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Functional Mushrooms: The Next Generation of Natural Medicines Transforming Human Health

*R. Rajalakshmi[1], Kunisetty Ramsai[2], Vijayashree[3], D. Deerajkumar[1], D. Prethikaa[1], S. Priyanga[1] and R. Savitha[1]

[1]PG Scholar (Dept. of Horticulture-Vegetable Science), Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, UT of Puducherry, India

[2]Farm Forestry Officer (Andhra Paper Limited, Rajahmundry, India)

[3]Ph.D. Scholar (Dept. of Horticulture- Vegetable Science), Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, UT of Puducherry, India

*Corresponding Author's email: rajilakshmiramesh2810@gmail.com

Functional mushrooms are emerging as one of the most promising sectors within horticulture, nutraceuticals and natural product biotechnology. Beyond their basic nutritional value, several mushroom genera - including *Ganoderma*, *Hericium*, *Cordyceps*, *Lentinula*, *Grifola* and *Inonotus* - are now recognized for their clinically relevant bioactive compounds, such as beta-glucans, triterpenoids, phenolics and ergothioneine. These compounds are associated with immunomodulation, neuroprotection, anti-inflammatory responses, antioxidant defense and antitumor properties (Zhang *et al*., 2016). Rapid advancements in controlled-environment mushroom cultivation, substrate optimization and liquid-state fermentation have created new opportunities for farmers, entrepreneurs and health industries. This article explores the biochemical basis of mushroom functionality, major medicinal species, modern cultivation approaches, value-added products, market trends and future prospects, offering a comprehensive scientific understanding for horticultural professionals.

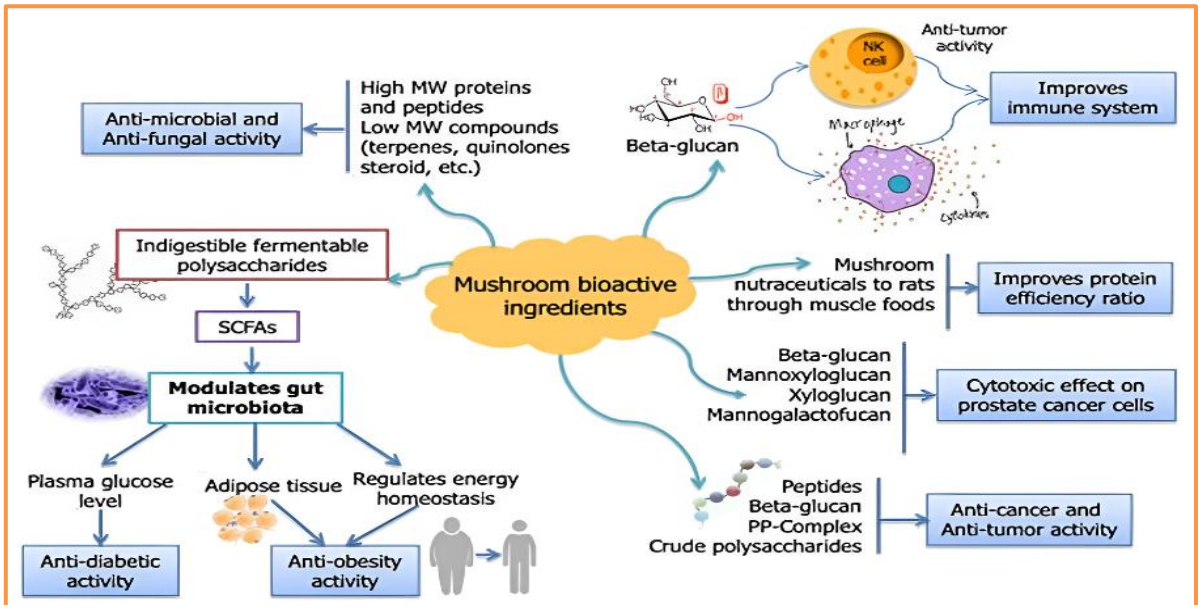
Keywords: Therapeutic mushrooms, immune modulation, neuroprotection, Reishi, Lion's Mane, Cordyceps, Turkey Tail, medicinal bio actives, nutraceuticals.

Introduction

The global nutraceutical and functional food market has seen a transformational shift toward natural, plant-based and fungi-derived products. Functional mushrooms - species containing bioactive secondary metabolites capable of enhancing physiological functions - represent one of the fastest-growing categories in this domain (FAO, 2022). Although mushrooms have been used for over 2,000 years in traditional Asian medicine, only in recent decades has modern science validated their therapeutic potential, leading to widespread commercial interest (Benedict *et al.*, 2020). The surge in chronic diseases, lifestyle-related health issues, antibiotic resistance and interest in immune-boosting foods post-COVID has intensified demand for mushroom-based supplements (WHO, 2021). For horticulture and agricultural biotechnology, this sector provides a unique opportunity: low-input, high-value biomass production coupled with scientific validation and expanding global markets.

Bioactive Compounds That Make Mushrooms "Functional"

Functional mushrooms contain specific molecules with pharmacological roles. Understanding these compounds helps farmers, healthcare professionals and industries assess mushroom quality and therapeutic potential.



Schematic diagram depicting health promoting and medicinal properties of mushroom bioactive ingredients (MW = Molecular weight; NK cell-Natural killer cell; PP-complex: Protein-polysaccharide complex; SCFA = Short-chain fatty acids).

Beta-glucans: These polysaccharides modulate innate immunity by activating macrophages, NK cells and dendritic cells (Vetvicka & Vetvickova, 2015).

- Highly concentrated in *Ganoderma*, *Lentinula*, *Maitake* and *Oyster* mushrooms.
- Beta-1,3 and beta-1,6 glucans are particularly potent immunomodulators.

Triterpenoids: Found mainly in *Ganoderma lucidum*.

- Exhibit anti-inflammatory, hepatoprotective and anticancer effects (Baker & Friedman, 2018).
- Responsible for the mushroom's slightly bitter taste.

Polysaccharide peptides (PSP) and polysaccharide-K (PSK): Extracted from *Trametes versicolor* (Turkey Tail), widely researched for anticancer supportive therapies (Sullivan *et al*., 2006).

Ergothioneine: A potent antioxidant amino acid unique to fungi. Protects mitochondria and prevents DNA damage (Jayachandran *et al*., 2017).

Hericenones & Erinacines: Neuroactive compounds found in *Hericium erinaceus* (Lion's Mane). Stimulate nerve growth factor (NGF) synthesis, support neuroregeneration and memory (Hobbs, 2021)

Major Functional Mushrooms and Their Health Impacts

Reishi (*Ganoderma lucidum*): Often called the "Mushroom of Immortality."

Functions:

- Immune enhancement
- Stress reduction
- Anti-inflammatory activity
- Liver detoxification

Scientific basis: Reishi contains >400 bioactive compounds, including triterpenoids and ganoderic acids, with documented anticancer and immunomodulatory effects (Baker & Friedman, 2018).

Practical use: Dried fruiting bodies, extracts or capsules.

Lion's Mane (*Hericium erinaceus*)

Functions:

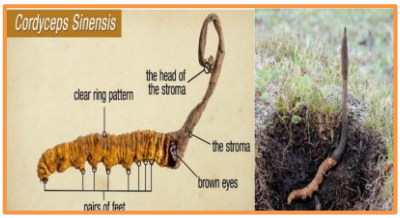
- Enhances cognition
- Supports nerve repair
- Improves gut health

Lion's Mane stimulates NGF and BDNF-like activity due to erinacines and hericenones, making it a leading natural nootropic (Hobbs, 2021).

Practical use: Powder, tea, fortified foods or dual-extract tinctures.

Cordyceps (*C. militaris* and *C. sinensis*): Traditionally used for stamina and lung health.

C. militaris



C. sinensis

Functions:

- Enhances oxygen utilization
- Improves ATP production
- Supports respiratory health
- Acts as an adaptogen

Scientific basis: Cordycepin (3'-deoxyadenosine) promotes energy metabolism and anti-fatigue activity (Benedict *et al*., 2020).

Turkey Tail (*Trametes versicolor*)

Functions:

- Strong immune stimulant
- Supports cancer therapy
- Gut microbiome modulator

PSK and PSP extracted from this mushroom are approved in Japan for oncology support (Sullivan *et al*., 2006).

Shiitake, Maitake, Chaga and Oyster Mushrooms: These species contribute significantly to cardiovascular health, cholesterol reduction, antioxidant protection and immune enhancement (Zhang *et al*., 2016).

Shiitake, Maitake, Chaga and Oyster Mushrooms

Cultivation of Functional Mushrooms: Scientific and Practical Aspects

Functional mushroom cultivation requires precision because bioactive content varies with substrate, strain and environmental conditions.

Substrate Optimization: Different species require specific substrates,

- *Ganoderma*: hardwood sawdust + supplements
- *Hericium*: enriched sawdust blocks
- *Cordyceps*: rice-based or silkworm pupa-based substrates
- *Lentinula edodes*: sterilized logs or supplemented sawdust

Enrichment with bran, gypsum or mineral mixtures increases yield and bioactive molecule concentration (Chang & Miles, 2004).

Controlled Environmental Production: High-value medicinal species respond strongly to environmental control.

Key parameters:

- **Temperature:** 18–28°C depending on species
- **Humidity:** 80–95%
- **Fresh air exchange:** essential for avoiding CO_2 buildup
- **Light intensity:** species-specific
- **Sterility:** critical for preventing contamination

These parameters influence bioactive compound synthesis, especially beta-glucans and triterpenoids.

Liquid-State Fermentation (LSF): A cutting-edge biotechnology used for:

- Mycelial biomass production
- Extraction of metabolites (cordycepin, PSP, etc.)
- Faster and more controlled yields

Industries now prefer LSF for *Cordyceps* and *Ganoderma* due to consistency and pharmaceutical-grade purity (FAO, 2022).

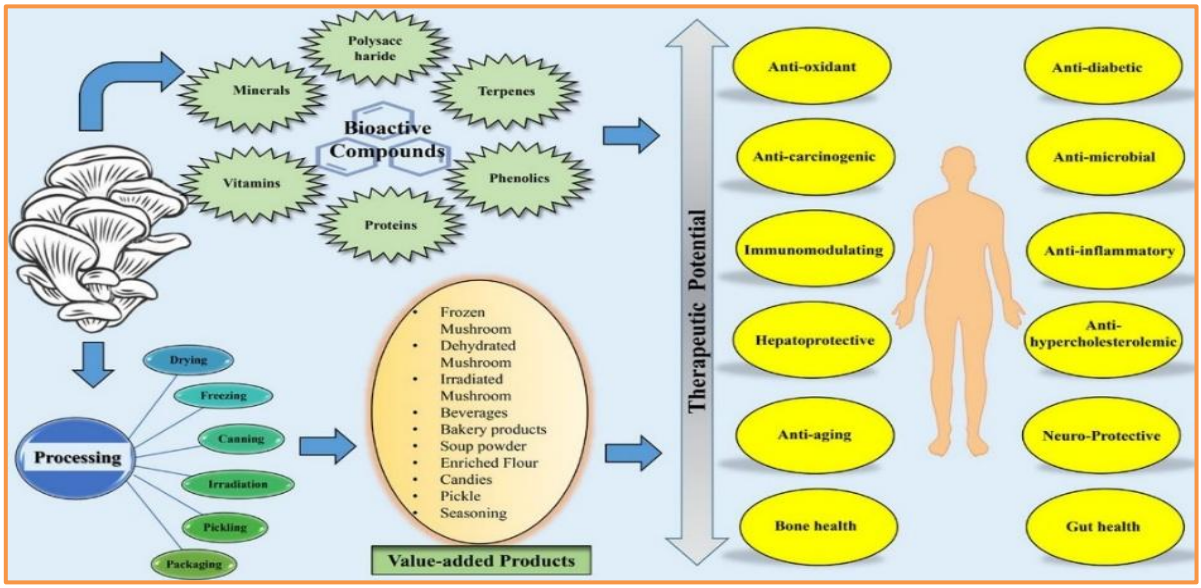
Use of Agricultural Waste: Functional mushroom cultivation supports waste recycling,

- Paddy straw
- Sawdust
- Coffee husk
- Sugarcane bagasse
- Wheat bran

This enhances sustainability and reduces production costs.

Value-Added Functional Mushroom Products

Functional mushrooms are rarely consumed as fresh produce; instead, they are processed into concentrated formats for stability and potency.

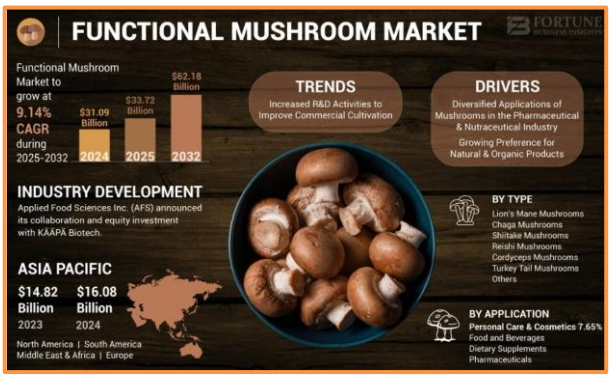


Bioactive components of mushrooms: Processing effects and health benefits

Major categories include:

- Hot-water extracts
- Alcoholic extracts (for triterpenoids)
- Dual-extract tinctures
- Powdered capsules
- Mushroom-infused teas and coffees
- Mycelium-based nutraceuticals
- Fortified foods (biscuits, beverages, soups)

Market preference is shifting toward **standardized extracts** with quantified bioactive compounds (Jayachandran *et al.*, 2017).



Functional mushroom market trend

Global Market Trends

The functional mushroom industry has witnessed exponential growth due to lifestyle diseases and rising consumer preference for natural healthcare.

Current trends:

- Increased demand for immunity enhancers
- Rapid growth of mushroom coffees, chocolates and supplements
- Expansion of mushroom biotechnology startups
- Rising consumption of nootropic mushrooms like Lion's Mane
- Premium pricing for medicinal species (high-profit margin for growers)

FAO (2022) reports functional mushrooms as one of the fastest-expanding segments in the medicinal plant and fungi sector.

Challenges and Safety Concerns: Despite their benefits, several issues must be addressed:

Product Adulteration: Many "functional mushroom" products contain starch or mycelium fillers. Consumers must look for:

- Fruiting body extracts
- Beta-glucan percentage labelling
- Certification

Contamination Risks: Heavy metal accumulation can occur if substrates are not tested.

Dose Standardization: Unlike pharmaceuticals, nutraceutical dosing is inconsistent across brands.

Drug Interactions: Some mushrooms may interact with immunosuppressants, anticoagulants or diabetes medications (WHO, 2021). Proper regulation and scientific validation are essential for safe use.

Future Prospects: The integration of functional mushrooms into mainstream healthcare is accelerating. Current research points toward future innovations such as:

- Mushroom-derived pharmaceuticals
- Personalized mushroom supplements based on genomics
- Nanoparticle-based mushroom drug delivery systems
- Fortified vegetable and mushroom hybrid crops
- Mycelium-based biodegradable packaging and biomaterials

The future of functional mushrooms extends far beyond food - they represent a convergence of biotechnology, horticulture, medicine and sustainability.

Conclusion

Functional mushrooms have evolved from traditional remedies into scientifically validated natural medicines. Their diverse bioactive compounds - beta-glucans, triterpenoids, PSP, ergothioneine and neuroactive molecules - offer significant health benefits supported by modern research. With advances in controlled-environment cultivation, fermentation biotechnology and value-added processing, functional mushrooms represent a high-potential enterprise for horticulturists and innovators. Their future lies not only in human health but also in sustainable agriculture and global food security.

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