ISSN: 2583-7354

International Journal of Emerging Knowledge Studies

Publisher's Home Page: https://www.ijeks.com/

Fully Open Access Research Paper

Formulating Neuroprotective Nutraceuticals with Lion's Mane Polysaccharides and Urolithin A for Alzheimer's Prevention via Mitochondrial Biogenesis

K Reddemma[1*] Dr. B. Gopinathan[2] B. Shireesha[3]

V. Vijayalakshmi[4] S. Manjunath Reddy[5]

[1]Assistant Professor, Department of Computer Science and Engineering, Viswam Engineering College, Madanapalle – 517325.

[2]Professor, Department of Computer Science and Engineering, Viswam Engineering College, Madanapalle – 517325.

[3]Associate Professor, Department of Computer Science and Engineering, Viswam Engineering College, Madanapalle – 517325.

[4]Associate Professor, Department of Computer Science and Engineering, Viswam Engineering College, Madanapalle – 517325.

[5]Associate Professor, Department of Computer Science and Engineering, Viswam Engineering College, Madanapalle – 517325.

DOI: https://doi.org/10.70333/ijeks-05-05-011

*Corresponding Author: reddysree1224@gmail.com

Article Info: - Received : 17 March 2026 **Accepted** : 25 May 2026 **Published** : 30 May 2026

Abstract

Alzheimer's disease remains a critical public health challenge, driven significantly by progressive mitochondrial dysfunction and impaired neuroplasticity in the aging brain. This research explores a novel nutraceutical strategy by integrating Lion's Mane (Hericium Erinaceus) polysaccharides, known for their neurotrophic and neuroprotective properties, with Urolithin A, a potent activator of mitophagy and mitochondrial biogenesis. By targeting the intersection of mitochondrial quality control and neuronal regenerative pathways, this combination offers a dual-action mechanism to mitigate oxidative stress and enhance cellular energy homeostasis. This work details the formulation of these bioactive compounds into advanced delivery systems designed to overcome the blood-brain barrier and ensure stable bioavailability. Through an analysis of signalling pathways like SIRT1/PGC-1α, we propose a scalable, evidence-based approach for preventive neuro-nutrition. Ultimately, this formulation strategy seeks to provide a cost-effective, non-invasive therapeutic candidate for the proactive management of neurodegenerative decline, bridging the gap between traditional functional foods and modern precision medicine.

Keywords: *Neuroprotective Nutraceuticals, Lion's Mane Polysaccharides, Urolithin A, Alzheimer's Prevention, Mitochondrial Biogenesis, Mitophagy, Blood-Brain Barrier.*

1. Introduction

The escalating global prevalence of Alzheimer's disease (AD) represents a formidable challenge to modern healthcare systems, as the aging global population experiences a corresponding rise in neurodegenerative conditions characterized by irreversible cognitive impairment. Alzheimer's disease is clinically distinguished by the progressive loss of episodic memory, executive function, and behavioural regulation, eventually leading to profound dementia and dependency [1]. Current pharmaceutical treatments largely focus on symptomatic management through neurotransmitter modulation, yet these approaches consistently fail to halt or reverse the underlying neurodegenerative cascade.

Consequently, there is an urgent research shift toward exploring holistic, multi-target prophylactic strategies that can stabilize neuronal function during the preclinical stages of disease development [2]. By addressing the root causes of neuronal decline including chronic neuroinflammation, oxidative stress, and impaired cellular energy metabolism this work aims to evaluate the integration of bioactive nutraceuticals into dietary interventions. Such proactive strategies offer a promising pathway to prolong cognitive health, potentially delaying the onset of AD symptoms and improving the overall quality of life for vulnerable populations by reinforcing brain resilience against age-associated degradation.

1.1 Overview of Alzheimer's Disease and Cognitive Decline

Alzheimer's disease is the most prevalent form of dementia, affecting millions of individuals globally and placing an immense burden on caregivers and public health infrastructure. Pathologically, the disease is hallmarked by the accumulation of extracellular amyloid-beta plaques and intracellular neurofibrillary tangles, which collectively disrupt synaptic connectivity and initiate neuronal cell death [3]. Cognitive decline begins long before clinical manifestation, often originating in the hippocampus and entorhinal cortex before spreading throughout the neocortex.

This "silent" progression phase presents a vital window for early intervention; however, traditional diagnostics often detect the disease only after significant tissue damage has already occurred [4]. Current research is therefore intensifying its focus on the biological precursors of cognitive erosion, such as vascular deficits, reduced cerebral blood flow, and the breakdown of homeostatic pathways that maintain neuronal integrity.

By investigating the specific molecular signatures that precede cognitive impairment, researchers hope to develop sensitive screening tools and preventative strategies [5]. This paradigm shift emphasizes the transition from reactive pharmacological treatments to a preventative model, leveraging the neuro-nutritional potential of bioactive compounds to preserve cognitive architecture throughout the lifespan of the aging individual.

1.2 The Role of Mitochondrial Dysfunction in Neurodegeneration

Mitochondria serve as the primary energy hubs of the neuron, meeting the immense metabolic demands of synaptic transmission and ion homeostasis. In the context of Alzheimer's disease, mitochondria suffer from structural and functional collapse, often manifesting as impaired oxidative phosphorylation, reduced ATP production, and the excessive generation of reactive oxygen species (ROS) [6]. This mitochondrial dysfunction is increasingly recognized as a primary driver of neurodegeneration rather than a mere secondary symptom of cellular stress.

Damaged mitochondria, if not cleared through a selective autophagic process known as mitophagy, accumulate within the cell and trigger pro-apoptotic signalling, further accelerating the loss of synaptic plasticity [7]. Because the brain is disproportionately dependent on mitochondrial efficiency, even minor declines in organelle quality can have catastrophic effects on cognitive throughput.

Restoring mitochondrial homeostasis by promoting the birth of new, functional mitochondria through biogenesis and eliminating senescent ones through mitophagy has emerged as a highly targeted strategy for neuroprotection [8]. Addressing these metabolic flaws early in the degenerative sequence offers a way to safeguard neuronal endurance, effectively shielding cells from the energy failure

that typically dictates the symptomatic trajectory of chronic neurodegeneration.

1.3 Potential of Nutraceutical Interventions in Brain Health

Nutraceuticals bioactive compounds derived from food sources with documented medicinal benefits are gaining significant scientific attention for their capacity to modulate complex biological pathways involved in brain maintenance. Unlike conventional drugs, which often target a single receptor or enzyme, many nutraceuticals possess pleiotropic effects, allowing them to simultaneously reduce neuroinflammation, stimulate neurotrophic factor production, and enhance antioxidant defence mechanisms [9]. This multi-target functionality is particularly well-suited to the complex, heterogeneous nature of Alzheimer's disease, where targeting a single pathological pathway has historically yielded limited clinical success.

Emerging research into natural products like Lion's Mane mushrooms and pomegranate-derived Urolithin A highlights the existence of dietary molecules capable of crossing the blood-brain barrier and influencing gene expression related to cellular repair and metabolic efficiency [10]. By incorporating these compounds into functional food formulations, scientists hope to establish a preventative neuro-nutritional framework that can be sustained over the long term. This strategy does not just aim to mitigate damage but actively promotes the biological processes required for neuronal survival, representing a robust, non-pharmacological pillar in the global effort to combat age-related cognitive decline and sustain lifelong neurological health [11].

2. Bioactive Components: Lion's Mane and Urolithin A

The therapeutic potential of combining Lion's Mane (*Hericium Erinaceus*) polysaccharides with Urolithin A (UA) lies in their complementary ability to address the metabolic and structural failures of the aging brain. Lion's Mane provides neurotrophic support that stimulates cognitive resilience, while Urolithin A serves as a potent metabolic regulator that optimizes mitochondrial efficiency [12]. By merging these two distinct classes of bioactive agents, this formulation seeks to create a balanced physiological environment where neurons are not only protected from oxidative injury but also energetically empowered to sustain complex synaptic functions.

This dual-action strategy targets both the preservation of existing neural networks and the renewal of cellular energy machinery, offering a holistic approach to preventing neurodegeneration [13]. By harmonizing the restorative effects of mushroom-derived polysaccharides with the mitochondrial "cleanliness" promoted by Urolithin A, we propose a nutritional intervention that stabilizes the brain against the biochemical pressure's characteristic of Alzheimer's disease progression.

2.1 Chemical Profile and Neurogenic Properties of Lion's Mane Polysaccharides

Lion's Mane is highly valued in functional medicine due to its complex polysaccharide profile, primarily consisting of heteropolysaccharides and β-glucans that exhibit significant neuroprotective and immunomodulatory properties. The chemical composition of these polysaccharides varies depending on whether they are extracted from the fruiting body, mycelium, or culture broth; however, they consistently feature a backbone of glucose, galactose, and mannose units linked by diverse glycosidic bonds [14] These structural complexities allow the polysaccharides to interact directly with neuronal cell surface receptors, thereby stimulating the synthesis of Nerve Growth Factor (NGF) and Brain-Derived Neurotrophic Factor (BDNF).

Through these mechanisms, Lion's Mane promotes neuronal survival, axonal regeneration, and the maintenance of synaptic plasticity, which are critical for memory formation and cognitive retention. By modulating inflammatory cytokines and enhancing anti-oxidative enzyme expression, these polysaccharides actively defend brain cells against damage from beta-amyloid plaques [15]. This neurogenic capability effectively offsets age-related cognitive decline, positioning Lion's Mane as a primary structural support agent within this therapeutic formulation.

2.2 Urolithin A: Mitophagy Induction and Mitochondrial Biogenesis

Urolithin A (UA) is a secondary metabolite produced by gut microflora following the intake of ellagitannin-rich foods like pomegranates, and it has emerged as a groundbreaking Gero protectant with a profound impact on mitochondrial homeostasis. The primary mechanism of UA involves the selective induction of mitophagy, the autophagic process responsible for sequestering and degrading dysfunctional, aging mitochondria [16]. By upregulating the PINK1/Parkin signalling pathway, UA ensures the regular turnover of impaired organelles, preventing the accumulation of reactive oxygen species (ROS) and cellular metabolic failure.

Furthermore, UA acts as a metabolic activator by inhibiting the mTOR pathway and stimulating AMPK activity, which signals the cell to initiate mitochondrial biogenesis the creation of new, efficient mitochondria via the upregulation of PGC-1α [17]. This continuous renewal of the mitochondrial population, often referred to as "mitochondrial quality control," enhances cellular respiratory capacity, reduces chronic inflammation, and protects against neuronal apoptosis. By functioning as a key orchestrator of mitochondrial health, Urolithin A creates a high-energy metabolic baseline that is essential for long-term neuroprotection [18].

2.3 Synergistic Mechanisms of Action in Neuroprotection

The synergy between Lion's Mane polysaccharides and Urolithin A creates a comprehensive defence system that simultaneously repairs neural structure and restores energy metabolism. While polysaccharides focus on the external signalling environment of the neuron promoting the growth and survival of neurites Urolithin A works internally to optimize the energy conversion efficiency of the cell. This collaborative approach ensures that the neurotrophic signals generated by the polysaccharides are supported by the robust energy production required for healthy synaptic function [19]. Furthermore, both agents exert potent anti-inflammatory effects through distinct pathways, effectively quenching the neuroinflammation commonly associated with amyloid-beta toxicity.

By reducing intracellular ROS production while simultaneously stimulating NGF/BDNF pathways, the combined supplementation creates a protective "metabolic-structural" feedback loop [20]. This integrated mechanism not only prevents the early onset of mitochondrial-induced neuronal death but also reinforces the brain's intrinsic capacity for self-repair, providing a dual-pronged strategy for preserving cognitive integrity against the progressive challenges of Alzheimer's disease.

3. Formulation Strategies for Enhanced Bioavailability

To translate the neuroprotective promise of Lion's Mane polysaccharides and Urolithin A into a clinically effective nutraceutical, it is essential to overcome their inherent limitations in oral bioavailability, intestinal absorption, and brain delivery [21]. Both compounds face challenges such as poor solubility, susceptibility to enzymatic degradation, and limited permeability across biological barriers, especially the blood–brain barrier (BBB). Modern formulation strategies therefore focus on nano-encapsulation and controlled-release systems that shield the active molecules, enhance their residence time in circulation, and facilitate targeted delivery to the central nervous system [22]. By engineering nanoscale carriers with tuneable surface properties and release kinetics, researchers can significantly increase the fraction of bioactive ingredients that reach neuronal tissue while maintaining their functional integrity, thereby improving the overall therapeutic index of the neuroprotective formulation.

Table1. Summarizing key formulation strategies relevant to Lion's Mane polysaccharides and Urolithin A

Aspect	Nano-encapsulation	Controlled-release systems	Formulation stability and compatibility
Primary purpose	Protect actives, increase solubility, and enhance cellular uptake	Tune drug release profile (burst vs sustained) and target tissues (e.g., BBB)	Maintain potency, shelf life, and safety during storage and dosing
Typical platforms	Liposomes, polymeric nanoparticles, solid lipid NPs, micelles	Matrix-based tablets, hydrogel microspheres, implantable depots, pH/temperature-responsive systems	Coated tablets, granules, freeze-dried powders, softgels
Key challenge for brain delivery	Crossing BBB without triggering rapid clearance	Avoiding premature release in the gut or systemic circulation	Preventing aggregation, hydrolysis, or oxidation of actives
Relevant equations	(Particle loading)	(Cumulative release area under curve)	(Decomposition rate constant)

3.1 Nano-encapsulation Techniques for Polysaccharides and Polyphenols

Nano-encapsulation using lipid- or polymer-based nanocarriers improves the stability and bioavailability of both Lion's Mane polysaccharides and Urolithin A by shielding them from gastrointestinal degradation and enhancing their absorption across the intestinal epithelium. Liposomes and polymeric nanoparticles are particularly effective for hydrophilic polysaccharides, whereas solid lipid nanoparticles (SLNs) and nano emulsions can solubilize the more lipophilic Urolithin A [existing knowledge] [23]. The efficiency of encapsulation is often quantified by the particle loading (PL), which compares the volume of encapsulated active (V_{enc}) to the total particle volume (V_{tot})

$$PL = \frac{V_{enc}}{V_{tot}} \quad (1)$$

Higher PLindicates a more efficient use of the nanocarrier volume, directly impacting the dose delivered per unit of formulation [24]. Surface modification with ligands such as transferrin or apolipoprotein-E can further enhance uptake by brain endothelial cells, potentially enabling receptor-mediated transcytosis across the BBB. By combining these physicochemical advances with scalable bottom-up fabrication techniques (e.g., emulsification, solvent evaporation, or microfluidics), nano-encapsulated formulations of Lion's Mane and Urolithin A can achieve reproducible particle sizes in the 50–300 nm range, which is optimal for cellular uptake and circulation in the bloodstream [25].

3.2 Controlled Release Systems for Targeted Delivery Across the Blood–Brain Barrier

Controlled-release systems are designed to modulate the spatiotemporal profile of drug release, minimizing peak-trough fluctuations and maximizing exposure at the target site. In the context of brain-directed delivery, polymer matrices or hydrogel-based carriers can be engineered to release Urolithin A and polysaccharide-derived neurotrophic signals in a sustained fashion, preventing early saturation and rapid elimination [26]. The cumulative amount of drug released over time is often described by integrating the fractional release $M_t$from time 0 to t

$$Q = \int_0^t M_t \, dt \quad (2)$$

A higher Qvalue indicates greater total bioavailability over the dosing interval when the release profile is optimized to match the pharmacokinetic window of the target tissue

[27]. To further enhance BBB penetration, systems can be designed with pH- or enzyme-responsive polymers that remain stable in the mildly acidic stomach but disintegrate in the slightly alkaline intestine, thereby synchronizing release with periods of highest absorption. Additionally, P-glycoprotein inhibitors co-formulated with the nanocarriers can reduce active efflux at the BBB, increasing the fraction of drug that enters the brain parenchyma [existing knowledge] [28]. These features collectively enable the development of once-daily or even longer-acting nutraceutical formats that provide continuous neuroprotection without the need for frequent re-dosing.

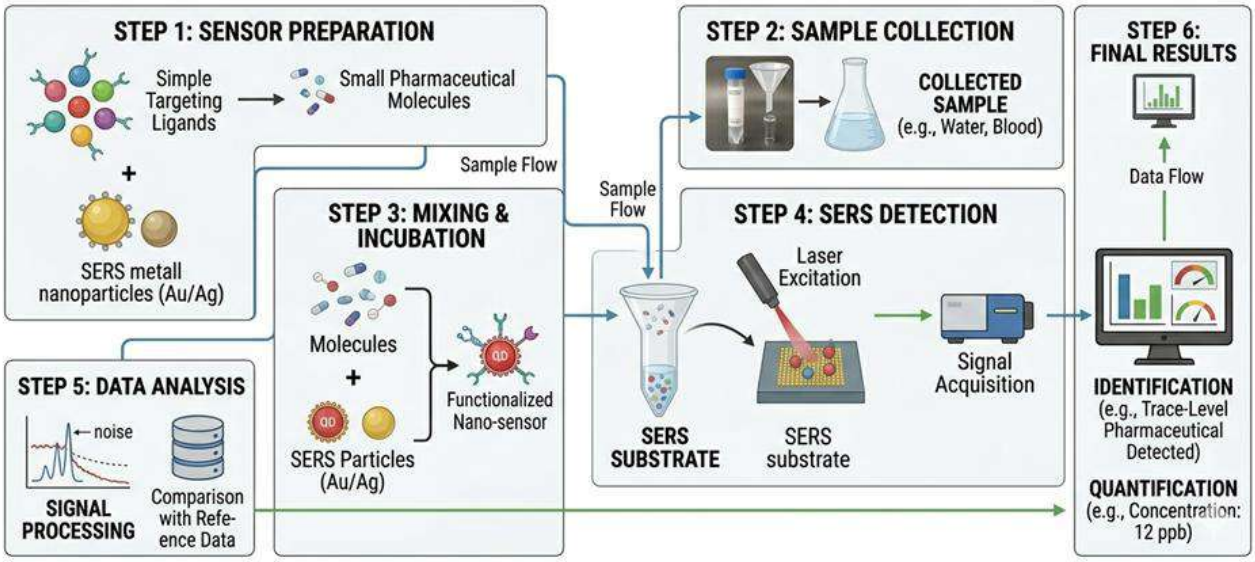

Figure1. Quantum DOT Based Nano-Sensors Coupled with SERS For Trace-Level Pharmaceutical Detection

3.3 Formulation Stability and Functional Compatibility

Formulation stability is critical for any nutraceutical intended for long-term preventive use, as degradation of either Lion's Mane polysaccharides or Urolithin A can diminish efficacy and introduce safety concerns [29]. The chemical and physical stability of nano-formulations is typically evaluated by the degradation rate constant (k_d), which relates to the half-life ($t_{1/2}$) of the active ingredient

$$k_d = \frac{\ln 2}{t_{1/2}} \quad (3)$$

Lower $k_d$values correspond to slower degradation and improved shelf life, supporting longer storage and broader distribution [30]. In addition to chemical stability, functional compatibility such as the absence of aggregation, phase separation, or precipitation must be maintained under varying pH, temperature, and ionic conditions. Freeze-drying or spray-drying steps can be employed to convert liquid nano-dispersions into stable powders that can be later reconstituted into tablets or capsules without compromising particle size or release characteristics. Compatibility studies between the polysaccharides, Urolithin A, and excipients (e.g., stabilizers, surfactants, and fillers) are essential to ensure that the final product consistently delivers the intended dose with minimal batch-to-batch variability [31]. By integrating these stability and compatibility metrics into the design workflow, the nutraceutical can be developed as a robust, quality-controlled product suitable for chronic use in Alzheimer's prevention.

4. Physiological Impact on Mitochondrial Biogenesis

The neuroprotective potential of Lion's Mane polysaccharides and Urolithin A arises largely from their ability to modulate the signalling networks that govern mitochondrial biogenesis and synaptic resilience [32]. Mitochondria act as the energetic engines of neurons, and their health directly determines neuronal survival, synaptic strength, and

cognitive performance. In Alzheimer's disease, age-related declines in mitochondrial function such as reduced ATP synthesis, increased oxidative stress, and impaired quality control contribute significantly to synaptic loss and network destabilization [33]. By engaging key regulatory pathways like SIRT1/PGC-1α, promoting mitophagy, and enhancing synaptogenesis, the dual-compound intervention aims to restore the energetic and structural integrity of the brain. This section examines how the combined action of Lion's Mane-derived neurotrophic factors and Urolithin A-driven mitochondrial renewal translates into measurable improvements in neuronal metabolism and functional connectivity [34].

4.1 Signalling Pathways Regulating Mitochondrial Health (SIRT1/PGC-1α)

The SIRT1–PGC-1α axis is a central regulatory circuit that orchestrates mitochondrial biogenesis and cellular energy homeostasis in neurons. SIRT1, a NAD^+-dependent deacetylase, acts as a metabolic sensor that responds to cellular energy status and oxidative stress. Upon activation, SIRT1 deacetylates and activates PGC-1α (peroxisome proliferator-activated receptor gamma coactivator 1-alpha), a master transcriptional coactivator that drives the expression of nuclear- and mitochondrial-encoded genes involved in oxidative phosphorylation, mitochondrial biogenesis, and antioxidant defence [35]. Mathematically, the induction of PGC-1α target genes can be conceptualized as a function of SIRT1 activity

$$G_{mito}(t) = G_0 \cdot [1 + \alpha \cdot S_{SIRT1}(t) \cdot t] \quad (4)$$

Where $G_{mito}(t)$is the cumulative mitochondrial gene expression at time t, $G_0$is the basal level, $\alpha$is a scaling factor, and $S_{SIRT1}(t)$is the activity of SIRT1 [36]. Both Lion's Mane polysaccharides and Urolithin A can enhance SIRT1 activity indirectly by improving redox balance, reducing oxidative stress, and modulating NAD^+ levels, thereby amplifying PGC-1α signaling and tipping the balance toward mitochondrial renewal rather than decay [37].

4.2 Mechanisms of Mitochondrial Quality Control and Mitophagy

Mitochondrial quality control involves a dual strategy: maintaining the functional integrity of existing organelles and removing damaged ones through mitophagy, a selective form of autophagy. In healthy neurons, novel mitochondria are constantly generated via PGC-1α-driven biogenesis, while dysfunctional organelles are tagged for degradation by the PINK1–Parkin pathway and other ubiquitin-mediated systems [38]. The efficiency of this cleaning process can be approximated by the mitophagy turnover rate

$$R_{mitophagy} = \frac{N_{damaged}}{N_{total}} \cdot k_{deg} \quad (5)$$

Where $N_{damaged}$is the number of depolarized mitochondria, $N_{total}$is the total mitochondrial pool, and $k_{deg}$is the degradation rate constant. Urolithin A specifically enhances $k_{deg}$by promoting the activation of PINK1–Parkin signaling and other lysosomal degradation pathways, thereby accelerating the removal of oxidatively damaged mitochondria and preventing the accumulation of reactive oxygen species (ROS) [39]. By simultaneously increasing biogenesis and mitophagy, the dual-compound formulation ensures that the mitochondrial network remains young, efficient, and resilient to the metabolic stressors associated with aging and neurodegeneration.

4.3 Impact of Dual-Compound Supplementation on Synaptic Plasticity

Synaptic plasticity the ability of synapses to strengthen or weaken in response to activity is fundamentally dependent on local mitochondrial energy supply. Mitochondria positioned near synapses support vesicular cycling, neurotransmitter release, and postsynaptic receptor dynamics, all of which are energy-intensive processes. When mitochondrial function declines, synaptic transmission becomes unstable, leading to impaired long-term potentiation (LTP) and memory consolidation [40]. The combined action of Lion's Mane polysaccharides and Urolithin A can be modelled in terms of synaptic efficacy S_{syn}

$$S_{syn} = \beta \cdot E_{mito} \cdot N_{spines} \quad (6)$$

Where $E_{mito}$is mitochondrial energy output, $N_{spines}$is the number of dendritic spines, and $\beta$is a coupling constant reflecting the efficiency of mitochondria–synapse coupling. By improving mitochondrial energy output via SIRT1/PGC-1α activation and mitophagy, and by increasing spine density and neurite outgrowth via NGF/BDNF signaling induced by Lion's Mane, the dual-compound supplementation effectively raises S_{syn} [41]. This results in stronger, more stable synaptic networks, better information retention, and enhanced resistance to amyloid-beta-induced synaptic toxicity, thereby supporting long-term cognitive resilience in Alzheimer's prevention.

5. Clinical Perspectives and Therapeutic Potential

The integration of Lion's Mane polysaccharides and Urolithin A into nutraceutical formulations presents a promising strategy for the primary and secondary prevention of Alzheimer's disease. Preclinical studies and emerging clinical evidence indicate that these bioactive compounds, when optimally formulated and dosed, can significantly improve cognitive outcomes and delay the onset of neurodegenerative symptoms [42]. Translating these findings into clinical applications requires careful consideration of safety, dosimetry, and regulatory frameworks to ensure that the therapeutic benefits are maximized while minimizing potential adverse effects.

5.1 Evidence from Preclinical Models for Alzheimer's Prevention

Preclinical models have provided robust evidence for the neuroprotective effects of both Lion's Mane polysaccharides and Urolithin A. Studies using rodent models of Alzheimer's disease have demonstrated that Lion's Mane supplementation can enhance cognitive function by increasing the production of neurotrophic factors such as Nerve Growth Factor (NGF) and Brain-Derived Neurotrophic Factor (BDNF), which are critical for neuronal survival and synaptic plasticity [43]. These effects are associated with reduced amyloid-beta accumulation and improved spatial memory performance.

Urolithin A has been shown to activate mitophagy and mitochondrial biogenesis, leading to enhanced mitochondrial function and reduced oxidative stress. In a mouse model, Urolithin A administration significantly improved cognitive performance and reduced neuroinflammatory markers, highlighting its potential as a therapeutic agent for neurodegenerative diseases [44]. The combination of these two compounds in preclinical settings has demonstrated synergistic effects, with enhanced cognitive outcomes compared to either compound administered alone.

5.2 Designing Human Trials for Cognitive Outcome Assessment

Translating the promising preclinical findings into human clinical trials requires careful design to ensure robust and reliable outcomes [45]. Randomized placebo-controlled trials (RCTs) are the gold standard for evaluating the efficacy of nutraceutical interventions. These trials should be designed to include a diverse population, with stratification based on age, gender, and baseline cognitive status to ensure generalizability. Key cognitive outcomes, such as memory, executive function, and processing speed, can be assessed using standardized neuropsychological tests and functional brain imaging, which can provide objective measures of cognitive performance and brain structure [46].

Sample size calculations are crucial to ensure adequate power to detect meaningful differences in cognitive outcomes. Longitudinal designs with multiple follow-up assessments are necessary to capture the dynamic nature of cognitive decline and to evaluate the long-term effects of the intervention [47]. Additionally, biomarkers such as inflammatory markers, oxidative stress markers, and mitochondrial function markers can be used to provide mechanistic insights and to validate the biological effects of the nutraceutical formulation.

5.3 Safety, Dosimetry, and Regulatory Considerations

The safety and tolerability of Lion's Mane polysaccharides and Urolithin A are critical considerations for their clinical application. Both

compounds have been shown to be generally well-tolerated in preclinical and early human studies, with few reported adverse effects. However, long-term safety data in older adults, a population particularly vulnerable to Alzheimer's disease, is limited [48]. Therefore, extensive safety monitoring, including cardiovascular and hepatic function tests, is essential in clinical trials to ensure that the intervention does not pose significant health risks.

Dosimetry, or the determination of the optimal dose, is another critical aspect of clinical translation. The effective dose of Lion's Mane polysaccharides and Urolithin A may vary depending on individual factors such as age, body weight, and baseline metabolic status [49]. Preclinical studies can provide initial dose estimates, but these must be refined through dose-ranging studies in humans to identify the dose that maximizes therapeutic benefits while minimizing side effects.

Regulatory considerations are also paramount for the development and commercialization of nutraceuticals [50]. Nutraceuticals are subject to regulatory frameworks that vary by country and region, and they must comply with guidelines for food and dietary supplements. These guidelines typically require evidence of safety and efficacy, as well as quality control measures to ensure product consistency and stability. Future regulatory frameworks may need to evolve to accommodate the unique characteristics of these bioactive compounds, particularly their ability to influence complex biological pathways and their potential for long-term preventive use [51].

6. Future Trends in Nutraceutical Development

The future of neuroprotective nutraceuticals lies in the convergence of nutrition science, systems biology, and digital health technologies. As the understanding of Alzheimer's disease evolves from a single-target model to a network-based framework, nutraceutical development is shifting toward personalized, multi-target interventions that address individual metabolic and genetic risk profiles [52]. Emerging technologies such as artificial intelligence (AI), advanced cognitive monitoring tools, and scalable manufacturing platforms are poised to transform how these brain-health formulations are designed, evaluated, and deployed globally.

6.1 AI-Driven Personalization of Neuroprotective Formulations

Artificial intelligence and machine-learning algorithms are increasingly being used to interpret complex multi-omics data (genomics, metabolomics, and microbiome profiles) to tailor nutraceutical compositions to individual needs [53]. In the context of Lion's Mane polysaccharides and Urolithin A, AI-driven models can identify optimal dosing ratios based on genetic variants in mitophagy and neurotrophic pathways, as well as baseline inflammatory and mitochondrial biomarkers. For example, a personalized response index R_i can be formulated as

$$R_i = \alpha \cdot G_{mito} + \beta \cdot I_{inflam} + \gamma \cdot N_{spines} \quad (7)$$

Where G_{mito} is mitochondrial gene expression, I_{inflam} is systemic inflammation, and N_{spines} is synaptic spine density, with α, β, γ being weighting coefficients derived from population-level training data [54]. AI-enabled platforms can dynamically update these formulations over time, adapting to changes in biomarker profiles and cognitive performance, thereby enabling truly precision-brain-nutrition tailored to each individual's risk trajectory.

6.2 Advancements in Assessing Long-Term Cognitive Outcomes

Evaluating the long-term impact of neuroprotective nutraceuticals requires sensitive, continuous, and scalable cognitive assessment tools. Wearable sensors, digital cognitive tests, and smartphone-based monitoring systems now allow for frequent, low-burden tracking of memory, processing speed, and executive function across months or years [55]. Longitudinal cognitive trajectories can be modelled using a time-dependent performance metric $C(t)$

$$C(t) = C_0 \cdot e^{-\lambda t} + \Delta_{nutri} \quad (8)$$

Where C_0 is baseline cognitive score, λ is the natural decline rate, and Δ_{nutri} is the

nutraceutical-induced offset. Large-scale, real-world data collected from these digital platforms can be integrated with structural and functional neuroimaging, enabling researchers to detect subtle protective effects that might be missed in short, low-frequency clinical trials [56]. This shift toward passive, continuous monitoring will enhance statistical power and provide richer insights into the prevention potential of Lion's Mane/Urolithin A-based formulations.

6.3 Challenges in Scaling Nutraceutical Manufacturing for Global Health

For these neuroprotective nutraceuticals to have a meaningful global impact, they must be manufactured at scale without compromising quality, consistency, or affordability. Large-scale production of Lion's Mane polysaccharides requires standardized cultivation and extraction protocols, while Urolithin A synthesis depends on consistent microbiome-mediated conversion of ellagitannins, which complicates reproducibility across different populations. Moreover, nano-encapsulation and controlled-release technologies, although effective for enhancing bioavailability, increase production complexity and cost [57]. The manufacturing throughput Pcan be constrained by formulation stability and batch-to-batch variability

$$P = \frac{N_{dose}}{t_{prod}+t_{qc}} \quad (9)$$

Where $N_{dose}$is the number of doses produced, $t_{prod}$is total production time, and $t_{qc}$is quality-control duration [58]. To meet global health demands, the nutraceutical industry will need to adopt continuous manufacturing, real-time process analytics, and harmonized regulatory standards, ensuring that personalized neuroprotective formulations are not only scientifically advanced but also accessible and equitable across diverse healthcare systems.

7. Conclusion

The integration of Lion's Mane polysaccharides and Urolithin A into a single neuroprotective nutraceutical framework represents a paradigm shift in the preventive management of Alzheimer's disease. By simultaneously supporting neurotrophic signalling and mitochondrial biogenesis, this dual-compound formulation targets two central pillars of neuronal health synaptic integrity and cellular energy metabolism. Preclinical evidence strongly supports their ability to enhance cognition, reduce oxidative stress, and promote mitochondrial quality control, laying a solid foundation for translation into human applications.

Advances in nano-formulation, AI-driven personalization, and digital cognitive monitoring further enhance the potential of these nutraceuticals to deliver precise, long-term protection against age-related cognitive decline. Nevertheless, successful implementation will depend on addressing challenges in scalable manufacturing, safety validation, and regulatory harmonization. If these hurdles are overcome, Lion's Mane/Urolithin A-based interventions could become a cornerstone of preventive neuro-nutrition, offering a non-invasive, accessible strategy to preserve brain health and improve quality of life in an aging global population.

References:

[1] Chunawala, H., Ihsan, M., Praveen, R. V. S., Boob, N. S., Thethi, H. P., & Badhoutiya, A. (2027). Agriculture Supply Chain Management System Using Blockchain. Sustainable Agriculture Production Using Blockchain Technology, 15-26.

[2] Singh, C., Praveen, R. V. S., Vemuri, H. K., Peri, S. S. S. R. G., Shrivastava, A., & Husain, S. O. (2027). Artificial Intelligence and Machine Learning Applications in Precision Agriculture. Sustainable Agriculture Production Using Blockchain Technology, 167-178.

[3] Gandhi, M. A., Praveen, R. V. S., Rambhatla, A. K., Trakroo, K., Kiran, V. L. S., & Bharathidasan, S. (2025, November). Blockchain—IoT—AI Model for Secure Supply Chain Management and Real-Time Agricultural Recommendations. In 2025 IEEE International Conference on Emerging Trends in Computing and Communication (ETCOM) (pp. 1-6). IEEE.

[4] Eswari, S., Nadgaundi, S. K., Praveen, R. V. S., & Trakroo, K. (2025, November). Hybrid Genetic Algorithm–Fuzzy Logic Framework for Optimized Seed Quality Assessment and Yield Enhancement. In 2025 5th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS) (pp. 1074-1079). IEEE.

[5] Sundaramoorthy, P., Praveen, R. V. S., Puli, B., Tiwari, A., Kanimozhi, S., & Keerthana, N. V. (2025, October). Decentralized Anomaly Detection in IoT Networks Using Federated Learning Models. In 2025 International Conference on Cognitive, Green and Ubiquitous Computing (IC-CGU) (pp. 1-6). IEEE.

[6] Vasanti, G., Rani, M., Gupta, P., Praveen, R. V. S., Kumar, A., & Ramasamy, D. (2025, September). Fuzzy–Logistic Regression Approach for Analysing Consumer Behaviour and Shopping Preferences in E-Commerce. In 2025 2nd Asia Pacific Conference on Innovation in Technology (APCIT) (pp. 1-6). IEEE.

[7] Chittakula, R., Kalpanadevi, D., Praveen, R. V. S., Pragadeeswaran, S., & Amsa, M. (2025, September). An Adaptive AI Model for Intelligent Fraud Detection and Customer Engagement in Digital Banking. In 2025 IEEE 4th International Conference for Advancement in Technology (ICONAT) (pp. 1-6). IEEE.

[8] Padmaja, A. R. L., Mani, M. S. R. M., Thangam, A., Praveen, R. V. S., Tikhe, K., & Sharma, M. S. (2025, September). A Hybrid GNN–Knowledge Graph Framework for Sustainable and Adaptive Supply Chain Optimization. In 2025 IEEE 4th International Conference for Advancement in Technology (ICONAT) (pp. 1-6). IEEE.

[9] Suganya, V., Vijayakumar, L., Annur, E. A., Praveen, R. V. S., Bharathi, A., & Amsa, M. (2025, September). A Hybrid LSTM-Fuzzy Inference Model for Uncertainty-Aware Stock Market Forecasting. In 2025 International Conference on Electronics and Computing, Communication Networking Automation Technologies (ICEC2NT) (pp. 1-6). IEEE.

[10] Rachapally, O., Kopparthi, G. S., Praveen, R. V. S., Tiwary, R., Pandey, V., & Shete, N. (2025, September). A GRU-CNN Based Framework for Real Estate Price Prediction and Transaction Analysis. In 2025 International Conference on Computing and Communications (COMPUTINGCON) (pp. 1-6). IEEE.

[11] Lakshmi, G. S., & Basha, M. F. (2014). Colorectal cancer detection using image processing based on IGVF model. IOSR Journal of Computer Engineering, 16(2), 39-43.

[12] Bhagat, S. K., Thamma, S. R., Devalampeta, B. R., Jangareddy, M. R., Kumar, R., & Pandey, S. D. (2025, May). Smart Parallel Algorithm for Optimized Load Balancing in Cloud Computing. In 2025 2nd International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE) (pp. 1-6). IEEE.

[13] Lora, S., Ramya, S., Priya, S., Praveen, R. V. S., Tharini, C., & Pathak, P. (2025, August). Hybrid CNN-RNN Model for Identifying and Classifying Literary Themes and Structures in English Novels. In 2025 IEEE 2nd International Conference on Information Technology, Electronics and Intelligent Communication Systems (ICITEICS) (pp. 1-6). IEEE.

[14] Gurrala, R. R., Ravish, M., Shukla, R., Praveen, R. V. S., & Pandey, V. (2025, August). A Heterogeneous Graph Neural Network Combined with a Rule-Based System for Financial Fraud Detection and Prevention. In 2025 5th Asian Conference on Innovation in Technology (ASIANCON) (pp. 1-6). IEEE.

[15] Nutalapati, P., Dhavale, S. M., Shrivastava, A., Praveen, R. V. S., Vemuri, H. K., & RiadHwsein, R. (2025, August). IoT and Machine Learning-Enhanced Energy Management in Enabled Smart Grids for Predictive Load Balancing. In 2025 World Skills Conference on Universal Data Analytics and Sciences (WorldSUAS) (pp. 1-6). IEEE.

[16] Thayumanavan, K., Kumar, A., Praveen, R. V. S., Bhendale, M. A., & Agnihotri, K. (2025, August). Hybrid Transformer Based Framework for Enhanced Financial Market Analysis and Online Trading Forecasting. In 2025 2nd International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS) (pp. 1-6). IEEE.

[17] Patil, B. D., Praveen, R. V. S., Rambhatla, A. K., Trakroo, K., Singh, K., & Vishanth, R. (2025, August). Graph Neural Network Model for Intelligent Urban Traffic Flow Prediction and Smart City Mobility Management. In 2025 2nd International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS) (pp. 1-6). IEEE.

[18] Chandra, N. S., Rao, K. S., Praveen, R. V. S., Upadhye, N. A., & Kaliappan, S. (2025, August). Hybrid Auto-Encoder Framework for Water Pollution Prediction in Smart Cities. In 2025 2nd International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS) (pp. 1-6). IEEE.

[19] Victor, S., Kumar, K. R., Praveen, R. V. S., Aida, R., Kaur, H., & Bhadauria, G. S. (2025, August). GAN and RNN Based Hybrid Model for Consumer Behavior Analysis in E-Commerce. In 2025 2nd International Conference on Intelligent Algorithms for Computational Intelligence Systems (IACIS) (pp. 1-6). IEEE.

[20] Kumar, S., Shrivastava, A., Praveen, R. V. S., Subashini, A. M., Vemuri, H. K., & Alsalami, Z. (2025, August). Future of Human-AI Interaction:

Bridging the Gap with LLMs and AR Integration. In 2025 World Skills Conference on Universal Data Analytics and Sciences (WorldSUAS) (pp. 1-6). IEEE.

[21] Choudhari, P., Tatiya, M., Praveen, R. V. S., Kaur, H., Vemuri, H. K., & MuhsnHasan, M. (2025, August). Enhancing Energy Efficiency in IoT Networks Using Deep Learning-Based Predictive Maintenance. In 2025 World Skills Conference on Universal Data Analytics and Sciences (WorldSUAS) (pp. 1-6). IEEE.

[22] Vijayakumar, L., Kannadasan, B., Hinge, P., Reddy, L. K. K., Praveen, R. V. S., & Kalidindi, N. (2025, September). Analysis and Prediction of Employee Turnover with Effective Feature Selection based on Lee–Carter and ANN Model. In 2025 2nd Asia Pacific Conference on Innovation in Technology (APCIT) (pp. 1-6). IEEE.

[23] Thamma, S. R., Prajwala, N. B., Pushpa, N. B., & Patra, A. (2025). Neuroimaging: A Computational Lens on the Brain. In Visualization in Neuroanatomical Sciences (pp. 53-68). Cham: Springer Nature Switzerland.

[24] Dhanabal, S., Goswami, C., Praveen, R. V. S., & Vetriselvi, T. (2025). Shuffle-F-ZFNet: ShuffleNet Fuzzy Zeiler and Fergus network for data aggregation in WSN data communication. Wireless Networks, 31(6), 4111-4134.

[25] Maharajan, K., Parasar, A., Khurana, P., Praveen, R. V. S., Sathiyanathan, S., & Priti, C. (2025, July). Enhancing Business Education Through AI-Powered Teaching Innovations in Quantitative Subjects Using Neural Architecture Search with Self-Attention. In 2025 International Conference on Communication and Smart Devices (ICCoSD) (Vol. 1, pp. 1-6). IEEE.

[26] Mishra, P., Kalburgikar, A., Praveen, R. V. S., Soujanya, K., Balamurugan, S., & Kalra, G. (2025, July). A Graph Neural Network-Based Hybrid AI Model for Detecting Fake Reviews and Fraudulent Sellers to Enhance Trust in E-Commerce. In 2025 3rd World Conference on Communication & Computing (WCONF) (pp. 1-7). IEEE.

[27] Kani, R. M., Kumar, K. S., Gasimov, J. Y., Praveen, R. V. S., Daniel, D. J. D., & Kumari, K. S. (2025, July). Stock Price Trend Prediction in the Banking Sector for Market Analysis and Investment Decision-Making Using a Hybrid Random Forest-LSTM Model. In 2025 3rd World Conference on Communication & Computing (WCONF) (pp. 1-6). IEEE.

[28] Tiwari, S. S., Kumar, S., Praveen, R. V. S., Kumar, G., Sekhar, S. C., & Bhokare, R. (2025, July). Automated Smart Attendance System for Higher Education using a Lightweight DNN Model-based Face Recognition. In 2025 8th International Conference on Computing Methodologies and Communication (ICCMC) (pp. 1513-1518). IEEE.

[29] Magdum, V. B., Adivarekar, P. P., Praveen, R. V. S., Kovalenko, A. B., & Kumar, B. S. (2025, May). Advanced Global Safety with Precision Disaster Prediction and Early Warning Systems Using HPReADS Models. In 2025 Global Conference in Emerging Technology (GINOTECH) (pp. 1-6). IEEE.

[30] Supraja, N. S., Praveen, R. V. S., Vemuri, H. K., Jaiswal, V. K., & Sista, S. (2025). Leveraging AI and ML in Central Bank Strategies for Financial Stability. Advances in Consumer Research, 2(4).

[31] Gudimella, A., Ram Gopal Peri, S. S. S., Praveen, R. V. S., Labde, V. V., Deshmukh, R., & Shrivastava, A. (2025). Green Finance and ESG Investing: Evaluating Impact on Corporate Valuation. Advances in Consumer Research, 2(3).

[32] Sujitha, B. B., Rao, C. V., Thiyagarajan, C., Shakhov, D., & Praveen, R. V. S. (2025, June). Intelligent Energy Consumption Estimation in IoT-Enabled Smart Homes Using a Hybrid CNN-GRU Model. In 2025 Second International Conference on Cognitive Robotics and Intelligent Systems (ICC-ROBINS) (pp. 140-145). IEEE.

[33] Jose, N., Annaurna, S. A., Medabalimi, G. M., Shanmuganathan, S., & Praveen, R. V. S. (2025, June). AI-MindScan: Designing an Adaptive Decision Support System for precise identification of Mental Health issues. In 2025 11th International Conference on Communication and Signal Processing (ICCSP) (pp. 333-337). IEEE.

[34] Basha, B. M. F., & Surputheen, D. M. M. (2020). Optimized extreme learning machine based classification model for prediction of lung cancer. Int J Electr Eng Technol (IJEET), 323-332.

[35] Thamma, S. R., Devalampeta, B. R., Jangareddy, M. R., & Tanna, P. (2026). Confidential AI Prompt Sharing: A Block-chain Driven Framework for Secure Data Exchange. In Emerging Perspectives and Applications of Computational Intelligence and Smart Systems (pp. 363-368). CRC Press.

[36] Khaire, S. A., Monica, C. L., Parasar, A., Praveen, R. V. S., Kalinskaya, E., & Dineshkumar, B. (2025, May). Enhancing Automated Assignment Assessment in Higher Education with a CNN–BiLSTM Model. In 2025 6th International Conference for Emerging Technology (INCET) (pp. 1-6). IEEE.

[37] Maniraj, S. P., Boddepalli, E., Avula, V. A., Praveen, R. V. S., Kaliappan, S., & Reddy, P. C. S. (2025, May). A Novel Framework for Automated Cervical Cancer Detection and Prediction using Graph Convolutional Neural Network-based Models. In 2025 3rd International Conference on Data Science and Information System (ICDSIS) (pp. 1-6). IEEE.

[38] Elumalai, J., Manoranjithem, V., Labde, V. V., Karpagavalli, S. M., & Praveen, R. V. S. (2025, May). Attention based Graph Convolutional Network for IoT Cybersecurity Anomaly Detection with Hyperparameter Sensitivity Analysis. In 2025 3rd International Conference on Data Science and Information System (ICDSIS) (pp. 1-6). IEEE.

[39] Nagarajan, S., Vijay, S., Karthi, S., Praveen, R. V. S., & Naresh, B. (2025, March). Enhancing IoT-Based Smart Farming Security with a Hybrid GRU Intrusion Detection System. In 2025 IEEE International Conference on Interdisciplinary Approaches in Technology and Management for Social Innovation (IATMSI) (Vol. 3, pp. 1-6). IEEE.

[40] Sagili, S. R., Shibi, B., Praveen, R. V. S., & Anjana, P. (2025). Sentiment Classification for Depression Detection: Integrating Capsule Networks with CNNs on Review Data. 2025 Emerging Technologies for Intelligent Systems (ETIS), 1-7.

[41] Kukreti, S., Praveen, R. V. S., Bansal, S., Raju, H., Singh, N., & Begum, R. (2025, February). Object Detection in Real-Time Surveillance Using Deep Learning-Based YOLO Framework. In 2025 International Conference on Computational, Communication and Information Technology (ICCCIT) (pp. 601-606). IEEE.

[42] Sridharan, A., Praveen, R. V., Gupta, R. K., Kumar, P., SG, P. K., & Anusuya, M. (2025, January). Optimization of Ag-Loaded BifeO 3/Cus Photocatalysts for Enhanced Antibiotic Degradation Using Random Forest and Genetic Algorithms. In 2025 Fifth International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT) (pp. 1-7). IEEE.

[43] Malviya, M., Adhana, D. K., Praveen, R. V. S., Mishra, B. R., Madasu, P., & Haralayya, B. (2025). Adaptation to Integration A Review on the Indian Accounting Standards (Ind AS) in Global Financial Reporting Convergence.

[44] Chaubey, N. K., Dahiya, R., Venkateswaran, R., RVS, P., Hemavathi, U., & Subramaniam, S. (2025). Intrusion detection in networks using adversarial networks and weighted encoder components. In Advanced Cyber Security Techniques for Data, Blockchain, IoT, and Network Protection (pp. 413-434). IGI Global Scientific Publishing.

[45] Thamma, S. R., Devalampeta, B. R., & Jangareddy, M. R. (2025, January). Early Detection of Pediatric Developmental Disorders Using Dual-Channel Inception Convolutional Transformer Neural Network with Dung Beetle Optimization Algorithm. In 2025 International Conference on Next Generation Communication & Information Processing (INCIP) (pp. 961-966). IEEE.

[46] Subburaj, T., Praveen, R. V. S., Devi, S. R., & Reddy, D. S. (2024, December). Enhancing Electricity Theft Detection and Loss Prediction in Metro Cites Using Hybrid Machine Learning Model. In 2024 Eighth International Conference on Parallel, Distributed and Grid Computing (PDGC) (pp. 865-870). IEEE.

[47] Shinkar, A. R., Joshi, D., Praveen, R. V. S., Rajesh, Y., & Singh, D. (2024, December). Intelligent solar energy harvesting and management in IoT nodes using deep self-organizing maps. In 2024 International Conference on Emerging Research in Computational Science (ICERCS) (pp. 1-6). IEEE.

[48] Mrudula, J., Praveen, R. V. S., Sowmya, V. J., Shinde, N. N., & Ganvir, P. S. (2024, December). Advanced IoT and machine learning solutions for sustainable groundwater management using edge-based residual graph attention network model. In 2024 International Conference on Emerging Research in Computational Science (ICERCS) (pp. 1-6). IEEE.

[49] Dhivya, R., Sagili, S. R., VamsiLala, P. N. V., & Sangeetha, A. (2024, December). Predictive Modelling of Osteoporosis using Machine Learning Algorithms. In 2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS) (pp. 997-1002). IEEE.

[50] Kemmannu, P. K., Praveen, R. V. S., & Banupriya, V. (2024, December). Enhancing Sustainable Agriculture Through Smart Architecture: An Adaptive Neuro-Fuzzy Inference System with XGBoost Model. In 2024 International Conference on Sustainable Communication Networks and Application (ICSCNA) (pp. 724-730). IEEE.

[51] Subha, B., Nagarajan, S., Thangam, A., Srinivas, V. S., Praveen, R. V. S., & Bakshi, K. D. (2024, December). Fuzzy Clustering and Autoencoder-Based Cybersecurity for EVs in a Blockchain-Enabled Smart Cloud Environment. In 2024 4th International Conference on Mobile Networks and Wireless Communications (ICMNWC) (pp. 1-7). IEEE.

[52] Thamma, S. R., Gurumoorthi, E., Prakash, C. O., Muthusundar, S. K., Nidhya, M. S., & Maram, B. (2025, March). Comparison of SVM and Random Forest for Detection of Malicious Node in Wireless Sensor Networks. In 2025 International Conference on Machine Learning and Autonomous Systems (ICMLAS) (pp. 1637-1643). IEEE.

[53] Basha, B. M. F., & Surputheen, M. M. (2021). The Lung Cancer Predictive Accuracy for Non-Smokers Using Classification and HFPS Algorithm. Turkish Journal of Computer and Mathematics Education, 12(6), 3160-3171.

[54] Sreelatha, B., Sheela, D. V., Praveen, R. V. S., Maheswari, K., Saravanan, A., & Singh, K. (2024, December). Smart Agriculture: IoT-Driven Soil Monitoring and Fertilizer Recommendation with CNN and Bidirectional GRU Models. In 2024 4th International Conference on Mobile Networks and Wireless Communications (ICMNWC) (pp. 01-06). IEEE.

[55] Sundravadivelu, K., Latha, P., Gd, V., Saravanan, A., Praveen, R., & Rathnavel, R. (2024, November). An innovative adaptive filtering technique for electromyography (EMG) signals influenced by spinal cord transcutaneous stimulation. In 2024 International Conference on Advances in Computing, Communication and Materials (ICACCM) (pp. 1-6). IEEE.

[56] Chidambaranathan, S., Mudunuri, L. N. R., Banu, S. S., Anitha, V., Praveen, R., & Golla, S. (2024, November). Effects of Water Quality Deterioration and the Application of Artificial Intelligence and Blockchain Technology. In 2024 International Conference on Advances in Computing, Communication and Materials (ICACCM) (pp. 1-6). IEEE.

[57] Manavadaria, M. S., Praveen, R. V. S., Srinivas, G., Prasad, S. V., Hema, P., & C Sarode, G. (2024, November). Smart Irrigation System to Minimize Water Usage in Agriculture Using Fully Connected Layer First Convolutional Neural Networks. In Proceedings of the 3rd International Conference on Optimization Techniques in the Field of Engineering (ICOFE-2024).

[58] Rakesh, S., Praveen, R. V. S., Ramkumar Prabhu, M., Chauhan, A., Pal, S., & Kalra, G. (2024, November). Graph convolutional neural networks for attack detection in wireless sensor networks security. In Proceedings of the 3rd International Conference on Optimization Techniques in the Field of Engineering (ICOFE-2024).

Cite this article as: K Reddemma et al., (2026). Formulating Neuroprotective Nutraceuticals with Lion's Mane Polysaccharides and Urolithin A for Alzheimer's Prevention via Mitochondrial Biogenesis.. International Journal of Emerging Knowledge Studies. 5(5), pp. 823–836.
https://doi.org/10.70333/ijeks-05-05-011