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Potential of mushroom in industrial applications

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Introduction:

Mushrooms, often celebrated for their rich flavors and textures, are emerging as versatile powerhouses in multiple domains. Nutritionally, they are a boon for vegetarian and flexitarian diets, packed with essential vitamins (A, C, D, E, and K), minerals like potassium and selenium, and antioxidants such as polyphenols and ergotheioneine. This makes them a valuable source of nutrients that are often lacking in plant-based diets. Beyond their dietary benefits, mushrooms are transforming sustainability practices through their mycelium, which is being developed into innovative, eco-friendly building materials that reduce environmental impact and promote a circular economy. Their role in mycoremediation further highlights their environmental significance, as they effectively decompose pollutants and restore contaminated soils. In medicine, mushrooms like Reishi, Shiitake, and Cordyceps are renowned for their immune-boosting, anti-inflammatory, and antioxidant properties, supporting treatments for various health conditions and enhancing overall wellness. This blend of nutritional, environmental, and medicinal benefits underscores mushrooms as a multifaceted marvel, bridging traditional uses with modern advancements.

Mushroom as food and nutrition

Mushrooms, a unique member of the fungal kingdom, stand out in the culinary world for their impressive nutritional profile and versatility. Unlike typical plant or animal-based foods, mushrooms are a remarkable option for those on vegetarian or flexitarian diets, offering a host of benefits without notable side effects (Thakur 2014). Rich in vitamins (A, C, D, E, and K), minerals (notably potassium and selenium), and antioxidants (such as polyphenols and ergotheioneine), they address common nutritional gaps, particularly for vegans who often lack calcium, selenium, and Vitamin B12. Notably, mushrooms like Cordyceps sinensis have become favorites among world-class athletes, contributing to China's long-standing dominance in Asian sports. Their role in human health is versatile: they act as a wholesome food source, a medicinal aid for illness, and a dietary supplement for various health states. Mushrooms are also used in complementary medicine to alleviate the side effects of cancer treatments and have a history of treating numerous physiological disorders. With a composition of 90% water, 2–40% protein, 40–60% carbohydrates, 3–32% crude fiber, 8–10% ash, and 2–8% fat, mushrooms are indeed a superb and often overlooked treasure of nature (Fekadu 2015).

Nutrient	Amount
Total fat	0.3 g
Cholesterol	2 mg
Sodium	5 mg
Potassium	318 mg
Total Carbohydrate	3.3 g
Dietary fiber	1 g
Sugar	2 g
Protein	3 g

Table 1: Nutritional fact of mushroom (NIN, Hyderabad) (amount per 100 g)

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Mushroom as a building material

Mushrooms are making a transformative impact in the realm of building materials, thanks to their remarkable versatility and sustainability. Mycelium, the root system of fungi, is being harnessed to create innovative and eco-friendly construction materials. This fungal network can be cultivated into lightweight, strong, and biodegradable composites, offering a green alternative to traditional materials. Not only does mycelium-based construction reduce environmental impact through low energy consumption and minimal waste, but it also contributes to a circular economy by being compostable at the end of its life cycle (Jones et al., 2022). Pioneering projects are showcasing mycelium's potential, from insulating panels to robust structural elements, demonstrating that this natural material might well become a cornerstone of future sustainable architecture (Smith & Williams, 2021). Thus, mushrooms are evolving from a culinary delight to a cornerstone of green building innovation, reflecting nature's ingenuity in solving modern challenges.

Material	Description	Applications
Mycelium Insulation	A lightweight and biodegradable insulation material made from mycelium.	Thermal and acoustic insulation in buildings.
Mycelium Bricks	Compressed mycelium-based bricks that is strong and sustainable.	Structural walls, partitions, and paving.
Mycelium Panels	Panels made from mycelium composites, offering flexibility and strength.	Wall panels, ceiling tiles, and modular construction.
Mycelium Composites	Mixtures of mycelium with agricultural by-products to form durable, eco-friendly materials.	Furniture, architectural details, and decorative elements.
Mycelium-based Foam	A foamed material with mycelium that provides excellent cushioning and insulation.	Packaging, impact-resistant surfaces, and insulation.

Table 2: Use of mushroom in different building materials.

Mushrooms: A Powerful Agent in Mycoremediation

Extensive research highlights mushrooms as a potent tool in mycoremediation, a method for soil treatment that minimizes the formation of harmful by-products. Mushrooms are adept at breaking down various pollutants through processes such as biodegradation, biosorption, and bioconversion (Abdel-Shafy & Mansour, 2016; Kulshreshtha et al., 2013). They are efficient decomposers of cellulose, hemicellulose, and lignin and can accumulate and release a range of elements, including toxic ones (Pletsch et al., 1999; Annible et al., 2006). Edible and medicinal mushrooms play a crucial role in environmental cleanup by stimulating microbial activity and aiding in the decontamination of polluted sites (Thomas et al., 2009). Their broad potential for soil remediation is exemplified by their ability to mobilize and degrade contaminants, including heavy metals and xenobiotic compounds, making them a valuable alternative to bacteria (Ali et al., 2017; Thakur et al., 2015). Fungal species such as *Agaricus*, *Amanita*, and *Boletus* are particularly effective in this regard, utilizing their hyphae to cleanse contaminated environments.

Mushroom species	Waste pollutants
Pleurotus ostreatus	Green polyethylene (GP) starch based plastic polymer degradation and oxodegradable plastic degradation; convert passion fruit waste into βglucoside

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Pleurotus platypus	Copper, zinc, iron, cadmium, nickel, lead
Pleurotus sajor	Heavy metals
Agaricus macrosporus, Beauveria bassiana	Cd, Hg, Cu, Zn, Pb, Cr, Cd
Auricularia sp. Schizophyllum, Polyporus sp.	Green dye, namely, malachite was degraded

Table 3: Mushroom and its role in waste pollutants management

Mushroom as medicine

Mushrooms have long been celebrated for their medicinal properties, offering a wealth of health benefits backed by both traditional practices and modern research. Various mushroom species, such as *Reishi*, *Shiitake*, and *Cordyceps*, are known for their potential to enhance immune function, reduce inflammation, and combat oxidative stress (Beyer et al., 2019). Their bioactive compounds, including polysaccharides and triterpenoids, contribute to these therapeutic effects, supporting their use in managing chronic diseases and boosting overall wellness (Hobbs, 2003). Notably, mushrooms are increasingly recognized for their role in complementary medicine, aiding in the treatment of conditions ranging from cancer to cardiovascular diseases (Barrett, 2010). As research continues to uncover their diverse benefits, mushrooms stand out as a potent natural remedy with a promising future in healthcare.

Mushroom Species	Medicinal Uses
Reishi (*Ganoderma lucidum*)	Enhances immune function, reduces stress, improves sleep quality, and has anti-cancer properties.
Shiitake (*Lentinula edodes*)	Boosts immune system, supports cardiovascular health, has anti-cancer and anti-inflammatory effects.
Cordyceps (*Cordyceps sinensis*)	Improves energy levels, enhances athletic performance, supports respiratory health, and has anti-aging effects.
Chaga (*Inonotus obliquus*)	Rich in antioxidants, supports immune function, and may have anti-cancer and anti-inflammatory properties.
Maitake (*Grifola frondosa*)	Supports immune system, regulates blood sugar levels, and has anti-cancer and anti-inflammatory benefits.
Turkey Tail (*Trametes versicolor*)	Boosts immune response, supports gut health, and has potential anti-cancer properties.
Lion's Mane (*Hericium erinaceus*)	Enhances cognitive function, supports nerve health, and has neuroprotective and anti-inflammatory effects.
Poria (*Poria cocos*)	Supports digestion, promotes diuresis, and has calming effects.
Enoki (*Flammulina velutipes*)	Supports immune function, has antioxidant properties, and may help regulate cholesterol levels.
Auricularia (*Auricularia auricula-judae*)	Supports immune health, has anti-inflammatory properties, and may aid in blood circulation.

Table 4: Different mushroom species and their medicinal uses

Challenges and future directions

Despite their impressive potential, scaling up mushroom-based technologies presents several challenges. Key limitations include the need for standardized production processes and overcoming scalability issues associated with mycelium cultivation (Jones et al., 2022). Additionally, there is a pressing need for more research into optimizing growth conditions and improving the cost-effectiveness of mushroom-derived materials (Smith &

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Williams, 2021). Innovations in biotechnology and materials science could facilitate broader adoption by enhancing the efficiency and economic viability of these technologies (Abdel-Shafy & Mansour, 2016). Looking ahead, the field holds promise for transformative developments, including more sustainable building materials and advanced environmental cleanup solutions. As research progresses, mushrooms could play a pivotal role in addressing global challenges, bridging gaps between ecological sustainability and technological advancement.

Conclusion

The potential of mushrooms in various industrial applications represents a groundbreaking shift towards sustainable and innovative practices across various sectors. Their versatility extends from creating eco-friendly building materials and advancing waste management through mycoremediation to offering novel solutions in biotechnology. As research and development continue to address current challenges, such as scalability and cost-effectiveness, mushrooms are poised to make significant contributions to sustainable development and environmental stewardship. By harnessing their unique properties and expanding their applications, we can unlock new opportunities for reducing ecological footprints and fostering a greener future. The ongoing exploration of mushrooms' industrial potential promises to revolutionize traditional practices and pave the way for a more sustainable and resilient economy.

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