

Mushroom Nutraceuticals: From Functional Foods to Future Health Products

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OPEN ACCESS

Keywords

Mushroom, nutraceuticals, bioactive compounds.

How to cite this article:

Kalita, L., Saikia, D. and Handique, K. 2026. Mushroom Nutraceuticals: From Functional Foods to Future Health Products. *Vigyan Varta* 7 (10): 124-127.

ABSTRACT

Mushrooms are valuable sources of nutraceuticals and functional food ingredients, containing bioactive compounds such as β -glucans, phenolics, terpenoids, sterols and ergothioneine. Species including shiitake, oyster mushroom, reishi, lion's mane and *Cordyceps militaris* have shown promising nutritional, antioxidant, immunomodulatory and gut-health-related potential. However, much of the available evidence is based on laboratory and animal studies, emphasizing the need for well-designed human clinical trials. The nutraceutical potential of mushrooms is influenced by species, cultivation, processing, extraction and formulation, making standardization and quality control essential. Advances in mushroom biotechnology, sustainable cultivation and precision fermentation are creating opportunities for producing high-value bioactive compounds while utilizing agricultural residues. Overall, mushroom nutraceuticals offer promising prospects at the intersection of mycology, nutrition, biotechnology and sustainable food production.

INTRODUCTION:

Mushrooms, traditionally valued as nutritious foods, are increasingly recognized as important sources of nutraceuticals and functional food ingredients

due to their proteins, dietary fibre, vitamins, minerals and bioactive compounds such as β -glucans, phenolics, terpenoids, sterols, ergothioneine and nucleoside derivatives.

These compounds have attracted scientific interest for their potential antioxidant, immunomodulatory, anti-inflammatory, metabolic and gut-health-related properties (Singh *et al*, 2025). Mushroom nutraceuticals can be developed from fruiting bodies, mycelial biomass, spores or purified extracts and incorporated into powders, capsules, beverages and functional foods. Among the major bioactive components, β -glucans are particularly important because their structural characteristics influence their biological activity, including potential effects on immune responses, inflammation and the gut microbiota, while ergothioneine, a sulphur-containing antioxidant compound, has attracted attention for its potential role in protecting cells from oxidative stress and supporting healthy ageing (Syahputra *et al*, 2025). Several species, including shiitake (*Lentinula edodes*) and oyster mushrooms (*Pleurotus* spp.), are especially promising nutraceutical resources; shiitake contains bioactive compounds such as lentinan and eritadenine (Baral, 2025), while *Pleurotus* species provide β -glucans, phenolics, proteins, fibre and ergothioneine (Araújo *et al*, 2025) and can be cultivated efficiently on agricultural residues. However, much of the evidence for mushroom-derived health benefits comes from laboratory and animal studies, and human clinical evidence remains limited for many species and products. Therefore, standardization, scientific validation and well-designed clinical trials are essential for establishing reliable nutraceutical applications and translating the growing potential of mushrooms into evidence-based health products and sustainable food systems. Reishi (*Ganoderma lucidum*) contains β -glucans and triterpenoids such as ganoderic acids (Yang *et al*, 2025), which have shown immunomodulatory, antioxidant and anti-inflammatory activities in laboratory studies, although clinical evidence remains limited. Lion's mane (*Heridium erinaceus*) is being

investigated for its potential cognitive and neuroprotective properties, particularly due to compounds such as hericenones and erinacines. Similarly, *Cordyceps militaris* contains bioactive compounds including cordycepin, adenosine, polysaccharides and carotenoids (Park, 2025), with modern cultivation and fermentation technologies being explored to enhance their production. Overall, these mushrooms show promising nutraceutical potential, but further well-designed human studies are needed to establish their health benefits.

From food to nutraceutical

Producing a mushroom nutraceutical is considerably more complex than simply drying a mushroom and converting it into powder. The composition and biological activity of the final product can be influenced by the mushroom species and strain, whether the material is derived from the fruiting body or mycelial biomass, cultivation substrate, temperature, pH, humidity, light, harvesting stage, drying and storage conditions, extraction solvent and extraction method, purification procedures, formulation and bioavailability. Standardization is one of the major challenges facing the mushroom nutraceutical industry.

Modern mushroom biotechnology is helping address this challenge. Ultrasound-assisted, microwave-assisted and enzyme-assisted extraction methods are being investigated to improve the recovery of polysaccharides and other bioactive compounds (Guo *et al*, 2025). Controlled fermentation can also be used to influence metabolite production. In the future, precision fermentation and optimized cultivation systems may allow specific compounds to be produced more consistently and economically. Such approaches could transform mushrooms from conventional food crops into controlled biological systems for

producing high-value nutraceutical ingredients.

The relationship between mushrooms and the gut microbiome represents another rapidly developing area of research. Mushroom polysaccharides and other compounds can reach the gastrointestinal tract and interact with intestinal microorganisms. These microorganisms may transform mushroom-derived compounds into metabolites that subsequently interact with the host. Understanding these interactions could help explain some of the biological effects associated with mushroom consumption and may lead to the development of mushroom-based prebiotic or microbiome-targeted foods (Mizuno and Minato, 2024).

Mushrooms also have an important role in sustainable agriculture and the circular bioeconomy. Species such as *Pleurotus* can grow on agricultural residues and agro-industrial by-products, converting materials of relatively low economic value into edible biomass and nutritionally valuable products. This creates opportunities for combining mushroom cultivation with waste utilization, rural entrepreneurship, food security and nutraceutical production. In countries such as India, where large quantities of agricultural residues are generated annually, this approach has considerable potential.

Future Prospects

Future research on mushroom nutraceuticals should focus on standardized extracts, bioavailability, mushroom–microbiome interactions, safety and well-designed clinical trials. Species authentication and quality control, including monitoring for contaminants and other hazards, are essential to ensure product safety and efficacy. Such efforts will help establish scientifically validated benefits and support the development of reliable

mushroom-based nutraceuticals (Guo *et al.*, 2025).

CONCLUSION

Mushrooms represent a promising intersection of mycology, nutrition, biotechnology and food science, offering diverse bioactive compounds such as β -glucans, ergothioneine, triterpenoids and cordycepin (Singh *et al.*, 2025). Future research should emphasize safety, bioavailability, standardization and clinical validation rather than unsubstantiated claims. Advances in biotechnology and sustainable cultivation could further enhance the development of evidence-based mushroom nutraceuticals while promoting value addition and efficient utilization of agricultural biomass.

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