Lion's Mane Mushroom: Nutritional Profile, Bioactive Compounds, Functional Properties, and Applications in Functional Food Systems

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ABSTRACT

Lion's Mane mushroom (*Hericium erinaceus*) holds a significant place in traditional Chinese medicine (TCM), valued for centuries for benefiting various internal organs and overall well-being. It is also celebrated as a culinary delicacy in East Asia, prized for its fleshy, meat-like texture and mild, seafood-like flavor. High concentrations of glutamic and aspartic acids generate a pronounced umami taste, enhancing its culinary appeal and supporting its use as a natural flavor enhancer. Nutritionally, it provides dietary fiber, essential minerals, and high protein content, notably in the mycelial biomass (up to 42.5% dry weight), making it especially suitable as a protein source in meat alternative applications. The mushroom's therapeutic potential is rooted in its novel bioactive constituents. Hericenones (in fruiting bodies) and erinacines (in mycelia) are diterpenoids that stimulate nerve growth factor (NGF) synthesis, supporting neuronal function. Furthermore, immunomodulatory β-glucans, antioxidant phenolic compounds, and ergothioneine contribute to its overall health benefits. However, these functional properties are predominantly supported by in vitro and animal studies. Despite growing interest in its medicinal properties, integrated evaluations of the nutritional composition, bioactive profile, and technological potential of *H. erinaceus* for modern food applications remain limited. By leveraging both its sensory attributes and scientifically validated functional value, *H. erinaceus* can be incorporated into beverages, staple foods, and meat substitutes. This comprehensive review examines its dual role as a medicinal and culinary mushroom, to hopefully enhance understanding of the mushroom and inspire its future applications in food technology.

1 Introduction

Fungi represent a highly diverse kingdom occupying specialized ecological niches and playing essential roles in ecosystem functioning (Daranagama **2023**). Within this kingdom, the genus Hericium (family Hericiaceae, order Russulales) is distinguished by its unique morphology, long-standing culinary and medicinal use, and growing scientific validation of diverse bioactivities (Kostanda et al. **2024**; Qi **2024**; Tan et al. **2024**). The genus encompasses several notable species, with *Hericium erinaceus* (Bull.) Pers., commonly known as Lion's Mane, being the most extensively studied and commercially valuable (Li et al. **2020**; Thongbai et al. **2015**). Other recognized species include *H. coralloides* (Scop.) Pers. and *H. americanum* Ginns (Koga **2024**). *Hericium* species produce distinctive basidiomata that typically lack a cap and stipe, forming white, fleshy, icicle-like spines arranged in branched or cushion-like structures (Gonkhom et al. **2021**) (Figure **1**). These spines are white at first, but as they age, they progressively turn yellow and ultimately brown (Thongbai et al. **2015**).

FIGURE 1

Fruiting bodies of *Hericium erinaceus* from Mountain Goč, Serbia. (Figure by author).

The genus is widely distributed throughout Asia, North and South America, and Europe, commonly found on decaying hardwood such as beech or oak trunks (Kunca et al. **2018**; Tan et al. **2024**). This broad distribution has facilitated its discovery and utilization by diverse cultures throughout history. *H. erinaceus* was the first strain of *Hericium* to be cultivated for commercial purposes, beginning in China (Gonkhom et al. **2021**). In recent years, global interest in *H. erinaceus* has risen sharply, driven by the increasing body of scientific research validating their therapeutic potential (Figure **2**). Web of Science records show a rapid growth in publications since 2015, with much of the work centered on molecular mechanisms of bioactive compounds and preclinical studies on functional properties, as well as a developing focus on food applications. In contrast, comparatively few studies have investigated the functional properties of the wild edible species *H. coralloides* and *H. americanum*, and their broader applications, particularly in food systems, have not yet been explored.

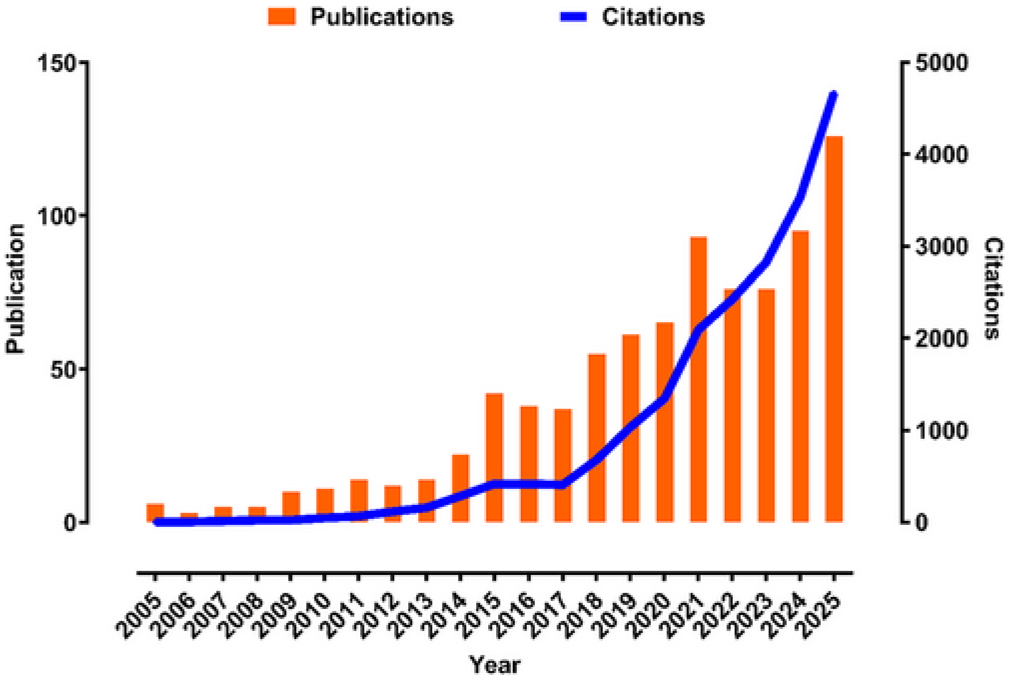

FIGURE 2

Publication and citation trends of *Hericium erinaceus* from January 1, 2005 to December 31, 2025 (Web of Science). (Figure by author).

The remarkable functional properties of *H. erinaceus* are largely attributed to a diverse array of bioactive compounds contained within their fruiting bodies and mycelia (Friedman **2015**; Kostanda et al. **2024**). Among the most notable are the hericenones and erinacines, a group of low molecular weight compounds uniquely found in *H. erinaceus*, which have shown the ability to stimulate the synthesis of nerve growth factors (NGF), essential for the development, maintenance, and survival of nerve cells in the brain and peripheral nervous system (Kostanda et al. **2024**; Szućko-Kociuba et al. **2023**). Furthermore, *H. erinaceus* is rich in polysaccharides, particularly β-glucans, which are well-known for their immunomodulatory effects, potentially enhancing the body's defense mechanisms (Chaiyasut et al. **2018**). Other bioactive constituents identified include various phenolic compounds, known for their antioxidant properties, contributing to the overall health benefits (Kim **2020**).

Although research on *H. erinaceus* is expanding, there is a lack of reviews that comprehensively address the nutritional value, functional properties, and technological aspects of *H. erinaceus* in relation to its role as a food ingredient. Most existing reports emphasize its medicinal and pharmacological properties, with limited discussion on sensory attributes, stability, and performance within real food systems. This limits the translation of current knowledge into practical and industrial applications. Therefore, this review aims to provide a comprehensive overview of *H. erinaceus*, examining its nutritional value, key bioactive compounds, functional properties, and sensory characteristics, alongside recent advances in food applications and product development. It seeks to establish a clearer foundation for food researchers and industry stakeholders interested in developing evidence-based functional foods using *H. erinaceus*.

2 Traditional Culinary and Medicinal Use in East Asia

Valued in East Asian culinary and medicinal traditions, especially in China where it is known as Hou Tou Gu (meaning “monkey head mushroom”), H. erinaceus has a long-standing cultural importance (Qi **2024**). Traditionally consumed as a food with no reported adverse health effects, it has been celebrated not only for its unique, seafood-like flavor and fleshy texture but also for its therapeutic properties (Sholyavei et al. **2020**). The use of this mushroom dates back to the Sui Dynasty, when it was commonly prepared as a soup. Historical records, such as the Miscellaneous Records of Unusual Objects in Linhai Soil from the Book of Sui, documented that people enjoyed consuming *H. erinaceus* in this manner (Tan et al. **2024**).

Aside from its culinary value, *H. erinaceus* has an extensive history of usage in Traditional Chinese Medicine (TCM) (Thongbai et al. **2015**). According to the Materia Medica of Dietary Therapy from the Tang Dynasty, *H. erinaceus* was commonly prescribed for the kidney, stomach, and spleen (Tan et al. **2024**). During this period, the mushroom was even regarded as a food reserved for royalty, appreciated for its ability to boost energy and promote general well-being (Siti Amalina **2017**). Centuries later, the Compendium of Materia Medica, compiled during the Ming Dynasty, further described *H. erinaceus* as possessing benefits that promote digestion and support the health of the five internal organs (liver, lung, spleen, heart, and kidney) (Tan et al. **2024**). Interestingly, these ancient texts described the mushroom's taste as sweet and mild, highlighting its role not only as a medicinal ingredient but also as a valued culinary delicacy. Reflecting this esteem, *H. erinaceus* is recognized as one of the “Four Famous Cuisines” in China, alongside bear's paws, trepang, and shark's fin (Wang et al. **2014**).

Although *H. erinaceus* has been less prominent in traditional Japanese and Korean cuisines than in China, it has been used in simmered dishes, soups, and convalescent foods, particularly in temple and seasonal cooking. In Japan, where it is known as *Yamabushitake*, its use is traditionally associated with benefits to the central nervous system (Brandalise et al. **2023**). The name derives from its resemblance to the chest ornament worn by *yamabushi*, ascetic Buddhist monks of mountainous regions (Buch **2024**). In Korea, *H. erinaceus*, known as *Norukungdaei*, is primarily consumed as an edible mushroom in local cuisine (Horie et al. **2008**; Khan et al. **2013**). Collectively, these traditional uses reflect an early understanding of food as a therapeutic medium, predating the modern concept of functional foods.

3 Nutritional Profile

3.1 Proximate Composition

Mushrooms, in general, are recognized as a low-calorie food source. Due to their comparatively low fat and digestible carbohydrate content, they can be used to enhance the nutritional profile of foods (Das et al. **2021**). They are also a source of dietary fiber and protein, contributing to their nutritional value (You et al. **2022**). *H. erinaceus* is valued not only for its unique texture and culinary applications but also for its impressive nutritional profile.

Comparison of the proximate composition of *H. erinaceus* fruiting bodies and submerged-cultured mycelial biomass revealed distinct nutritional profiles (Table 1). Fruiting bodies were richer in carbohydrates (60.6-76.5% DW), with moderate protein (15.4-28.7% DW) and fat (1.6-3.1% DW), providing 371–386 kcal/100 g energy (Gonkhom et al. **2024**; Koutrotsios et al. **2016**; Sharif et al. **2016**). In contrast, submerged-cultured mycelial biomass contained higher protein (42.5% DW), slightly more fat (6.3% DW), and lower carbohydrates (42.9% DW), resulting in a higher energy value (398 kcal/100 g) (Cohen et al. **2014**). These findings suggest that fruiting bodies are better suited for direct consumption, while protein-dense mycelial biomass is more suitable for functional food formulations and bioactive extraction, as well as a sustainable ingredient for meat alternatives. It should be noted that published data on the proximate content of *H. erinaceus* mycelial biomass remains limited, and most available reports are relatively dated, prompting the need for updated and comprehensive compositional analyses.

TABLE 1. Literature comparison of the proximate content of various *Hericium erinaceus* strains, as determined by the AOAC (Association of Official Analytical Chemists) methods.

Strain	**Type**	**Carbohydrate (% DW)**	**Protein (% DW)**	**Fat (% DW)**	**Moisture (% DW)**	**Fiber (% DW)**	**Ash (% DW)**	**Energy (kcal/100 g)**	**References**
H. erinaceus	Mycelial biomass	42.9	42.5	6.3	3.9	NA	4.4	398	(Cohen et al. **2014**)
H. erinaceus HE4514	Fruiting body	60.6	28.7	1.6	NA	6.0	9.2	371	(Koutrotsios et al. **2016**)

Strain	**Type**	**Carbohydrate (% DW)**	**Protein (% DW)**	**Fat (% DW)**	**Moisture (% DW)**	**Fiber (% DW)**	**Ash (% DW)**	**Energy (kcal/100 g)**	**References**
H. erinaceus	Fruiting body	76.5	18.8	2.0	NA	7.1	7.5	386	(Sharif et al. **2016**)
H. erinaceus MFLUCC 21-0019	Fruiting body	60.9	15.4	3.1	86.9	11.6	8.9	NA	(Gonkhom et al. **2024**)

- Abbreviations: DW, dry weight; NA, not available.

Variations in the proximate composition of *H. erinaceus* reflect the influence of strain, cultivation conditions, and substrate. Gonkhom et al. (**2024**) reported significant differences in protein, fat, fiber, and carbohydrate levels among four strains grown under identical conditions in Thailand. Similar trends in other regions confirm that nutrient composition is both strain- and environment-dependent (Atila et al. **2018**; Rodrigues et al. **2015**). This highlights the importance of strain selection for functional foods and nutraceuticals: protein-rich strains suit high-protein or meat-alternative products, while carbohydrate- and fiber-rich strains enhance bakery or staple food formulations. Continued strain-specific characterization is essential to optimize *H. erinaceus* for sustainable, health-focused applications.

3.2 Polysaccharides

Polysaccharides represent the major bioactive compounds of *H. erinaceus* and are among the most extensively studied constituents. Structurally, the majority of the polysaccharides obtained from the fruiting bodies of *H. erinaceus* using hot water extraction were heteropolysaccharides containing glucose, xylose, mannose, and galactose residues (He et al. **2017**). Among the polysaccharides of *H. erinaceus*, homopolysaccharides, particularly β-glucans, represent the most valuable and extensively studied polysaccharide class, owing to their well-documented antioxidant, anticancer, immunomodulatory, and neuroprotective activities (Qiao et al. **2024**; Rüstem et al. **2023**; Tripodi et al. **2022**; Wu et al. **2019**). β-glucans isolated from *H. erinaceus* are composed of glucose units linked primarily through glucose β-(1→3) glycosidic bonds, with β-(1→6) branching along the backbone. This arrangement has been experimentally shown to interact with immune receptors and activate multiple signaling pathways, enhancing immune response (He et al. **2017**). Structural variations, including molecular weight, the type of β-glycosidic bonds, and chain conformation, have been reported to significantly affect their functional behavior both in biological systems and in food matrices, although some proposed effects remain hypothetical and require further validation (Łysakowska et al. **2023**). For example, β-glucans with a triple helix structure and higher molecular weight isolated from *H. erinaceus* are suggested to surround starch fragments, thereby reducing their enzymatic hydrolysis and exerting stronger inhibitory effects on in vitro starch digestion (Ma et al. **2021**). This finding suggests promising opportunities for the incorporation of *H. erinaceus* into functional foods aimed at glycemic control, although further in vivo validation is warranted.

3.3 Amino Acids

Essential amino acids, including histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine, are present in higher levels in *H. erinaceus* (47.30%) compared to *Sparassis nemecii* (44.00%), *Laetiporus sulphureus* (41.25%), and *Polyporus umbellatus* (43.49%) analyzed in one study (Kopylchuk et al. **2023**). This finding corresponds with Li et al. (**2022**), which reported that the ratio of essential amino acids to nonessential amino acids in *H. erinaceus* (52.85%) is in the range of other commonly consumed mushrooms such as *Lentinus edodes* and *Flammulina velutipes* (47.48%–72.03%). These essential amino acids are nutritionally significant, as they are often limited in plant-based diets, making *H. erinaceus* a valuable protein complement in vegetarian and vegan cuisines. Cohen et al. (**2014**) also noted that the number of amino acids in the mycelial biomass of *H. erinaceus* was 30.65 mg/g, approximately twice that of the fruiting bodies (14.33 mg/g). This higher amino acid content suggests that mycelial biomass may be a more suitable substrate for food formulations, particularly in the development of high-protein or amino acid–enriched functional foods.

3.4 Lipids

The lipid fraction of *H. erinaceus* is relatively low compared to its protein and carbohydrate components, but it is nutritionally valuable due to its favorable fatty acid profile. Studies indicate that unsaturated fatty acids predominate, particularly linoleic acid (C18:2), followed by oleic acid (C18:1), which together account for a significant proportion of the total lipid content (Cohen et al. **2014**). The dominance of polyunsaturated fatty acids (PUFAs) highlights its potential role in cardiovascular health, as these compounds are associated with cholesterol regulation and anti-inflammatory properties (Krittanawong et al. **2021**). This finding, however, contradicts Saini et al. (**2021**), which reported that *H. erinaceus* had the lowest PUFAs/SFAs ratio among other mushrooms tested in their study, due to a predominance of palmitic acid.

Given the low total lipid content of the mushroom, this composition is not expected to significantly affect overall dietary fat contribution. Furthermore, lipids function as modulators and transporters of volatile compounds responsible for aroma in food. They can produce odors and flavors, serve as precursors for odor and flavor compounds, or alter the odors and flavors of other substances (Shahidi and Hossain **2022**). Therefore, the lipid composition not only supports the nutraceutical potential of *H. erinaceus* but also influences the sensory profile of *H. erinaceus*, contributing to aroma, texture, and the savory flavor complexity appreciated in gastronomy.

3.5 Vitamins

The vitamin composition of *H. erinaceus* illustrates its biochemical complexity and nutritional potential. Teng et al. (**2014**) reported that the fruiting bodies contain a corrinoid compound identified as vitamin B_{12}. Unlike true vitamin B_{12}, this form lacks coenzyme activity, rendering it biologically inactive. However, Friedman (**2015**) suggests that the active form of vitamin B_{12} might potentially be regenerated through chemical modification, specifically by opening the lactone ring structure. While this represents a biochemical possibility, further research is needed to establish whether such conversion could provide a reliable dietary source of active cobalamin. If successful, this approach could enhance the mushroom's nutritional significance, particularly for vegetarians and individuals seeking sustainable meat alternatives.
Additionally, *H. erinaceus* naturally contains a significant amount of ergosterol, a precursor of vitamin D_2 that is rich in mushrooms, making *H. erinaceus* a valuable non-animal source of vitamin D_2. Enhancing the vitamin D_2 content of *H. erinaceus* through UV treatment provides an innovative strategy for functional food formulation (Joradon et al. **2022**).

3.6 Minerals

The mineral composition of *H. erinaceus* further enhances its nutritional and functional value. Fruiting bodies and mycelial biomass are particularly rich in essential macro- and microelements such as potassium, phosphorus, magnesium, calcium, and iron, which play central roles in electrolyte balance, skeletal health, and oxygen transport (Yadav et al. **2024**). Potassium is the most abundant mineral, consistent with trends observed in other edible mushrooms, followed by phosphorus and magnesium (Cohen et al. **2014**). Trace minerals such as zinc, copper, and manganese are also present in bioavailable forms, supporting antioxidant defense and immune function (Stojek et al. **2024**). Importantly, *H. erinaceus* has been shown to contain negligible or undetectable levels of harmful heavy metals such as lead, mercury, and copper when cultivated under controlled conditions. Cohen et al. (**2014**) stated that the fruiting bodies and mycelial biomass of *H. erinaceus* exhibited the lowest amount of cadmium, a toxic element known to disrupt numerous biological and enzymatic processes, compared with other mushrooms examined. This distinguishes it from some wildforaged mushrooms that may accumulate toxic elements from the environment. Therefore, the composition of minerals in *H. erinaceus* not only reinforces its reputation as a nutritional, health-promoting food but also enhances consumer confidence in its safety and suitability for functional food formulations.

4 Bioactive Compounds

The rich array of bioactive compounds found in the mycelia and fruiting bodies of *H. erinaceus* has attracted significant interest in their health-promoting properties. Among the most well-studied are the hericenones and erinacines, which are exclusive to the species. The known bioactive compounds found in *H. erinaceus* are described in Table **2**.

TABLE 2. Summary of reported functional properties of *Hericium erinaceus* with corresponding evidence type, experimental models, and key findings.

Functional properties	Evidence type	Model	Key Findings	References
Antioxidant effects	In vivo	Yeast (*Saccharomyces cerevisiae*)	Reduced free radical levels and oxidative stress markers	(Tripodi et al. **2022**)
Antimicrobial activity	In vitro	Bacterial cultures	Inhibited Gram-positive (*Bacillus subtilis, Micrococcus luteus*, and *Staphylococcus aureus*) and Gram-negative (*Escherichia coli* and *Pseudomonas aeruginosa*) bacteria	(Lomberg et al. **2023**)
	In vitro	*Helicobacter pylori* culture	Demonstrated inhibition against *H. pylori*	(Ngan et al. **2021**)
Anti-inflammatory effects	In vitro	Murine RAW 264.7 macrophage cells	Inhibited pro-inflammatory mediators via modulation of NF-κB and MAPK pathways	(Xie et al. **2022**)

Functional properties	Evidence type	Model	Key Findings	References
	Animal	Cerebellar ataxia rat model	Upregulated Trem2, Tgfb1, and Tgfb2 genes involved in anti-inflammatory response	(Chau et al. **2023**)
Anticancer effects	In vitro	Human gastric cancer cells	Increased ROS production and induced apoptosis	(Tung et al. **2021**)
	Animal	Xenograft mouse model	Suppressed tumor growth and induced apoptosis	
	In vitro	HCT-8 colon cancer cells	Sterol derivatives inhibited cell proliferation	(Cao et al. **2023**)
Anti-diabetic effects	Animal	Streptozotocin-induced diabetic rats	Improved glucose tolerance and alleviated hepatic functions	(Cai et al. **2020**)
	Animal	Type-2 diabetes mellitus mouse model	Modulated glucose imbalance and lipid metabolism by enhancing glucose uptake and inhibiting fatty acid synthesis	(Cui et al. **2023**)
Immunomodulatory action	In vitro	Human THP-1 monocytic cells	Stimulated lymphocyte proliferation and cytokine expression	(Wu et al. **2019**)

Functional properties	Evidence type	Model	Key Findings	References
	In vitro	Murine RAW264.7 macrophage cells	Activated macrophages and promoted cytokine secretion via NF-κB, MAPK, and PI3K/Akt pathways	(Yang et al. **2022**)
Neuroprotective activity	In vitro	PC-12 neuronal cells	Enhanced cell viability, reduced ROS accumulation, and protected cells from apoptosis	(Lew et al. **2020**)
	Animal	Status epilepticus mouse model	Improved hippocampal neuronal survival	(Jang et al. **2019**)
	Animal	Rat model of traumatic brain injury	Improved spatial memory and inhibited neuronal cell death	(Lee et al. **2024**)
	Animal	MPTP-induced Parkinson's disease mouse model	Prevented neuronal cytotoxicity and ROS production, and activated pathways for neuronal survival	(Lee et al. **2020**)
	Human	Patients with mild Alzheimer's disease	Reduced apparent diffusion coefficient (ADC) values in parahippocampal cingulum (PHC)	(Li et al. **2020**)

- Abbreviation: ROS, reactive oxygen species.

4.1 Hericenones

Hericenones are aromatic benzyl alcohol derivatives primarily isolated from the fruiting bodies of *H. erinaceus* that have been shown to stimulate nerve growth factor (NGF) synthesis both in vitro and in vivo, highlighting the species' neurotrophic potential (Wang et al. **2025**). Recent studies have further clarified their functional relevance; for example, Cvetković et al. (**2025**) reported strong antioxidant and DNA-protective effects of ethanolic *H. erinaceus* extracts, partly attributed to hericenone-mediated mitigation of oxidative stress.

Supporting these findings, hericenone C, one of the major secondary metabolites of H. erinaceus, was reported to attenuate inflammatory pain in a formalin-induced mouse model by inhibiting nociceptive behavior via the NF-κB signaling pathway. It also reduced accumulation of CD11c-positive inflammatory cells (Li et al. **2024**). These results validate the possibility of hericenones as potent neuroactive compounds with potential roles in neuronal growth and protection. However, despite animal and in vitro evidence, their efficacy in humans remains poorly characterized. No clinical trials have established their bioavailability, effective dosage, or long-term safety, limiting translation into evidence-based dietary recommendations. Further human studies are therefore required to validate their functional benefits and practical application.

4.2 Erinacines

Erinacines are a group of cyathane-type diterpenoids predominantly produced in the mycelium of *H. erinaceus* and are structurally distinct from the hericenones found in its fruiting bodies. Erinacine A has been established as a potent inducer of NGF synthesis, with studies confirming its capacity to enhance neurotrophic signaling and neuronal differentiation in experimental models (Lee et al. **2020**). Subsequent studies expanded this group to include several related compounds, including erinacines C and S, each exhibiting varying neuroprotective activity (Lin et al. **2023**; Rascher et al. **2020**).

Recent research has focused on improving the isolation and quantification of erinacines, particularly erinacine A, to enhance purity, reproducibility, and applicability in food and nutraceuticals. Naumoska et al. (**2025**) developed a two-dimensional chromatographic method that yields high-purity erinacine A from *H. erinaceus* mycelia with improved extraction efficiency and stability. Liu et al. (**2024**) compared strains and cultivation conditions, revealing substantial differences in erinacine A production and guiding selection of high-yield strains. These advances underscore the growing emphasis on standardization and optimization, supporting the use of erinacine-enriched *H. erinaceus* in functional foods and cognitive health supplements.

Erinacines have attracted clinical interest for cognitive enhancement and neuroprotection. Li et al. (**2020**) reported that in a 49-week double-blind, placebo-controlled trial, daily supplementation with *H. erinaceus* mycelia capsules containing 15 mg erinacine A significantly improved cognitive performance in early-stage

Alzheimer's patients, while also maintaining neurotrophic biomarkers with good safety. More recently, Černelič Bizjak et al. (**2024**) found that daily supplementation of 3.44 mg of erinacine A in healthy adults over the age of 55 years-old significantly increased gut microbiota diversity and cognitive performance without adverse effects. These results suggest that erinacines can modulate neurotrophic pathways in humans, and that beneficial effects may be achievable with relatively small, consistent doses. These results provide a preliminary reference for designing nutraceuticals and functional foods for cognitive health. However, the bioavailability of erinacines in humans is still poorly understood. Černelič Bizjak et al. (**2024**), in their study, explored this indirectly by measuring fecal CHI3L1, a chitinase-like protein associated with gut immune response and host-fungal reactions. However, the absence of significant CHI3L1-related effects suggests that the cognitive benefits observed were not strongly influenced by this pathway. Since CHI3L1 lacks true enzymatic chitinase activity and primarily reflects inflammatory and mucosal responses rather than actual degradation of chitin or direct absorption of bioactive compounds, this approach provides limited information on erinacine bioavailability in humans (Liu et al. **2024**). Most studies investigating erinacine pharmacokinetics remain preclinical. For example, a study in Sprague-Dawley rats demonstrated that orally administered erinacine. A exhibited moderate bioavailability (~24%), was distributed to the brain within hours, and crossed the blood-brain barrier via passive diffusion (Tsai et al. **2021**). These findings may not directly translate to humans due to gastrointestinal physiology, thereby highlighting the need for well-designed human bioavailability studies.

4.3 Lovastatin

Lovastatin is a naturally occurring polyketide and a member of the statin family, widely recognized for its ability to inhibit 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase, the rate-limiting enzyme in cholesterol biosynthesis (Zhang et al. **2020**). Traditionally sourced from *Aspergillus terreus*, this compound has inspired interest in identifying alternative fungal producers with added nutritional value (Pandey et al. **2019**). In a recent study, *H. erinaceus* was reported to contain approximately 5.8 mg/100 g of lovastatin in the mycelial biomass and between 0.3–3.1 mg/100 g in the fruiting bodies, indicating that lovastatin concentration is markedly higher in the mycelial stage compared to the mature fruiting structures (Lazur et al. **2024**). In contrast, Cohen et al. (**2014**) observed a lovastatin content of 1.44 mg/100 g in the fruiting bodies, while none was detected in the mycelial biomass. These discrepancies likely reflect differences in strain, cultivation conditions, developmental stage, and analytical methods. While such variation may limit the use of *H. erinaceus* as a pharmaceutical source, it may still provide functional benefits when incorporated into foods. Developing standardized cultivation and optimized extraction could improve consistency, supporting both nutraceutical and functional food applications.

4.4 Ergosterol

Ergosterol is the principal sterol component in fungal cell membranes and serves as a precursor for vitamin D_2 upon ultraviolet (UV) irradiation. In *H. erinaceus*, ergosterol contributes not only to structural membrane integrity but also to its antioxidant and nutraceutical properties (Joradon et al. **2022**). Recent studies have quantified and characterized ergosterol content under different cultivation and processing conditions. Kała et al. (**2025**) reported that ergosterol levels in *H. erinaceus* vary depending on substrate composition and extraction solvent, with the highest yield achieved using 70% ethanol and water, obtained from fruiting bodies cultivated on a substrate composed of beech sawdust and wheat bran (628 mg/100 g). An innovative concept was presented by Duru et al. (**2025**), who developed a biofortification strategy combining solid-state fermentation (SSF) with *H. erinaceus*, followed by UV-B irradiation of colonized corn flour to enhance its nutritional and functional qualities. The study demonstrated that UV-B exposure efficiently converted ergosterol from both the fungal mycelium and the cereal matrix into vitamin D_2, achieving concentrations up to 18.98 µg/100 g. This work underscores the value of *H. erinaceus* as a bioactive fermentation agent and natural source of ergosterol for vitamin D_2-enriched functional food development.

4.5 Ergothioneine

Ergothioneine is an amino acid derivative produced by certain fungi and bacteria, which humans obtain only through diet. It is a stable antioxidant capable of accumulating in specific tissues and has been linked to potential benefits against oxidative stress and age-related diseases (Lei et al. **2025**). A preclinical study by Roda et al. (**2022**) found that *H. erinaceus* extract demonstrated a significant decrease of oxidative stress markers and was able to trigger a partial oxidative stress recovery in aged mice. Oxidative stress is a major limiting mechanism of longevity, as well as a key factor implicated in the onset and progression of numerous age-related neurological, cardiovascular and metabolic diseases and cancer (Vatner et al. **2020**). Thus, safeguarding against oxidative stress is the principal mechanism to be utilized in ensuring healthy aging. The study by Roda et al. (**2022**) concluded that these preventative effects could be attributed to the particularly high content of ergothioneine, described as the “longevity vitamin.” Furthermore, dietary ergothioneine is efficiently absorbed in the intestine and distributed to various body tissues, where it is retained at high levels (Tang et al. **2018**). Therefore, *H. erinaceus*, with its high ergothioneine content, represents a promising source for the development of functional foods and nutraceuticals aimed at combating oxidative stress and age-related diseases.

4.6 γ-Aminobutyric Acid (GABA)

As the principal inhibitory neurotransmitter in the mammalian central nervous system, γ-aminobutyric acid (GABA) plays a key role in regulating neuronal excitability, mood, and stress responses through GABA-A and GABA-B receptor pathways (Barakat and Aljutaily **2025**). Imbalances in GABA signaling are associated with insomnia, anxiety, and depressive disorders (Zhu et al. **2024**). Beyond its endogenous role, GABA is naturally present in various foods, and its dietary intake has attracted growing scientific and commercial interest owing to its ability to influence both peripheral and central nervous system functions (Ushidee-Radzi et al. **2025**). Specifically, dietary GABA contributes to blood pressure regulation, stress alleviation, and the promotion of relaxation, making it a desirable bioactive component for incorporation into functional foods and nutraceuticals (Hepsomali et al. **2020**; Zareian et al. **2020**). However, GABA levels in plant-based foods are generally lower than in animal-derived products, underscoring the need for alternative non-animal GABA sources (Lee et al. **2023**). In this context, edible mushrooms, particularly *H. erinaceus* have emerged as promising candidates. Cohen et al. (**2014**) reported that *H. erinaceus* fruiting bodies contained 42.93 μg/g of GABA, while the mycelial biomass exhibited 56.00 μg/g, highlighting the species' notable potential as a natural, plant-based GABA source suitable for functional food development.

5 Functional Properties

The functional properties of *H. erinaceus*, including its antioxidant effects, antimicrobial activity, anti-inflammatory effects, anticancer effects, anti-diabetic effects, immunomodulatory action, and neuroprotective activity, are summarized in Table **2**.

5.1 Antioxidant Effects

Research has demonstrated the potent antioxidant properties of *H. erinaceus*. These effects are primarily attributed to its polysaccharides, phenolic compounds, and other bioactive metabolites, which can scavenge free radicals and enhance endogenous antioxidant defense systems in vitro and in animal models, as well as reduce oxidative stress, a major factor implicated in the progression of aging (Lei et al. **2025**; Tu et al. **2021**). For instance, an aqueous extract of *H. erinaceus*, rich in β-glucans, reduced free radical levels in yeast cells, suggesting potential anti-aging mechanisms (Tripodi et al. **2022**). While these findings provide mechanistic insights, their direct translation to human health benefits remains to be clinically validated.

Nonetheless, these antioxidant properties have clear applications in food technology beyond their biomedical significance. Oxidative processes such as lipid peroxidation are major contributors to food spoilage, off-flavor formation, and nutrient loss (Petcu et al. **2023**). Incorporating *H. erinaceus* extracts into food products may inhibit these processes, thereby prolonging shelf-life and maintaining sensory quality. They offer a natural alternative to synthetic preservatives that could reduce rancidity in high-fat foods or preserve color stability in processed meats.

5.2 Antimicrobial Activity

Several studies have explored the antimicrobial potential of *H. erinaceus* extracts against a range of pathogenic microorganisms. In vitro work by Lomberg et al. (**2023**) observed inhibition against Gram-positive (*Bacillus subtilis, Micrococcus luteus*, and *Staphylococcus aureus*) and Gram-negative (*Escherichia coli* and *Pseudomonas aeruginosa*) bacteria, suggesting the presence of compounds with broad-spectrum antimicrobial properties. Moreover, *H. erinaceus* demonstrated in vitro inhibition against *Helicobacter pylori*, a common bacterium in stomach infections (Ngan et al. **2021**). This suggests its potential application in functional foods aimed at supporting gastric health and preventing infection. While these observations indicate antimicrobial promise, the underlying mechanisms and clinical relevance in humans require further investigation.

From a food technology perspective, the antimicrobial properties may help reduce food spoilage and pathogenic contamination, supporting the development of natural preservation strategies. Mushroom by-products, such as caps, stipes, and mycelial residues, have been explored as bio-based, biodegradable packaging materials, offering a sustainable way to upcycle by-products while promoting a circular economy (Hernández-García et al. **2026**). This presents an opportunity for *H. erinaceus* to potentially be utilized as an active packaging component, capable of enhancing food safety and extending product freshness through natural bioactive mechanisms.

5.3 Anti-Inflammatory Effects

H. erinaceus has shown promising anti-inflammatory properties attributed to its rich profile of bioactive secondary metabolites, including erinacines, hericenones, and polysaccharides. Xie et al. (**2022**) reported that several secondary metabolites isolated from *H. erinaceus* exhibited potent inhibitory effects on pro-inflammatory mediators, such as nitric oxide (NO), tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6), by modulating the NF-κB and MAPK signalling pathways in murine RAW 264.7 macrophage cells. These findings suggest that *H. erinaceus* compounds may help attenuate inflammation at the molecular level through both oxidative and cytokine regulation. In a complementary in vivo study, Chau et al. (**2023**) demonstrated that *H. erinaceus* administration in a cerebellar ataxia rat model upregulated the expression of Trem2, Tgfb1, and Tgfb2 genes involved in anti-inflammatory response, which suggests a potential role in restoring immune functions under neuroinflammatory conditions. These properties highlight the mushroom's promise as a source of nutraceuticals targeting chronic inflammatory diseases, pending clinical validation.

5.4 Anticancer Effects

Emerging research suggests bioactive compounds from *H. erinaceus* display anticancer potential. Tung et al. (**2021**) reported that erinacine S increased reactive oxygen species (ROS) production and induced apoptosis in human gastric cancer cells. In a xenograft mouse model, erinacine S also suppressed tumor growth, with apoptosis mediated through FasL and TRAIL signaling pathways. Cao et al. (**2023**) demonstrated that extracts from different varieties of *H. erinaceus* exhibited significant inhibitory activity against HCT-8 colon cancer cells, indicating that both the composition and extraction method influence the mushroom's anticancer efficacy. The study also suggested that sterol derivatives, including ergosterol, dehydro-ergosterol, neo-ergot sterols, and γ-ergosterol, are responsible as the active component against the cell line. These preclinical findings indicate that *H. erinaceus* contains bioactive compounds with potential anticancer properties and that these compounds can serve as functional ingredients for foods that go beyond basic nutrition. These foods may appeal to health-conscious consumers seeking cancer-preventive diets.

5.5 Anti-Diabetic Effects

Studies have begun to explore the potential of *H. erinaceus* in managing diabetes. Cai et al. (**2020**) found that the administration of *H. erinaceus* extract improved glucose tolerance by mediating glycogen synthesis and ameliorated hepatic dysfunction by attenuating liver damage in streptozotocin-induced diabetic rats. Another study reported that polysaccharides from H. *erinaceus* showed potential effects against glucose imbalance and lipid metabolism in mice induced with type-2 diabetes mellitus by promoting serum glucose uptake and inhibiting fatty acid synthesis (Cui et al. **2023**). While direct evidence on anti-diabetic effects in humans is limited, these preliminary results suggest *H. erinaceus* as a functional dietary ingredient exhibiting great potential in modulating glucose metabolism.

5.6 Immunomodulatory Action

β-glucans, a type of polysaccharide derived from various mushroom species, are widely recognized for their immunomodulatory properties, which involve the activation of the host immune system and/or the enhancement of macrophage functionality. Wu et al. (**2019**) elucidated the structure of a β-D-glucan isolated from *H. erinaceus* and demonstrated immune-enhancing activity, including the stimulation of lymphocyte proliferation and upregulation of inflammatory cytokines TNF-α, IL-6, and IL-1β in the human monocytic cell line THP-1. Similarly, Yang et al. (**2022**) reported that polysaccharides extracted from *H. erinaceus* fruiting bodies enhanced immune responses by activating macrophages and promoting cytokine secretion via the NF-κB, MAPK, and PI3K/Akt signalling pathways in murine RAW264.7 macrophage cells. The immune-enhancing effects of *H. erinaceus* can be harnessed to design immune-supporting functional foods, a trend that has surged post-pandemic.

5.7 Neuroprotective Activity

The neuroprotective activity of *H. erinaceus* is largely attributed to erinacines and hericenones, which stimulate nerve growth factor (NGF) synthesis. Recent studies highlight its potential to support cognitive function and protect against neurodegenerative diseases across a range of disease models. Lew et al. (**2020**) demonstrated that *H. erinaceus* exerted neuroprotective effects against corticosterone-induced oxidative stress in PC-12 neuronal cells, a cellular model mimicking depression. These effects were attributed to its bioactive compounds, which enhanced cell viability, reduced reactive oxygen species (ROS) accumulation, and protected cells from apoptosis. Additionally, *H. erinaceus* extracts were shown to improve hippocampal neuronal survival in a status epilepticus mouse model, indicating their potential role in reducing seizure-induced neuronal injury (Jang et al. **2019**). The study commented that erinacine A in the extracts may be responsible for exerting neuroprotection against seizure. However, it is likely that several functional substances may produce synergistic effects. Accordingly, novel erinacines derived from *H. erinaceus* mycelium have been shown to exert cerebral protective effects in a rat model of mild traumatic brain injury by improvements in spatial memory while inhibiting neuronal cell death (Lee et al. **2024**). Treatment with erinacine An in mouse model of Parkinson's disease also prevented the cytotoxicity of neuronal cells and the production of ROS, as well as the activation of conserved signaling pathways for neuronal survival (Lee et al. **2020**). In a double-blind placebo-controlled study, erinacine A-enriched capsules reduced apparent diffusion coefficient (ADC) values in parahippocampal cingulum (PHC) in early-stage Alzheimer's patients, suggesting that *H. erinaceus* supplementation could improve structural deterioration of PHC (Li et al. **2020**). In the context of gastronomy, this property offers unique opportunities to market *H. erinaceus* as a “brain food” that could cater to consumers seeking cognitive enhancement through diet.

6 Applications of *Hericium erinaceus* in Foods: Technological and Sensory Outcomes

H. erinaceus has attracted growing research interest in the food industry, primarily due to its nutritional and functional bioactive compounds. Although its commercial popularity remains limited, scientific studies have increasingly explored its incorporation into diverse food products (Figure **3**).

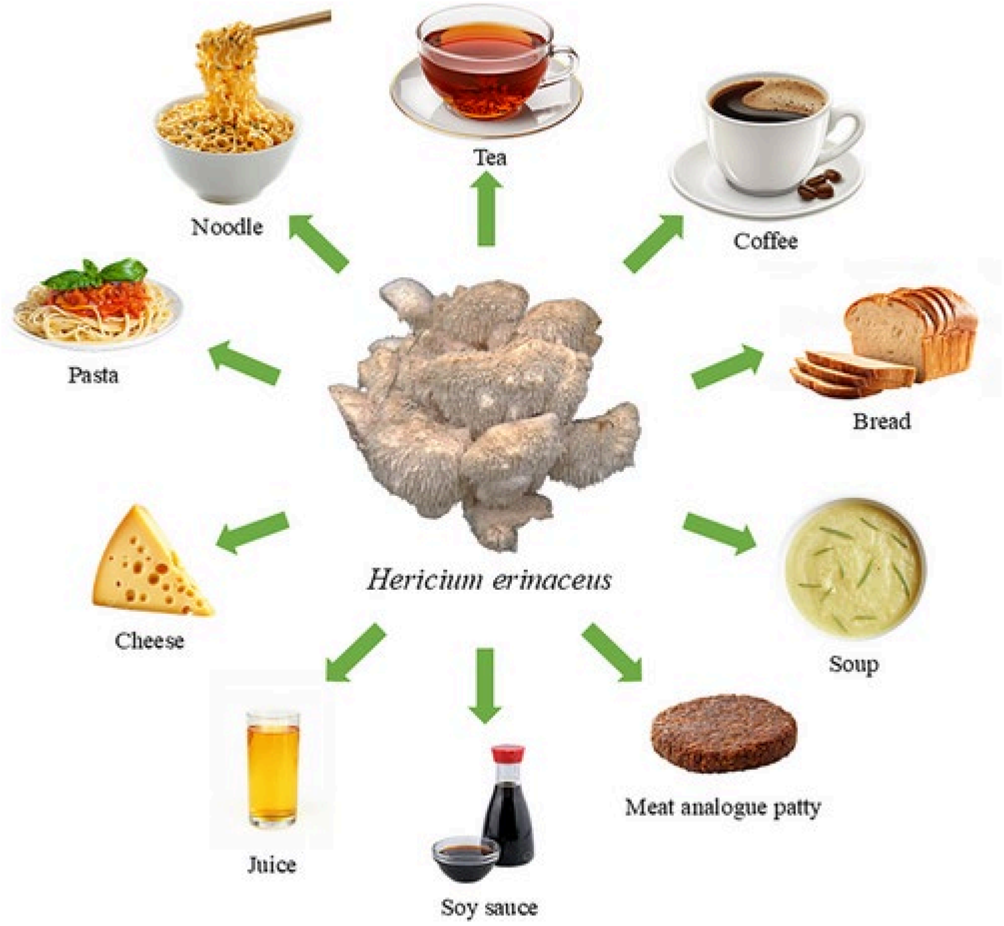

FIGURE 3

Recent food applications of Hericium erinaceus. (Figure by author).

6.1 Beverages

A notable application in beverages is the fortification of coffee with *H. erinaceus*. A study by Kała et al. (**2024**) examined the potential of *H. erinaceus* powder as an additive for the preparation of machine-brewed, instant, and traditionally brewed coffees, leading to an increase in bioelements including Mg^{2+}, K^{+}, and Ca^{2+}, which are involved in many biochemical processes in the body. The presence of bioactive compounds such as lovastatin and ergosterol, both of which are associated with cholesterol-lowering and immune-enhancing functions, was also observed. As drinking coffee is a daily routine for many people, this innovation delivers functional benefits without major dietary change. Importantly, further in vitro or human studies are required to verify the bioavailability and physiological efficacy of these bioelements and bioactive compounds when delivered through coffee consumption. A concern is that the caffeine content across machine-brewed, instant, and traditionally brewed coffees fortified with *H. erinaceus* was consistently lower than in their respective controls, which presents a commercial limitation, as caffeine is a primary driver of consumer preference in coffee beverages.

Tea preparations of *H. erinaceus* have recently been explored as a practical format for delivering its bioactive compounds. In a comparative study, Ghosh et al. (**2021**) prepared both infusion and decoction teas from *H. erinaceus* and conducted mycochemical and antioxidant profiling. The results revealed that the infusion contained significantly higher levels of phenolic compounds (1.72 mg gallic acid equivalent/g) compared to the decoction (0.28 mg/g). Both preparations demonstrated notable antioxidant activities, although the infusion was consistently superior. The presence of compounds such as lycopene and β-carotene, albeit in small amounts, further contributed to the functional profile. Tea represents an accessible medium for incorporating mushroom-derived antioxidants into daily diets. Recent studies have demonstrated the potential of fungal species such as *Pleurotus sajor-caju* and *Eurotium cristatum* in tea fermentation, enhancing both bioactive profiles and sensory qualities (Jiang et al. **2024**; Su et al. **2022**). Although this approach has yet to be applied to *H. erinaceus*, the concept suggests promising opportunities for developing novel functional beverages that deliver health-promoting benefits.

6.2 Meat Alternative

Studies indicate that *H. erinaceus* shows promise as an ingredient in meat alternatives. The incorporation of *H. erinaceus* powder into soy-based meat analogues enhanced the fibrous structure (Gao et al. **2025**). Increasing its proportion led to gradual decreases in hardness and chewiness, likely due to the insoluble dietary fiber disrupting the rigid gel network formed by soy proteins. In addition, *H. erinaceus* powder supplementation upregulated 101 volatile flavor compounds, primarily aldehydes (fatty notes), ketones (fruity aromas), and alcohols (mushroom-like characteristics), thereby increasing flavor complexity. Higher levels of *H. erinaceus* powder also increased redness (a*) and yellowness (b*) values, attributed to polysaccharide-mediated Maillard reactions, which produced a darker, more visually appealing product compared to soy-based analogues. However, formulations exceeding 20% decreased fluorescence intensity, consistent with protein–β-glucan complex formation. This interaction may reduce protease accessibility and potentially lower protein digestibility, thereby compromising the perceived nutritional quality of the product.

Similarly, Marcello and Halim (**2024**) developed patties using *H. erinaceus* fruiting bodies with pumpkin seeds and soy flour, comparing them to conventional meat patties. A higher mushroom content increased moisture capacity and created a less springy, chewy texture resembling ground meat. Sensory evaluation reported higher overall acceptability for meat analogues with a higher ratio of *H. erinaceus*, highlighting enhanced juiciness and appearance.

Notably, these studies incorporated *H. erinaceus* at relatively low supplementation levels alongside established plant proteins such as soy. This partial substitution strategy might mitigate production costs, as the primary protein matrix remains derived from inexpensive, widely available sources, while the mushroom component functions as a value-adding enhancer rather than a bulk protein replacement (Oh and Kim **2025**; Panda et al. **2025**). Such an approach may improve economic feasibility while retaining functional and sensory benefits.

Looking forward, emerging food technologies such as 3D food printing present opportunities for incorporating *H. erinaceus* into structured meat substitutes. Previous studies have demonstrated the feasibility of producing 3D printable vegan meat analogues fortified with mushroom, including *Ganoderma lucidum*, *Lactarius deliciosus*, and *Pleurotus ostreatus*, where the addition of fungal biomass improved printability, texture, and nutritional value (Demircan et al. **2023**). Given its fibrous morphology and high protein content, *H. erinaceus* holds strong potential as a novel biomaterial for next-generation 3D-printed meat substitutes.

6.3 Staple Foods

The integration of *H. erinaceus* into staple foods has been shown to enhance both their functional and physicochemical properties. In Chinese noodles, incorporation of *H. erinaceus* powder increased antioxidant activity and reduced starch digestibility, suggesting potential benefits for glycemic control. Subsequent physicochemical analysis revealed notable changes in noodle quality. The addition of mushroom powder enhanced brightness (L*), redness (a*), and yellowness (b*) values, as well as increased hardness, gumminess, and chewiness (Wang et al. **2021**). While excessive incorporation (>6%) could further reduce starch digestion and increase antioxidant capacity, noodle quality might potentially be compromised. In cream soup, the addition of *H. erinaceus* powder enhanced antioxidant capacity. Mechanical analysis revealed that increasing the amount of *H. erinaceus* powder enhanced the umami taste and reduced bitterness while simultaneously increasing the viscosity, resulting in a thicker consistency. Although the addition caused slight darkening in color, consumer panels reported favorable flavor and overall palatability, indicating that the mushroom complemented the product's sensory profile (Yang et al. **2014**).

Similar benefits were observed in cereal-based products such as bread and pasta. In wheat bread, the addition of *H. erinaceus* powder increased antioxidant activity but also adversely affected structural properties, reducing loaf volume and increasing crumb hardness while lowering springiness. Sensory panels rated appearance, color, and aroma positively, particularly at the lowest enrichment levels (3%). However, texture scores declined with increasing *H. erinaceus*, consistent with instrumental texture analysis, while the highest addition (12%) garnered a relatively low flavor rating. These findings suggest that excessive substitution may negatively affect sensory quality, particularly texture and taste, which are critical determinants of consumer acceptance (Łysakowska et al. **2025**). Pasta enriched with mushroom powders, including *H. erinaceus*, displayed higher protein and fiber contents (Szydłowska-Tutaj et al. **2022**).

Physicochemical outcomes included decreased brightness (L*) and yellowness (b*) values and changes in firmness, which impacted texture perception. Sensory analysis revealed that while excessive supplementation reduced acceptability due to color and texture changes, a moderate substitution level (5%) was well received, showing strong potential for nutritional enhancement without compromising consumer appeal.

Collectively, these studies demonstrate that *H. erinaceus* fortification can improve the nutritional and functional quality of staple foods while introducing distinct physicochemical and sensory characteristics. It is noteworthy that most staple food fortification studies utilized *H. erinaceus* fruiting body powder rather than mycelial biomass. While fruiting bodies are traditionally consumed and widely accepted, their cultivation takes time and space, potentially limiting scalability and increasing production costs. In contrast, mycelial biomass produced via submerged fermentation offers a shorter production cycle and better standardization, which prompts assessment of its functional performance and economic viability in staple food applications (Romero et al. **2025**; Shin et al. **2025**).

6.4 Fermented Foods

Unlike direct incorporation of *H. erinaceus* powder into staple foods such as noodles, bread, or soups, its application in fermented foods involves dynamic interactions with microbial systems, which significantly influence product functionality, safety, and sensory quality. An example is the use of *H. erinaceus*-derived crude milk-clotting enzymes in cheese production. Kishimoto et al. (**2020**) demonstrated that cheese prepared with these enzymes not only achieved successful coagulation but also exhibited antifungal activity, thereby prolonging shelf-life. This approach positions *H. erinaceus* not as a bulk ingredient but as a biotechnological tool. This can be taken a step further through precision fermentation, which enables controlled and scalable production of functional enzymes. In particular, strain selection and genetic engineering strategies could be employed to enhance the yield and stability of milk-clotting enzymes from *H. erinaceus*, thus improving their efficiency in milk production (Augustin et al. **2024**; Knychala et al. **2024**). Beyond enzyme utilization, *H. erinaceus* also serves as a substrate in microbial fermentation. Chaiyasut et al. (**2018**) reported that lactic acid bacteria (LAB)-mediated fermentation of *H. erinaceus* juice with *Lactobacillus fermentum* HP3 enhanced bioactivity, particularly improving glycemic regulation in animal models by lowering blood glucose and increasing insulin sensitivity. Similarly, in soy sauce fermentation, the incorporation of *H. erinaceus* powder altered microbial diversity and enhanced volatile compound profiles while inhibiting the growth of the spoilage bacterium *Stenotrophomonas*, resulting in improved product safety and flavor complexity (Zhao et al. **2021**). Future studies could further advance this application using response surface methodology (RSM) to systematically optimize fermentation conditions for improved sensory quality and product consistency. In particular, the level of *H. erinaceus* supplementation could be evaluated alongside key processing variables such as temperature and pH to determine their interactive effects on the overall flavor profile of soy sauce (Shin Yee et al. **2024**; Song et al. **2025**).

7 Sensory Properties

The key flavor-active compounds, taste components, and texture contributors in *H. erinaceus* are summarized in Table **3**. Together, these determinants explain the characteristic “seafood-like” flavor, savory taste, and creamy mouthfeel often reported for *H. erinaceus* (Friedman **2015**; Qi **2024**). Understanding how these compounds behave across handling, storage, and processing is central to formulation and to achieving consistent consumer acceptance in modern foods (Deng et al. **2024**; Sun et al. **2020**).

TABLE 3. Key flavor and sensory components of *Hericium erinaceus*, their contributions and functional relevance.

Component	Chemical compounds	Sensory character	Functional role	Processing and storage effects	References
Volatile aroma compound	1-octen-3-ol, 1-octen-3-one, 2-octanone, benzaldehyde, phenylacetaldehyde	Fresh mushroom, nutty, floral	Defines aroma profile and consumer appeal	C8 volatiles decline with storage; aldehydes and 1-octanol increase; affected by drying, irradiation, and temperature.	(Deng et al. **2024**; Zhong et al. **2024**)
Heterocycles (S/N) and pyrazines	2-methyl-3-furanthiol; 2-ethylpyrazine; 2,6-diethyl pyrazine	Savory, roasted, meaty	Enhance depth and savory character	Formation influenced by matrix composition and thermal processes.	(Deng et al. **2024**; Zhu et al. **2024**)
Umami amino acids	Glutamic acid, aspartic acid	Savory, broth-like	Synergizes with 5'-nucleotides to raise equivalent umami concentration (EUC)	Levels vary with strain, maturity, and processing.	(Li et al. **2022**; Sun et al. **2020**)

Component	Chemical compounds	Sensory character	Functional role	Processing and storage effects	References
5'-Nucleotides	IMP, GMP, XMP	Amplifies umami, rounding saltiness	Drives amino acid–nucleotide synergy (equivalent umami concentration)	Reported ranges vary widely across studies and species.	(Phat et al. **2016**; Yang et al. **2022**)
Polysaccharides (β-glucans)	Cell-wall and soluble fractions	Creamy mouthfeel, viscosity, gelation	Texture optimization; potential to lower glycemic impact	Soluble mycelial β-glucans disperse well; viscosity is sensitive to shear and pH.	(Du et al. **2019**; Feng et al. **2019**; Wang et al. **2019**)
Lipid fraction	Palmitic acid, linoleic acid,	Fatty, buttery, oxidized notes (context-dependent)	Reservoir/precursor for volatiles	Lipid oxidation and flavor formation influenced by process and storage.	(Saini et al. **2021**; Shahidi and Hossain **2022**)

- Abbreviations: GMP, guanosine monophosphate; IMP, inosine monophosphate; XMP, xanthosine monophosphate.

The use of modern instrumental techniques such as headspace solid-phase microextraction gas chromatography–mass spectrometry (HS-SPME-GC–MS) and headspace gas chromatography-ion mobility spectrometry (HS-GC-IMS) have significantly validated organic compounds responsible for the odor of *H. erinaceus*. The aroma of *H. erinaceus* is largely driven by C8 fungal volatiles such as 1-octen-3-ol, 1-octen-3-one, and 2-octanone that impart a fresh “mushroom-like” note, supported by aldehydes and aromatics (e.g., benzaldehyde, phenylacetaldehyde) that add sweet, floral, and nutty nuances (Deng et al. **2024**; Zhong et al. **2024**). Gas chromatography–olfactometry has also identified sulphur- and nitrogen-containing compounds (e.g., 2-methyl-3-furanthiol, 2-ethylpyrazine, and 2,6-diethylpyrazine) as potent odor contributors that strengthen roasted and savory notes (Deng et al. **2024**; Zhu et al. **2024**). Lipids can modulate aroma by serving as reservoirs and precursors of volatile compounds, with processing and storage affecting pathways of flavor development and oxidation (Deng et al. **2024**; Shahidi and Hossain **2022**). Gas chromatography with flame ionization detector (GC-FID) revealed that palmitic acid and linoleic acid are the predominant fatty acids in *H. erinaceus* (Saini et al. **2021**). Post-harvest changes are dynamic: comprehensive HS-GC-IMS and HS-SPME-GC-MS studies show declines in key C8 volatiles with storage and increases in unsaturated aldehydes (E-2-octenal, E-2-nonenal) and 1-octanol, shifting the profile from fresh to more fatty or aged notes (Deng et al. **2024**; Zhong et al. **2024**).

Savory taste in *H. erinaceus* arises from the synergy of amino acids (notably glutamic and aspartic acids) with 5'-nucleotides (IMP, GMP, XMP). This can be expressed as an equivalent umami concentration (EUC) to capture their combined impact (Li et al. **2022**; Sun et al. **2020**). Reported EUC and nucleotide levels vary widely among studies and are sensitive to strain, maturity, substrate, and processing, underlining the importance of sourcing and process control for consistent taste performance (Phat et al. **2016**; Yang et al. **2022**). Importantly, instrumental measurements do not always reflect human sensory experience. For example, electronic tongue systems may detect strong umami signals below human thresholds without overall flavor perception. Therefore, instrumental outputs should be interpreted alongside human sensory panels (Jayasundar et al. **2021**; Ross **2021**; Shin Yee et al. **2025**).

In terms of texture and mouthfeel, β-glucans and other polysaccharides contribute to water binding, viscosity, thickening, and gel formation. Such properties can be leveraged to create a creamier mouthfeel in soups and sauces and to improve structure in plant-based patties and breads. Furthermore, soluble β-glucans from mycelial biomass disperse effectively in beverages, supporting broader flexibility in formulations (Du et al. **2019**; Wang et al. **2019**). Beyond texture, *H. erinaceus* β-glucans can slow starch digestibility and attenuate glucose release in starchy foods, aligning technological functionality with potential glycemic benefits (Feng et al. **2019**; Wang et al. **2021**).

Sensory performance of *H. erinaceus* in food applications reflects their ability to enhance flavor, texture, and color across diverse food products. In Chinese noodles, fortification has been reported to modulate starch digestion, resulting in increased firmness and lower brightness, as determined by texture profile analysis and colorimetry. At moderate inclusion levels, bread exhibited improved loaf volume and springiness improved, according to mechanical tests (Łysakowska et al. **2025**; Wang et al. **2021**). In addition, *H. erinaceus* powder has been reported to reduce hardness and chewiness according to texture profile analysis, enrich the volatile flavor profile with aldehydes, ketones, and alcohols as determined by gas chromatography, and deepen color according to colorimetry, as a result of Maillard reactions associated with polysaccharides. Collectively, these changes suggest improved flavor complexity and visual appeal when the inclusion level is optimized (Gao et al. **2025**; Sun et al. **2020**).

Most studies focus on instrumental analyses; however, human sensory evaluation is essential to determine flavor, texture, visual appearance, and overall acceptability. For example, in cream soups, sensory panel assessments indicated that enrichment with *H. erinaceus* was preferred due to enhanced umami taste, reduced bitterness, appealing color, and overall palatability (Yang et al. **2014**).

Achieving a consistent “seafood-like” savory character and desirable mouthfeel requires attention to species, strain, substrate, and maturity, as well as careful control of storage and processing to preserve C8 volatiles. Calibrating β-glucan content helps target textures while potentially supporting lower glycemic impact. Integrating these sensory and technological considerations upstream of formulation strengthens product quality and acceptance across categories from soups and noodles to plant-based analogues, baked goods, and beverages (Gao et al. **2025**; Łysakowska et al. **2025**; Wang et al. **2021**).

8 Cultivation Approaches

As *H. erinaceus* faces conservation concerns in Europe, where it is red listed in 13 of 23 countries due to habitat loss, reliable cultivation methods are increasingly important (Koga **2024**; Szućko-Kociuba et al. **2023**). Solid-state fermentation (SSF) mimics its natural wood-decaying habitat by growing the fungus on moist solid substrates such as softwood or hardwood sawdust (Costa et al. **2020**). This method involves microbial growth on solid substrates without free-flowing water (Chutimanukul et al. **2023**). Fruiting body production of *H. erinaceus* generally follows three stages. A spawn run conducted at 21–24°C for 10–14 days, primordia formation at 10–15.6°C for 3–5 days, and fruiting body development at 18–24°C over the next 4–5 days (Gonkhom et al. **2022**). Various agricultural and food-based substrates have been explored to enhance mycelial growth and functional properties. For example, cultivation on red and white jasmine showed moderate inhibition of *Proteus mirabilis*, known for causing urinary tract infections (UTIs) (Darmasiwi et al. **2022**), while Gonkhom et al. (**2022**) explored the use of 15 different substrates, including oat, millet, barley, rice, brown rice, rice berry, sticky rice, red sorghum, wheat, mung bean, corn seed, coir, bagasse, rice straw, and paddy, for the cultivation of *H. erinaceus*. The highest mycelial growth was observed with wheat grain. Agricultural by-products and food waste, such as rice bran, corn husk, and wheat bran, have also been investigated as cost-effective and sustainable alternatives (Ban et al. **2024**; Jozífek et al. **2025**; Lin et al. **2024**). Challenges of SSF include long lag phases, controlling uniform pH, moisture, and oxygen throughout the substrate, and mitigating potential contamination (Borkertas et al. **2025**; Chilakamarry et al. **2022**). Despite these limitations, SSF remains fundamental for providing the physical matrix required for fungal growth and fruiting.

Submerged liquid fermentation (SLF) offers an alternative approach focused on producing a high yield of mycelial biomass and polysaccharides (Berovic and

Zhong **2023**). In SLF, mushroom mycelia are cultivated in a liquid nutrient-rich medium within bioreactors or shake flasks under controlled conditions, including agitation, aeration, temperature, and pH (Figure **4**) (Klaus and Wan-Mohtar **2022**). It is desirable to cultivate *H. erinaceus* in these controlled conditions so a high concentration of bioactive compounds, such as erinacines, can be afforded. Not only could the production of bioactive compounds using SLF lower the costs of their production, but it is also considered the only effective way to obtain some specific compounds, such as erinacines, as their chemical synthesis yields a very small amount (Wang et al. **2026**). The optimization of SLF conditions for the yield of mycelial biomass, polysaccharides, and erinacine biosynthesis has been the subject of numerous investigations (Gonkhom et al. **2022**; Khurana et al. **2022**; Wolters et al. **2015**). Besides that, SLF allows for rapid and scalable production of mycelial biomass, which is rich in polysaccharides and select metabolites, depending on the species and strain used (Klaus and Wan-Mohtar **2022**). SLF also facilitates easier downstream extraction and purification of target metabolites, as the liquid medium enables the recovery of extracellular products, such as exopolysaccharides and other secondary metabolites, directly from the culture broth, thereby reducing extraction costs compared to solid-substrate systems that require mechanical disruption (Madhusudhan et al. **2015**).

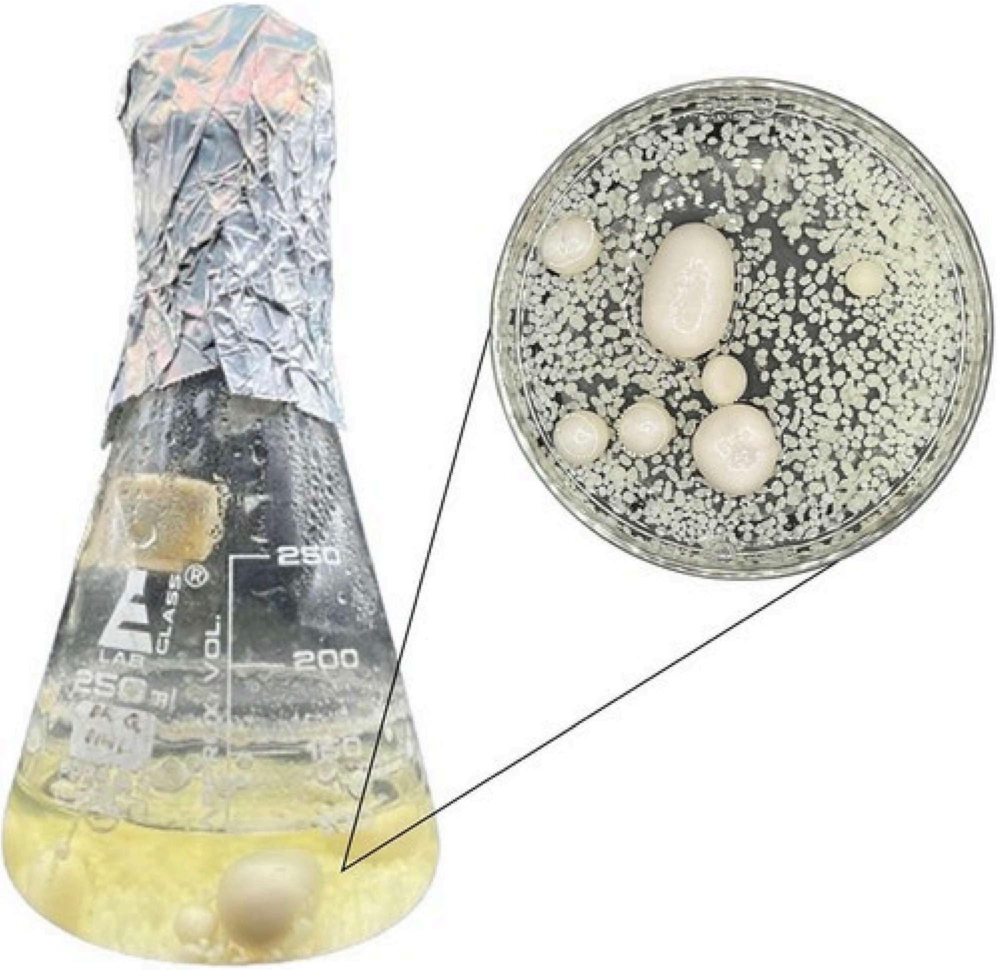

FIGURE 4

Submerged liquid fermentation (SLF) of *Hericium erinaceus*. (Figure by author).

9 Regulatory and Safety Considerations

In many Asian countries, *H. erinaceus* is widely consumed without specific pre-market approval. Available toxicological evidence in animals demonstrated low acute and sub-chronic toxicity, with no significant adverse effects observed at relatively high doses of fruiting body or mycelial extracts (Chen et al. **2022**; Mahadevan et al. **2025**). Nevertheless, regulatory oversight is evolving, and many authorities have increasingly emphasized product standardization, safety evaluation, and substantiation for food products containing *H. erinaceus*. In the European Union, fruiting bodies of *H. erinaceus* are permitted for use in food and dietary supplements due to their documented history of significant consumption prior to May 15, 1997. However, food ingredients derived from the mycelium are considered 'novel foods' under the Novel Food Regulation (EU) 2015/2283 and must undergo rigorous safety assessment by the European Food Safety Authority (EFSA) before market authorization (Molitorisová et al. **2021**; Violo **2024**). This requirement presents a potential barrier to the development and commercialization of erinacine-enriched functional foods, as erinacines are predominantly produced in the mycelium rather than the fruiting body. In contrast, regulatory frameworks in the United States, overseen by the U.S. Food and Drug Administration, offer some flexibility. Mushroom mycelia may be used in food and dietary supplements, provided that appropriate labeling, safety responsibilities, and scientific evidence are fulfilled by manufacturers (Barwant et al. **2026**; Das et al. **2023**; Violo **2024**). Overall, these regional regulatory differences emphasize the need for harmonized international guidelines to support the safe and effective global commercialization of *H. erinaceus*-derived functional foods.

On another note, such labelling strategies protect consumers from hypersensitivity responses, as rare allergic reactions have been reported with *H. erinaceus*. These include a case of anaphylaxis characterized by abdominal pain, diarrhea, and swelling occurring shortly after consumption (Watson and Kobernick **2022**). Another report described acute respiratory distress syndrome (ARDS) in a patient with diabetes following intake of *H. erinaceus* supplements, suggesting that certain compounds may trigger immune responses in susceptible individuals (Menon et al. **2025**). However, systematic clinical evidence on such adverse events remains limited. This highlights the need for post-market surveillance and consumer safety monitoring and well-designed human clinical studies, particularly in the context of high-dose bioactive-rich formulations. Furthermore, although toxicological data from animal studies indicate a wide safety margin, concentrated extracts may exhibit distinct results from those of whole mushrooms. This underscores the importance of dose standardization, rigorous quality control, and a clear distinction between food-grade and therapeutic applications within regulatory frameworks.

10 Conclusion

With a long history in traditional medicine and cuisine, Lion's Mane mushroom (*H. erinaceus*) is increasingly recognized in food science for its bioactive profile and culinary versatility. Rich in compounds such as erinacines and hericenones, experimental studies have reported neuroprotective, anti-inflammatory, and cognitive-enhancing potentials. These findings position *H. erinaceus* within the emerging concept of “brain foods” and functional nutrition frameworks aligned with Sustainable Development Goal (SDG) 3 (Good Health and Well-being). However, most supporting evidence is derived from in vitro and animal studies, and clinical relevance remains insufficiently established.

In line with SDG 2 (Zero Hunger), expanding the use of *H. erinaceus* offers opportunities to address nutritional insecurity. Its favorable nutritional profile, perceived functional benefits, and naturally dense, meat-like texture make it a promising ingredient for sustainable, protein-enhanced foods. Incorporation into staple foods, fortified products, and culturally adaptable formulations may improve dietary quality while reducing dependence on resource-intensive animal proteins (Ahmad et al. **2022**). Key challenges include maintaining flavor consistency, preserving texture during processing, and protecting heat-sensitive bioactives from degradation.

Several research gaps must be addressed to support its application in functional foods. Although numerous bioactive compounds have been associated with cognitive benefits, the bioavailability, digestive stability, and subsequent absorption of these compounds within complex foods remain poorly understood, as current evidence is largely derived from in vitro or animal models. Therefore, well-designed human clinical trials with clearly defined endpoints (e.g., cognitive performance, inflammatory biomarkers, gut-brain axis indicators) are required to validate health claims, establish effective dosages, and support evidence-based product development (Cha et al. **2024**; Luo **2025**).

Advances in submerged liquid fermentation offer scalable and environmentally sustainable methods for generating consistent mushroom biomass and bioactive compounds. However, challenges such as strain variability and optimization of culture conditions (temperature, pH, aeration, substrate composition, and nutrient parameters) for fermented mycelium must be addressed to maximize consistent yield. Multi-omics approaches, such as metabolomics profiling, may further support strain optimization and batch-to-batch reproducibility (Adejor et al. **2025**; Cortada-Garcia et al. **2024**). In addition, extraction and purification methods, particularly for mycelial biomass, erinacines, and β-glucans, should be benchmarked using scalable, food-grade solvents to improve compatibility within food matrices and stability during processing and storage (Lazić et al. **2024**; Parada et al. **2015**).

Overall, *H. erinaceus* shows strong potential as both a functional and culinary ingredient. Its successful integration into food technology will depend on rigorous clinical validation, targeted process optimization, and sustainable production strategies that bridge laboratory findings with real-world applications.

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