

From Fungi to Fortune: Empowering Communities through Sustainable Mushroom Enterprises in India

By

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Abstract

This paper delves into the transformative potential of mushroom cultivation as a means to foster sustainable livelihoods in India. This paper explores the journey of mushroom enterprise development, highlighting key stages such as research and development, training and capacity building, production, marketing, and policy support. By harnessing the power of mushrooms, communities can not only generate income but also contribute to environmental conservation and food security. This abstract offers a glimpse into the comprehensive approach required to create thriving mushroom enterprises that uplift rural communities and promote sustainable development in India.

Key Words: Mushroom cultivation, Environmental sustainability, Livelihoods, Economic development, Nutritional value

1. Introduction

The increasing population, diminishing agricultural land, climate change, water scarcity, and the demand for high-quality food products at competitive prices are pressing issues that require immediate attention. As an agrarian country, India must diversify its agricultural activities, particularly in areas like horticulture, to address these challenges and ensure food and nutritional security for its people. The horticulture sector already contributes significantly to India's Gross Value Addition (GVA), accounting for about 33%, and makes up 6% of the country's GDP. With the global population continuing to rise, the consumption of horticultural products is also increasing. Mushrooms, in particular, offer a unique solution as they utilize vertical space

efficiently and address concerns related to food quality, health, and environmental sustainability. India generates a vast amount of agro-waste annually, approximately 620 million tons,[15] much of which goes to waste in the fields. Mushroom cultivation provides an opportunity to recycle this waste into a valuable source of protein, thereby mitigating environmental pollution and enhancing food security.

The labor-intensive nature of mushroom cultivation, along with significant value addition, reliance on locally available raw materials, low initial investment, simple technology, and minimal space requirements, make it a viable commercial venture. Moreover, mushroom cultivation creates job opportunities, especially in rural areas, contributes raw materials to the food industry, and offers high returns for investors. This not only helps alleviate poverty but also promotes social development in rural communities, aligning well with various farming systems. Integrated mushroom cultivation within existing farming systems has the potential to supplement rural income, generate employment, and foster inclusive growth [7]. By harnessing the economic and environmental benefits of mushroom cultivation, India can achieve sustainable agricultural practices, improve livelihoods, and contribute to overall economic development.

2. Literature review

Mushrooms are indeed recognized as a highly nutritious food source, containing essential components for a balanced diet. They are considered a potential substitute for muscle protein due to their high digestibility [8]. Additionally, mushrooms are rich in quality proteins, providing most of the essential amino acids that are often deficient in many vegetables and cereals, particularly lysine [7]. Furthermore, mushrooms are an excellent source of vitamin D, a nutrient not readily available in other food supplements [9]. In many Asian countries, mushrooms are consumed not only as food but also for their medicinal properties. Research has explored the medicinal aspects of mushrooms [3], and they are used in traditional systems of medicine such as Ayurveda in India [1][4]. Studies suggest that mushroom consumption can promote immune function, potentially reducing the risk of cancer and inhibiting tumor growth [11]. Mushrooms are particularly favored by individuals with diabetes and hypertension due to their low caloric value, low sugar and fat content, and absence of cholesterol [2]. Fresh button mushrooms have high moisture content but are still rich in protein, fiber, ash, carbohydrates, and essential minerals and vitamins. They contain calcium, phosphorus, sodium, iron, potassium, thiamine (B1), riboflavin (B2), ascorbic acid (C), and niacin (B3) [6]. In recent years, mushrooms have gained recognition as a "super food" due to their impressive nutritional profile. They are packed with key nutrients like selenium, vitamin D, glutathione, and ergothioneine, which help combat oxidative stress and

reduce the risk of chronic conditions such as cancer, heart disease, and dementia. Moreover, mushrooms impart a strong natural flavor, allowing consumers to reduce salt intake in mushroom-based meals, further benefiting health outcomes.

The study lacks detailed exploration of various mushroom species' nutritional and medicinal properties, potentially overlooking differences in nutrient composition and health benefits among different varieties. Additionally, it falls short in examining how bioactive compounds in mushrooms interact with biological processes to provide health benefits, leaving a gap in understanding their mechanisms of action. Furthermore, there's a dearth of robust clinical evidence supporting claims about the efficacy and safety of mushroom-based interventions for immune function, cancer prevention, and other health outcomes. While the study briefly mentions traditional uses of mushrooms, it fails to delve into their cultural significance or indigenous knowledge, which could offer valuable insights. Moreover, it neglects to address factors influencing consumer preferences and behaviors, such as taste preferences and cultural norms, crucial for promoting mushroom consumption and improving public health. Lastly, the study overlooks considerations for sustainable mushroom cultivation practices and their environmental impact, including resource use efficiency, waste management, and ecological footprint, which are vital for long-term sustainability."

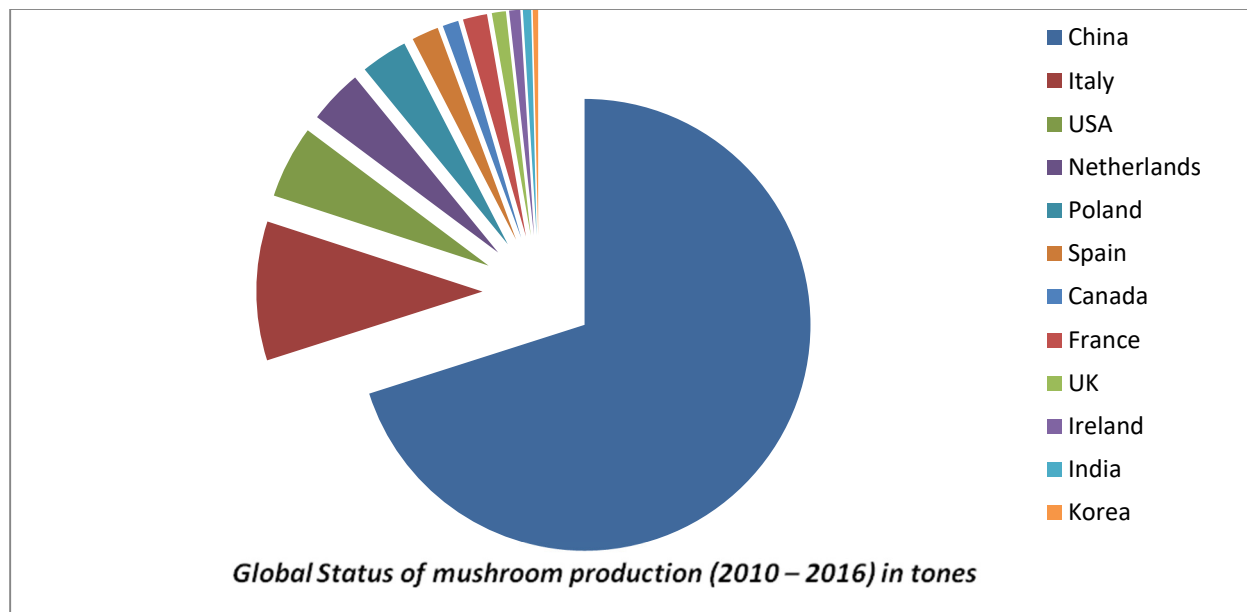
2.1. Objectives of this paper

Comprehensive Exploration of Mushroom Enterprise Development: This paper aims to delve into the transformative potential of mushroom cultivation in fostering sustainable livelihoods in India. It will explore key stages of mushroom enterprise development, including research and development, training, capacity building, production, marketing, and policy support.

Gap Identification in Existing Literature: The paper seeks to identify gaps in the existing literature regarding mushroom cultivation, particularly focusing on the nutritional and medicinal properties of different mushroom species, mechanisms of action underlying health benefits, clinical evidence supporting claims, cultural perspectives, consumer behaviors, and sustainability considerations. By pinpointing these gaps, the paper aims to pave the way for future research directions and policy interventions in the field of mushroom cultivation in India.

3. Exploring the Global Landscape of Mushroom Production

The global mushroom industry has experienced remarkable growth over the past two decades, driven by the introduction of newer types of mushrooms for commercial cultivation. China has emerged as the leader in mushroom production, consumption, and exportation, followed closely by the USA and the Netherlands. China's mushroom cultivation spans over 60 different species, ranging from small-scale to industrial operations. Over the last 50 years, world mushroom production has seen a steady increase, rising from 0.30 million tons in 1965 to 12.74 million tons by 2015 [13]. According to FAO data, the top three mushroom-producing countries - China, USA, and the Netherlands - collectively contribute 60% of the world's production, with China alone accounting for 46%, nearly half of the global output. The global mushroom market reached a value of USD 50.3 billion in 2021, and it is projected to continue expanding at a compound annual growth rate (CAGR) of 9.7% from 2022 to 2030, reaching USD 115.8 billion by 2030 (Grandview Research, 2022). One significant driver for this growth is the increasing demand for protein-rich diets, particularly among the rising vegan population worldwide. In terms of production contribution, shiitake, oyster, wood ear, and button mushrooms hold significant shares, accounting for 22%, 19%, 18%, and 15%, respectively, of the total mushroom production globally [14]. This diversification in mushroom varieties reflects the evolving preferences of consumers and the industry's adaptability to meet changing demands and market trends. The dominance of the Asia Pacific region in the mushroom market, with a revenue share of 78.6% in 2021, can be attributed to its high production rate and large consumer base, particularly in countries like China and India. **Figure** highlights the global status of mushroom production in tons from 2010 to 2016. This data underscores the significant contribution of the Asia Pacific region to the global mushroom production, reflecting the region's importance as a key player in the mushroom industry.



Source: Compiled from FAO, FAOSTAT Production database.

4. National Insights into Production and Trends

The mushroom industry in India has experienced significant growth in both production and consumption, primarily driven by increased awareness of its commercial and nutritional significance. India's Foreign Direct Investment (FDI) policy aims to attract investment in technology for the development and production of vegetables and mushrooms under controlled conditions, further bolstering the industry's potential for growth (Annual report 2017-2018). Despite being the largest importer of mushrooms in the world, with Germany, China, and France being the main sources, India contributes only about 3% of the total global button mushroom production. However, mushroom cultivation plays a crucial role in improving the livelihoods of rural communities in India, offering economic, nutritional, and medicinal benefits. The history of mushroom cultivation in India dates back to 1943 when Thomas publicized the cultivation of paddy straw mushrooms, which led to the dissemination of cultivation techniques across the country. The Indian Council of Agricultural Research (ICAR) initiated the cultivation of button mushrooms in 1961, with research schemes established in various locations such as Solan, Punjab, Bengaluru, and New Delhi. Solan, known as the "Mushroom City of India," emerged as a significant hub for mushroom cultivation. Despite favorable agro-climatic conditions, abundant agricultural waste, low-cost labor, and rich fungal biodiversity, India's mushroom industry has witnessed relatively lukewarm growth compared to the rest of the world. Current estimates suggest that India produces approximately 155,553 metric tons of mushrooms annually, representing less than 1% of the global production. The majority of mushroom production in India consists of white button mushrooms, followed by oyster mushrooms, paddy

straw mushrooms, milky mushrooms, and others. Although white button mushrooms dominate production in India, their share in global trade remains below 40%. Per capita consumption of mushrooms in India is relatively low, estimated to be less than 100 grams per year. However, the Indian mushroom industry has seen some success in export markets, generating revenue through the export of white button mushrooms in canned and frozen forms. Mushroom production in India during 2016 (ICAR-DMR, Solan official data) is given in **Table-1**.

Table-1:Mushroom production in India during 2016 (ICAR-DMR, Solan official data)					
States	Button mushroom	Oyster mushroom	Milky mushroom	Other mushrooms	Total(Production in metric tones)
Andhra Pradesh	3000	500	15	0	3515
Arunachal Pradesh	20	5	0	1	26
Assam	20	100	5	0	125
Bihar	950	1500	150	0	2600
Chhattisgarh	20	200	35	89	344
Delhi	3000	50	20	0	3070
Goa	4200	20	0	0	4220
Gujarat	10000	1200	0	0	11200
Haryana	15000	50	50	0	15100
Himachal Pradesh	9000	110	30	10	9150
J&K	565	15	50	0	630
Jharkhand	200	20	0	0	220
Karnataka	700	320	160	0	1180
Kerala	0	500	300	0	800
Maharashtra	10000	2000	50	0	12050
Madhya Pradesh	10	5	0	0	15
Manipur	0	10	0	50	60
Meghalaya	25	2	0	0	27
Mizoram	0	50	0	0	50
Nagaland	0	75	0	250	325

Odisha	126	6310	0	9550	15986
Punjab	16000	2000	0	0	18000
Rajasthan	100	1000	0	200	1300
Sikkim	1	2	0	0	3
Tamil Nadu	6500	2000	1500	0	10000
Tripura	0	100	0	0	100
Uttarakhand	8189	1228	819	0	10236
Uttar Pradesh	7000	100	0	0	7100
West Bengal	50	1500	0	500	2050
Andaman & Nicobar	0	300	0	0	300
Total	94676	21272	3184	10650	129782
Source: VP SHARMA et al.					

Despite the growing demand for mushrooms and spawn in India, the majority of commercial spawn is supplied by private units, with limited involvement from public sector organizations. Overall, while India's mushroom industry shows promise, there is room for further growth and development to capitalize on its potential benefits for both rural livelihoods and the economy.

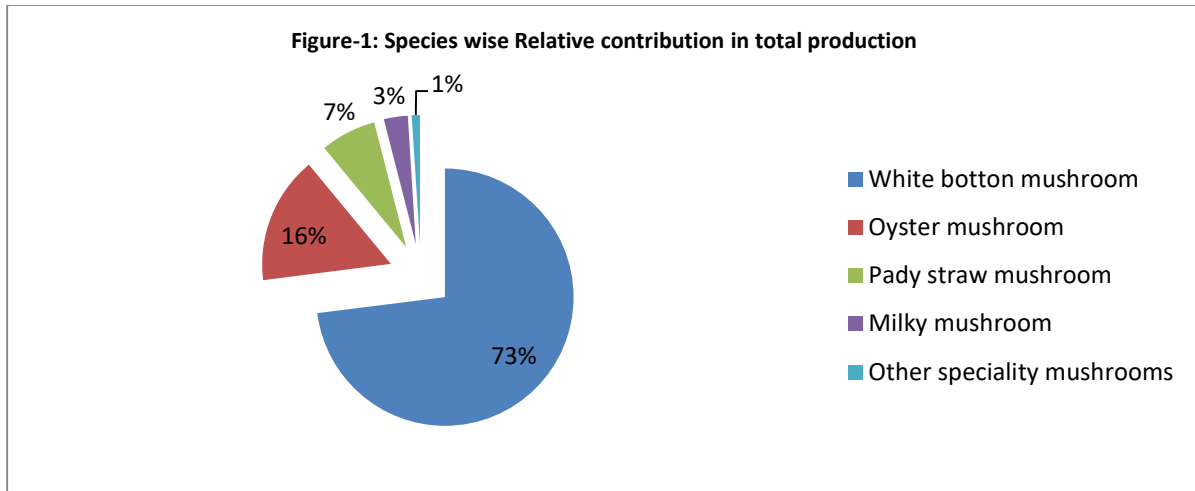
5. Analysis of Mushroom Species Contribution to Total Production

In India, the commercial cultivation of mushrooms encompasses five main species: white button mushroom (*Agaricus bisporus*), oyster mushrooms (*Pleurotus* spp.), paddy straw mushrooms (*Volvariella volvacea*), milky mushrooms (*Calocybe indica*), and shiitake mushrooms (*Lentinula edodes*). However, the vast majority of mushroom production is dominated by the first three species, which collectively contribute around 96% of the total mushroom production in the country. **(Figure-1)**

White button mushrooms, oyster mushrooms, and paddy straw mushrooms are the primary contributors to India's mushroom industry. These species are favored for their suitability for cultivation in various regions, adaptability to different growing conditions, and market demand.

Their popularity stems from their culinary versatility, nutritional value, and relatively straightforward cultivation techniques.

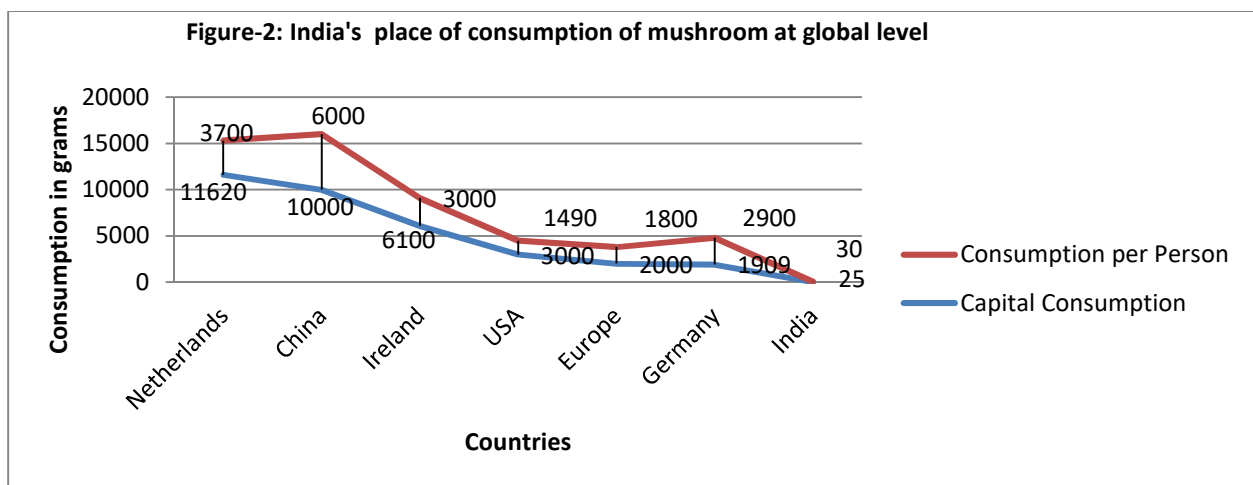
Milky mushrooms, indigenous to India and tropical in nature, have commercial cultivation primarily restricted to the southern states of the country. Despite being a native species, milky mushrooms contribute only around 3% to the total mushroom production in India. Factors such as limited commercial cultivation infrastructure and regional preferences may influence the lower production volume of milky mushrooms compared to other species. Paddy straw mushrooms have gained popularity, particularly in states like Odisha and Chhattisgarh, where production has increased and now accounts for approximately 7% of the total mushroom production in India. The cultivation of paddy straw mushrooms often utilizes agricultural waste materials such as rice straw, making it an attractive option for farmers and cultivators. Shiitake mushrooms, although valued for their culinary and medicinal properties, have yet to be extensively cultivated on a commercial scale in India. Despite efforts to standardize cultivation techniques, such as short-duration indoor cultivation technology developed at ICAR-DMR, Solan, commercial exploitation of shiitake mushrooms remains limited. Challenges such as market demand, cultivation expertise, and infrastructure may hinder the widespread adoption of shiitake mushroom cultivation in India. Overall, while India boasts a diverse range of mushroom species suitable for commercial cultivation, the dominance of white button, oyster, and paddy straw mushrooms underscores the importance of these species in driving the growth of the country's mushroom industry.



Source: Directorate of Mushroom Research (ICAR), Solan, India.

5.1. Indian Position in Global Mushroom Consumption and Production

The consumption of mushroom in India is currently about 30-40 g as compared to 2-3 kg in USA and Europe [10]. In India per capita consumption is about 90 g, which is very less compared to other countries including USA 1.49 kg and China 1.16 kg (Directorate of Mushroom Research ICAR, Solan, India 2011). Mushroom consumption in India is very low as compared to a lot of mushroom consuming countries. **Figure-2** depicts that mushroom consumption in India is negligible when compared to other mushroom consuming countries. Since, the trend of mushroom consumption has seen a very slow rate of growth in India, farming of mushroom has not caught up with the global trend.

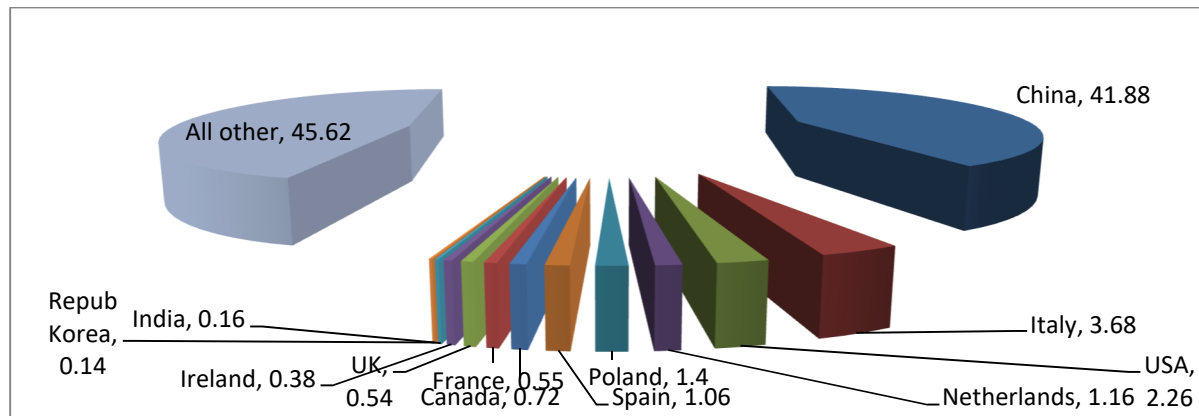


Source: Directorate of Mushroom Research (ICAR), Solan, India.

A total of approximately 0.13 million tones of mushrooms were produced by mushroom farming in India between 2010 and 2017. Even though, this number looks big, but it looks insignificant when compared to other mushroom producing countries. World consumption of mushroom and the share position of India in world consumption is highlighted in **Figure-3**. Since the cost of

farming mushrooms is going high in the west, this is a perfect opportunity for Indian Farmers and entrepreneurs to start thinking seriously about mushroom farming in India.

Figure-3: World mushroom production share and India's position



Source: Directorate of Mushroom Research (ICAR), Solan, India.

5.2. Status of mushroom production in Chhattisgarh

The status of mushroom production in Chhattisgarh, a state in central India, is steadily growing, driven by various initiatives to promote mushroom cultivation as a sustainable livelihood option and nutritional supplement for rural communities. While Chhattisgarh may not be among the top mushroom-producing states in India, it has shown promising developments in recent years.

It seems there's a growing demand for mushrooms in Chhattisgarh, particularly in urban centers like Bilai, Durg, Raipur, and Bilaspur. While there have been some mushroom cultivation farms established in the state in recent years, they are not sufficient to meet the local demand. This presents a significant opportunity for mushroom growers and producers to expand their operations and cater to the needs of hotels, restaurants, malls, and supermarkets in the region.

The fact that establishments like Grand Dhillon, Baby loan, Malls, and Big Bazaar are purchasing 200 to 250 kg of mushrooms per day from nearby states like Odisha and Madhya Pradesh indicates a substantial market potential within Chhattisgarh itself. By enhancing local mushroom production and supply chains, you can not only meet the existing demand but also potentially capture additional market share and reduce dependence on imports from neighboring states.

Investing in mushroom cultivation infrastructure, such as climate-controlled facilities and efficient distribution networks, can help increase local production capacity and ensure consistent supply to meet the requirements of hotels, restaurants, and retailers. Collaborating with local

farmers, businesses, and government agencies to promote mushroom cultivation and consumption can also contribute to the growth of the industry in Chhattisgarh.

Moreover, emphasizing the freshness and quality of locally grown mushrooms can be a selling point for attracting customers who prefer locally sourced ingredients. By addressing the gap between demand and supply within the state, you can create a more sustainable and economically viable mushroom industry in Chhattisgarh while supporting local businesses and communities.

Several factors contribute to the growth of mushroom production in Chhattisgarh:

Government Initiatives: The state government, along with various agricultural departments and agencies, has implemented schemes and programs to encourage mushroom cultivation among farmers. These initiatives often include training sessions, subsidies on inputs, and technical support to promote mushroom farming as an alternative income source.

Agricultural Diversity: Chhattisgarh's diverse agro-climatic conditions provide suitable environments for mushroom cultivation. With abundant agricultural waste available as substrates, such as rice straw and sugarcane bagasse, farmers have the raw materials necessary for mushroom cultivation.

Rural Entrepreneurship: Mushroom cultivation has emerged as a viable option for rural entrepreneurship in Chhattisgarh. Small-scale mushroom farms are increasingly being set up by farmers and rural entrepreneurs, contributing to local economic development and employment generation.

Research and Development: Research institutions and agricultural universities in Chhattisgarh are actively involved in conducting research and development activities related to mushroom cultivation. This includes the development of high-yielding mushroom strains, innovative cultivation techniques, and value-added mushroom products.

Market Opportunities: Growing consumer awareness about the nutritional benefits of mushrooms has led to increased demand in local and regional markets. Additionally, Chhattisgarh's proximity to major urban centers provides access to lucrative markets for fresh and processed mushroom products.

Despite these positive developments, challenges such as limited access to quality spawn, lack of infrastructure for post-harvest handling and processing, and inadequate market linkages remain areas that need attention to further enhance mushroom production in Chhattisgarh. However,

with continued government support, investment in research and infrastructure, and capacity-building efforts, the state has the potential to significantly contribute to India's mushroom industry.

6. Prospects and Opportunities for Mushroom Cultivation in India

India is not a major producer of any of the mushroom varieties, but it does cultivate all edible and medicinal mushrooms in one or other part, due to its diverse climatic conditions. Mushrooms can make a valuable dietary and can play an important role in contributing to the livelihoods of rural and peri-urban dwellers, through food security and income generation. The current scenario of mushroom production in India is quite encouraging with an overall increase in 5 to 6 folds and was estimated to cross 50,000 tons [17]. India has rich genetic resources of edible mushrooms its need for conservation and utilization for sustained production. Further, India has diverse climatic conditions in different regions and possible to cultivate many varieties of mushrooms [11]. Successful mushroom cultivation for trade requires to working in joint natures or partnership with regional agro-industries, universities or wholesalers can help reduce vulnerability ([16]. The development of R&D, infrastructure facilities and distribution network provides the greater scope for marketing of fresh mushrooms. The marketing of fresh mushrooms would determine the future of the mushroom industry in India. The awareness and knowledge about nutritional and medicinal values of mushrooms will increase the production and consumption of mushroom in India. From a dietary perspective, mushrooms are a particular food in vegetarian-predominant in India. With a domestic population of more than one billion, India itself is a large market for mushroom. The quality mushroom spawn, modern cold storage facility and well-equipped processing units are facilitated the mushroom production. The technology can be profitably considered in rural and urban areas where land is a limiting factor and chiefly available of agro-wastes.

However, mushroom cultivation also provides opportunities for improving the sustainability of small farming systems through their cycling of organic matter and then returned to the land as fertilizer. India has a good combination of both the technical and non-technical manpower needed to operate the mushroom growing activities. Mushroom cultivation is based on recycling of agricultural residues, which are available in huge quantities in every corner of the country. India is a largely agricultural country and producing a huge quantity of agro-wastes every year approximately 620 million tons [15]. Agro-waste includes crop waste, animal waste (manure) and food processing wastes. A total of 50% of agricultural residues are produced by rice, wheat and oilseed crops [13]. India produces approximately 130 million tones of paddy straw of which

only about half is used for fodder and 50 million tons of cane trash. During rice and wheat harvesting and milling three types of residues is formed viz., straw, husk, and bran, which are used as a cattle feed, packing material, heating, cooking fuel and cooking oil. Direct incorporation of paddy straw increases methane emission from the irrigated fields and impact global warming [12]. Black carbon emission from biomass burning, is the second largest contributor to the current global warming. In the past, the entire paddy and wheat straw was burned by the Indian farmers but nowadays it is being converted as a bio-renewable source. Other predominant agro wastes are maize, cotton, millets, pulse, sunflower and other stalks, bulrushes, groundnut shells, coconut trash, vegetable residue, coir dust, husk, dried leaves, pruning, coffee husk, tea waste. Total of 39 residues from 26 crops, those agro wastes are the valuable substrate for mushroom production and organic manure forming. To initiate the farmers towards bioorganic farming at a commercial scale which could be profitable to the rural society [14]. At present the areas with Rice- Wheat cropping system of India is facing tough challenge to handle the mounting crop residues. Mushroom cultivation can effectively utilize these agro residues for production of protein rich food and plays crucial role in management of these agro residues. The supply and demand gap in the world trade of mushrooms and the shrinkage of production in western countries due to high labor costs would result in better market prices for Indian mushroom producers.

With a domestic population of more than 1.3 billion, India itself is a large market for mushrooms. To be successful in both domestic and export market it is essential to produce quality fresh mushrooms and mushroom fortified value added products at competitive rates without any agro chemical residues. Efforts should also be made to exploit the commercial utilization of mushroom substrate left after cultivation for preparation of organic manure, vermin compost, briquettes, etc.

Recently, unemployment is increasing rapidly both in developed and developing countries. In this situation, self-employment can be one important way to increase employment. Mushroom processing and storage can be another option of an enterprise as this is labor consuming and skill oriented. Mushroom cultivation not only provides a gainful employment to Indian rural youths, but the cost of mushroom production per unit area will be greatly reduced [5]. Mushroom cultivation and consumption trend in India, the government of India took several steps for its sustainable development. Also, encourages entrepreneurs and business houses to set up high technology farms as industrial ventures and the plan called 100% export oriented units. The policy initiatives triggered a good response from entrepreneurs/investors and several firms established integrated units at different locations by imported technologies. However, India lags

behind many European and Asian countries in the generation of newer production technologies, their refinement, popularization and adoption by farmers.

7. Conclusion

While mushroom cultivation in India is still in its early stages, its potential to enhance rural livelihoods through economic, nutritional, and medicinal contributions cannot be overstated. Despite only a small percentage of the farming population currently engaged in small-scale seasonal production, mushroom cultivation offers a reliable and efficient means for resource-poor cultivators to grow nutritious food in a short period of time. Furthermore, it presents an opportunity to generate a highly tradable commodity, thereby contributing to income generation and economic empowerment. The immense potential for mushroom production in the region extends to all edible and medicinal varieties, paving the way for the growth of entrepreneurs and improving the living standards, especially of rural communities. Various schemes initiated by organizations like the Mission for Integrated Development of Horticulture (MIDH) and financial institutions like NABARD provide crucial financial assistance for improving living standards through mushroom cultivation. Mushroom cultivation not only serves as a pathway for sustainable agripreneurship but also integrates seamlessly into the Integrated Farming System, complementing primary agriculture and generating additional income through the utilization of agricultural byproducts. As India continues to explore and harness the full potential of mushroom cultivation, it holds the promise of driving inclusive growth and prosperity across rural landscapes.

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