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Reviewed Article

Mushroom Species: Diversity, Utility, and Conservation

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Abstract

Mushrooms, as a taxonomically diverse group of fungi, have garnered increasing scientific interest due to their ecological significance and extensive utility in various industries. This review contributes a comprehensive analysis that integrates the ecological, economic, and medicinal aspects of mushrooms, shedding light on the novel and holistic understanding of these remarkable organisms. It emphasizes the urgent requirement for a more cohesive approach to studying and preserving mushroom diversity, considering their integral role in ecosystems and their potential to address pressing global challenges. The primary aim of this paper is to provide a holistic assessment of mushroom species diversity, delve into their diverse utilities across various sectors, and emphasize the imperative need for their conservation. The article is based on an extensive examination of scientific literature, encompassing research articles, reports, and databases. The paper showcases the extraordinary diversity of mushroom species, with countless yet-to-be-identified species. Despite their ecological and economic importance, mushroom populations face formidable threats from habitat degradation, overharvesting, and climate change. Mushrooms, often overshadowed by more charismatic organisms, are indispensable components of ecosystems and hold tremendous potential for various industries. To ensure their sustained existence, comprehensive conservation strategies are imperative, including the establishment of protected areas, sustainable harvesting practices, and the promotion of cultivation techniques. Additionally, raising awareness among the public and policymakers about the multifaceted significance of mushrooms is essential. Finally, the paper recommends fostering interdisciplinary collaborations to explore untapped mushroom potential, incorporating mushroom conservation into biodiversity plans, and launching educational initiatives to heighten public awareness. This review serves as a foundational resource for future studies and initiatives aimed at preserving mushroom diversity and harnessing their manifold benefits for society and the environment.

Keywords: Fungi, ecological roles, medicinal, saprophytic nature, food value

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Introduction

Mushrooms, a captivating and enigmatic group of organisms within the fungal kingdom, have long existed in the shadows of the botanical world (Chugh et al., 2022). While their ecological, culinary, medicinal, and biotechnological importance is undeniable, they remain relatively understudied and underappreciated (Abulude et al., 2004). This review embarks on a journey to shine a well-deserved spotlight on mushroom species, elucidating their incredible diversity, multifaceted utility, and the pressing need for their conservation. In this era of heightened environmental awareness, understanding the biodiversity of our planet has become paramount. However, within the Kingdom of Fungi, mushrooms represent a realm rife with gaps in our knowledge (Naranjo-Ortiz and Gabaldón, 2019). Taxonomic uncertainties persist, hindering our ability to grasp the full extent of fungal diversity. Additionally, despite their ecological significance, the roles mushrooms play in ecosystems remain inadequately explored. Such gaps impede comprehensive conservation efforts and harnessing their potential benefits.

While our fascination with mushrooms spans centuries, a true understanding of their ecological and utilitarian roles has only recently begun to emerge (Miller, 2022). Furthermore, the ecological importance of these organisms extends beyond their roles as decomposers or mycorrhizal partners; it encompasses their influence on nutrient cycling, soil health, and even the resilience of forests (Abulude et al., 2003).

Intriguingly, the culinary world has embraced mushrooms for their unique flavors and textures. However, the full potential of this biodiversity in gastronomy remains largely untapped. Medicinally, certain mushroom species have shown immense promise, yet limitations in research have hindered the widespread recognition and utilization of their therapeutic properties.

Biotechnology and industry, too, have started to recognize the value of mushrooms, leading to innovative applications such as mycelium-based materials and biofuels (Antunes et al., 2020). Nevertheless, these developments are still in their nascent stages, with ample room for exploration (Jo et al., 2023).

Literature review

One of the main topics of mushroom research is their pharmacological potential and clinical application. Mushrooms contain various bioactive compounds, such as polysaccharides, terpenoids, phenolics, and alkaloids, that can modulate the immune system, inhibit tumor growth, regulate blood glucose and cholesterol levels, and protect against oxidative stress and inflammation (Kumar et al. 20201). Several mushroom species, such as *Ganoderma lucidum, Lentinula edodes, Trametes versicolor*, and *Cordyceps*

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sinensis, have been extensively studied for their therapeutic effects on various diseases, such as cancer, diabetes, neurodegeneration, and infections (El-Ramady et al., 2022; Łysakowska et al., 2023). However, more clinical trials are needed to validate the safety and efficacy of mushroom-derived products in human health (Agrawal and Dhanasekaran, 2019). Mushrooms can be grown on various substrates, such as agricultural wastes, logs, sawdust, and synthetic materials, using different techniques, such as solid-state fermentation, liquid fermentation, bag cultivation, and bottle cultivation (Thakur, 2020). Advances in mushroom production have led to increased yield, quality, and diversity of mushroom products. Moreover, mushroom cultivation can also contribute to waste management, environmental protection, and rural development.

Mushrooms can be enriched with various nutrients and bioactive compounds by modifying their growing conditions or applying post-harvest treatments. For example, mushrooms can be exposed to ultraviolet light to increase their vitamin D content (Keegan et al., 2013), or supplemented with selenium to enhance their antioxidant activity (Cardwell et al., 2018). Value-added mushrooms can provide additional health benefits and market value for consumers and producers. Mushrooms are a valuable resource for food, nutrition, medicine, and biotechnology. Recent research has shown the potential of mushrooms to improve human health and well-being, as well as to address some of the global challenges, such as food security, environmental sustainability, and rural development (El-Ramady et al., 2022). However, more research is needed to explore the diversity and functionality of mushrooms and their constituents, as well as to optimize their production and utilization.

There are many types of edible mushrooms, each with its own unique taste and nutritional profile. Here are some of the most popular edible mushrooms:

1. **Cremini mushrooms**: These mushrooms belong to the white button mushroom family and are slightly more mature than white button mushrooms (Figure 1). They have a meatier texture and a deeper flavor than white buttons.

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(Figure 1. Cremini mushrooms

Domain (Eukaryota), Kingdom (Fungi), Division (Basidiomycota), Class (Agaricomycetes), Order (Agaricales), Family (Agaricaceae), Geus (Agaricus), Species (*A. bisporus*). *Agaricus bisporus*, often known as "crimini" and "white" mushrooms, are the same species as portobellos and cremini mushrooms; the only distinction is the maturity stage at which they are found. Cremini mushrooms have a meaty texture and a moderate, earthy flavor.

2. **Morel mushrooms**: These mushrooms (Figure 2) have a unique honeycomb-like appearance and a meaty taste.

Figure 2. Morel mushrooms

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Domain (Eukaryota), Kingdom (Fungi), Division (Ascomycota), Class (Pezizomycetes), Order (Pezizales), Family (Morchellaceae), Genus (Morchella). True morel mushrooms belong to a genus and family of fungi called Morchellaceae called Morchella. There are species referred to as "morels" in other genera of the Morchellaceae and in the genus Gyromitra of the Helvellaceae family. Ascomycetes, or cup fungus, are linked to morels in general.

3. **Shiitake mushrooms**: These mushrooms (Figure 3) are native to East Asia and have a rich umami flavor.

Figure 3. Shiitake mushrooms

Domain (Eukaryota), Kingdom (Fugi), Division (Basidiomycota), Class (Agaricomycetes), Order (Agaricales), Family (Omphalotaceae), Genus (Lentinula), Species (*L. edodes*). Edible shiitake mushrooms are a native of East Asia. Their caps grow between 2 and 4 inches (5 and 10 cm) long and range in color from tan to dark brown. Shiitake are fungi that naturally grow on dead hardwood trees, yet they are often consumed like vegetables.

4. **Portobello mushrooms**: These mushrooms (Figure 4) are mature cremini mushrooms with a large cap and a meaty texture.

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Figure 4. **Portobello mushrooms**

Domain (Eukaryota), Kigdom (Fugi), Division (Basidiomycota), Class (Agaricomycete), Order (Agaricales), Family (Agaricaceae), Geus (Agaricus), Species (*A. bisporus*). The mature cremini mushroom variety known as portobello has a strong flavor and a meaty texture. A good source of 15 different vitamins, minerals, and antioxidant phytonutrients, such as copper, selenium, and B vitamins, they have few calories and are low in fat.

5. **Oyster mushrooms**: These mushrooms (Figure 5) have a delicate flavor and a velvety texture.

Figure 5. **Oyster mushrooms**

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Domain (Eukaryota), Kingdom (Fungi), Division (Basidiomycota), Class (Agaricomycetes), Order (Agaricales), Family (Pleurotaceae), Genus (Pleurotus), Species (*P. ostreatus*). Botanical Name (*Pleurotus ostreatus*). Scientists have shown that compared to other grown mushrooms, oyster mushrooms have higher antioxidant concentrations. Oyster mushrooms are presumably used in so many dietary supplements because of this. Ergothioneine is an amino acid that is abundant in mushrooms.

6. **Enoki mushrooms**: These mushrooms (Figure 6) have a mild flavor and a crunchy texture.

Figure 6. **Enoki mushrooms**

Domain (Eukaryota), Kingdom (Fungi), Division (Basidiomycota), Class (Agaricomycetes), Order (Agaricales), Family (Physalacriaceae), Genus (Flammulina), Species (*F. filiformis*), Binomial name (*Flammulina filiformis*). An edible fungus that resembles long strings—almost like noodles—is the enoki mushroom. Enoki mushrooms are widely used in Chinese and Japanese cuisine, where they are known as enokitake and golden needle, respectively.

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7. **Chanterelle mushrooms**: These mushrooms (Figure 7) have a fruity aroma and a nutty flavor.

Figure 7. **Chanterelle mushrooms**

Chitin and chitosan, two polysaccharides, are abundant in chanterelle mushrooms. These two substances encourage the immune system to make more cells while protecting your cells from harm. Additionally, they have a reputation for assisting in the reduction of inflammation and the danger of several malignancies. A flexible forest mushroom with a golden funnel form, chanterelles can be the main attraction or an essential supporting role in a recipe. They can be utilized as a stand-alone ingredient or as a component of a killer wild mushroom blend.

8. **Lion's mane mushrooms**: These mushrooms (Figure 8) have a seafood-like flavor and a stringy texture similar to crab or lobster meat when cooked (Joseph, 2023).

Figure 8. Lion's mane mushrooms

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Domain (Eukaryota), Kingdom (Fungi), Division (Basidiomycota), Class (Agaricomycetes), Order (Russulales), Family (Hericiaceae), Genus (*Hericium*), Species (*H. erinaceus*), Binomial name (*Hericium erinaceus*). Lion's mane is used by people for a variety of medical conditions, including reducing the risk of heart disease, increasing the immune system, and controlling diabetes. To verify these advantages, more study is necessary. The fourth most intense antioxidant activity was found in lion's mane mushrooms, according to research done to understand the antioxidant properties of several varieties of mushrooms. By reducing the effects of inflammation in adipose tissue, several studies also point to the advantages of lion's mane mushrooms in the battle against obesity.

These are just some of the many types of edible mushrooms available around the world.

The aim of this comprehensive review is threefold: Firstly, to bridge the gaps in our understanding of mushroom taxonomy and ecology, shedding light on the myriad species that shape our world. Secondly, to underscore the multifaceted utility of mushrooms, whether in the kitchen, the pharmacy, or the laboratory. Lastly, to emphasize the urgency of conserving these remarkable organisms, whose habitats are increasingly threatened. In pursuit of these aims, this review article navigates through the rich diversity of mushroom species, explores their ecological roles, delves into their utilitarian significance, and addresses the challenges they face.

Materials and Methods

For existing peer-reviewed meta-analyses, the taxonomic data, ecological data, conservation status, biotechnological applications culinary and medicinal properties of mushroom species were extracted from field studies, research articles, and ecological databases. These were conducted with a thorough search of online databases. Additionally, for the case studies that were undertaken to compare the meta-analysis research, the original papers were collected. The main databases used for this literature search include PubMed (MEDLINE), Springer, Elsevier, and others. These are some of the best and most extensively used resources for food chemistry and mushroom species research. Studies published from 2013 through 2023 are the studies that were searched for. Additionally, reference lists for any pertinent papers appropriate for this review were hand-searched to identify further investigations. The sole language that was used for published articles was English. Mushrooms, fungi, saprophyte, historical information, and culinary evaluation are among the search terms. Meta-analyses detailing the immediate and long-term consequences and nutritional benefits of mushrooms on the well-being of people were included as inclusion criteria. The first author, publication

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year, risk factors, study design, study duration, population, and health outcome were all searched for in the data-gathering procedure.

Discussion

Mushrooms, belonging to the fungal kingdom, encompass a staggering diversity of species, each with unique ecological roles, culinary attributes, and potential medicinal and biotechnological applications. This study has sought to provide an integrated view of mushroom species, emphasizing their diversity, utility, and conservation status. Herein, we discuss the implications of our findings and the broader significance of mushroom research.

1. Diversity and Taxonomy: The exploration of mushroom diversity revealed the sheer number of species populating various ecosystems worldwide (Zhang et al., 2021; Burki et al., 2021). Taxonomically, the fungal world remains incompletely understood, with many species yet to be formally described. The ongoing discovery of new species underscores the need for continued taxonomic research to elucidate their evolutionary relationships and ecological roles.

2. Ecological Significance: Mushrooms play pivotal roles in ecosystem functioning. As decomposers, mycorrhizal partners, and symbiotic associates of various organisms, they influence nutrient cycling, plant health, and overall ecosystem stability (van der Heijden et al., 2015). This review article underscores the importance of conserving mushroom diversity to preserve these ecological services.

3. Culinary and Medicinal Uses: Many mushroom species have long been valued for their culinary and medicinal properties. Their unique flavors, textures, and nutritional profiles make them sought-after ingredients in cuisines worldwide (Amit et al., 2017). Additionally, bioactive compounds found in certain mushrooms exhibit potential health benefits, spurring pharmaceutical research. However, this paper highlights the importance of responsible harvesting and cultivation practices to ensure the sustainability of these resources.

4. Biotechnological Applications: The biotechnological potential of mushrooms is vast, encompassing mycoremediation, bioplastic production, and pharmaceutical development (Ghosh et al., 2023; Vaksmaa et al., 2023). The findings here, emphasize the need for further research and investment in harnessing these applications for environmental and human well-being.

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5. Conservation Challenges: Conservation assessments revealed that many mushroom species face threats, primarily due to habitat loss, climate change, and overexploitation (Mueller et al., 2022). Identifying and categorizing threatened species is a crucial step in their protection. Conservation efforts should focus on preserving both mushroom species and their habitats.

6. Ethical Considerations: Ethical concerns in mushroom research encompass respect for indigenous knowledge, fair access to genetic resources, and the ethical treatment of research subjects (Wei et al., 2021; Mueller et al., 2022). Researchers and policymakers should prioritize ethical guidelines in all aspects of mushroom-related activities.

Mushrooms, with their remarkable diversity, multifaceted utility, and ecological significance, warrant increased attention in scientific research, conservation, and sustainable utilization. This study provides a foundation for future investigations and underscores the importance of preserving these fungal treasures for future generations. Ultimately, a holistic approach to mushroom science that combines taxonomic, ecological, culinary, medicinal, and biotechnological perspectives will contribute to a more profound understanding of these fascinating organisms and their role in shaping our world.

Conclusion

This comprehensive exploration of mushroom species, encompassing their diversity, utility, and conservation status, illuminates the multifaceted significance of these enigmatic organisms. Throughout this study, several key conclusions and overarching themes have emerged.

Diversity as a Keystone: Mushrooms are emblematic of the remarkable biodiversity within the fungal kingdom. Their vast array of forms, functions, and ecological roles underscores their importance in terrestrial ecosystems. The intricate relationship between mushrooms, plants, and other organisms underscores the necessity of considering mushroom conservation within broader ecological contexts.

Ecological Significance: As decomposers, mycorrhizal partners, and symbiotic associates, mushrooms hold pivotal roles in nutrient cycling, soil health, and plant vitality. Their presence or absence can influence entire ecosystems. Conservation efforts must recognize the ecological significance of these organisms and their intricate interplay with other biota.

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Culinary and Medicinal Wonders: The culinary and medicinal uses of mushrooms have been cherished for centuries across diverse cultures. Their flavors, textures, and nutritional value make them culinary treasures, while bioactive compounds offer substantial potential for human health. However, the sustainable utilization of mushrooms, particularly in wild harvesting, demands careful consideration and management to prevent overexploitation.

Biotechnological Frontiers: The biotechnological potential of mushrooms is a burgeoning field. From mycoremediation to pharmaceuticals and bioplastics, mushrooms offer solutions to contemporary challenges. Their pivotal role in sustainable practices, such as waste recycling, has profound implications for environmental conservation and resource management.

Conservation Imperatives: Mushroom conservation is an urgent concern. Many species face threats, and their conservation hinges on preserving not only the organisms themselves but also their habitats. Stricter regulations and sustainable harvesting practices are critical steps toward safeguarding mushroom diversity.

Research Gaps and Ethical Considerations: This study underscores several research gaps, urging further exploration in taxonomy, ecology, and biotechnology. Ethical considerations, including indigenous knowledge and the responsible use of genetic resources, should be at the forefront of mushroom research.

In light of these conclusions, it is evident that mushrooms, with their intricate tapestry of diversity, utility, and ecological roles, merit continued research, conservation, and sustainable management. They stand as both biological wonders and invaluable resources for humanity. As we move forward, embracing an inclusive and interdisciplinary approach to mushroom science and conservation will be paramount. By doing so, we can ensure the preservation of these fungal treasures and harness their potential for the betterment of our environment and society.

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