Published by

British Journal of Contemporary Research

BEXFORD PUBLISHING

Current Roles of Mushroom in 21st Century Health Sustainability: A Review on Mushroom and Their Roles in Health Sustenance

Review Article | Volume 1 | Issue 3 | 2026 | Article Number: 021

Accepted: 27 July 2026 | Published: 10 August 2026 | ISSN: 2979-8582 (Online)

Crossref : **https://doi.org/10.67693/BJCR-WASS3AGP**

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Abstract

Mushrooms are known for their nutritional, medicinal, and ecological benefits, making them a valuable resource for health and sustainability research. In this review, we compiled results of around 85 peer-reviewed studies retrieved from PubMed, Scopus, ScienceDirect and Google Scholar between 2010 and 2025. From the reviewed evidence it is concluded that mushrooms contain a long list of proteins, Dietary Fiber, vitamins, minerals, and bioactive compounds such as polysaccharide, terpenoids, phenolic compounds etc. In vitro and in vivo studies have shown antioxidant, antimicrobial, anti-inflammatory, antidiabetic, immunomodulatory and anticancer activity of these constituents. Several well-studied fungi like Agaricus bisporus, Pleurotus ostreatus, Lentinula edodes, Ganoderma lucidum, Hericium erinaceus and Trametes versicolor have shown considerable therapeutic potential, including free radical scavenging, immune modulation and supportive effects on cancer treatment. In addition to their health attributes, mushrooms play a role in the quest for environmental sustainability in a number of ways such as bioremediation, biodegradation, recycling of agricultural wastes, as well as low impact cultivation. All these collectively indicate that mushrooms are multi-functional organisms that possess a great potential as functional foods, natural therapeutics and as sustainable biological resources. While there are promising results, continued clinical trials and the development of large-scale cultivation, product development, and pharmaceutical applications are required to take full advantage of their nutritional, medicinal and ecological benefits.

Keywords: Mushroom, Antidiabetic Potential, Sustainability, Cancer Therapy, Phenolic Compounds, Antioxidant Activity, Antimicrobial Activity

Introduction

Fungi are a large and important group of organisms which produce easily recognized fruiting bodies that are known as mushrooms. They are a member of Kingdom Fungi which consists of diverse groups such as yeasts and macro-fungi, often very conspicuous. Although mushrooms are well-known to people as food or medicine, they also play important roles in ecosystems as decomposers of organic materials, as they help recycle nutrients, and as formers of symbiotic relationships with plants by means of mycorrhizal associations. The mushrooms appear after the rain or when the weather is damp and humid, with different types growing in different environments such as a forest, grassland, or in urban areas. They are very varied in form and size, and edible, medicinal or poisonous. Button mushrooms (*Agaricus bisporus*) and oyster mushrooms (*Pleurotus ostreatus*) are edible mushrooms, cherished for their taste and richness in various nutrients, that are a common staple in many parts of the world. 3 Medicinal mushrooms like Ganoderma lucidum (otherwise known as reishi) have been utilized for a very long time in conventional medications, particularly different European countries, for their medical gainful properties. However, other species are very poisonous and even deadly, such as Amanita phalloides (death cap), therefore an accurate identification of edible and poisonous species is very important. 4

Mushrooms have been culturally relevant and therapeutic over the years. The Egyptians, Greeks and Chinese were aware of their double purpose as food and medicine. Ganoderma lucidum was once considered a 'medicine of immortality' in traditional Chinese medicine with the ability to prolong one's life and improve vitality. As in Asia mushrooms were also integrated into dietary practices, such as Agaricus bisporus and Boletus edulis (porcini), but their medicinal uses were not well known in Europe until the middle-ages were over and systematic scientific studies of mushroom health benefits started in modern times. The medicinal properties of species including Cordyceps sinensis, Lentinula edodes (shiitake), and Grifola frondosa (maitake) are well researched and studied, particularly for their immune-boosting, anti-inflammatory, and anti-cancer benefits. 4, 6

Mushrooms also have a high nutritional value, making them important for food.Another contributor to the global significance of mushrooms is their high nutritional value. They contain high levels of plant based protein, vitamins (especially B-complex and vitamin D) and minerals (selenium, copper and potassium) as well as dietary fibre. Some mushrooms, including Ganoderma lucidum and Lentinula edodes, have been studied for their ability to interfere with tumor growth, control cholesterol levels, and support health of the heart.6 7

In addition to being a healthy food, mushrooms are touted as being sustainable. They can be grown on organic waste materials like sawdust, coffee grounds and the by-products of agriculture, with very little land, water and energy usage in comparison to traditional livestock production which pollutes the environment too. 8, in addition, mushrooms help to reduce waste and promote bioremediation. In particular, Pleurotus ostreatus has been found to break down plastics and toxic compounds with potential innovative solutions for waste management and pollution control. Their participation in a circular economy highlights their contribution to developing environment-friendly food systems. 9

These properties make mushrooms a species of great importance for various ecological, nutritional, medicinal and environmental purposes. Across the globe, mushrooms offer special potential and promise for helping to advance human health and sustainability as we address global challenges like climate change, food insecurity, and chronic disease burdens. This review brings together existing information on their nutritional profile, bioactive compounds, therapeutic potential and environmental functions highlighting the importance of these plants in the sustainable food systems and future biotechnological applications.

Materials and Method

The method of the review was micro-managed to comprehensively assess and synthesize available data about food, medicinal and environmental functions of mushrooms. Hence, the present study offers a comprehensive and coherent analysis of their significance towards health sustenance and sustainability.

Literature Search Strategy

Research was carried out by systematically searching across major scientific databases such as PubMed, ScienceDirect, Scopus, Frontier, Springer and Google Scholar for peer-reviewed articles pertaining to mushrooms. The focused search strategy used specific keywords, including nutritional value of mushrooms, medicinal mushrooms, mushroom bioactive compounds, mushrooms and sustainability, and fungi in ecosystem services. Only articles from the last 15 years (with some selected classical articles for historical context; 2010-2025) were included to ensure the articles are relevant and timely.

Inclusion and Exclusion Criteria

The following criteria were used to select studies: (1) original research or review papers focusing on edible or medicinal mushrooms or their biological roles such as nutritional or pharmacological (2) articles in full-text in English, and (3) papers published in peer-reviewed journals or any scientific publication available in the open access system. Articles that were not mission oriented, lacked clear mushroom data, or were editorials, opinion pieces or redundance were excluded. From this, some 85 articles were chosen for review, considering the above criteria.

Data Extraction and Synthesis

Articles showing a total of 16 themes related with mushrooms were selected and their contents were obtained systematically, focusing on mushroom taxonomy, nutritional composition, bioactive compounds, medicinal potential, ecological importance and roles in sustainability. The extracted data were compiled and correlated into themes and provided a coherent story line. This provided a clear, structured and meaningful integration across a range of studies.

Quality Assessment

Included studies were evaluated on their methodological quality for transparency in reporting, rigour of experimental design and reliability of results. Special emphasis was placed on publications concerning the mushroom's bio-compounds and their pharmacological activities as well as the ecological use in bioremediation.

Identification of Research Gaps

The review also discussed the limitations of existing knowledge, including the need for more research on mushrooms, like the clinical testing of mushroom-derived treatments on a larger scale, innovative sustainable mushroom cultivation systems and more studies on the potential of mushrooms in environmental pollution reduction.

Use of this model makes the information generated more reliable, which results in a useful publication for students, researchers and people who are interested in the nutritional, medicinal and ecological values of mushrooms.

Results and Discussion

This review focuses on increasing the reader's knowledge of how many medicinal, ecological and nutritional values mushrooms different mushrooms species provide, including *Agaricus bisporus* (button mushroom), *Pleurotus astreatus* (oyster mushroom), *Lentinula edodes* (ahiitake) and Ganoderma lucidum

(reishi). [10] These species are characterized by the presence of large proportions of bioactive compounds, such as terpenoids, polysaccharides and phenolic compounds, with promising health-promoting properties. [11]The next section summarizes the results of the scientific research carried out to date, which showed the nutritional composition, medicinal properties and the importance of mushrooms in maintaining good health. [11]

Antioxidant activity

For instance, *Pleurotus ostreatus* could be considered to have stronger potential towards free radical detoxification compared to aqueous extracts with its IC50 of 21.3ug/ml in DPPH assay, [12] attributed to its rich polysaccharide, phenolic and unique antioxidant, ergothioneine content.[11] Similarly, the growth stage also affected the antioxidant activity (ABTS radical neutralisation) of the *lentinula edodes* ethanol extract, wherein more pronounced effect was detected in mature fruiting bodies. [5] Extract of *Ganoderma lucidum* have also showed strong DPPH and ABTS radical detoxifying, which `were largely linked to ganodermic acids and polysaccharides. [13] *Hericium erinaceus* [7] containing high levels of phenolic contents and flavonoids demonstrated significant Ferric reducing antioxidant power (FRAP) and oxygen radical absorbance capacity (ORAC), resulting to the contribution of several bioactive classes for the antioxidant mechanism.[7]

Table 1: Antioxidant activity of selected mushrooms

Species	Extract type	Assay method	IC_{50}Value/Activity	Reference
Pleurotus ostreatus	Methanol	DPPH	21.3 µg/mL	Jayekumer *et al.*, 2017
Lentinula edodes	Ethanol (mature)	ABTS	15.6 µg/mL	Ropus *et al.*, 2012
Ganoderma lucidum	Hot water extract	DPPH/ABTS	12.4 µg/mL (DPPH)	Zhu *et al.*, 2013
Hericium erinaceus	Ethanol	FRAP/ORAC	Higher reducing power	Li *et al.*, 2023

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Cytotoxic and Anti-Cancer Activity

Mushrooms have been long regarded for their anti- cancer properties. Extract of *Ganoderma lucidum,* containing triterpenoids such as ganodermic acids, demonstrated cytotoxic effect on liver (HepG2) and lung (A549). Using cancer cell models, with IC_{50} values between 40-70 ug/mL.[14] *Grifola frandosa* (maitake) beta glucan. Mushroom extracts have been shown to induce apoptosis and suppress angiogenesis in breast cancer models, for example *pleutotus ostreatus* derived extract loaded with chitosan nanoparticles significantly promoted apoptosis and inhibited angiogenesis in breast cancer cell. [15]

Furthermore, polysaccharides (PSP and PSK) extracted from *Tranetes versicular* (Turkey tail) have been approved as supplementary cancer therapies in Japan, showing improved survival rate in colorectal and gastric cancer patients. [16]

Recent studies on Hericium erinaceus have also displayed cytotoxic effect against gastric cancer cell attributed to erinacines and herincenous, [7]

Table 2: Cytotoxic/anti-cancer activity of mushrooms

Species	Bioactive compound(s)	Target cell line	IC_{50} Value	Reference
Ganoderma lucidum	Ganoderic acids	HepG2, A549	40–70 µg/mL	Boh *et al*., 2007
Grifola frondosa	Beta-glucans	Breast cancer	Dose-dependent	Mori *et al*., 2009
Trametes versicolor	PSP/PSK	Clinical trials	NA (adjuvant use)	Borchers *et al*., 2008
Hericium erinaceus	Erinacines, hericenones	Gastric cancer	25–60 µg/mL	Li *et al*., 2023

Antibacterial Activity

The antimicrobial potential of mushrooms has been shown against both Gram- positive and Negative bacteria. In case of Staphylococcus and Escherichia coli, *Pleurotus ostreatus* was more inhibitory showing 10-15 mm of inhibition when using the methanol extract, and the hydrous extract was less effective. The antifungal activity of [17] *Agaricus bisporus* ethanol extract to candida albicans was related to phenolic compounds and lectins. [18] In the comparative study, the inhibition zone of antibacterial activity of all the extract by organic solvents was compared with the inhibition zone of extract by water, which shows that the Extracts prepared by Organic solvents such as methanol and ethanol are more effective in inhibiting the bacterial growth even more so than water -based extract because of the high solubility of the terpenoids and phenolics in the polar organic solvents. [18]

Antidiabetic Activity

Mushrooms contain polysaccharides and phenolic compounds that have demonstrated antidiabetic properties. Alfa-glucosidase and alpha-amylase inhibitory activities of 10 Extract from *Agaricus blazei* and *Pleurotus* spp. were 50-90 µeg/mL, which is similar when compared to the activity of acarbose. [21] *Ganoderma lucidum* polysaccharide treatment improved glucose tolerance, insulin sensitivity and reduced oxidative stress in an in vivo experiment using diabetic rat model. [22]

Anti-Inflammatory and Immunomodulatory Activity

Mushrooms also show strong immunomodulatory and anti-inflammatory effects. *Ganoderma lucidum* extracts suppressed pro-inflammatory cytokines (TNF-α, IL-6) while enhancing IL-10 production in macrophage models. [14] *Pleurotus ostreatus* ethanolic extracts inhibited COX-2 expression and nitric oxide release, demonstrating activity comparable to synthetic NSAIDs. [23]

Mushroom beta-glucans have been shown to activate innate immune cells such as macrophages and NK cells, contributing to cancer immunotherapy and improved resistance to infections. [24]

Conclusion

Mushrooms are increasingly recognized as multifactorial resources, providing nutritional value, therapeutic potential, and environmental benefit. Their bioactive compounds have shown strong antioxidant, antidiabetic, antimicrobial, and anticancer properties making them promising candidates for health-promoting food and natural drug development. Also sustainable mushroom cultivation supports waste recycling and environmental conservation. While these findings are good and encouraging, more

clinical studies and standardized extraction methods are important to translate or interpret experimental findings into practical application. Harnessing mushroom more effectively could provide valuable contributions to both human health and ecosystem sustainability

Conflict of interest

The author declares no conflicts of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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