inflammation.	Polysaccharides, β-glucans	Maintains brain health and reduces inflammation.

promote mitochondrial biogenesis, ensuring energy supply for neurons. The neuroprotective mechanisms of these compounds include their ability to prevent mitochondrial dysfunction through their antioxidant properties and their protective actions on mitochondrial membranes, as well as the prevention of apoptotic factor release for treating neurodegenerative disorders effectively[8].

2.5 Modulation of Gut-brain Axis and Microbiome

The gut-brain axis plays a significant role in maintaining brain health. Mushroom-derived polysaccharides positively influence gut microbiota composition, promoting beneficial bacteria that produce Short-Chain Fatty Acids (SCFAs)[9]. The SCFAs decrease body-wide inflammation while controlling brain equilibrium through neuroinflammatory management, leading to protective brain results (Table 1).

3. Functional Mushrooms with Neuroprotective Potential

3.1 Lion's Mane *(Hericium erinaceus)*

Lion's Mane is renowned for its neuroprotective properties, largely attributed to its bioactive compounds, erinacines and hericenones. These compounds stimulate the production of NGF, which is essential for the survival and growth of neurons. Lion's Mane demonstrates significant potential for Alzheimer's disease therapy because it stimulates NGF production to generate new cells and strengthens synaptic connections while helping neurons heal from damage[10]. Clinical studies have shown that Lion's Mane supplementation can improve cognitive function, memory, and concentration, particularly in older adults experiencing mild cognitive impairment (Figure 1).

3.2 Reishi *(Ganoderma lucidum)*

Reishi contains potent triterpenes and polysaccharides that help modulate the immune system and reduce neuroinflammation. These compounds inhibit the activation of microglial cells and downregulate pro-inflammatory cytokines, protecting neurons from



Figure 1. Lion's mane *(Hericium erinaceus).*



Figure 2. Reishi *(Ganoderma lucidum)*.



Figure 3. Cordyceps *(Cordyceps sinensis)*.

chronic inflammation-driven damage. Scientific studies indicate that Reishi shows potential for treating neuropsychiatric conditions, which include stress, together with depression and anxiety disorders[11]. The adaptogenic benefits of this substance work to control the Hypothalamic-Pituitary-Adrenal (HPA) axis, which maintains appropriate stress responses as well as supports emotional stability (Figure 2).

3.3 Cordyceps *(Cordyceps sinensis)*

Cordyceps is rich in cordycepin and adenosine, which play crucial roles in neural energy metabolism. These compounds enhance ATP production, ensuring neurons receive sufficient energy to maintain their function and resilience. Cordyceps protects brain tissue from harm resulting from both neurotoxic substances and limited blood supply within the brain through its stress-reducing effects on cells while conserving mitochondrial functionality[12]. Scientific research using animal subjects has discovered that Cordyceps can protect brain tissue from ischemic damage, thus demonstrating potential as a stroke and other ischemic conditions treatment agent (Figure 3).

3.4 Chaga *(Inonotus obliquus)*

Chaga mushrooms contain betulinic acid and melanin, which are powerful antioxidants that combat oxidative stress and protect neurons from free radical damage. Additionally, Chaga supports neurovascular integrity by enhancing blood flow to the brain and strengthening the Blood-Brain Barrier (BBB)[13]. A strong and functional BBB functions to shield brain tissue from harmful substances and invaders, which protects brain health while decreasing the probability of neurodegenerative disease development (Table 2 and Figure 4).



Figure 4. Chaga *(Inonotus obliquus)*.

Table 2. Functional mushrooms with neuroprotective potential

Mushroom	Key Bioactive Compounds	Neuroprotective Actions	Potential Applications
Lion's Mane (*Hericium erinaceus*)	Erinacines, Hericenones	Promotes neurogenesis, enhances NGF production, supports cognitive function	Cognitive enhancement and memory improvement
Reishi (*Ganoderma lucidum*)	Triterpenes, Polysaccharides	Reduces neuroinflammation, modulates stress response, and offers antioxidant support.	Stress, anxiety, and neuropsychiatric disorders
Cordyceps (*Cordyceps sinensis*)	Cordycepin, Adenosine	Enhances neural energy metabolism, protects against ischemic injury, and reduces neurotoxicity	Neuroprotection in ischemia and energy regulation
Chaga (*Inonotus obliquus*)	Betulinic Acid, Melanin	Defends against oxidative stress, protects neurovascular integrity, supports BBB function	Oxidative stress reduction and vascular health

4. Advanced Preclinical and Clinical Evidence

4.1 Cellular Studies: Neuroprotection in Primary Neuronal Cultures

Cellular studies using primary neuronal cultures provide a controlled environment to understand the direct effects of functional mushrooms on neurons. *In vitro* studies have shown that bioactive compounds such as erinacines from Lion's Mane and triterpenes from Reishi can enhance neuronal survival by reducing oxidative stress and inhibiting apoptosis. The compounds help activate neurite development processes while simultaneously supporting increased neural network connections and tissue restoration between neurons[14]. Laboratory results indicate that mushroom extracts affect Nrf2/ARE signalling pathways to upscale antioxidant enzyme production, thus ensuring protection for neurons against oxidative damage.

4.2 Animal Models: Effects in Alzheimer's, Parkinson's, and Stroke Models

In vivo studies using animal models of Alzheimer's disease have demonstrated that Lion's Mane can improve memory and learning by increasing NGF levels, reducing amyloid-β plaque deposition, and mitigating synaptic degeneration. Similarly, Reishi's anti-inflammatory properties have been shown to reduce microglial activation and suppress the production of pro-inflammatory cytokines, thereby slowing the progression of Parkinson's disease in rodent models[15]. The experimental stroke research shows that Cordyceps reduces infarct damage size and strengthens tissue recovery through its capacity to boost mitochondrial performance and ATP synthesis, which protects brain cells from ischemic damage.

4.3 Clinical Trials: Human Cognition, Memory, and Neurological Function Outcomes

Clinical evidence, though still emerging, highlights the potential of functional mushrooms in enhancing cognitive performance and protecting against neurodegeneration. Human trials involving Lion's Mane have reported improvements in cognitive function, memory, and focus in elderly individuals with mild cognitive impairment. Participants consuming Lion's Mane extract showed significant enhancements in recall abilities and mental clarity over several months of supplementation[16]. Reishi has been studied for its adaptogenic effects, helping reduce stress and anxiety while improving sleep quality, factors that indirectly support neurological health. Large-scale medical studies must begin to determine universal medication amounts and extended-duration safety tests (Figure 5).

5. Potential for Treating Neurodegenerative and Neurological Disorders

5.1 Alzheimer's Disease: Amyloid-β Clearance and Tau Protein Modulation

Medical applications have been discovered for functional mushrooms because they effectively

treat Alzheimer's Disease (AD) pathological features, including amyloid-β plaque accumulation and tau protein hyperphosphorylation. Research indicates that Lion's Mane (*Hericium erinaceus*) contains erinacines and hericenones compounds which activate NGF synthesis and strengthen neurologic survival while improving synaptic connections[17]. Additionally, these bioactives can upregulate autophagy, facilitating

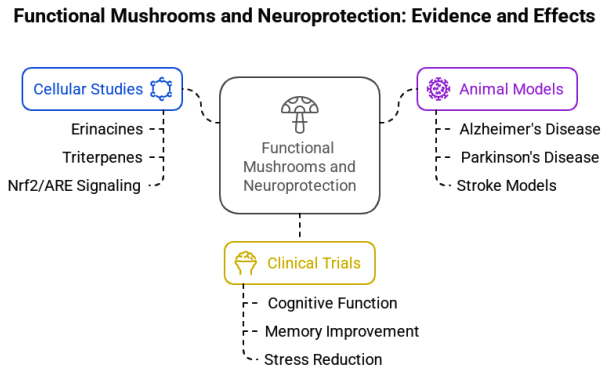


Figure 5. Functional mushrooms and neuroprotection: evidence and effects.

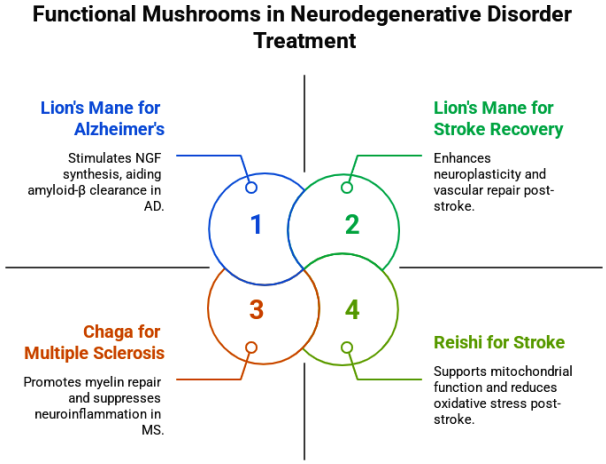


Figure 6. Functional mushrooms in neurodegenerative disorder treatment.

the clearance of amyloid-β plaques and reducing oxidative stress. Some studies suggest that mushroom polysaccharides can modulate tau protein aggregation, preventing the formation of neurofibrillary tangles - a critical contributor to cognitive decline in AD.

5.2 Parkinson's Disease: Dopaminergic Neuron Preservation and α-Synuclein Aggregation Prevention

The clinical loss of dopaminergic neurons in the substantia nigra throughout Parkinson's Disease (PD) results in motor dysfunction together with other symptoms. Functional mushrooms Reishi (*Ganoderma lucidum*) and Cordyceps (*Cordyceps sinensis*) protect neurons because they limit dopaminergic cell death and reduce oxidative stress damage in these cells. Active compounds like triterpenes and cordycepin can suppress α-synuclein aggregation, which is a key pathological feature of PD[18]. Furthermore, mushroom extracts have been found to modulate mitochondrial function, enhancing cellular energy production and reducing the vulnerability of dopaminergic neurons to oxidative stress.

5.3 Multiple Sclerosis: Myelin Repair and Neuroinflammation Suppression

Multiple Sclerosis (MS) features as an inflammatory disorder that destroys nerve myelin while causing long-term inflammation in the central nervous system. The myelin repair process benefits from functional mushroom polysaccharides and betulinic acid content, particularly found in Chaga mushrooms. Moreover, these bioactive compounds can suppress the production of pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β, reducing neuroinflammation. Reishi's immunomodulatory properties help balance immune responses, preventing further damage to myelin and supporting neural regeneration[19].

5.4 Stroke and Brain Injury: Enhancement of Neuroplasticity and Vascular Repair

The recovery of stroke patients, together with the rehabilitation of brain tissue, requires sophisticated sequences of neuroplasticity and vascular repair mechanisms. Studies have demonstrated that functional mushroom Cordyceps improves mitochondrial cell efficiency for ATP generation, along with strengthened cellular durability during ischemic injuries. Bioactives such as adenosine play a crucial role in improving cerebral blood flow and reducing infarct size[20]. Lion's Mane, with its ability to promote NGF production, can accelerate axon regeneration and synaptogenesis, contributing to improved functional recovery after brain injury. Additionally, Reishi's anti-inflammatory and antioxidative actions help protect neurons from further damage during the post-injury inflammatory response (Figure 6).

6. Pharmacokinetics, Bioavailability, and Formulation Strategies

6.1 Metabolism and Absorption of Bioactive Compounds

Bioactive compounds such as polysaccharides as well as triterpenes and polyphenols, and alkaloids are found

in functional mushrooms. The complex chemical properties, along with low solubility characteristics, make it difficult for several compounds to be absorbed in addition to being metabolised properly. For example, polysaccharides such as β-glucans are often poorly absorbed in the upper gastrointestinal tract and primarily exert their effects through interactions with Gut-Associated Lymphoid Tissue (GALT) or by modulating the gut microbiome[21]. Triterpenes and phenolic compounds, on the other hand, undergo first-pass metabolism in the liver, which reduces their systemic bioavailability. Research needs to develop delivery systems for these compounds since their absorption in the stomach faces barriers because of both enzymatic breakdown and sensitivity to pH, and because of this, bioavailability problems affect treatment effectiveness.

6.2 Role of Nanotechnology and Liposomal Delivery in Enhancing Bioavailability

Research groups developed innovative formulation approaches because of poor absorption rates and quick metabolism processes through nanotechnology implementation. Bioactive compound protection through nanoemulsions and liposomes, and nanoparticles enables both intestinal passage preservation and cellular intake improvement and prolonged circulation duration[22]. For instance, liposomal delivery systems encapsulate hydrophobic compounds like triterpenes, improving their solubility and facilitating absorption through cell membranes. Nanoencapsulation of mushroom extracts can provide targeted delivery to the brain by crossing the Blood-Brain Barrier (BBB), ensuring higher concentrations of neuroprotective compounds reach neuronal tissues. The bioactivities from mushrooms get better stability through the use of Solid Lipid Nanoparticles (SLNs) and polymeric nanoparticles, while being released gradually thanks to these nanotopologies. This improves their pharmacokinetic performance[23].

6.3 Synergistic Effects with Other Natural Compounds (Curcumin and Resveratrol)

The therapeutic combination of functional mushrooms produces strengthened effects for neuroprotection when used with other natural protective compounds. Fermented mushrooms function synergistically with compounds in turmeric and grapes since these natural agents employ comparable antioxidant and anti-inflammatory mechanisms, which enhances the therapeutic benefits derived from mushroom extracts[24]. Curcumin, known for its poor bioavailability, can be stabilised through co-administration with mushroom polysaccharides that improve intestinal absorption. Similarly, resveratrol enhances mitochondrial function and reduces oxidative stress, complementing the actions of mushroom-derived antioxidants. The combined use of these natural compounds helps protect neural cells and enhances absorption through metabolic reduction and joint pathway activation of Nrf2/ARE signalling and BDNF upregulation mechanisms[25].

7. Challenges, Limitations, and Future Directions

7.1 Standardisation and Quality Control in Mushroom Extracts

Advancing functional mushroom use for neuroprotection requires addressing the problem of inconsistent standards. The bioactive compound content of mushroom-derived products shows significant variations because of distinctions between production methods and mushroom species, together with factors from the environment and the extraction process. For example, the concentration of erinacines in Lion's Mane or triterpenes in Reishi can fluctuate depending on the growth substrate and harvesting conditions. Additionally, quality control measures are not always enforced, leading to potential contamination with heavy metals, pesticides, or other toxins. The medical use and research of functional mushrooms need standardised extraction protocols together with quantitative active ingredient measurements and Good Manufacturing Practices (GMP) for proper production methods[26].

7.2 Need for Multi-centre, Randomised Clinical Trials

The field faces an important barrier from the absence of extensive, large-scale randomised controlled trials, which both preclinical studies and small clinical trials have proved encouraging. Most studies have

been conducted on animal models or in small human cohorts, making it difficult to generalise findings across diverse populations. Additionally, existing clinical trials often suffer from short durations, limited sample sizes, and variability in dosage and formulations. Well-developed RCT research designs must be conducted for validating functional mushroom efficacy while determining correct dosage levels and identifying long-term safety risks[27]. The study of various mushroom varieties and their possible combination effects with standard neurodegenerative disease treatments needs investigation through forthcoming research.

7.3 Potential for Pharmaceutical Drug Development and Synthetic Analogues

Researchers show increasing interest in creating pharmaceutical drugs from mushroom compounds and manufactured chemical equivalents of these compounds. The strategic extraction of erinacines plus cordycepin with triterpenes represents a potential solution to develop advanced therapeutic drugs along with superior penetration ability. Moreover, the synthesis of structurally modified analogues could improve properties such as BBB permeability, metabolic stability, and target specificity[28]. Additionally, integrating these compounds into combination therapies alongside existing neuroprotective drugs could open new therapeutic avenues. Research advancement requires molecular docking examinations and clinical testing of mushroom-derived libraries to produce FDA-approved neurotherapeutics from natural sources.

8. Conclusion

The natural neuroprotective properties of functional mushrooms result from their multiple bioactive compounds, which include polysaccharides and the secondary metabolites terpenoids and polyphenols and alkaloids. These compounds exert antioxidant, anti-inflammatory, and neurotrophic effects, making them attractive candidates for combating neurodegenerative disorders such as Alzheimer's disease, Parkinson's disease, multiple sclerosis, and stroke. Multiple cellular mechanisms, such as Nrf2/ARE signalling, microglial polarisation and synaptic plasticity, can be manipulated by Lion's Mane together with Reishi and Cordyceps and Chaga which demonstrates their combined effectiveness in supporting brain structure preservation and cognitive flexibility[29].

In the future, these mushrooms could pave the way for innovative therapeutic applications. Advances in formulation strategies, such as nanotechnology and liposomal delivery, promise to enhance the bioavailability of mushroom-derived compounds, improving their clinical efficacy. The pharmaceutical effects of natural neuroprotectants become stronger when users take them with well-known agents such as curcumin and resveratrol. However, to fully harness their potential, large-scale clinical trials and rigorous standardisation protocols are essential. Establishing a clear understanding of dosage regimens, long-term safety, and mechanistic pathways will be crucial for their integration into mainstream medicine. The advancement of research reveals elemental mushroom compounds to evolve as individual remedies and cultivate base versions and innovative pharmaceutical formulations[30].

The special properties of functional mushrooms create a distinct connection between conventional medicine and contemporary pharmacology to serve as an innovative platform for developing personalised brain protection drugs. Research on functional mushrooms now advances toward scientific validation for therapeutic application as a way to fight neurodegenerative conditions.

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10. Author Contribution

Shaik Aminabee: Conceptualisation, supervision, and final review. Santhi Krupa Dasari: Literature review and manuscript writing. G. Manasa: Data collection and manuscript editing. K. Ravi Shankar: Critical revision and expert insights. Siram Teja Manikanta, Nalam Vineela Nirmala, Lingineni Mani Deepa Chandrika, Siddineni Siva Karthik, Nakka Jonus Evangel: Data

collection, literature search, and manuscript support. All authors have read and agreed to the published version of the manuscript.

11. References

1. Feigin VL, Vos T, Nichols E, Owolabi MO, Carroll WM, Dichgans M, *et al*. The global burden of neurological disorders: Translating evidence into policy. Lancet Neurol. 2020; 19:255-265. https://doi.org/10.1016/S1474-4422(19)30411-9 PMid:31813850.
2. Deb A, Thornton JD, Sambamoorthi U, Innes K. Direct and indirect cost of managing Alzheimer's disease and related dementias in the United States. Expert Rev Pharmacoecon Outcomes Res. 2017; 17:189-202. https://doi.org/10.1080/14737167.2017.1313118 PMid:28351177 PMCid:PMC5494694.
3. Al-Obaidi JR. Proteomics of edible mushrooms: A mini-review. Electrophoresis. 2016; 37:1257-1263. https://doi.org/10.1002/elps.201600031 PMid:26891916.
4. Prasanth DSNBK, Aminabee SK, Rao AL, Guntupalli C, Reddy AR, Kulandaivelu U, *et al*. Inhibitory effects of *Manosa alliacea* in Freund's adjuvant arthritis on inflammatory markers and its confirmation by i*n silico* strategy. Thai J Pharm Sci. 2021; 45(6):532-544. https://doi.org/10.56808/3027-7922.2535
5. Muszynska B, Grzywacz-Kisielewska A, Kala K, Gdula-Argasinska J. Anti-inflammatory properties of edible mushrooms: A review. Food Chem. 2018; 243:373-381. https://doi.org/10.1016/j.foodchem.2017.09.149 PMid: 29146352.
6. Nowakowski P, Markiewicz-Zukowska R, Bielecka J, Mielcarek K, Grabia M, Socha K. Treasures from the forest: Evaluation of mushroom extracts as anti-cancer agents. Biomed Pharmacother. 2021; 143:1-12. https://doi.org/10.1016/j.biopha.2021.112106 PMid:34482165.
7. Aminabee SK, Prabhakara MC, Prasad RGSV, Rao AL. Screening of pharmacological activity of cerium oxide nanoparticles *in vitro*. Biomed Pharmacol J. 2011; 4(2):287-289. https://doi.org/10.13005/bpj/296
8. Valverde ME, Hernandez-Perez T, Paredes-Lopez O. Edible mushrooms: Improving human health and promoting quality life. Internet J Microbiol. 2015; 2015:37-63. https://doi.org/10.1155/2015/376387 PMid:25685150 PMCid:PMC4320875.
9. Rai SN, Mishra D, Singh P, Vamanu E, Singh MP. Therapeutic applications of mushrooms and their biomolecules, along with a glimpse of an *in silico* approach in neurodegenerative diseases. Biomed Pharmacother. 2021; 137:11-13. https://doi.org/10.1016/j.biopha.2021.111377 PMid:33601145.
10. Prasanth DSNBK, Aminabee SK, Rao AL, Teja N, Bhargavi K, Monika C, *et al*. Antihelmintic activity of *Mansoa alliacea* against *Pheretima posthuma*: *in vitro* and *in silico* approach. Thai J Pharm Sci. 2020; 44(3):186-196. https://doi.org/10.56808/3027-7922.2451
11. Zhang R, Xu S, Cai Y, Zhou M, Zuo X, Chan P. Ganoderma lucidum protects dopaminergic neuron degeneration through inhibition of microglial activation. J Evid Based Complement Altern Med. 2011; 2011:15-10. https://doi.org/10.1093/ecam/nep075 PMid: 19617199 PMCid: PMC3136196.
12. Sabaratnam V, Kah-Hui W, Naidu M, David PR. Neuronal health - can culinary and medicinal mushrooms help? J Tradit Complement Med. 2013; 3:62-68. https://doi.org/10.4103/2225-4110.106549 PMid:24716157 PMCid: PMC3924982.
13. Tong Z, Chu G, Wan C, Wang Q, Yang J, Meng Z, *et al*. Multiple metabolites derived from mushrooms and their beneficial effect on Alzheimer's diseases. Nutrients. 2023; 15:1-27. https://doi.org/10.3390/nu15122758 PMid:37375662 PMCid:PMC10300938.
14. Li Z, Luo R, Zhang Y, Yan X, Pang Q. Effective protein extraction from mycelium and fruiting body of *Auricularia auricula* for proteomics studies. Int J Food Prop. 2018; 21:2156-2166. https://doi.org/10.1080/10942912.2018.1499111
15. Gao L, Kumar V, Vellichirammal NN, Park S, Rudebush TL, Yu L, *et al*. Functional, proteomic and bioinformatic analyses of Nrf2- and Keap1-null skeletal muscle. J Physiol. 2020; 598:5427-5451. https://doi.org/10.1113/JP280176 PMid:32893883 PMCid: PMC7749628.
16. Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc Series B Stat Methodol. 1995; 57:289-300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x
17. Lima RS, Carrettiero DC, Ferrari MFR. BAG2 prevents tau hyperphosphorylation and increases p62/SQSTM1 in cell models of neurodegeneration. Mol Biol Rep. 2022; 49:7623-7635. https://doi.org/10.1007/s11033-022-07577-w PMid:35612780.
18. Cai R, Zhang Y, Simmering JE, Schultz JL, Li Y, Fernandez-Carasa I, *et al*. Enhancing glycolysis attenuates Parkinson's disease progression in models and clinical databases. J Clin Invest. 2019; 129:4539-4549. https://doi.org/10.1172/JCI129987 PMid:31524631 PMCid:PMC6763248.
19. Kroemer G, Galassi C, Zitvogel L, Galluzzi L. Immunogenic cell stress and death. Nat Immunol. 2022; 23:487-500. https://doi.org/10.1038/s41590-022-01132-2 PMid:35145297.
20. Costa CAD, Manaa WE, Duplan E, Checler F. The endoplasmic reticulum stress/unfolded protein response and their contributions to Parkinson's disease physiopathology. Cells. 2020; 9:1-24. https://doi.org/10.3390/cells9112495 PMid:33212954 PMCid:PMC7698446.
21. Margiotta A. Role of SNAREs in neurodegenerative diseases. Cells. 2021; 10:1-15. https://doi.org/10.3390/cells10050991 PMid:33922505 PMCid:PMC8146804.

22. Feng J, Zheng Y, Guo M, Ares I, Martínez M, Lopez-Torres B, *et al*. Oxidative stress, the blood-brain barrier and neurodegenerative diseases: the critical beneficial role of dietary antioxidants. Acta Pharm Sin B. 2023; 13:3988-4024. https://doi.org/10.1016/j.apsb.2023.07.010 PMid: 37799389 PMCid: PMC10547923.
23. Pizzino G, Irrera N, Cucinotta M, Pallio G, Mannino F, Arcoraci V, *et al*. Oxidative stress: harms and benefits for human health. Oxid Med Cell Longev. 2017; 2017:84-911. https://doi.org/10.1155/2017/8416763 PMid:28819546 PMCid:PMC5551541.
24. Di Paolo M, Papi L, Gori F, Turillazzi E. Natural products in neurodegenerative diseases: a great promise but an ethical challenge. Int J Mol Sci. 2019; 20:1-12. https://doi.org/10.3390/ijms20205170 PMid:31635296 PMCid:PMC6834164.
25. Trovato Salinaro A, Pennisi M, Di Paola R, Scuto M, Crupi R, Cambria MT, *et al*. Neuroinflammation and neurohormesis in the pathogenesis of Alzheimer's disease and Alzheimer-linked pathologies: modulation by nutritional mushrooms. Immun Ageing. 2018; 15:8-11. https://doi.org/10.1186/s12979-017-0108-1 PMid:29456585 PMCid: PMC5813410.
26. Aminabee S, Rao AL, Eswaraiah MC. *In vivo* antioxidant activity of different fractions of Indigofera barberi against paracetamol-induced toxicity in rats. Turk J Pharm Sci. 2020; 17(2):136-140. https://doi.org/10.4274/tjps.galenos.2018.30306 PMid:32454772 PMCid:PMC7227916.
27. Carrettiero DC, Hernandez I, Neveu P, Papagiannakopoulos T, Kosik KS. The cochaperone BAG2 sweeps paired helical filament-insoluble tau from the microtubule. J Neurosci. 2009; 29:2151-2161. https://doi.org/10.1523/JNEUROSCI.4660-08.2009 PMid: 19228967 PMCid: PMC2768429.
28. Qu D, Hage A, Don-Carolis K, Huang E, Joselin A, Safarpour F, *et al*. BAG2 gene-mediated regulation of PINK1 protein is critical for mitochondrial translocation of PARKIN and neuronal survival. J Biol Chem. 2015; 290:30441-3452. https://doi.org/10.1074/jbc.M115.677815 PMid:26538564 PMCid:PMC4683266.
29. Aminabee S, Rao AL, Sowmya K, Nymisha D, Lakshmi KKN, Manikanta KVNS, *et al*. Evaluation of analgesic activity of *Ficus palmata*. Iran J Pharm Sci. 2019; 15(3):47-60.
30. Wilson EL, Metzakopian E. ER-mitochondria contact sites in neurodegeneration: genetic screening approaches to investigate novel disease mechanisms. Cell Death Differ. 2021; 28:1804-1821. https://doi.org/10.1038/s41418-020-00705-8 PMid:33335290 PMCid: PMC8185109.