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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 have gained considerable attention as functional foods and nutraceutical agents because of their rich nutritional composition and diverse bioactive compounds. In recent years, increasing scientific evidence has highlighted their potential role in disease prevention, health promotion, and industrial applications within the food and pharmaceutical sectors.

Objective: To review the nutritional value, bioactive constituents, therapeutic potential, and industrial integration of medicinal and edible mushrooms as emerging nutraceutical products.

Materials and Methods: A narrative review of the literature was conducted using electronic databases including PubMed, Scopus, ScienceDirect, and Google Scholar. Relevant peer-reviewed articles published between 2010 and 2024 were identified using keywords related to mushroom nutraceuticals, bioactive compounds, functional foods, medicinal mushrooms, and industrial applications. The retrieved literature was critically reviewed and synthesized narratively.

Results: The reviewed literature demonstrated that medicinal mushrooms are rich sources of β-glucans, polysaccharides, phenolic compounds, terpenoids, proteins, vitamins, and minerals. These bioactive constituents have been associated with antioxidant, anti-inflammatory, immunomodulatory, antimicrobial, and metabolic benefits. Species such as *Ganoderma lucidum*, *Lentinula edodes*, *Cordyceps militaris*, *Hericium erinaceus*, and *Grifola frondosa* were among the most extensively investigated and showed promising nutraceutical potential. Furthermore, increasing industrial utilization of mushroom-derived products in dietary supplements, functional foods, and pharmaceutical formulations was observed across the reviewed studies.

Conclusion: Mushrooms represent valuable nutraceutical resources with significant nutritional, therapeutic, and commercial potential. Continued research, standardization of bioactive compounds, and regulatory development are necessary to support their broader integration into healthcare, food industries, and evidence-based nutraceutical applications.

INTRODUCTION

Mushrooms have long been recognized as valuable dietary components because of their unique nutritional composition and medicinal properties. In recent decades, scientific interest in mushrooms has increased substantially owing to the discovery of numerous bioactive compounds with potential therapeutic applications. These compounds include polysaccharides, β-glucans, phenolic compounds, terpenoids, lectins, and peptides, which have demonstrated antioxidant, anti-inflammatory, immunomodulatory, antimicrobial, and anticancer activities in experimental and clinical studies [1,2].The concept of nutraceuticals has gained considerable attention as consumers increasingly seek natural products that provide health benefits beyond basic nutrition. Nutraceuticals are defined as food-derived products that offer physiological benefits and may contribute to the prevention or management of various diseases [3]. Among natural nutraceutical sources, mushrooms occupy a unique position because they combine high nutritional value with a wide range of biologically active compounds [4].Edible and medicinal mushrooms are rich sources of proteins, dietary fiber, essential amino acids, vitamins, minerals, and low-fat content, making them attractive components of a healthy diet [5]. Furthermore, several mushroom species, including *Ganoderma lucidum*, *Lentinula edodes*, *Cordyceps militaris*, *Hericium erinaceus*, and *Grifola frondosa*, have been extensively investigated for their potential health-promoting properties [6,7]. Research has demonstrated that mushroom-derived compounds may support immune function, regulate blood glucose levels, improve cardiovascular health, and contribute to neuroprotection [8].The growing prevalence of chronic non-communicable diseases has stimulated interest in functional foods and natural therapeutic products. Mushroom-based nutraceuticals have emerged as promising candidates because of their potential role in reducing oxidative stress, modulating inflammatory pathways, and enhancing host defense mechanisms [9]. Consequently, the global nutraceutical industry has witnessed increasing incorporation of mushroom-derived ingredients into dietary supplements, functional beverages, pharmaceutical formulations, and health-promoting food products [10].Despite the increasing commercialization of mushroom-based products, several challenges remain regarding standardization, quality control, cultivation practices, extraction techniques, and regulatory approval. Variability in bioactive compound concentrations among species and production systems may affect product efficacy and reproducibility [11]. Therefore, continued scientific investigation is necessary to establish evidence-based applications and facilitate wider industrial integration of mushroom-derived nutraceuticals [12].The present review aims to examine the nutritional composition, bioactive constituents, therapeutic potential, and industrial applications of medicinal and edible mushrooms, highlighting their growing importance in the nutraceutical and functional food sectors..

MATERIALS AND METHODS

Study Design and Setting

This study was conducted as a narrative review of the literature to evaluate the nutritional potential, bioactive constituents, therapeutic applications, and industrial integration of medicinal and edible mushrooms. The review aimed to synthesize current scientific evidence regarding the role of mushrooms as nutraceutical agents and functional food ingredients.

Literature Search Strategy

A comprehensive literature search was performed using electronic databases, including PubMed, Scopus, ScienceDirect, Web of Science, and Google Scholar. Relevant peer-reviewed articles published between January 2010 and December 2024 were identified using combinations of the keywords "mushroom nutraceuticals," "medicinal mushrooms," "functional foods," "bioactive compounds," "dietary supplements," "industrial applications," and "mushroom-derived products."

Eligibility Criteria

Articles published in English that discussed the nutritional composition, bioactive compounds, health benefits, therapeutic applications, cultivation technologies, industrial utilization, and commercialization of edible or medicinal mushrooms were included. Review articles, original research studies, clinical trials, and experimental investigations were considered. Conference abstracts, editorials, duplicate publications, and articles lacking relevant scientific information were excluded.

Data Extraction and Synthesis

Relevant information regarding mushroom species, bioactive constituents, nutritional properties, therapeutic potential, and industrial applications was extracted from the selected publications. The findings were reviewed, summarized, and synthesized narratively to provide a comprehensive overview of current evidence regarding mushroom-based nutraceuticals.

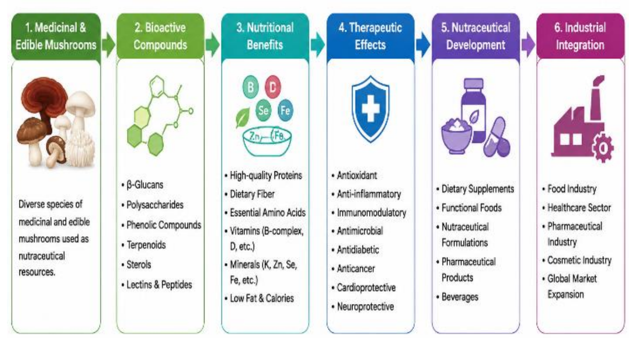
Ethical Considerations

Ethical approval was not required because this review was based exclusively on previously published literature and did not involve human participants, animals, or identifiable personal data.

RESULTS

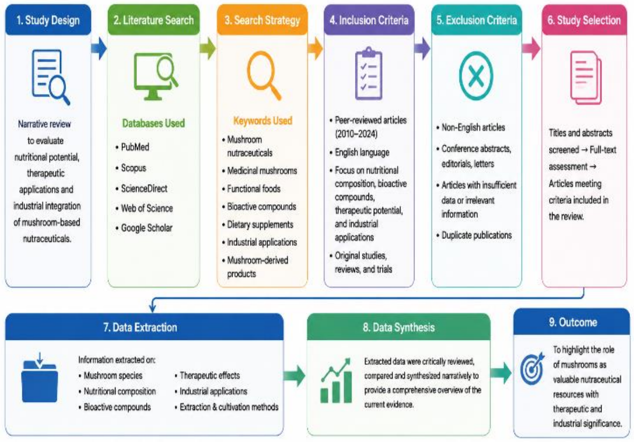
The reviewed literature demonstrated that mushrooms possess substantial nutritional and nutraceutical value because of their rich composition of bioactive compounds and essential nutrients. Several edible and medicinal mushroom species, including *Ganoderma lucidum* (Reishi), *Lentinula edodes* (Shiitake), *Cordyceps militaris*, *Hericium erinaceus* (Lion's Mane), *Grifola frondosa* (Maitake), *Inonotus obliquus* (Chaga), and *Pleurotus* species, were consistently identified as important sources of biologically active constituents with potential health-promoting effects. The overall relationship between mushroom-derived bioactive compounds, their therapeutic effects, and industrial applications is illustrated in **Figure 1**.The nutritional profile of mushrooms was found to include high-quality proteins, dietary fiber, essential amino acids, vitamins (particularly B-complex vitamins and vitamin D), minerals, and low levels of fat and calories. In addition, mushrooms contain a diverse range of bioactive compounds such as β-glucans, polysaccharides, phenolic compounds, terpenoids, sterols, lectins, and peptides, which contribute to their functional and therapeutic properties.Several studies reported significant antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, antidiabetic, anticancer, cardioprotective, and neuroprotective activities associated with mushroom-derived compounds. β-glucans were the most extensively studied compounds and were frequently associated with immune enhancement and modulation of inflammatory responses. Phenolic compounds and terpenoids demonstrated strong antioxidant activity, while polysaccharides showed potential in supporting metabolic and immune health.The major medicinal mushroom species identified in the reviewed literature, together with their principal bioactive compounds, therapeutic properties, and representative nutraceutical applications, are summarized in **Table 1.** Among these species, Ganoderma lucidum, *Lentinula edodes*, *Grifola frondosa*, and *Cordyceps militaris* were the most extensively investigated because of their diverse pharmacological activities and commercial significance.The reviewed evidence also highlighted the growing industrial integration of mushroom-based products. Mushroom-derived ingredients are increasingly incorporated into dietary supplements, functional foods, nutraceutical formulations, beverages, pharmaceutical preparations, and cosmetic products. Advances in cultivation technologies, extraction methods, and biotechnology have further enhanced the commercial potential of medicinal mushrooms.Despite the promising findings, the reviewed studies demonstrated considerable heterogeneity regarding mushroom species, cultivation conditions, extraction techniques, dosage formulations, and outcome measures. Such variability may influence the concentration of bioactive compounds and the reproducibility of reported health benefits. The methodology adopted for literature identification, study selection, data extraction, and narrative synthesis is presented in **Figure 2.** Overall, the literature supports the growing role of mushrooms as valuable nutraceutical resources with significant nutritional, therapeutic, and industrial applications. Collectively, the findings presented in **Figure 1**, **Figure 2**, and **Table 1** highlight the expanding scientific and commercial importance of mushroom-based nutraceuticals.

Figure 1: Conceptual Framework of Mushroom-Based Nutraceuticals: From Bioactive Compounds to Industrial Applications



This conceptual framework illustrates the progression of mushroom-derived bioactive compounds from their nutritional composition and therapeutic properties to their development as nutraceutical products and subsequent industrial integration. Medicinal and edible mushrooms contain biologically active constituents such as β-glucans, polysaccharides, phenolic compounds, terpenoids, sterols, lectins, and peptides that contribute to multiple health-promoting effects, including antioxidant, anti-inflammatory, immunomodulatory, antimicrobial, antidiabetic, anticancer, cardioprotective, and neuroprotective activities. These properties support the development of functional foods, dietary supplements, pharmaceutical products, and other industrial applications.

Figure 2. Study Design and Literature Selection Process of the Narrative Review.



This figure presents the methodological framework used for the narrative review. The process included identification of relevant literature through electronic databases (PubMed, Scopus, Science Direct,Web of Science, and Google Scholar), application of predefined inclusion and exclusion criteria, screening and selection of eligible studies, data extraction, narrative synthesis of findings, and interpretation of evidence regarding the nutritional, therapeutic, and industrial significance of mushroom-based nutraceuticals.

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

Mushroom Species	Key Bioactive Compounds	Primary Therapeutic Activities	Representative Nutraceutical Applications
Ganoderma lucidum (Reishi)	β-glucans, triterpenoids, polysaccharides	Immunomodulatory, anti-inflammatory, antioxidant, hepatoprotective	Immune-support supplements, liver health formulations, anti-fatigue products
Lentinula edodes (Shiitake)	Lentinan, eritadenine, polyphenols	Cholesterol-lowering, anticancer, immune-enhancing	Functional foods, cardiovascular nutraceuticals, oncology-support products
Grifola frondosa (Maitake)	D-fraction β-glucans, polysaccharides	Antidiabetic, immunostimulatory, antioxidant	Glucose-regulation supplements, immune-support formulations
Cordyceps militaris	Cordycepin, adenosine, polysaccharides	Anti-fatigue, anti-inflammatory, metabolic enhancement	Energy-enhancing products, endurance supplements
Inonotus obliquus (Chaga)	Polyphenols, melanin, β-glucans, triterpenes	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 products
Pleurotus tuber-regium	Polysaccharides, phenolic compounds	Antioxidant, gut microbiota modulation	Prebiotic supplements, digestive health formulations

Major medicinal mushroom species and their principal bioactive compounds, therapeutic properties, and representative nutraceutical applications. The table highlights the diverse health-promoting effects of mushroom-derived constituents, including immunomodulatory, antioxidant, anti-inflammatory, cardiometabolic, and antimicrobial activities, which support their growing utilization in functional foods and nutraceutical industries.

DISCUSSION

The growing interest in functional foods and nutraceuticals has led to increased scientific attention toward medicinal and edible mushrooms because of their exceptional nutritional composition and diverse pharmacological properties. Over the past decade, mushrooms have emerged as promising natural products that bridge the gap between nutrition and medicine, providing health benefits beyond basic dietary requirements [13]. The findings of the present review demonstrate that mushrooms are rich sources of biologically active compounds, including β-glucans, polysaccharides, terpenoids, phenolic compounds, sterols, lectins, and peptides, which contribute to a wide range of therapeutic effects and industrial applications [14].One of the most significant findings of the reviewed literature is the remarkable nutritional value of mushrooms. In addition to being low in fat and calories, mushrooms provide high-quality proteins, dietary fiber, essential amino acids, vitamins, and minerals, making them attractive components of a balanced diet [15]. Their nutritional profile supports their use as functional foods capable of contributing to disease prevention and health promotion. Several studies have reported that regular consumption of edible mushrooms may improve overall nutritional status while simultaneously providing protective effects against chronic diseases associated with oxidative stress and inflammation [16].Among the numerous mushroom species investigated, *Ganoderma lucidum* (Reishi), *Lentinula edodes* (Shiitake), *Grifola frondosa* (Maitake), *Cordyceps militaris*, and *Hericium erinaceus* (Lion's Mane) have received substantial scientific attention because of their diverse bioactive constituents and demonstrated health-promoting properties [17]. These species contain unique compounds that exhibit antioxidant, anti-inflammatory, immunomodulatory, antimicrobial, antidiabetic, anticancer, cardioprotective, and neuroprotective activities. The therapeutic potential of these mushrooms has encouraged their incorporation into dietary supplements, functional foods, and pharmaceutical formulations aimed at supporting overall health and well-being [18].A major area of interest within mushroom research is their immunomodulatory activity. β-glucans, particularly those isolated from Ganoderma lucidum and *Lentinula edodes*, have been extensively studied for their ability to stimulate innate and adaptive immune responses [19]. These polysaccharides activate macrophages, dendritic cells, natural killer cells, and other immune components, thereby enhancing host defense mechanisms. Such properties have generated interest in the use of mushroom-derived compounds as adjunctive therapies for infectious diseases, immune disorders, and cancer management [20]. The antioxidant capacity of mushrooms also represents a significant contributor to their nutraceutical value. Phenolic compounds, ergothioneine, flavonoids, and terpenoids have demonstrated substantial free-radical scavenging activity, reducing oxidative stress and protecting cellular structures from damage [21]. Oxidative stress plays a crucial role in the pathogenesis of numerous chronic diseases, including cardiovascular disease, diabetes mellitus, neurodegenerative disorders, and certain cancers. Consequently, mushroom-derived antioxidants may offer valuable preventive and therapeutic benefits for these conditions [22]. Another important finding from the reviewed literature is the role of mushrooms in metabolic health. Several studies have reported that mushroom-derived polysaccharides and bioactive metabolites may improve glucose metabolism, insulin sensitivity, and lipid profiles . Species such as *Grifola frondosa* and *Pleurotus ostreatus* have demonstrated promising antidiabetic and hypolipidemic effects, suggesting their potential utility in the management of metabolic syndrome and related disorders. These findings are particularly relevant given the increasing global prevalence of obesity, diabetes, and cardiovascular disease [23]. Beyond their therapeutic applications, mushrooms have gained substantial commercial importance within the nutraceutical industry. Increasing consumer awareness regarding natural health products has driven demand for mushroom-derived supplements, functional beverages, fortified foods, and pharmaceutical preparations [24]. Advances in cultivation technologies, extraction methods, biotechnology, and product formulation have facilitated the large-scale production of mushroom-based nutraceuticals. As a result, the global market for medicinal mushroom products continues to expand, creating new opportunities for food manufacturers, pharmaceutical companies, and healthcare industries [25].Despite the promising evidence supporting mushroom-based nutraceuticals, several challenges remain. Considerable variability exists in cultivation practices, extraction techniques, processing methods, and environmental conditions, all of which may influence the concentration and bioavailability of bioactive compounds [26]. Furthermore, the absence of universally accepted quality-control standards may contribute to inconsistencies among commercial products. Standardization of cultivation, extraction, and manufacturing procedures is therefore essential to ensure product quality, efficacy, and safety [27]. Another important limitation identified in the literature is the relative scarcity of large-scale randomized clinical trials evaluating the efficacy and long-term safety of mushroom-derived nutraceutical products. While numerous in vitro studies, animal experiments, and preliminary clinical investigations have reported encouraging results, stronger clinical evidence is required before many health claims can be fully validated. Future research should focus on well-designed multicenter clinical trials, standardized outcome measures, and comprehensive safety assessments to strengthen the evidence base for mushroom-based interventions [28]. Overall, the reviewed evidence strongly supports the growing role of mushrooms as valuable nutraceutical resources. Their rich nutritional composition, diverse bioactive constituents, broad therapeutic potential, and expanding industrial applications position them among the most promising natural products in contemporary functional food and nutraceutical research. Continued scientific investigation, technological innovation, and regulatory development will be essential for maximizing the health benefits and commercial potential of mushroom-derived products in the future.

Future Directions

Future research should focus on the identification and characterization of novel bioactive compounds derived from medicinal and edible mushrooms. Advances in biotechnology, metabolomics, and molecular biology may facilitate a deeper understanding of the mechanisms underlying the therapeutic effects of mushroom-derived constituents. Standardization of cultivation practices, extraction techniques, and product formulations is essential to ensure consistency, quality, and reproducibility of nutraceutical products. Furthermore, large-scale randomized clinical trials are required to establish the efficacy, safety, optimal dosage, and long-term health benefits of mushroom-based nutraceuticals. The integration of precision nutrition, artificial intelligence, and sustainable cultivation technologies may further accelerate the development of innovative mushroom-derived functional foods and therapeutic products.

Conclusion

Mushrooms represent valuable nutraceutical resources because of their rich nutritional composition and diverse range of bioactive compounds. Scientific evidence supports their antioxidant, anti-inflammatory, immunomodulatory, antimicrobial, antidiabetic, cardioprotective, neuroprotective, and anticancer properties. The increasing incorporation of mushroom-derived ingredients into dietary supplements, functional foods, pharmaceutical formulations, and other industrial products highlights their growing commercial and therapeutic significance. Continued research, product standardization, and regulatory development are necessary to maximize their health benefits and facilitate their broader integration into healthcare and food industries.

Ethical Approval

Ethical approval was not required for this study because it was based exclusively on previously published literature and did not involve human participants, animals, or identifiable personal data.

Data Availability Statement

No new datasets were generated or analyzed during the preparation of this review article. All information presented in this manuscript was obtained from previously published studies available in the scientific literature.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this review article.

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The author contributed substantially to the conception, literature review, analysis, writing, revision, and final approval of the manuscript and accepts full responsibility for its content.

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