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REVIEW

Mushroom Farming: A Potential Tool for Nutritional Security and Income Generation in Bangladesh

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ABSTRACT

Purpose: *The main goal of this review is to examine the medicinal benefits, profitable cultivation, environmental factors, pest management, mushroom growth, quality, and industry development of mushrooms in Bangladesh. The study also focuses on the health-promoting effects of mushrooms and their role as a valuable food source.*

Research Method: *This review is prepared using available scientific literature obtained from Science, Scopus, PubMed, Science Direct, Journals, Books, and Google Scholar. The selected studies covered topics concerning mushroom cultivation, environmental impacts, pest challenges, medicinal properties, and health benefits of mushrooms.*

Findings and Values: *Mushrooms offer numerous health benefits, including anti-diabetic, anti-bacterial, anti-inflammatory, anti-cancer, antioxidant, and anti-helminthic properties. They are also rich in essential nutrients like carbohydrates, dietary fiber, proteins, vitamins, and minerals like potassium, calcium, iron, manganese, and magnesium. The mushroom industry in Bangladesh is characterized by its efficient use of resources, low investment costs, and innovation potential, making it a profitable and sustainable enterprise. Environmental factors greatly influence mushroom yield and quality, while pest infestations by flies, mites, ants, and cockroaches pose major challenges. Farmers often rely on costly control measures, which incur high expenses and low profits. The review literature highlights mushrooms as both a nutrient-rich functional food with diverse medicinal benefits and a profitable, resource-efficient industry in Bangladesh, while also identifying environmental and pest challenges that affect sustainability.*

Keywords: *Edible mushroom, Health benefits, Medicinal importance, Minerals, Nutrients, Plant-based food.*

INTRODUCTION

The mushroom *Pleurotus florida* is a robust

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organism that forms the fruiting body of a decomposed organic matter, humus, or its nutrient source. Currently, around fourteen thousand species of mushrooms have been identified globally, with the most commonly cultivated varieties in Bangladesh being *Ganoderma lucidum*, *Volvariella volvacea*, *Pleurotus ostreatus*, and *Agaricus bisporus* (Mohiuddin *et al.* 2015). *Pleurotus florida* belongs to the genus *Pleurotus* and the family Pleurotaceae (Alexopoulos 1996). Among the known species, approximately 7,000 (50%) are considered to have varying degrees of edibility, with over 3,000 recognized as the primary edible mushrooms (Raphael & Nwatu 2015). In recent times, edible fungi, known for their prolific reproductive structures, have become a valuable source of nutrition in Bangladesh (Alam *et al.* 2008). These fungi possess gills that house microscopic reproductive units, aiding in their spread across substrates or external environments (Lakhanpal 2014). Species of the *Pleurotus* genus, commonly referred to as mushrooms, are among the most widely recognized and nutritionally valuable edible fungi globally (Khan *et al.* 2008). They grow in humid and subhumid areas, and are simply cultured on a large scale (Akindahunsi & Oyetayo 2006, Chirinang & Intarapichet 2009). Due to their attractive flavor, rich nutritional content, texture, and higher productivity, mushrooms have been branded as a brilliant food item for combating malnourishment in emerging nations (Ma *et al.* 2014, Sufer *et al.* 2016).

Macronutrients and micronutrients are essential components for maintaining good health. Edible mushrooms are highly nourishing and can be associated with meat, milk, and eggs in their nutritional values (Khatun *et al.* 2015). Mushroom species such as *Calocybe indica*, *P. ostreatus*, *P. sajor-caju*, and *P. florida* are rich in carbohydrates (37–48%), proteins (20–25%), ash content (8–13%), lipids (4–5%), and fibers (13–24%). The moisture content in these mushrooms ranges from 86 to 87.5%. As stated by Malaysiana *et al.* (2016), mushrooms are excellent sources of both macro and micronutrients. They provide non-starchy carbohydrates, high dietary fiber, proteins with essential amino acids, minerals, B complex, and vitamin C (Randive 2012, Croan 2004), and are recognized as one of the few vegetarian sources of vitamin D and conjugated linoleic acid ($C_{18}H_{32}O_2$). Mushrooms also possess antioxidant properties due to mixtures like ergothioneine ($C_9H_{15}N_3O_2S$) (Weigand-Heller *et al.* 2012). Additionally, the niacin content in mushrooms is about ten times higher than in most other plant-based foods.

Washing the mushrooms resulted in the highest production of sporophores, with a maximum fruit body weight of 197.82 g, organic yield of 278 g, efficiency of 55%, and biotic efficiency of 96%. The nutrient and mineral content of the washed sporophores included protein (31.80%) and lipids (3.6%), along with potassium, phosphorus, calcium, iron, magnesium, copper, zinc, and manganese (1.3, 0.8, 32, 43, 12 mg, and 3.5, 12.5, 2.3 mcg, respectively, per 100 g of mushroom) (Malaysiana *et al.* 2016). The maximum biotic efficacy (212.8%) was achieved using a sawdust substrate (Rashid *et al.* 2016). *Pleurotus* species are particularly beneficial for individuals with hypertension (Ebigwai *et al.* 2012), diabetes, and obesity problems (Agrawal *et al.* 2010). Washing is notably effective and yields multiple fruiting bodies when using sawdust, a low-cost and broadly used substrate for mushroom cultivation in Bangladesh (Malaysiana *et al.* 2016).

Mushrooms are extremely multipurpose and can thrive under a broader range of conditions than many other plants (Rosado *et al.* 2002). They require high moisture (80–90%) and warm temperatures (25–30°C) for nonsexual growth, known as spawn successively, and cooler temperatures (18–25°C) for pod body development (Viziteu 2000). Various agricultural byproducts and waste materials serve as suitable substrates for mushroom cultivation. Mushroom farming is increasingly recognized as a profitable and rapidly growing business among entrepreneurs (Naraian *et al.* 2011) as it has low production costs and can easily adapt to local agroecological conditions (Pant *et al.* 2006). Tariqul *et al.* (2012) emphasized the importance of understanding the nutritional composition of food to ensure a balanced diet for the population. Given these considerations, their study was conducted to gather information on the medicinal value, profitable cultivation, environmental factors, and industry development of mushrooms in Bangladesh. Specifically, the research aimed to assess the effects of using growing media made from spent mushroom droppings on the growth, quality, and nutrient content of mushrooms.

METHODOLOGY WITH LIMITATIONS OF THE STUDY

The study conducted a scoping review to map and summarize current knowledge on the significance of mushrooms in health and the plant-based food industry. The researcher searched Web of Science, Scopus, PubMed, Science Direct, Journals, Books, and Google Scholar. This study also reviewed abstracts where available. Additionally, information was gathered from government organizations and NGOs through personal communication. Literature reviews were scrutinized to identify additional relevant studies, while the results of review analyses were excluded from the previous studies. Blogs and newspapers were used only for context. This study searched the database from its inception until 2025, with no language limits at the search stage. The researcher combined keywords and controlled vocabulary. “Edible Mushroom”, “Health Benefits”, “Medicinal Importance”, “Minerals”, “Nutrients”, and “Plant-based Food Industry”. This study adapted this string to each database.

Primary reviews are reporting data on mushrooms related to medicinal properties, health benefits, nutritional value, industrial uses, cultivation, and value addition. Editorials, opinion pieces, news items, patents without data, duplicate reports, and conference abstracts lacking methods or results. The study used a standardized form to capture bibliographic details, study aim, design, setting, organism confirmation method, substrate and cultivation conditions, interventions or processing steps, outcomes, effect measures and key conclusions. This review used published data, with no involvement of human participants nor any requirement for ethics endorsement. Research review methods and outcomes across studies may limit direct comparison.

IMPORTANCE OF MUSHROOM

Mushrooms as plant-based food

Mushrooms are an adaptable and nutritious food that has been consumed universally for centuries (Tariqul *et al.* 2012). They are treasured for both their unique savors and touches and their rich, nourishing shape. Mushrooms are low in calories and fat while being a moral basis of important nutrients such as protein, dietary fiber, vitamins, and minerals (Fanzo *et al.* 2012). Mushrooms also comprise bioactive compounds that offer countless health benefits. In addition to their cookery uses, mushrooms are also used in functional foods and dietary supplements, owing to their probable health benefits such as backup immune function, reducing inflammation, and promoting overall wellness (Michalska *et al.* 2025). With their grouping of taste, nutrition, and health benefits, mushrooms remain a treasured and excellent food choice worldwide (Fig. 1).

Medicinal importance

Edible mushrooms are highly nutritious and particularly rich in protein and carbohydrates. They are also recognized as excellent sources of minerals and vitamins (Han *et al.* 2016). Nutritional standards for these mushrooms, as outlined by the USDA (2020), are shown in detail in Table 1. Han *et al.* (2016) investigated the beneficial goods of the precipitate derived from oyster mushrooms, specifically *Pleurotus sajor-caju*. The results revealed that *Pleurotus sajor-caju* powder possesses a high carbohydrate content of 60.47 g per 100 g, equating to 451.60 calories per gram. According to Samsudin & Abdullah (2021), mushrooms contain both edible and non-digestible carbohydrates, with both types contributing significantly to the total carbohydrate content. Aremu *et al.* (2009) stated that the metabolizable vigor morals for *Ganoderma* spp. (1476.7 kJ/100 g) and *Hebeloma mesophaeum* (1513.5 kJ/100 g) specify that these mushrooms are substantial foundations of dynamism, analogous to mueslis

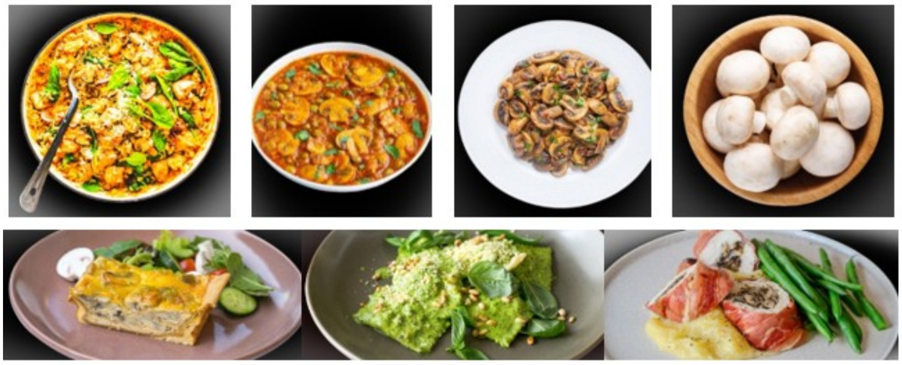

Figure 1. Mushrooms as Plant-based Food.
Source: Compiled and designed by the author based on published literature

in their energy satisfied.

Lung health: Mushrooms may support lung health and offer protection against situations like chronic obstructive pulmonary disease and asthma due to their anti-inflammatory and antioxidant effects (Sing *et al.* 2021).

Gastric cancer: Ba *et al.* (2023) noted that some mushrooms contain compounds that could hinder the growth of gastric cancer cells and promote better stomach health.

Anti-Cancer: Various compounds in mushrooms may have general anti-cancer effects, potentially help prevent or treat different cancer types (Hasan *et al.* 2025).

Immune system: Rich in polysaccharides and beta-glucans, mushrooms can increase the immune system, refining the body's skills to battle infections and diseases (Edo *et al.* 2025).

Breast cancer: Certain mushrooms have compounds that may lower the risk of breast cancer or slow tumor growth through their anti-cancer properties (Gariboldi *et al.* 2023).

Colorectal cancer: Compounds found in mushrooms may help prevent or treat colorectal cancer by inhibiting cancer cell growth and supporting digestive health (Bentharavithana *et al.* 2025).

Anti-Tumor: Many mushrooms contain substances that may prevent or slow the formation of tumors, aiding in cancer prevention and treatment (Park 2022).

Antibiotics: Some mushrooms produce natural antibiotics that can help fight bacterial infections.

Anti-HIV: Choengpanya *et al.* (2021) noted that the extracts from certain mushrooms have shown potential in inhibiting HIV replication, providing a complementary approach to traditional treatments.

Anti-Cholesterol: Mushrooms might assist in lowering blood cholesterol levels, which can reduce the risk of cardiovascular diseases (Goyal & Grewal 2024).

Anti-Helminthic: Certain mushrooms possess properties that can help eliminate parasitic worms, offering a natural solution for helminthic infections (Nath *et al.* 2022).

Anti-Inflammatory: The anti-inflammatory compounds in mushrooms can reduce inflammation throughout the body, which is beneficial for managing chronic inflammatory conditions (Michalska *et al.* 2025).

Anti-Oxidant: Mushrooms are rich in antioxidants, which assist in counterbalancing injurious free radicals and lessen oxidative stress, hypothetically reducing the risk of lingering sicknesses (Alam *et al.* 2008).

Anti-Bacterial: Their normal sterile belongings can help battle bacterial contaminations and sustain general health (Samad *et al.* 2023).

Anti-Diabetic: Mushrooms may aid in managing blood sugar levels and restoring insulin sensitivity, which is useful for folks with diabetes (Shamim *et al.* 2023).

Heavy metal content in mushrooms: Mushrooms are known bioaccumulators of both essential and toxic metals, raising food safety concerns worldwide. Several studies have reported the presence of heavy metals such as lead (Pb), cadmium (Cd), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), chromium (Cr), nickel (Ni), aluminum (Al), and mercury (Hg) in edible species (Kalac & Svoboda 2001, Dursun *et al.* 2006, Cocchia *et al.* 2006, Chen *et al.* 2009).Globally, research emphasizes the essential elements like Fe, Cu, Mn, Zn, and Cr present in mushrooms that contribute to biological functions; toxic elements such as Cd and Pb have no physiological benefits and pose serious health risks (Radulescu *et al.* 2010, Cayır *et al.* 2010).

In Bangladesh, Mohiuddin *et al.* (2015) investigated four edible mushroom species for their protein content and metal accumulation, noting variations in the levels of Na, Pb, Cu, Zn, Mn, K, Cd, and Fe. The protein content ranged from 13.8 to 34.3%, while metal concentrations varied from 0.54 to 2.25 μg/g for K, Na, 12.6 to 81.6 μg/g for Fe, 69.5 to 626.2 μg/g for Cu, 39.2 to 163.4 μg/g for Zn, 30.1 to 75.5 μg/g for Mn, 0.20 to 0.30 μg/g for Cd, and 0.13 to 0.59 μg/g for Pb. Arsenic and cadmium levels under the uncovering limits of the approaches were used. Notably, arsenic and cadmium concentrations remained below detectable thresholds in most samples.

Heavy metals pose significant food safety and health risks, with Cd, Pb, Hg, and Cu being particularly concerning for human health. While metals like Fe, Cu, Co, Mg, Cr, and Zn are essential for biological processes, Cd and Pb offer no beneficial effects, and they can be even harmful (Ouzouni *et al.* 2009, Falusi & Olanipekun 2007, Tuzen *et al.* 2007). To better visualize these findings, a forest plot could be developed, showing the range of metal concentrations across mushroom species, with separate grouping for essential trace elements (Fe, Cu, Zn, Mn, Cr) and toxic heavy metals (Pb, Cd, Hg, As). Such a plot would clearly highlight the comparative risks and nutritional contributions of different elements.

ENVIRONMENTAL FACTORS FOR THE CULTIVATION OF MUSHROOMS

Most mushrooms are often found on wooden surface because they favor dappled or dark environments. However, certain mushrooms can also be cultivated in sunny areas, such as fields with increasing compost. Mushrooms are also capable of adapting to less-than-ideal conditions if they have a rich substrate for growth. The main environmental factors that affect the stem height, stalk length, and cap size of mushrooms include temperature, humidity, fresh air, and the composition of the substrate (AMGA 2004).

Temperature and Relative Humidity

The optimal conditions for mushroom cultivation are around 21°C with relative humidity exceeding 90% (Khan *et al.* 2024). For button mushrooms, maintaining a temperature of 16–18°C is ideal for maturation, while 23–24°C is recommended for mycelial growth. Relative humidity in the growing environment should be kept between 80–85%. For button mushrooms, the mycelium thrives at temperatures between 23–25°C. Once the mycelium is fully developed, the temperature should be reduced to 53–60°C, with humidity levels around 90% (Houette *et al.* 2022).

Mycelial growth: The fungus *Phellinus* is widely utilized for its medicinal properties. Gonkhom *et al.* (2022) noted that the research has examined the optimal conditions for mycelial growth across 13 strains of this mushroom. Mycelial growth was most effective at 25°C, while it was significantly lower at 15°C and 35°C. The ideal pH range for plant growth is between 6 and 7. Typically, the best temperature range for mycelium development is between 24–27°C, with high humidity levels being crucial for

Table 1. Mean nutrient content of raw mushrooms per 100 g edible portion.

Nutrient	Common mushroom	Shiitake mushroom	Oyster mushroom	Enoki mushroom
Protein (g/100 g)	3.09	2.24	3.31	2.66
Moisture (g/100 g)	92.45	89.74	89.18	88.34
Ash (g/100 g)	0.85	0.73	1.01	0.91
Energy (kcal/100 g)	22.00	34.00	33.00	37.00
Dietary fiber (g/100 g)	1.00	2.50	2.30	2.70
Fat (g/100 g)	0.34	0.49	0.41	0.29
Calcium (mg/100 g)	3.00	2.00	3.00	0.00
Carbohydrate (g/100 g)	3.26	6.79	6.09	7.81
Iron (mg/100 g)	0.50	0.41	1.33	1.15
Ergosterol (mg/100 g)	56.00	85.00	64.00	36.00
Manganese (mg/100 g)	0.05	0.23	0.11	0.08
Copper (mg/100 g)	0.32	0.14	0.24	0.11
Potassium (mg/100 g)	318.00	304.00	420.00	359.00
Magnesium (mg/100 g)	9.00	20.00	18.00	16.00
Sodium (mg/100 g)	5.00	9.00	18.00	3.00
Phosphorus (mg/100 g)	86.00	112.00	120.00	105.00
Thiamin (mg/100 g)	0.08	0.02	0.13	0.23
Selenium (μg/100 g)	9.30	5.70	2.60	2.20
Niacin (mg/100 g)	3.61	3.88	4.96	7.03
Zinc (mg/100 g)	0.52	1.03	0.77	0.65
Pyridoxine (mg/100 g)	0.10	0.29	0.11	0.10
Pantothenic acid (mg/100 g)	1.50	1.50	1.29	1.35
Riboflavin (mg/100 g)	0.40	0.22	0.35	0.20

Source: USDA (2020); Ho *et al.* (2020).

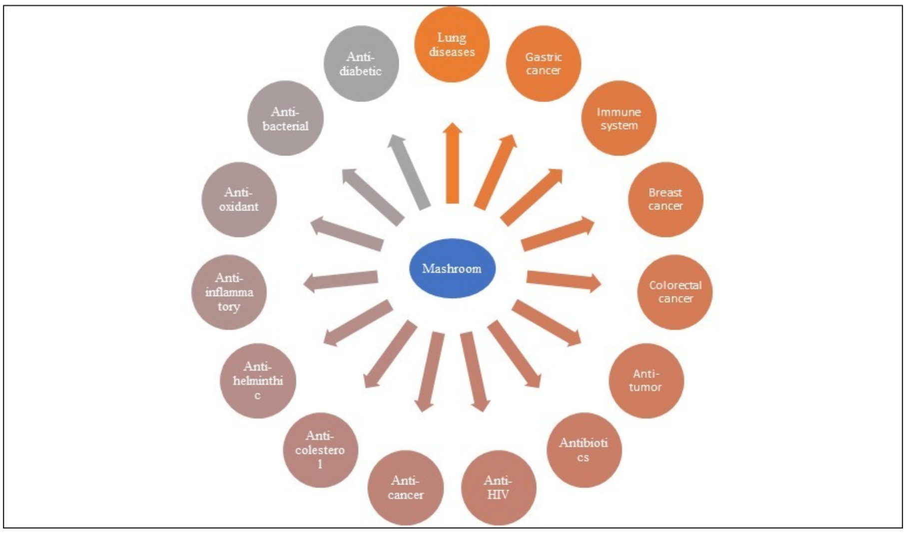

Figure 2. Health benefits of mushrooms.
Source: Compiled and designed by the author based on published literature

optimal growth. For *M. perniciosa*, mycelium developed best at a neutral pH, whereas *V. fungicola* showed poor growth under the same pH conditions (Gea *et al.* 2021). The resulting structures are shaped into desired forms and continue to develop, enhancing their utility.

Sunlight: Fungi lack chlorophyll and thus do not rely on sunlight for energy as plants do. Consequently, fungi can grow under variable intensities of light, including complete darkness (Sufer *et al.* 2016). Blue light can play a significant role in mushroom cultivation, enhancing the development and quality of various types, including oysters, shiitake, lion's mane, and psilocybin mushrooms.

Oxygen (O_2): Fungal growth is constrained by the availability of oxygen; in the absence of oxygen, the center of the cultivation may either fail to thrive or become susceptible to contamination (Camilleri *et al.* 2025). However, not all mycelia types can thrive without oxygen, and most fungi need at least some oxygen to grow. Oxygen (O_2) and carbon dioxide (CO_2) are crucial for mushroom cultivation.

Carbon dioxide (CO_2): Unlike plants, mushrooms do not need CO_2 for photosynthesis. However, CO_2 is essential for the development of the mushroom fruiting body and the growth of the mycelium (Lee *et al.* 2012). Without adequate CO_2 levels, mushrooms will not grow properly at their vegetative stage.

Nitrogen (N_2): The development of heat-loving (thermophilic) fungi relies on the accessibility of serviceable nitrogen and carbohydrates, including ammonia as a nitrogen source (Maheshwari *et al.* 2000). These nutrients, essential for supporting mushroom mycelium, are not utilized by other plants.

Fresh air: Proper ventilation is a crucial aspect of mushroom cultivation. It involves replacing stale, CO_2-rich air with fresh, O_2-rich air within the growing environment (Lee *et al.* 2012). This ventilation is vital for the optimal growth and development of fungi. Since mushrooms consume oxygen and release CO_2, they require a steady flow of fresh air to thrive (Camilleri *et al.* 2025). Most fungi are aerobic, meaning they need oxygen to survive, although yeast can grow in both the presence and absence of oxygen as a facultative anaerobe (Ivarsson *et al.* 2016).

Water: Mushrooms require a high moisture level throughout their life cycle, with their composition being over 90% water (Castellanos-Reyes *et al.* 2021). Fungi decay organic matter using enzymes that need water to break down the substrate. A mushroom sprayer efficiently provides even and consistent misting across all rows or sections of a mushroom bed, addressing the issues of over-spraying and under-spraying (Oei 2003). Reliable and accurate irrigation is crucial for maximizing mushroom yields. Maintaining a moisture level of 98–100% using a humidifier in the growing area is advised to provide sufficient humidity for the substrate (Islam *et al.* 2017). Regularly spraying the area around the mushrooms 2–3 times a day helps ensure optimal moisture levels.

MANAGING INSECT PESTS IN MUSHROOM CULTIVATION

Mushroom farms face various insect pests that can negatively affect yield and quality if not properly managed. Common pests of mushrooms include flies, mites, ants, and cockroaches, each presenting unique challenges for mushroom growers (Sattar *et al.* 2021).

Flies

Sciarid flies (Fungus Gnats): These small, dark flies are highly critical in mushroom cultivation (Navarro *et al.* 2021). Their larvae feed on mushroom mycelium and muck, leading to diminished growth and lower yields. Additionally, adult flies can spread fungal diseases.

Phorid flies: Also, they are branded as humpbacked flies. These pests lay eggs in the mushroom substrate, and the larvae that hatch feed on the mycelium, causing noteworthy harm (Mazin *et al.* 2021).

Management strategies: Maintain a clean growing environment to prevent fly breeding. Utilize sticky traps or light traps to capture adult flies (Bell *et al.* 2019); apply biological control agents, such as nematodes, or use insecticides specifically formulated for mushroom cultivation; ensure cleanliness, utilize fly traps, and uphold rigorous sanitation practices (Rinker 2017).

Mites

Mycophagous mites: These mites feed on mushroom mycelium and fruiting bodies, instigating physical harm that can lead to corruption and decomposition (Bosch *et al.* 2024).

Predatory mites: While some mites are injurious, greedy mites can be useful as they feed on extra pests and mites that harm mushrooms' fruiting bodies and mycelium (Rinker 2017).

Management strategies: Regularly inspect the growing environment for mite infestations. Maintain appropriate humidity levels to discourage mite population development. Introduce predatory mites as a natural form of pest control (Bell *et al.* 2019). Regulate humidity and temperature, and apply appropriate miticides if needed (Rinker 2017).

Ants

Ants (Formicidae) can be upsetting in mushroom farming as they may familiarize other pests with the mounting area (Bosch *et al.* 2024). It may also consume mushroom spores and small fruiting bodies (Dejean *et al.* 2023). Ants are another difficult pest in mushroom agriculture. They feed on the mushroom bodies, which can lead to noteworthy harm (Rinker 2017).

Management strategies: Keep the gardening area free from food scraps and biological material that might attract ants (Dejean *et al.* 2023). Use barricades or insecticidal baits everywhere the increasing area's boundary to avert ants from entering. Block access facts, organize ant baits, and retain mounting extents clean.

Cockroaches

Cockroaches (*Periplaneta americana*) are scavengers that can pollute mushroom produce by suckling on the mycelium, fruiting bodies, and substrates (Rinker 2017). It can also spread diseases by touching between dirty and clean areas. Cockroaches are damaging to mushroom gardening as they devour the mushrooms.

Management strategies: Seal cracks and entry openings to avert cockroach access. Maintain firm hygiene in and around the farming area. Use traps or embattled insecticides to control cockroach inhabitants (Bell *et al.* 2019). Eliminate food bases, use baits or traps, and uphold exceptional hygiene.

Integrated Pest Management (IPM): An integrated approach is endorsed for effectively dealing with insect pests in mushroom cultivation (Khan *et al.* 2020). This includes steady monitoring of the upward environment, maintaining cleanliness, utilizing biological controls, and applying chemical treatments only when essential. The goal of IPM is to diminish pest populations while minimizing environmental impacts and guaranteeing the fitness of the mushroom crop (Zhou *et al.* 2024).

PRODUCT DIVERSIFICATION

Fresh mushrooms: The international shop for renewed mushroom remnants is strong, with several species accessible for cooking use in bistros and households.

Processed products: Mushrooms are also processed into foodstuffs such as desiccated mushrooms, mushroom precipitates, extracts, and extras. These goods are supplied to health-conscious patrons and are used in practical foods, dietetic complements, and outdated medicine.

Mushroom-based innovations: Some corporate companies are determining mushroom-based substitutions to conformist harvests, such as mushroom leather, packaging materials, and meat substitutes, causative to sustainability efforts.

GROWTH AND YIELD OF MUSHROOM

Mushroom substrates are essentially cellulosic materials that support the growth, development, and fruiting of mushrooms. There is a rising interest in the cultivation of edible mushrooms, particularly *Pleurotus* spp., which has been rapidly increasing. This trend has the potential to create employment opportunities and contribute to economic growth in urban, semi-urban, and rural areas (Godfrey *et al.* 2010). Additionally, it offers a cost-effective solution for recycling agricultural waste (Akinmusire 2011, Jonathan 2012). As our understanding of the edible and toxic mushrooms expands, and as advancements in cultivation techniques are made, the use of various fungi as food continues to grow. To enhance mushroom growth and yield, various additives can be incorporated into substrates. It is widely recognized that both mycelium development and mushroom production benefit significantly from the inclusion of hemicelluloses, cellulose, lignin, and nitrogen content in the substrate (Mata & Savoie 2005).

Sawdust, a byproduct of sawmill operations, is widely available and serves as an effective substrate for mushroom cultivation. In addition, wheat bran is highly nutritious, offering proteins, carbohydrates, minerals, fats, and B vitamins, making it both cost-effective and readily accessible. The literature also discusses the use of other dense substrates like sawdust and various farming residues, such as sugarcane bagasse, coconut fiber, rice bran, rice husks, banana leaves, and peanut hulls, in mushroom farming (Beetz 2004, Baysal 2003).

Limited research has been conducted on the recital of various oyster mushroom varieties on farming derivatives, waste materials, and other substrates in Bangladesh. The farming of *Pleurotus* spp. has been increasingly adopted in response to environmental concerns in the country (Khan *et al.* 2008, Moonmoon 2010). Oyster mushrooms require high humidity levels (80–90%) and temperatures ranging from 25–30°C for the nonsexual growth phase, known as spawn development. For fruiting body formation, they need cooler temperatures, typically between 18–25°C (Viziteu 2000).

Khan *et al.* (1991) investigated the use of sawdust mixed with various organic materials, such as wheat bran, wheat chaff, cotton waste, and paddy straw, to create optimal conditions for spawn development. According to Kalita *et al.* (2001), the duration for spawn development can vary between 17 and 22 days liable on the type of substrate used. Sarker *et al.* (2007) stated that the proportion of mycelium colonization in oyster mushrooms was significantly partial by the inclusion of different levels of wheat bran. Mushroom farming is recognized as a highly profitable agricultural activity and can be a large foundation of income generation (Vinceti *et al.* 2013). It is a viable and attractive option for both the rural and peri-urban communities because it requires minimal space and does not demand a large initial investment (ATPSN 2013). Additionally, mushroom cultivation offers a sustainable solution for managing agricultural waste and by-products, turning them into valuable resources (Mala 2018). Mushrooms are incredibly diverse and widely distributed around the globe.

Historically, edible mushrooms were predominantly foraged from the wild and were challenging to cultivate or domesticate. Despite advances in cultivation techniques, wild harvesting remains a significant practice, especially in southern Asia and other developing regions of the world (Fanzo *et al.* 2012). Wild mushroom resources continue to be affected by both the contaminated environments and natural conditions. Consequently, there is an urgent need to adopt sustainable and safe food security solutions. Mushroom farming presents a promising option for addressing these concerns.

The seedling stage in vegetable production is a crucial period that influences growth, development, early yield, total yield, and fruit production per plant, making the use of quality seedlings essential. Recently, there has been an increase in the use of high-quality seedlings grown in controlled environments where climatic conditions are carefully managed (Demir *et al.* 2010). Seedling cultivation has recently experienced significant growth in Turkey. Growing vegetables from seedlings offers numerous advantages, including earlier harvests, time efficiency, and the conservation of land, energy, and seeds. Additionally, it ensures consistent and healthy crop production while minimizing dangers associated with early development stages. To take advantage of these benefits, farmers have increasingly shifted from using spores to utilizing seedlings, thereby expanding the cultivation of a variety of vegetable plantlets (Kasim *et al.* 2006). In the past, seedling cultivation was primarily focused on vegetables like tomatoes, peppers, cucumbers, and eggplants. However, in recent years, this practice has also extended to vegetables such as cabbage and lettuce. The growth of seedlings ready for planting is significantly influenced not only by climatic conditions but also by the quality of the seed propagation process (Ünlü *et al.* 2004). Promoting healthy seedlings requires not only favorable biological conditions but also the use of high-quality growing media. Therefore, it is crucial to seek out and utilize superior substrates to ensure optimal plant development (Sterrett 2001). Various types of vegetable-growing mediums and their effects were highlighted in the conducted tests (Moldes *et al.* 2007, Rippy *et al.* 2004, Ostos *et al.* 2008). A wide variety of materials are utilized for seed-sowing media.

The key requirements for these growing media are that they must be easy to initiate, cost-effective, and readily available in abundance (Demir *et al.* 2010). Peat is a primary medium for seedling production, though it is expensive. It has long been broadly cast as the key substrate module for growing sprouts in vessels (Ribeiro *et al.* 2008). Peat is a non-renewable supply, and its declining accessibility is driving up costs. The widespread habit of compost as an alternative substrate has prompted vegetable farmers to consider it as a replacement in the medium to long term (Sterrett 2001, Granberry *et al.* 2001). Recent investigators have focused on finding substitutes for traditional peat, aiming to use renewable, biodegradable materials rather than non-renewable sources like peat bogs (Verdock 1988). Several lessons have demonstrated that various biological materials, such as municipal solid waste, soil sludge, yard clippings, spent mushroom substrate, and even green waste, can be effectively used as growing media after proper composting, offering a viable alternative to peat (Benito *et al.* 2005). Nevertheless, using manure as a substrate can present challenges, including high salt content (Castillo *et al.* 2004), unfitting corporeal goods (Ribeiro *et al.* 1999), and inconsistent superiority and configuration (Hicklenton *et al.* 2001). Spent mushroom substrate, which contains composted supplies like straw, calcium sulfate, soil, manure, and residual nutrients and insecticides (Medina *et al.* 2009), plays a crucial role in growing vegetables.

A significant environmental issue in mushroom cultivation is the disposal of spent mushroom substrate. In Korkuteli, Turkey, a major mushroom-producing region, the amount of spent substrate produced annually ranges from 125,000 to 150,000 tons (Sönmez & Kaplan 2011). Research indicates that varying proportions (25%, 50%, 75%, and 100%) of spent mushroom substrate mixed with compost can be used for growing different types of seedlings. For less salt-sensitive plants like tomatoes, any substrate blend can be effective, while courgettes and black pepper seedlings can thrive with up to 75% spent mushroom substrate (Khan *et al.* 2021a, Mustakim *et al.* 2022). Peksen and Uzun (2008) found that a blend of aged spent mushroom substrate and profitable peat or solely consumed mushroom substrate could be used for growing kale and broccoli. Additionally, Islam *et al.* (2014) reported improved growth metrics such as leaf number, leaf size, plant height, and yield in vegetable seedlings grown with spent mushroom substrate. Lopes *et al.* (2015) noted that varying amounts of spent *Agaricus subrufescens* substrate led to reduced root and plant growth metrics compared to commercial alternatives. Marques *et al.* (2014) showed that incorporating spent mushroom substrate improved the quality and yield of lettuce seedlings. Sönmez (2017) highlighted that spent mushroom substrate could also be used as an effective medium for cultivating eggplant seedlings, offering a sustainable alternative to peat.

MARKET EXPANSION

The mushroom industry has seen significant growth, driven by increasing demand for both edible and medicinal mushrooms (Viziteu 2000). Advances in cultivation techniques, such as controlled environment farming and the use of organic substrates, have boosted production efficiency (Ünlü *et al.* 2004). This industry is also expanding due to the rising popularity of mushrooms as a nutritious food source and their use in health supplements. The development of the mushroom industry has led to innovations in packaging, distribution, and marketing, making mushrooms more accessible to global markets (Sterrett 2001). Additionally, research into the medicinal properties of certain mushroom species continues to open new opportunities in the pharmaceutical and wellness sectors. These diverse approaches illustrate the dynamic and evolving nature of the mushroom industry worldwide, highlighting the potential for innovation, profitability, sustainability, and growth of this sector (Ferdousi *et al.* 2020).

VARIOUS APPROACHES TO THE MUSHROOM INDUSTRY GLOBALLY

Mushroom cultivation provides a valuable solution to rural food shortages and offers various economic benefits (Godfrey *et al.* 2010). In developing countries, many farmers, who are often impoverished and lack information, find it challenging to adopt new agricultural practices. Mushroom farming is accessible and cost-effective, making it feasible for both men and women, including widows, to participate (Khan *et al.* 2021b). This sector is growing, offering opportunities without requiring significant investment or large plots of land. Governments recognize mushrooms as a nutritious addition to the diet, rich in essential macro- and micronutrients. The mushroom industry encompasses a variety of needs and challenges that must be addressed to ensure successful operations across different sectors.

Raw materials

Mushroom cultivation relies on easily accessible and low-cost materials such as hay, wood chips, and water (Ebigwai *et al.* 2012). These resources are abundant and simple to obtain, making mushroom farming a viable option even for small-scale operations. The ease of acquiring these materials, coupled with the availability of short training programs, allows individuals to quickly learn how to grow mushrooms (Mala 2018). This makes it possible to produce mushrooms at home or on underutilized land, offering a practical way for farmers to make efficient use of their resources. Mushroom farming is particularly advantageous for unemployed individuals, students, and women, as it provides a potential source of income (Feeney *et al.* 2014).

Labor

Mushroom production is labor-intensive, requiring both physical and mental efforts (Sharma *et al.* 2024). The process is simplified by the fact that mushrooms can be grown on substrates contained in bags or blocks, reducing the need for large land areas. In countries like Bangladesh, where there is a large population seeking employment, the availability of a workforce at reasonable wages is a significant advantage. As the population grows and fertile land diminishes, industries like mushroom farming on unused land present valuable employment opportunities, contributing to economic development (Khan *et al.* 2024).

Land

The mushroom industry stands out because it requires minimal land compared to other industries (Patel *et al.* 2025). Mushrooms are grown on substrates such as hay and wood chips, which can be contained in polythene bags (Grimm & Wösten 2018). These bags are then inoculated with mushroom spawn, a substrate already colonized by mycelium, the growing part of the fungus. This process, known as inoculation or spawning, creates the ideal conditions for mushroom growth, allowing for efficient use of small spaces.

Financial capital

Financial investment is necessary for any industry, but the mushroom sector is relatively low-cost (Dawadi *et al.* 2022). Compared to other industries, mushroom farming requires minimal capital investment while offering a high return. With mushrooms selling for around 200–250 BDT per kilogram and the cost of spawn being approximately 100 BDT per kilogram, the profit potential is significant (Islam 2022). This makes mushroom farming an attractive and lucrative business opportunity.

Entrepreneurship

Entrepreneurship is crucial in driving the mushroom industry forward. It involves the capacity to create, organize, and manage a business, taking on financial risks to achieve profit (Dey *et al.* 2024). Successful mushroom cultivation hinges on entrepreneurial skills to develop and expand the business. Entrepreneurs play a key role by introducing innovative ideas and strategies, capitalizing on market opportunities, and fostering the industry's growth (Ahmad *et al.* 2025). Their efforts help generate economic value and ensure the continued success of the mushroom sector.

RESEARCH AND DEVELOPMENT

Biotechnology

Advances in biotechnology are bringing a revolution in mushroom cultivation. Investigation in areas such as hereditary modification, disease resistance, pest resistance, and yield upgrading is a route to improve the effectiveness and profitability of mushroom production.

Medicinal research

Current lessons into the medicinal properties of mushrooms are growing their use in health and wellness harvests. This research focuses on bioactive complexes like beta-glucans, which have immune-boosting and anti-cancer properties.

CONCLUSION

This review highlights the multifaceted importance of mushrooms in Bangladesh, addressing their medicinal properties, cultivation profitability, environmental considerations, pest management, growth, quality, and industry development. Mushrooms are not only a rich source of bioactive compounds with proven health-promoting effects but also serve as a sustainable food option that can effectively combat malnutrition in rural communities. Despite challenges such as pests, including flies, mites, ants, and cockroaches, appropriate management practices and hygienic cultivation conditions can ensure higher yields and better quality. The mushroom industry, with its reliance on limited land, modest investment, and readily available resources, offers significant opportunities for entrepreneurship, employment generation, and income diversification. Mushrooms present immense potential as both a plant-based functional food and an agro-based enterprise, thereby contributing to public health, food security, and rural economic development in Bangladesh.

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