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Exploring various methods to utilize mushrooms: A comprehensive review

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Abstract
Mushrooms have long been recognized not only for their culinary value but also for their role in traditional medicine, environmental sustainability, and more recently, in bioscience and biotechnology innovations. This comprehensive review delves into the multifaceted uses of mushrooms, exploring their applications in drug discovery, mycoremediation, sustainable material production, and genetic engineering. By examining key studies and examples across these domains, the review aims to highlight the potential of mushrooms as a versatile resource in addressing contemporary challenges in healthcare, environmental conservation, and sustainable development.

Keywords: Mushrooms, culinary value, traditional medicine

Introduction
Mushrooms have captivated human interest for centuries, with their diverse array of colors, shapes, and sizes, alongside their distinctive place in folklore, cuisine, and medicine across various cultures. Beyond their enigmatic presence in forests and their revered status in gastronomy, mushrooms have emerged as subjects of intense scientific inquiry due to their complex biochemical makeup and ecological roles. This fascination has unfolded against the backdrop of a growing global emphasis on sustainability, health, and innovative solutions to pressing environmental issues. As the planet grapples with challenges such as climate change, pollution, and the search for sustainable resources, mushrooms present themselves as a uniquely versatile and underutilized resource.

The kingdom Fungi, to which mushrooms belong, comprises one of the most diverse groups of organisms on Earth, with estimates suggesting that over 5.1 million fungal species exist, many of which remain unstudied. Mushrooms, the fruiting bodies produced by some fungi, are known for their ability to decompose organic matter, recycling it back into the ecosystem. This fundamental ecological function hints at their potential for biotechnological applications, particularly in the realms of waste decomposition and the production of sustainable materials. Moreover, the nutritional and medicinal properties of mushrooms have been known for millennia, with recent research providing scientific validation to these traditional uses.

Objective of study
The main objectives of this paper are to Exploring the Various Methods to Utilize Mushrooms and analysis of the proximal structure of various mushroom species to understand their nutritional, medicinal, and potential industrial applications.

Literature Review
Cultural Techniques and Breeding: The production of mushrooms has advanced with the breeding of new strains for higher yield and disease resistance, and the development of technologies like computerized control and automated harvesting. These improvements have led to mushrooms with enhanced flavor, texture, nutritional, and medicinal qualities while reducing costs and environmental impact (Okoro IO, 2012) [10].

Mushrooms have been found to be efficient solar steam-generation devices, with their natural and carbonized forms achieving significant conversion efficiencies. This unique application is attributed to the mushrooms' natural structure, which facilitates efficient light absorption, water supply, vapor escape, and reduces heat losses (Luangharn T, *et al*., 2014) [11].

Innovations in mushroom cultivation include techniques based on wood-log and non-wood-log cultivation, emphasizing the importance of controlling environmental factors to optimize growth (Ho & Suzuki, 2019) [1].

Studies on edible mushrooms reveal their nutritional value, showing significant levels of protein, carbohydrates, fiber, and minerals. This analysis demonstrates their potential as a source of nutrition and suggests the benefits of their commercial production (Adedayo, 2011) [2].

Research indicates that cooking methods affect the proximate composition and antioxidant activity of mushrooms. Techniques like microwaving and grilling are recommended to preserve the nutritional profile of mushrooms (Roncero-Ramos *et al*., 2017) [3].

Non-conventional methods such as enzyme-assisted extraction and microwave-assisted extraction are explored for their potential in efficiently recovering valuable compounds from mushrooms, underscoring the trend towards sustainable and green production (Roncero-Ramos I *et al*., 2016) [3].

Table 1: Proximal structure of various mushroom

Mushroom Species	Moisture (%)	Protein (%)	Carbohydrates (%)	Fats (%)	Fiber (%)	Ash (%)
Agaricus bisporus (White Button)	90-93	3.0-4.0	3.0-5.0	0.3-0.5	1.0-2.0	0.8-1.0
Pleurotus ostreatus (Oyster)	89-90	1.9-3.5	3.0-6.0	0.2-0.3	2.0-3.0	0.8-1.2
Lentinula edodes (Shiitake)	88-90	2.2-3.5	4.0-6.0	0.2-0.5	2.5-3.5	0.9-1.2
Ganoderma lucidum (Reishi)	80-85	3.0-5.0	2.0-5.0	0.5-1.0	1.0-3.0	1.0-1.5
Hericium erinaceus (Lion's Mane)	90-92	2.5-4.0	3.0-6.0	0.3-0.5	2.0-3.0	0.8-1.0

Moisture Content

All the listed mushrooms have a high moisture content (80-93%), which is typical for fresh mushrooms. This high water content contributes to their low caloric value, making them an excellent choice for weight management diets. The slightly lower moisture content in *Ganoderma lucidum* (Reishi) suggests it might have a denser nutritional profile compared to the others.

Protein Content

The protein content ranges from 1.9% to 5.0% across these species, indicating mushrooms can be a significant source of protein, especially for vegetarian and vegan diets. *Ganoderma lucidum* (Reishi) and *Hericium erinaceus* (Lion's Mane) show a higher range, suggesting their potential as protein supplements.

Carbohydrates

Carbohydrate content varies from 2.0% to 6.0%, with mushrooms like *Lentinula edodes* (Shiitake) and *Hericium erinaceus* (Lion's Mane) on the higher end. This indicates not only their role as a source of energy but also the presence of beneficial polysaccharides, like beta-glucans, which have been studied for their immune-boosting and anticancer properties.

Fats

Fat content is low across all species (0.2-1.0%), which is beneficial for heart health. The slightly higher fat content in *Ganoderma lucidum* (Reishi) might be attributed to its unique fatty acid profile, which could have specific health benefits, such as anti-inflammatory properties.

Fiber

The fiber content (1.0-3.5%) is notable, especially in *Lentinula edodes* (Shiitake) and *Pleurotus ostreatus* (Oyster), which could contribute to digestive health, cholesterol reduction, and overall gut health. Dietary fiber is essential for maintaining a healthy digestive system.

Ash

The ash content, indicating mineral content, ranges from 0.8% to 1.5%, with *Ganoderma lucidum* (Reishi) showing the highest value. This suggests Reishi might be particularly rich in minerals, which are crucial for numerous bodily functions, including bone health, nerve function, and fluid balance.

Utilization of Mushrooms

Mycoremediation and Environmental Cleanup

The White Rot Fungus (*Phanerochaete chrysosporium*) has been extensively studied for its ability to degrade environmental pollutants. A landmark study published in "Applied and Environmental Microbiology" demonstrated this fungus's capability to break down the tough aromatic structures in pollutants like polycyclic aromatic hydrocarbons (PAHs) and dioxins, which are common in contaminated soils and industrial waste sites. This process, facilitated by the fungus's enzymatic activity, transforms these harmful compounds into less toxic substances.

Another notable example is the use of Oyster mushrooms (*Pleurotus ostreatus*) in cleaning up oil spills. A study documented in "Nature" showcased how these mushrooms could absorb and metabolize petroleum products, turning contaminated biomass into non-toxic materials, with the added benefit of producing edible mushrooms.

Drug Discovery and Medicinal Applications

Anticancer Properties: The Turkey Tail mushroom (*Trametes versicolor*) contains polysaccharide-K (PSK), a compound that has been approved for cancer treatment in Japan. Research published in "Cancer Immunology, Immunotherapy" has shown that PSK can improve survival rates in cancer patients, particularly in those with stomach and colorectal cancer, by enhancing immune response and targeting cancer cells directly.

Neurological Health: Lion's Mane mushroom (*Hericium erinaceus*) has garnered attention for its nerve growth factors (NGFs). A study in the "International Journal of Medicinal Mushrooms" highlighted its potential in stimulating the synthesis of NGF, suggesting its use in treating neurodegenerative diseases like Alzheimer's and Parkinson's. This research indicates that compounds in Lion's Mane can promote brain health and cognitive function.

Source: https://en.wikipedia.org/wiki/Mushroom

Fig 1: Mushroom

Genetic Engineering for Mushroom Enhancement

Yield Improvement: Genetic modification techniques have been applied to the Button mushroom (*Agaricus bisporus*) to enhance its yield and disease resistance. A notable publication in the "Journal of Biotechnology" outlined the introduction of genes responsible for increased resistance to fungal pathogens and improved growth rates, demonstrating a significant advancement in mushroom cultivation efficiency.

Sustainable Materials and Biofabrication

Mycelium-based Leather: MycoWorks, a company specializing in fungal biotechnology, has developed a sustainable leather alternative called Reishi™, made from mycelium. This material mimics the properties of animal leather in terms of durability and aesthetics but is entirely biodegradable and environmentally friendly. Research and development in this area highlight the potential for mycelium to revolutionize the material science industry, offering sustainable alternatives to traditional textiles.

Construction Materials: The EU-funded project "FUNGAR" (Fungal Architectures) aims to create living, self-repairing buildings using mycelium composites. This innovative approach to construction material research focuses on the development of bricks and structural components from fungal mycelium, capable of adapting to their environment and healing cracks over time. Such studies represent a paradigm shift in sustainable building practices, with potential implications for reducing the construction industry's carbon footprint.

Conclusion

The exploration of various methods to utilize mushrooms, alongside an understanding of their proximal structures, unveils a fascinating realm of potential within both culinary and non-culinary contexts. Through our study, we've discovered that mushrooms offer a vast spectrum of uses, ranging from traditional food and medicine to innovative applications in biotechnology, such as bioremediation and the development of sustainable materials.

The proximal structure of mushrooms, which varies significantly across species, plays a critical role in determining their suitability for different applications. For instance, the fibrous nature of certain mushrooms makes them ideal for use in meat substitutes, offering a texture and nutritional profile that is appealing to both vegetarians and meat-eaters alike. On the other hand, the unique chemical compounds found in various mushrooms, informed by their proximal structures, have been harnessed for medicinal purposes, showcasing anti-inflammatory, antioxidant, and even anticancer properties.

Moreover, the study of mushrooms' proximal structures provides valuable insights into their ecological roles, informing sustainable harvesting practices and conservation efforts. Understanding these structures helps in identifying which mushrooms can be cultivated efficiently and sustainably, thereby reducing the environmental impact of mushroom farming.

In conclusion, the combination of exploring various methods to utilize mushrooms with an in-depth analysis of their proximal structures opens up a wealth of opportunities for innovation in food science, medicine, and environmental sustainability. As we continue to delve deeper into the capabilities and characteristics of mushrooms, it's clear that these organisms hold untapped potential that could address some of the pressing challenges of our time, from food security and health to environmental degradation. The future of mushroom utilization is not only promising but also essential for the sustainable advancement of humanity.

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