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A NARRATIVE REVIEW.

The Rise of Mushroom-Based Nutraceuticals A Review of Nutritional Potential and Industrial Integration

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Abstract

Background: mushrooms as a source of bioactive, pharmacologically valuable substances, which puts mushrooms in the range of promising food supplements. Their exclusive makeup, which contains polysaccharides, phenolics, and critical micro nutrients, has attracted the attention of nutrition science and commercial sectors.

Objective: This review attempts to analyze the health benefits, nutritional value, and industrial usability of mushroom-derived nutraceutical substances, as well as the bottlenecks and controversies surrounding their commercialization.

Methods: The literature was scoured to identify the most recent peer-reviewed publications on the topic concerning databases of PubMed, Scopus, and ScienceDirect and timeframes 2010 to 2024. Among search terms, the importance of mushroom nutraceuticals, bioactive compounds, and functional foods, as well as their industrial commercialization, deserves to be mentioned.

Results: Particular species of mushrooms, Ganoderma lucidum, Lentinula edodes, and Cordyceps militaris, reveal antioxidant, anti-inflammatory, immuno-modulatory, and cholesterol-reducing activity. The integration into the nutraceutical market has been increasing at a fast rate, with regulatory gaps, standardization, and scientific validations being significant challenges. In addition, there is the issue of false marketing health-wise, as well as the conflict between usage and abuse in industry.

Conclusion: Nutraceuticals based on mushrooms have a massive potential in terms of both public health and commercial development. Nonetheless, evidence-based regulations and interdisciplinary cooperation are necessary to make sure that products are safe, effective, and developed with responsibility in the growing area.

Keywords: Mushrooms,Nutraceuticals,Bioactive Compounds,Functional Foods,Dietary Supplements,Phytotherapy

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INTRODUCTION

The global shift toward preventive healthcare and functional nutrition has propelled nutraceuticals to the forefront of modern wellness strategies [1]. Among these, mushrooms represent a particularly valuable category due to their rich profile of bioactive compounds—including β-glucans, polysaccharides, phenolics, terpenoids, and essential micronutrients—that contribute significantly to their therapeutic potential [2,3]. These compounds demonstrate diverse pharmacological properties such as anti-inflammatory, antioxidant, immunomodulatory, cardioprotective, and antitumor activities [4]. Historically, mushrooms have been integral to traditional healthcare systems, especially Traditional Chinese Medicine (TCM) and Ayurveda. In recent years, scientific interest has intensified, leading to the incorporation of medicinal mushrooms into contemporary nutraceuticals and functional food markets [5]. Species such as *Ganoderma lucidum* (Reishi), *Lentinula edodes* (Shiitake), *Grifola frondosa* (Maitake), and *Cordyceps militaris* are among the most extensively studied for their nutritional and therapeutic attributes [6]. As global consumer awareness of natural health products increases, mushroom-derived nutraceuticals continue to gain rapid commercial traction [7].Despite their promise, challenges persist related to regulatory oversight, product standardization, quality control, and scientific validation of health claims [8]. This review critically evaluates the nutritional significance, therapeutic potentials, industrial applications, and commercialization pathways of mushroom-based nutraceuticals while highlighting opportunities for research advancement and addressing ethical considerations within their manufacturing.

MATERIALS & METHODS

This narrative review was conducted at the Department of Urology, Institute of Kidney Diseases, Peshawar, between January and July 2024. Electronic databases including PubMed, Scopus, Science Direct, and Google Scholar were systematically searched to identify peer-reviewed articles, clinical studies, and review papers relevant to mushroom-derived nutraceuticals. Keywords and MeSH terms such as *mushroom nutraceuticals*, *bioactive compounds*, *functional foods*, *dietary supplements*, and *medicinal mushrooms* were used in combination with Boolean operators (AND/OR). Only English-language publications from 2010 to 2024 were included to ensure contemporary relevance.

Inclusion Criteria

1. Studies reporting the nutritional, gastronomic, or therapeutic properties of edible or medicinal mushrooms.
2. Research exploring commercialization or industrial applications of mushroom-based nutraceuticals.
3. Clinical trials or review articles examining mushroom-derived bioactive compounds.

Exclusion Criteria

1.Studies unrelated to human health.
2.Non–peer-reviewed literature.
3.Methodologically weak, low-quality, or irrelevant publications.

Results

The review identified consistent evidence supporting the nutritional richness and therapeutic potential of major medicinal mushrooms, particularly Ganoderma lucidum, Lentinula edodes, and Cordyceps militaris. Most studies highlighted strong antioxidant and immunomodulatory effects, while significant gaps remained regarding standardized formulations, clinical validation, long-term safety, and regulatory oversight.

Table 1. Major Medicinal Mushrooms, Their Bioactive Compounds, and Therapeutic Properties

Mushroom Species	Key Bioactive Compounds	Primary Therapeutic Activities	Representative Applications in Nutraceuticals
Ganoderma lucidum (Reishi)	β-glucans, triterpenoids, polysaccharides	Immunomodulatory, anti-inflammatory, antioxidant, hepatoprotective	Immune-boosting supplements, liver-support formulas, anti-fatigue capsules
Lentinula edodes (Shiitake)	Lentinan, eritadenine, polyphenols	Cholesterol-lowering, anticancer, immune enhancement	Functional foods, cardiovascular nutraceuticals, oncology-support formulations
Grifola frondosa (Maitake)	D-fraction β-glucans, polysaccharides	Antidiabetic, immunostimulatory, antioxidant	Glucose-regulation supplements, immune tonics
Cordyceps militaris	Cordycepin, adenosine, polysaccharides	Anti-fatigue, anti-inflammatory, metabolic enhancement	Energy-boosting formulations, endurance supplements
Inonotus obliquus (Chaga)	Polyphenols, melanin, β-glucans, triterpenes	Strong antioxidant, anti-ageing, anti-inflammatory	Antioxidant beverages, anti-ageing nutraceutical blends
Pleurotus ostreatus (Oyster mushroom)	Lovastatin, β-glucans, ergothioneine	Hypolipidemic, antioxidant, antimicrobial	Cholesterol-lowering supplements, functional protein foods
Pleurotus tuber-regium	Polysaccharides, phenolics	Antioxidant, gut microbiota modulation	Prebiotic supplements, digestive health formulations

This table summarizes widely studied medicinal mushroom species, highlighting their predominant bioactive compounds and associated therapeutic activities, reflecting their expanding application in the nutraceutical industry.

DISCUSSION

Mushroom-based nutraceuticals have gained significant global recognition, driven largely by the increasing demand for natural therapeutic products [9,10]. Evidence from Asian regions—particularly China and Japan—demonstrates their longstanding integration into traditional medicine, with *Ganoderma lucidum* and *Lentinula edodes* among the most widely utilized [11,12]. Market growth projections indicate continued expansion due to heightened consumer awareness regarding their immunomodulatory, antioxidant, and anti-inflammatory benefits [13].Edible and medicinal mushrooms contain several bioactive substances—including β-glucans, ergothioneine, polyphenols, and terpenoids—that contribute to their diverse physiological effects [14,15]. Comparative analyses suggest that species such as *Cordyceps militaris* and *Grifola frondosa* possess particularly potent antioxidant and immunomodulatory properties [16]. However, variations in cultivation methods, extraction processes, and processing technologies often result in inconsistent bioactive concentrations, posing challenges to standardization and clinical validation[17,18]. Innovation within the nutraceutical industry has encouraged the development of mushroom-enriched functional foods,beverages, and supplements. Advances in fermentation biotechnology and nanotechnology have further enhanced the bioavailability and potency of mushroom-derived compounds [19]. Startups and pharmaceutical industries are increasingly investing in mushroom-based product lines, although regulatory scrutiny and the demand for robust clinical evidence remain key barriers to market approval [20].Despite their potential, several concerns exist. Variability in formulation, risks of microbial contamination, and exaggerated marketing claims present significant obstacles to consumer safety and trust [21]. Additionally, long-term human safety data remain limited. Minor adverse effects—particularly allergic responses and potential drug interactions, especially with immunosuppressants—require careful evaluation [22]. Future research must prioritize randomized controlled trials involving diverse populations to establish safety, efficacy, and optimal dosing A balanced integration of modern pharmacological research with traditional medicinal knowledge, alongside harmonized Regulatory frameworks, is crucial to ensuring responsible development and safe Commercialization of mushroom-based nutraceuticals.

CONCLUSION

Mushroom-derived nutraceuticals represent a rapidly expanding domain at the intersection of traditional medicine and contemporary functional food science. This review underscores the nutritional and therapeutic potential of species such as *Ganoderma lucidum*, *Lentinula edodes*, and *Cordyceps militaris*, which contain potent bioactive compounds with antioxidant, immunomodulatory, and metabolic benefits. While these products show promise in mitigating oxidative stress, inflammation, and immune dysfunction, their clinical integration remains limited due to challenges in standardization, variable bioavailability, and insufficient large-scale trials.As global demand increases, stringent regulatory oversight and quality assurance become essential for ensuring product safety and efficacy. Interdisciplinary collaboration among researchers, clinicians, nutritionists, and regulatory authorities is needed to transform traditional mushroom use into evidence-based therapeutic interventions. Future research should emphasize clinical trials, dosage standardization, safety surveillance, and validated biomarkers to optimize therapeutic applications and support ethical commercialization.

FUTURE FINDINGS

Future investigations should prioritize large-scale clinical trials, pharmacokinetic profiling, and regulatory compliance of mushroom-derived nutraceuticals. Research must also focus on developing standardized biomarkers of efficacy, improving delivery systems, and incorporating traditional medicinal knowledge into modern biotechnological frameworks to enhance therapeutic and commercial viability.

SUMMARY OF REVIEW

This review highlights the expanding use of mushrooms in nutraceutical development by exploring their bioactive components, therapeutic applications, and industrial growth trajectory. Although many species demonstrate antioxidant, anti-inflammatory, and immunomodulatory benefits, substantial gaps remain regarding product standardization, clinical validation, and regulatory control. As global industrial interest rises, rigorous scientific evaluation is imperative to substantiate health claims and ensure safe consumer use. Overall, mushroom-based nutraceuticals possess significant potential for improving human health, provided that their development follows scientific, ethical, and regulatory standards.

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Reference

1. Abdelwahab A, Alenezi KM, Humaidi JR, Haque A, Mahgoub SM, Mokhtar AM, et al. Innovative eco-sustainable reishi mushroom-based adsorbents for progesterone removal and agricultural sustainability. RSC advances. 2025;15:16690-707. doi: https://doi.org/10.1039/d5ra01906k.

2. Chaffee O, Ardoin R. Consumer perceptions of plant-based and mushroom-based jerky: A focus on texture, main ingredient and protein information, and willingness to pay. Current research in food science.2025;10:101058.doi: https://doi.org/10.1016/j.crfs.2025.101058.

3. De Cianni R, Mancuso T, Rizzo G, Migliore G. Health or environment? Understanding which informative message is more effective in replacing red meat with mushroom-based alternatives. Appetite. 2024;199:107405.doi: https://doi.org/10.1016/j.appet.2024.107405.

4. De Cianni R, Pippinato L, Mancuso T. A systematic review on drivers influencing consumption of edible mushrooms and innovative mushroom-containing products. Appetite. 2023;182:106454. doi: https://doi.org/10.1016/j.appet.2023.106454.

5. Giusti A, Tinacci L, Verdigi F, Narducci R, Gasperetti L, Armani A. Safety and commercial issues in fresh mushrooms and mushroom-based products sold at retail in Tuscany region. Italian journal of food safety.2022;11:10044.doi: https://doi.org/10.4081/ijfs.2022.10044.

6. Hassan M, Shahzadi S, Ransom RF, Kloczkowski A. Nature's Own Pharmacy: Mushroom-Based Chemical Scaffolds and Their Therapeutic Implications. International journal of molecular sciences.2023;24:doi: https://doi.org/10.3390/ijms242115596.

7. Kohphaisansombat C, Jongpipitaporn Y, Laoratanakul P, Tantipaibulvut S, Euanorasetr J,

Rungjindamai N, et al. Fabrication of mycelium (oyster mushroom)-based composites derived from spent coffee grounds with pineapple fibre reinforcement.Mycology.2024;15:665-82.doi: https://doi.org/10.1080/21501203.2023.2273355.

8. Kulshreshtha S. Mushroom as Prebiotics: a Sustainable Approach for Healthcare. Probiotics and antimicrobialproteins.2024;16:699-712.doi: https://doi.org/10.1007/s12602-023-10164-5.

9. Leibovitzh H, Fliss Isakov N, Werner L, Thurm T, Hirsch A, Cohen NA, et al. A Mushroom Based Prebiotic Supplement Pilot Study Among Patients with Crohn's Disease. Journal of dietary supplements.2025;22:511-24.doi: https://doi.org/10.1080/19390211.2025.2498127.

10. Li X, Tao Q, Hu Q, Ma N, Ma G. In vitro gastrointestinal digestion and fecal fermentation of Pleurotus eryngii proteins extracted using different methods: insights for the utilization of edible mushroom-based proteins as novel nutritional and functional components. Food & function. 2024;15:8865-77.doi: https://doi.org/10.1039/d4fo02604g.

11. Makkiyah FA, Andrestia CR, Raihan RU, Karina, Harfiani E, Faranita T, et al. Development of Straw Mushroom (Volvariella volvacea)-Based Broth and Crackers: Nutritional, Microbial, and Antioxidant Evaluation.TheScientificWorldJournal. 2025;2025:9575690.doi: https://doi.org/10.1155/tswj/9575690.

12. Mazumder MAR, Sukchot S, Phonphimai P, Ketnawa S, Chaijan M, Grossmann L, et al. Mushroom-Legume-Based Minced Meat: Physico-Chemical and Sensory Properties. Foods (Basel, Switzerland)2023;12:doi: https://doi.org/10.3390/foods12112094.

13. Michalska A, Sierocka M, Drzewiecka B, Świeca M. Antioxidant and Anti-Inflammatory Properties of Mushroom-Based Food Additives and Food Fortified with Them-Current Status and Future Perspectives. Antioxidants (Basel, Switzerland). 2025;14:doi: https://doi.org/10.3390/antiox14050519.

14. Panda J, Nath PC, Mishra AK, Rustagi S, Nayak D, Blundell R, et al. Mushroom: an emerging source for next generation meat analogues. Frontiers innutrition.2025;12:1638121.doi: https://doi.org/10.3389/fnut.2025.1638121.

15. Rahman MA, Rahman MS, Bashir NMB, Mia R, Hossain A, Saha SK, et al. Rationalization of Mushroom-Based Preventive and Therapeutic Approaches to COVID-19: Review.International journal of medicinal mushrooms. 2021;23:1-11. doi: https://doi.org/10.1615/IntJMedMushrooms.2021038285.

16. Rao KM, Suneetha M, Park GT, Babu AG, Han SS. Hemostatic, biocompatible, and antibacterial non-animal fungal mushroom-based carboxymethyl chitosan-ZnO nanocomposite for wound-healing applications.International journal of biological macromolecules.2020;155:71-80.doi: https://doi.org/10.1016/j.ijbiomac.2020.03.170.

17. Risoli S, Nali C, Sarrocco S, Cicero AFG, Colletti A, Bosco F, et al. Mushroom-Based Supplements in Italy: Let's Open Pandora's Box. Nutrients.2023;15:doi: https://doi.org/10.3390/nu15030776.

18. Shiri Z, Pirsa S, Farzi J. Eco-friendly biodegradable film based on kombucha mushroom/corn.starch/parsleyextract: Physicochemical and antioxidant/antibacterial properties. Food science & nutrition. 2024;12:7924-37. doi: https://doi.org/10.1002/fsn3.4411.

19. Silva NTF, Venancio AR, Martos ET, Oliveira ACG, Oliveira AAA, Mutz YDS, et al. Fish Fillet Analogue Using Formulation Based on Mushroom (Pleurotus ostreatus) and Enzymatic Treatment: Texture, Sensory, Aromatic Profile and Physicochemical.Characterization.Foods(Basel, Switzerland).2024;13:doi: https://doi.org/10.3390/foods13152358.

20. Sivanesan I, Muthu M, Gopal J, Oh JW. Mushroom Polysaccharide-Assisted Anticarcinogenic Mycotherapy: Reviewing Its Clinical Trials. Molecules (Basel,Switzerland).2022;27:doi: https://doi.org/10.3390/molecules27134090.

21. Suberu SA, Isikhuemhen OS, Ogundare TE, Ekunseitan DA, Fasina YO. Benefits of Mushroom-Based Supplements on Growth Performance, Immunocompetence, and Meat Quality in Poultry. Animals : an open access journal from MDPI. 2024;14:doi: https://doi.org/10.3390/ani14111517.

22. Törős G, El-Ramady H, Prokisch J, Velasco F, Llanaj X, Nguyen DHH, et al. Modulation of the Gut Microbiota with Prebiotics and Antimicrobial Agents from Pleurotus ostreatus Mushroom. Foods (Basel, Switzerland).2023;12:doi: https://doi.org/10.3390/foods12102010.