

From Fungi to Feasts: A comprehensive Study of Mushroom Revolution in Agriculture, Medicine, and Income Generation

Anirban Hazra

Assistant Professor, School of Management, Swami
Vivekananda University, Kolkata, West Bengal, India.

Sriparna Das

Student of Masters in Hospital Administration, School of
Management, Swami Vivekananda University, Kolkata, West
Bengal, India.

Neelanjana Mitra

Assistant Professor, School of Management, Swami
Vivekananda University, Kolkata, West Bengal, India.

Abstract:

In this study, we delve into the world of mushrooms and their significant impact on agriculture, medicine, and income generation. Mushrooms are more than just a tasty addition to our meals; they're packed with nutrients, offering a low-calorie source of proteins, vitamins, and minerals. With global production soaring to 8 million metric tonnes annually, mushrooms are a crucial player in ensuring food security and boosting economic growth, especially in countries like India. However, challenges such as lack of technical know-how, marketing information, and quality spawn hinder their cultivation. Despite these hurdles, mushrooms hold immense promise for enhancing food security, creating livelihoods, and providing valuable medicinal properties. Our study underscores the need for further research and development to unlock the full potential of mushrooms for society's benefit.

Keywords: Mushrooms, Indian agriculture, Food security, Cultivation practices, Medicinal benefits.

1. Introduction:

For millennia, humans have relied on mushrooms not only as a source of sustenance but also for their medicinal properties. With over 1.5 million species of fungi in existence, approximately 10,000 produce the fruiting bodies we commonly refer to as mushrooms (Brown & Dugan, 2017). The cultivation of mushrooms dates back to ancient times, with historical records indicating that the Chinese were the first to cultivate mushrooms around 1100 AD (Liang et al., 2020). Today, mushrooms are cultivated worldwide, with annual global production estimated at around 8 million metric tonnes (Huang et al., 2019).

Due to their great nutritional value, mushrooms are prized for being an excellent source of vitamins, minerals, and proteins. Actually, fresh mushrooms have about double amount of protein than that of vegetables and four times the protein content than that of oranges (Chan, 1981). In addition, mushrooms have minimal fat and carbs, which makes them a great food for people with dietary restrictions, including those who have obesity, diabetes, or hypertension (Ahlawat et al., 2016). Furthermore, the nutritional value of mushrooms is further enhanced by the presence of important amino acids like tryptophan and lysine, which are frequently absent from cereals (Liang et al., 2020).

In recent years, there has been a growing recognition of the potential economic benefits of mushroom cultivation, particularly in developing countries like India. Mushroom cultivation not only provides a valuable source of income for farmers but also contributes to food security by diversifying agricultural practices (Sharma et al., 2017). Despite these benefits, challenges such as lack of technical knowledge, access to quality spawn, and marketing information pose significant barriers to mushroom cultivation in many regions (Sharma et al., 2017).

In this study, we aim to explore the multifaceted role of mushrooms in agriculture, medicine, and income generation, with a focus on the Indian context. By examining cultivation practices, medicinal properties, and economic opportunities associated with mushrooms, we seek to highlight the potential benefits they offer to individuals and communities alike.

2. Mushroom: Source and Origin

Mushrooms, known for their rich history in human diets and traditional medicine, have been harvested from the wild for

thousands of years. The term “mushroom” encompasses a diverse array of fungal fruit bodies, with approximately 10,000 species identified as edible out of an estimated 1.5 million fungi (Ramsbottom, J., 1954). Cultivation of mushrooms has ancient roots, with the Chinese pioneering their cultivation around 1100 AD (Koppell, CRS., 1990). Oyster mushrooms rank second in world production and hold significant cultural and culinary importance globally (Robinson, RF., 1957). Mushrooms are prized for their nutritional value, boasting high protein content and essential vitamins and minerals (Chang, ST., 2006). Their versatility makes them a valuable addition to diets, especially in regions where protein sources are limited. Despite their ancient origins, mushrooms continue to play a vital role in modern agriculture, medicine, and culinary arts.

3. Mushroom Growth, Structure and Composition

According to science, mushrooms are nutrient-rich, meaty fruiting forms that fall into one of several fungal genera. They are categorised as macro-fungi. They grow either above or below ground and can be hand-picked. They don't possess chlorophyll; instead, they are fed by other plant material called the substrate (Ahlawat & Tewari, 2007). The fruiting body of the mushroom is what is visible to the unaided eye, although its primary body is made up of microscopic filaments known as mycelium that spread throughout the substrate and gather nourishment by decomposing organic matter (Stamets, 1993).

A number of environmental conditions, including temperature, light, humidity, and the ratio of carbon dioxide to oxygen, can affect the growth, shape, and composition of mushrooms. According to Sanchez (2010), growers manage mushroom production by manipulating air conditions, which typically decide when a mushroom will fruit.

Three essential phases make up a mushroom's life cycle: vegetative development, reproductive growth, and fruit body production of spores (Shirur & Shivalingegowda, 2015). A mat of entwined hyphae makes up the mould colony, which is located in the soil beneath the mushroom. The mushroom starts off as tiny, white balls made composed of a pilage (cap) and a short stem (stipe) that progressively open up like an umbrella. Gills are visible beneath the thin membrane or veil (velum) that covers the cap as the mushroom grows (Manikandan, 2010).

Because they are an excellent source of vitamins, minerals, fibre, proteins, and other nutrients, mushrooms are highly valued. They are perfect for people with dietary restrictions like diabetes and obesity because they are low in fat and carbohydrates (Mattila et al., 2001). Furthermore, mushrooms are a helpful supplement to the diet because they include important amino acids like lysine and tryptophan, which are frequently missing in cereals (Pehrsson et al., 2003).

Mushrooms can be grown on a range of substrates and have different cultivation requirements. For instance, compost made from a combination of plant wastes, salts, and nutrients is commonly used to grow button mushrooms (*Agaricus bisporus*) (Sharma et al., 2017). Oyster mushrooms (*Pleurotus* spp.), on the other hand, can be cultivated on substrates such as straw, stalks, and leaves of various crops (Sanchez, 2010).

Understanding the growth, structure, and composition of mushrooms is essential for successful cultivation. By providing the right environmental conditions and substrate, farmers can ensure a bountiful harvest of these nutritious and versatile fungi.

4. History and Status of Mushroom Cultivation

Mushroom cultivation has a rich history dating back thousands of years, with evidence of humans harvesting wild mushrooms for food and medicinal purposes (Hay, 1887). The Chinese were among the first to cultivate mushrooms around 1100 AD, marking the beginning of organized mushroom farming (Zhanxi & Zhanhua, 2000).

The cultivation of mushrooms has a long history in India, having been referenced in historical religious texts such as the Rig Veda and the Atharva Veda (Jandaik & Kapoor, 1974). However, deliberate attempts to establish mushroom farming as a contemporary agricultural technique were not made until the 1960s. The Directorate of Mushroom Research was founded by the Indian Council of Agricultural Research (ICAR) in 1961 with the goal of developing methods for growing mushrooms (Sharma et al., 2017).

Today, mushroom cultivation in India has witnessed significant growth, particularly in the production of popular varieties such as button, oyster, and paddy straw mushrooms (Sharma et al., 2017). The country's diverse agro-climatic conditions provide ample opportunities for mushroom cultivation, with various

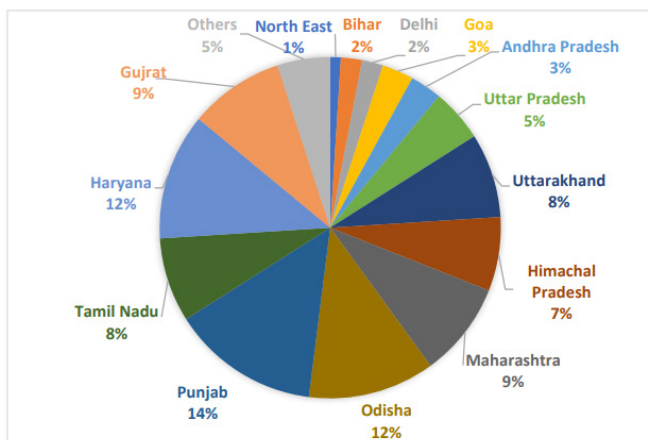
states emerging as leading producers.

Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, and Tamil Nadu are among the top mushroom-producing states in India (Sharma et al., 2017). The cultivation of button mushrooms, in particular, has gained prominence, accounting for a significant portion of the total production. Additionally, the cultivation of oyster and paddy straw mushrooms has seen a surge in recent years, driven by their high demand and nutritional value.

The adoption of modern cultivation technologies has played a crucial role in boosting mushroom production in India (Stamets, 1993). From compost preparation to spawning and crop management, farmers are leveraging scientific techniques to enhance productivity and quality. Moreover, the utilization of agricultural residues as substrates for mushroom cultivation has opened new avenues for sustainable farming practices and waste management.

Despite the progress made, challenges such as limited technical knowledge among farmers, inadequate marketing infrastructure, and quality spawn availability persist. Efforts are underway to address these challenges through capacity building initiatives, research collaborations, and policy interventions aimed at promoting mushroom cultivation as a viable agribusiness.

Fig. 1: Share of different states of India in National mushroom production



Source: Sharma VP, Sudheer KA, Gautam Y, Singh M, Kamal S (2017).

Burdwan district in West Bengal, one of India's most agriculturally and industrially evolved states, is well worth mentioning. In West Bengal, India, the Burdwan area is known as a "Granary of rice district" since there are plenty of agricultural leftovers to be found there. Protein-rich mushrooms could be grown using all of these leftover wastes as well as other trash materials that contaminate the environment (Medda, 2001). Mushroom farming is one way that agricultural wastes are recycled (Madan, 1994). The people living in the villages of Chhattisgarh cultivated mushrooms using their own techniques, using paddy straw as a substrate, and selling them in the local market for a profit (Thakur et al., 2003; Jandaik & Kapoor, 1974).

4.1. Types of cultivated Mushrooms

While thousands of mushroom species exist in nature, only a handful are grown commercially around the world. Mushroom farmers focus on varieties that are relatively easy to cultivate and have an established market demand. Let's take a look at some of the most popular cultivated mushrooms in India:

The Button Mushroom (*Agaricus bisporus*): This classic white variety is the undisputed king of the cultivated mushroom world. First domesticated and grown industrially in the early 20th century, button mushrooms now account for a whopping 73% of India's total mushroom production (Sharma et al., 2017). They require carefully controlled temperature and humidity levels during their distinct vegetative and reproductive growth phases (National Horticulture Board). Seasonal cultivation occurs mainly in the cooler winter months across the north Indian plains and hills (See Appendix, Fig. A2).

The Oyster Mushroom (*Pleurotus spp.*): With its distinctively shaped caps resembling oyster shells, this group of mushrooms ranks second in global production volumes. India's warm climate provides the perfect conditions for oyster cultivation, with major production hubs in states like Orissa, Andhra Pradesh, and the northeast (Jandaik & Kapoor, 1974). Oyster mushrooms can thrive on a wide range of agricultural waste substrates, making them a sustainable and environmentally friendly crop (See Appendix, Fig. A4).

The Paddy Straw Mushroom (*Volvariella volvacea*): As the name suggests, this variety loves to grow on paddy straw,

although other crop residues can also be used as substrates. Originating in China over 300 years ago, paddy straw mushrooms are now the sixth most cultivated mushroom worldwide (Zhanxi & Zhanhua, 2000). They are particularly popular in eastern and southern India, especially in coastal regions like Orissa, where both indoor and outdoor cultivation methods are employed (Ahlawat & Tewari, 2007) (See Appendix, Fig. A5).

The Milky Mushroom (*Calocybe indica*): This tropical mushroom is making steady inroads across the Indian mushroom industry, thanks to its suitability for the country's warm climatic conditions. Tamil Nadu currently leads the way in milky mushroom production, with cultivation spreading to states like Kerala, Orissa, and West Bengal. While similar to oyster mushrooms in some cultivation aspects, milky mushrooms require a unique casing layer to induce fruiting body formation (Madan et al., 1995) (See Appendix, Fig. A6).

These are just a few examples of the many mushroom varieties being grown by India's mushroom farmers. As consumer demand and cultivation techniques evolve, we may see even more varieties joining the ranks of commercially viable mushroom crops in the years to come.

5. Medicinal Mushrooms:

There is documented usage of medicinal mushrooms in traditional eastern medicine. Numerous mushrooms, mostly from the genera *Tremella*, *Flammulina*, *Ganoderma*, *Grifola*, *Lentinula*, and *Auricularia*, have been found to have therapeutic properties. The most widely used and traded mushroom in the world's commerce is *Ganoderma lucidum*. Given its diverse range of agroclimatic conditions, India possesses exceptional potential for producing an abundance of commercially edible and therapeutic mushrooms. Medicinal mushrooms are among the most commonly recommended natural products with anticancer properties. Medicinal mushrooms belong to a class of polysaccharides called beta-glucans, which enhance immunity against tumours. Currently, researchers at the Indian Institute of Horticultural Research (IIHR) in Hesaraghatta are creating technology to take advantage of mushroom varieties that support a healthy lifestyle.

Shiitake mushrooms have anti-tumor, anti-LDL cholesterol, and anti-thromobic properties. They can also help prevent high blood pressure, kidney disease, diabetes, cataracts, neuralgia, gallstones, numbness in the hands and feet, haemorrhoids, and enhance sexual function (Mori, 1974). It can help prevent excessive blood pressure, diabetes, haemorrhage, lung and breast disorders, jaundice, intestinal worm infections, and throat ailments. It is quite helpful. Moreover, it contains the digestive enzyme trypsin, which is essential for proper digestion, and lecithin, which helps to keep low blood cholesterol levels. Furthermore, it has been determined that the mushroom contains Retine, which can prevent tumour formation and the majority of malignancies, all of which may be caused by a normal deficiency in Retine (IFT, 1995).

Mushrooms are a remarkable supply of potassium, a mineral that enables lower increased blood strain and decreases the risk of stroke. One medium portabella mushroom has even greater potassium than a banana or a pitcher of orange juice. (Stamets, 1993) [See Appendix, Fig. A7]

Table 1: Medicinal values of few important mushrooms

Mushroom	Compound	Medicinal property
Ganoderma lucidum	Ganoderic acid, Beta-glucan	Augments immune system Liver protection Antibiotic properties Inhibits cholesterol synthesis
Lentinula edodes	Eritadenine Lentinan	Lower cholesterol Anti-cancer agent
A. bisporous	Lectins	Enhance insulin secretion
P. sajor-caju	Lovastatin	Lower cholesterol
Auricularia auricula	Acidic Polysaccharides	Decrease blood glucose
Trametes versicolor	Polysaccharide-K (Kresin)	Decrease immune system depression

Source: Manikandan, K. 2010.

Nutrition in Mushrooms

For hundreds of years, people have eaten mushrooms on a large scale. The Indian's lack of protein will be made up by mushrooms. The money will help the socially awkward average man become in better shape. It is believed that mushrooms are healthy for people of all ages, including the elderly. Ten percent of mushrooms are dry and ninety percent are water (Sánchez, 2010). Since mushrooms can be high in protein, fibre, and minerals, they are important for nutrition. Mushrooms are low in calories, free of gluten, fat, and cholesterol, and they contain very little sodium. Our bodies contain excessive amounts of minerals like potassium, iron, copper, zinc, and manganese in fruit. Because of their high digestion, mushrooms are thought to be a viable substitute for muscle protein (Pavel, 2009). [Refer to the Appendix, Fig. A8]. Furthermore, mushrooms are an abundant source of nutrients B1, B2, B12, C, D, and E (Heleno et al., 2010). Additionally, mushrooms are a fantastic source of vitamin D; without them, it would not be possible to obtain it from other food supplements (Pehrsson, et.al. 2003). Because of their high nutritional content, flavour, and delicacy, mushrooms are safe to eat and are now a commercially significant fungal product. Their production and consumption have increased significantly. The polysaccharide molecule beta-glucan, which enhances cellular immunological function, is another important component of mushrooms. The oyster mushroom has a high protein content, is low in carbohydrates and sugar, and lacks starch. These are the perfect meals for people with diabetes, heart problems, and those who don't want to gain weight (FAO, 1974). The table below lists the nutritional values of several mushrooms. The dry weight foundation g/100g represents the nutritional properties of various mushrooms (Manikandan, 2010).

Table 2: Nutritive values of different types of mushrooms (dry weight basis g/100g)

Mushroom	Carbohydrate	Fiber	Protein	Fat	Ash	Energy kcal
Auricularia auricula	82.80	19.80	4.20	8.30	4.70	351
Flammulina velutipes	73.10	3.70	17.60	1.90	7.40	378
Calocybe indica	64.26	3.40	17.69	4.10	7.43	391
Pleurotus sajor-caju	63.40	48.60	19.23	2.70	6.32	412
Pleurotus ostreatus	57.60	8.70	30.40	2.20	9.80	265
Lentinula edodes	47.60	28.80	32.93	3.73	5.20	387
Agaricus bisporus	46.17	20.90	33.48	3.10	5.70	499
Volvariella volvaceae	54.80	5.50	37.50	2.60	1.10	305

Source: Manikandan, K. (2010).

One of the biggest challenges facing Indian democracy is providing for the population's food demands in this environment. Malnutrition and various diseases spread among poor people due to their economic weakness. For this people are forced to search for alternative nutrition. Mushrooms are grown on wastes without the need for additional land in addition to their nutritional and medicinal properties.

Table 3: Composition of cultivated mushrooms and common vegetables per 100g

Name	moisture	Protein % Dry weight basis	Carbohydrates %	Fat gm	Calories kcal
Mushrooms	91.1	26.9	4.4	0.3	16
Potato	73.8	7.6	19.1	0.1	83
Beetroot	87.6	12.9	9.6	0.1	42
Green beans	88.9	21.6	7.7	0.2	35
Green peas	74.3	26.1	17.7	0.4	98
Cauliflower	91.7	28.8	4.9	0.2	25

Source: Manikandan, K. (2010)

6. Income Generation

Mushroom production is entirely distinct from growing green plants. Manufacturing mushrooms requires a deep understanding of fungal life cycles. With its contributions to agriculture, medicine, and the economy, mushroom growing enhances the resilience and standard of living of rural residents. In 1943, Thomas planted the first mushroom in India. Dr. E. F. K. Mental, a German artist, began the artwork in the middle of the 1960s since he was an FAO consultant in Solan and introduced button mushroom growing to India. The Indian Council of Agricultural Research (ICAR), New Delhi, started cultivating button mushrooms (*Agaricus bisporus*) in Solan for the first time in 1961.

The city of Solan is referred to as "Mushroom City of India." According to recent manufacturing data, the production of button mushrooms accounts for the highest amount at roughly 73%, with oyster mushrooms accounting for 16% (Sharma et al., 2017). [Figure 2]. In India, there are two types of mushroom

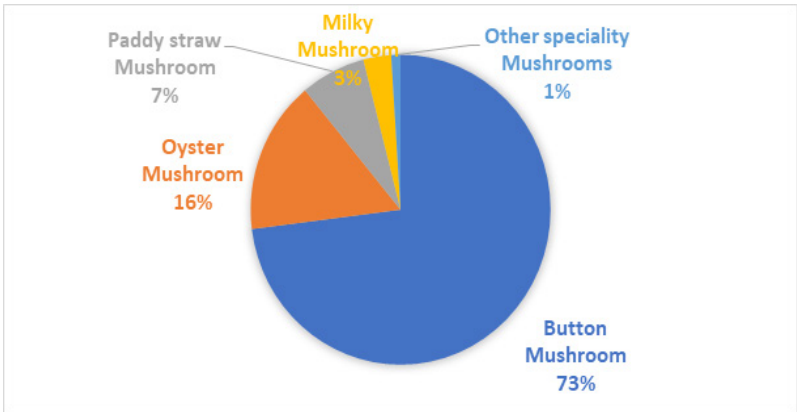
producers: spherical growers, who grow mushrooms all year round, and seasonal growers. Both farmers have concentrated on producing *Agaricus bisporus* white buttons, harvesting two to three plant lives in a 12-month period. The negative farmers’ economic standing increased gradually when they started growing mushrooms. By the year 2020 AD, India’s mushroom production could reach a magical yearly yield of 6,000,000,000 tonnes (Karthick and Hamsalakshmi, 2017). (Sharma, et.Al, 2017).

Table 4. Mushroom production (India)

Mushroom	Annual Production (tonnes)
Button mushroom	100,683
Oyster mushroom	6,399
Paddy straw mushroom and other	5,313
Milky mushroom	920

Source: Prakasam, 2012

Fig.2: Relative contribution of different species of mushroom (in total production)



Source: [https://link.springer.com
referenceworkentry/10.1007/978-3-319-78030-6_86](https://link.springer.com/referenceworkentry/10.1007/978-3-319-78030-6_86)

The ability to produce mushrooms is primarily dependent on the availability of manpower, excellent spawn, and raw fabric, or substrate. Growing mushrooms may be a very profitable

hobby with significant financial rewards. Farmers should get instruction on a variety of mushroom farming topics in order to fill the knowledge gap and encourage the use of new technologies. Employers that cultivate mushrooms provide job opportunities for unemployed adolescents and rural girls. The high benefit-to-cost ratio, the easily obtained and less expensive agricultural wastes, and the hospitable climate make the adoption of mushroom growing a profitable strategy for society advancement. Because mushrooms are an unconventional crop, the growing of different kinds of mushrooms in rotation is not very well-known in India.

Mushrooms are another type of plant that can be produced all year round. In the northern Indian plains, white button mushrooms can be produced in the winter. Tropical or subtropical mushrooms that can tolerate high temperatures, including paddy straw, oyster, or milky mushrooms, can be produced in the summer.

Table 5. Leading states in Mushroom cultivation in India State Annual Production (tonnes)

State	Annual Production (tonnes)
Punjab	60,000
Uttarakhand	8,000
Haryana	7,178
Uttar Pradesh	7,000
Tamil Nadu	6,500
Himachal Pradesh	5,993
Orissa	5,846
Andhra Pradesh	3,022
Delhi	3,070
Maharashtra	2,975
Kerala	800

Source: Singh et. al., 2011

Mushrooms Pack a Nutritional Punch When it comes to nutrition, mushrooms really punch above their weight. Just take a look at how they compare to some common vegetables per 100 grams:

With over 91% moisture content, mushrooms are incredibly low in calories, providing just 16 calories per 100g serving. Yet they

are a rich source of protein, packing nearly 27% protein by dry weight. This is higher than green beans at 21.6% and cauliflower at 28.8%.

Mushrooms also provide a good dose of carbohydrates at 4.4%, though vegetables like potatoes (19.1%), green peas (17.7%) and beetroots (9.6%) have higher carb levels. Where mushrooms really shine is their low-fat profile, with just 0.3 grams of fat per 100g serving.

Overall, mushrooms make an excellent addition to a balanced diet. Their low calorie, high protein, and low-fat combination make them particularly attractive for those looking to manage their weight or restrict certain macronutrients. Plus, their savory umami flavor can satisfy cravings while keeping things light.

Further, Mushroom refers to a fleshy and nutrient-wealthy fruiting frame of particular macro-fungi agencies that can be hand-picked and grown both above or beneath the ground. Some of the commonly available types are button, oyster, paddy, milky, and so on. Edible mushrooms are a considerable supply of potassium, Vitamin D, riboflavin, selenium, and so on., and are established to be highly useful in dealing with weight, constructing immunity, and reducing the dangers of numerous persistent sicknesses.

The India mushroom market is largely driven by consumer demand for nutrient-dense, cholesterol-free foods and health consciousness. Because of their taste, mushrooms are substituted for meat. Growing mushrooms provides an opportunity to produce an extremely tradeable good and advances earnings technologies. However, the majority of farmers are unable to benefit from their mushroom producing endeavours as a result of the unfavourable advertising strategy. It is a straightforward system where producers promote directly to retailers, but it has drawbacks of its own, such as seasonal mushroom production. Commercial mushroom farming has become more and more important recently as a result of its high cash output. Proteins, minerals, and antioxidants found in mushrooms may be essential for a growing child or expectant mother. Mushrooms must be processed and marketed as cost-introduced products that can provide acceptable profits, such as pickles, nuggets, dry powder, etc., in order to be successful.

7. Conclusion

Mushrooms are an amazing energy source. More protein can be found in mushrooms than in other veggies. In addition to strengthening the immune system, mushrooms help make up for deficiencies in mushroom protein. Protein, minerals, and antioxidants found in mushrooms are vital for a developing child's and a pregnant woman's health. After a thorough analysis of the study's various components, it was determined that farmers would benefit from rice cultivation and that, should the study be validated, lives would be healthier. There are numerous health benefits to mushrooms.

References

Ahlawat, O. P., & Tewari, R. P. (2007). Cultivation technology of paddy straw mushroom (*Volvariella volvacea*). Technical Bulletin. National Research Centre for Mushroom (ICAR), Chambaghat.

Ahlawat, O. P., Tewari, R. P., & Shwet, K. (2016). Mushroom cultivation in India: Present status, opportunities and challenges. *Mushroom Research*, 25(1), 1-12.

Brown, A. M., & Dugan, F. M. (2017). An introduction to fungi. In *Mushrooms: cultivation, nutritional value, medicinal effect, and environmental impact* (pp. 1-18). CRC Press.

Chan, S. T. (1981). Edible mushroom production in South-East Asia. *Mushroom Science*, 11, 629-643.

Chang, S. T. (2006). The world mushroom industry: trends and technological development. *International Journal of Medicinal Mushrooms*, 8(3), 297-314.

Huang, C. C., Miller, P. E., & Iglesias-Navas, M. A. (2019). Annual production of mushroom and mushroom products. *World Mushroom Industry: A Value Chain Analysis*, 1-22.

Jandaik, C. L., & Kapoor, J. N. (1974). Studies on cultivation of *Pleurotus sajor-caju*. *Mushroom Science*, 9(1), 667-672.

Karthick, K., & Hamsalakshmi, G. (2017). Economics of mushroom cultivation. *Ecofriendly Management of Plant Diseases*, 108-118.

Koppell, C. R. S. (1990). The major significance of 'minor' forest products: the local use and value of forests in the West African humid forest zone. *FAO Community Forestry Note*, 6.

Liang, Z. Q., Chen, Y. J., Tan, Q., & Yi, Y. P. (2020). Edible mushroom cultivation for food security and rural development in China: bio-innovation, technology dissemination and market analysis. *Sustainability*, 12(5), 2002.

Madan, M. (1994). Successful mushroom cultivation and marketing. National Mushroom Growers' Association.

Madan, M., Vasudevan, P., & Sharma, S. (1995). Cultivation of *Calocybe indica*. Food and Agriculture Organization of the United Nations.

Manikandan, K. (2010). Nutritional and Medicinal values of Mushrooms. Compendium on Mushroom Cultivation Technology, Directorate of Mushroom Research, Solan (HP), India.

Mattila, P., Konko, K., Eurola, M., Pihlava, J. M., Astola, J., Vahteristo, L., ... & Piironen, V. (2001). Contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. *Journal of Agricultural and Food Chemistry*, 49(5), 2343-2348.

Medda, S. (2001). An approach to mushroom cultivation through recycling of organic wastes. *Mushroom Research*, 10(2), 73-76.

Pehrsson, P. R., Haytowitz, D. B., & Holden, J. M. (2003). The USDA's national food and nutrient analysis program: update 2002. *Journal of Food Composition and Analysis*, 16(3), 331-341.

Ramsbottom, J. (1954). *Mushroom & Toadstools: a study of the activities of fungi*. London: Collins.

Robinson, R. F. (1957). Food from fungi. *Economic Botany*, 11(2), 126-145.

Sanchez, C. (2010). Cultivation of *Pleurotus ostreatus* and other edible mushrooms. *Applied Microbiology and Biotechnology*, 85(5), 1321-1337.

Sharma, V. P., Sudheer, K. A., Gautam, Y., Singh, M., & Kamal, S. (2017). Status of mushroom production in India. *Mushroom Research*, 26(2), 111-120.

Shirur, M., & Shivalingegowda, N. S. (2015). Mushroom marketing channels and consumer behaviour: a critical analysis. *Mysore Journal of Agricultural Sciences*, 49(2), 390-393.

Singh, M., Vikineswary, S., Abdullah, N., Kusai, N. A., & Sekaran, M. (2011). Productivity of oyster mushrooms on different substrates. *ICAR News*, 17(4), 4-9.

Stamets, P. (1993). *Growing gourmet and medicinal mushrooms*. Berkeley, USA: Ten Speed Press.

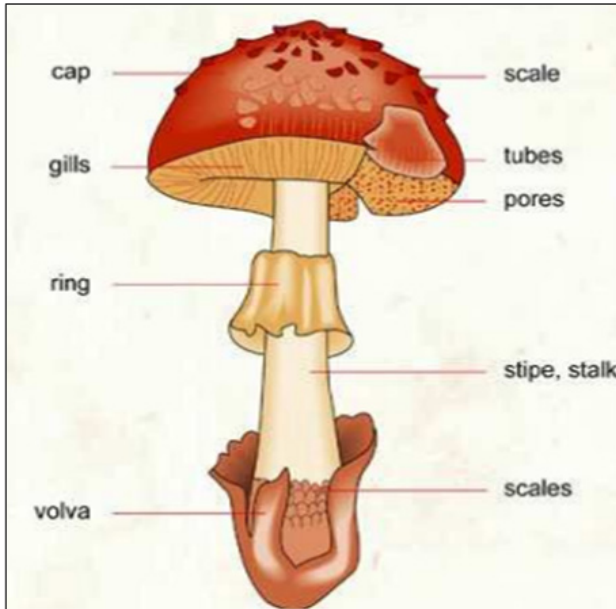
Thakur, M. P., Verma, K. C., & Sridev, S. (2003). Cultivation of paddy straw mushroom in Chhattisgarh. *Mushroom Research*,

12(1), 22-26.

Zhanxi, L., & Zhanhua, L. (2000). Training manual of APEMT China-chapter 11, *Volvariella volvacea* cultivation (pp. 100-109).

APPENDIX

Fig: A1: Morphology



Source: https://www.researchgate.net/figure/Labelled-diagram-of-a-mushroom-The-image-is-retrieved-from-https-wwwkagglecom_fig1_363262281

Fig: A2: Basic life cycle

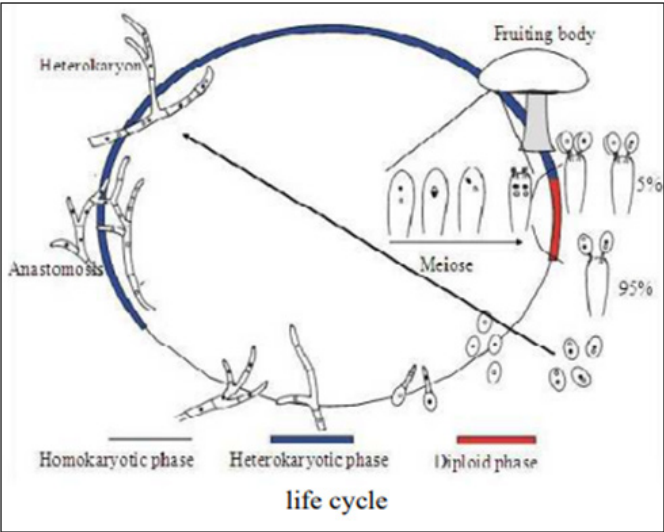


Fig.A3: Button Mushroom



White button mushroom (*Agaricus bisporus*)



Brown button mushroom (*Agaricus bisporus*)

Fig.A4: Oyster Mushroom

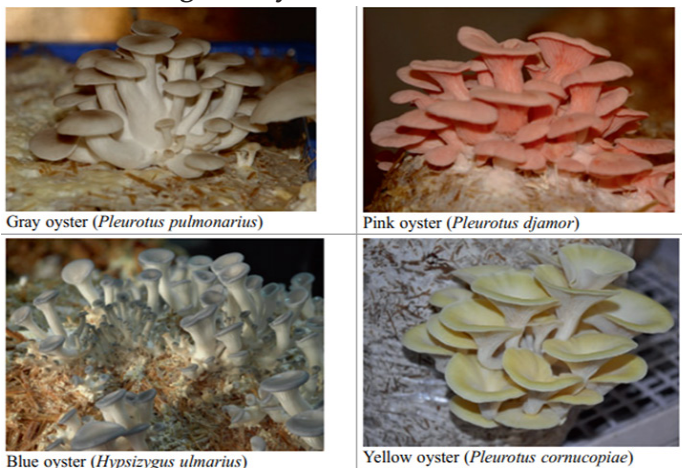


Fig. A5: Paddy Straw Mushroom

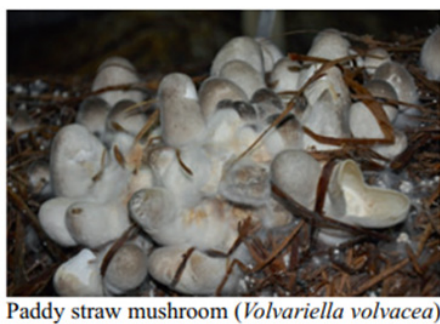


Fig. A6: Milky Mushroom



Fig.A7: Medicinal Mushroom



Fig. A8: Nutrition in Mushroom

