**EDIBLE MUSHROOMS: A PATH TO INDIA’S SELF-SUFFICIENCY BY 2047**

**Abstract:**

**This review investigates the role of edible mushrooms in promoting India's self-sufficiency and long-term growth by 2047. Mushrooms are a high in nutrients and environmentally friendly food source that contributes to food security, rural development, and ecological balance. Innovations in growing techniques have increased production and economic viability, making mushroom farming a viable agricultural industry. However, challenges such as inadequate infrastructure, market limitations, and a lack of awareness hinder its full potential. This study underscores the need of policy-driven assistance, such as financial incentives, research improvements, and market growth plans, for integrating mushrooms into conventional agriculture. By addressing these challenges and promoting innovation and entrepreneurship, the mushroom industry can strengthen economic sustainability and contribute to global environmental efforts.**

**Keywords:** Edible mushrooms, Self-reliance, Sustainable development, Economic growth, Food security, Mushroom cultivation

**1. Introduction:**

India’s Vision for 2047 India, known for its rich cultural heritage and diversity, stands at a pivotal moment in its quest for self-reliance. As the nation approaches 2047, marking a century since its independence, the ambition to achieve economic self-sufficiency while prioritizing sustainability has become increasingly urgent. To realize these goals, India must explore various sectors that can drive economic growth, ensure food security, and promote environmental care. Among these sectors, the edible mushroom industry has emerged as an unexpected yet powerful player, holding significant potential to reshape the agricultural landscape and contribute meaningfully to the vision of self-reliance by 2047.

Mushroom Industry: A Rising Star in Agriculture Traditionally, mushrooms in India were viewed as a niche product, enjoyed primarily in certain regions or culinary practices. They were often considered a delicacy or luxury item, available only in select markets(Royse & Schisler, 1980). However, this viewpoint has shifted, and today, the mushroom industry is becoming a crucial part of India’s agricultural framework. Mushrooms are no longer just a culinary novelty; they are now acknowledged for their considerable nutritional and economic benefits(Adetunji et al., 2022; Das et al., 2021; Painuli et al., 2020).

The mushroom industry in India stands out for its capacity to create significant economic opportunities, particularly for rural communities. Since mushrooms can be grown in limited spaces and require less investment than conventional crops, they offer an ideal solution for small-scale farmers. Additionally, mushrooms have quick cultivation cycles, allowing farmers to harvest and sell them more frequently, thus providing a reliable income stream(Balan et al., 2022). This accessibility makes mushroom farming an appealing option for those in rural and peri-urban areas, aligning with India’s broader objectives of poverty alleviation and rural development.

Nutritional and Medicinal Benefits of Mushrooms: Mushrooms are often called the "meat of the vegetable world" because they are high in protein and offer numerous health benefits(Kulkarni et al., 2022; Kumar & Netam, 2022). They are packed with essential vitamins and minerals, including B-vitamins, vitamin D, selenium, potassium, and antioxidants, all of which support overall health and well-being. Additionally, mushrooms provide important dietary fibers and are low in calories, making them a great addition to a balanced diet(Valverde et al., 2015).

Beyond their nutritional advantages, mushrooms possess a variety of medicinal properties. Certain types, like *Ganoderma lucidum (Reishi)* and *Pleurotus (Oyster),* are recognized for their immune-boosting, anti-inflammatory, and anti-cancer effects. These bioactive compounds have been acknowledged in traditional medicine systems, such as Ayurveda, as well as in modern medical research for their potential to address chronic diseases and enhance overall health. By encouraging the cultivation and consumption of medicinal mushrooms, India can address widespread health challenges like malnutrition and non-communicable diseases, aligning with its public health improvement goals as part of its self-reliance strategy(Owusu-Kwarteng et al., 2024).Economic Empowerment through Mushroom Cultivation Mushroom farming has emerged as a promising business, particularly for small-scale farmers and marginalized communities. With minimal land requirements and the ability to utilize agricultural waste as a growing medium, mushroom cultivation is a cost-effective option that supports India’s vision of sustainable agriculture. Farmers can turn organic waste like straw, sawdust, and other agricultural by-products into substrates for mushroom growth, fostering a circular economy that reduces waste and lessens environmental impact.Mushroom farming can seamlessly fit into current agricultural practices, providing farmers with an extra income stream without interfering with their traditional crops. This is especially advantageous for women and marginalized groups, who often have limited access to resources and land. Mushroom cultivation can be carried out in small areas, even within homes, allowing these groups to boost their household income and achieve financial independence. This not only creates opportunities for rural communities but also generates jobs, improves livelihoods, and encourages local entrepreneurship—essential elements of India’s vision for self-reliance. Environmental Stewardship and Sustainability As India faces ongoing environmental issues like deforestation, soil degradation, and water scarcity, the mushroom industry presents a sustainable alternative to traditional farming methods. Growing mushrooms requires less land and water than many other crops, making it an environmentally friendly agricultural choice. Additionally, mushrooms are crucial for biodegradation, as they can decompose complex organic materials and return them to the ecosystem.This myco-remediation process, which utilizes fungi to cleanse contaminated environments, provides an innovative solution to combat environmental pollution. Certain mushroom species can absorb heavy metals and break down pollutants in the soil, further aiding in environmental conservation. By integrating mushroom farming into India’s agricultural strategy, the country can lessen its environmental impact while tackling the intertwined issues of food security and sustainability.

The future of mushroom farming in India is closely tied to the integration of modern technology and innovative practices. With more investment in research and development, India can improve its standing in the global mushroom industry, accessing international markets and positioning itself as a key exporter of both fresh and processed mushroom products.

**2. Nutritional Content of Common Mushroom Species:**

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| --- | --- | --- | --- | --- | --- | --- | --- |
| Nutrient | *Shiitake* | *Maitake* | *Reishi* | *Lion’s Mane* | *Morel* | *Enoki* | *Oyster* |
| Calories (per 100g) | 34 kcal | 31 kcal | 56 kcal | 22 kcal | 90 kcal | 37 kcal | 33 kcal |
| Carbohydrates (g) | 6.8 g | 6.1 g | 12 g | 3.7 g | 14.7 g | 7.6 g | 6.1 g |
| Protein (g) | 2.2 g | 1.9 g | 1.8 g | 2.4 g | 3.1 g | 2.6 g | 2.3 g |
| Fiber (g) | 2.5 g | 2.7 g | 9 g | 2.4 g | 2.8 g | 3.1 g | 2.3 g |

Table 1: Nutritional content of common mushrooms species ((Morales et al., 2017; Salmones et al., 2018; Valverde et al., 2015)

**3. A Look into India's Past: Challenges and Achievements:**

Mushrooms are grown on organic wastes from farms, plantations and factories(Smith, 2022). These otherwise waste byproducts can be profitably recycled to produce value added mushrooms. Currently millions of tons of agricultural wastes like straw, corn cobs, grass, sawdust, sugarcane bagasse, cotton waste, coffee pulp, oil palm waste, water hyacinth plants, coconut husk, tree leaves, branches and logs etc are discarded, burned or dumped which create environmental pollution. These wastes can be used alone or in combination to create mushroom growing substrate. With moderate help and careful management, the very people hungry for food can grow a new food source in the form of cultivated mushrooms (Saratale et al., 2009).A Look into India's Past: Challenges and Achievements:To fully appreciate the significance of mushrooms in India's future, it is essential to glance back at the nation's historical journey. From the time of independence to the present, India has encountered numerous obstacles that have hampered its progress. Population growth, poverty, environmental degradation, and an overwhelming dependence on conventional agriculture have presented formidable challenges. However, India has also experienced moments of triumph, with advancements in science, technology, and industry propelling the nation forward.As India strives to overcome its past limitations and build a self-reliant future, it must embrace innovative approaches that redefine its economic, social, and environmental paradigms. The mushroom industry, with its sustainable practices and potential to uplift marginalized communities, offers a beacon of hope in this transformative process(Johnson, 2023).

**4. The Promise of Mushrooms: Nutritional and Medicinal Advantages:**

Mushrooms, often referred to as the "meat of the vegetable world," possess a wide array of nutritional benefits that make them a valuable addition to the Indian diet. Low in calories, fat-free, and rich in protein, vitamins, and minerals, mushrooms can play a significant role in addressing malnutrition and enhancing food security(Gupta, 2024). The inclusion of mushrooms in everyday meals can improve public health, especially in vulnerable populations.Furthermore, mushrooms are a treasure trove of medicinal properties, with many species known for their immune-boosting, anti-inflammatory, and anti-cancer properties(Chen et al., 2016). Traditional medicine systems in India, such as Ayurveda and Unani, have long recognized the therapeutic potential of certain mushrooms, and modern scientific research continues to uncover their healing capabilities(S. Verma et al., 2023).

**5. Environmental Stewardship: Mushrooms as Agents of Sustainability:**

As the world grapples with climate change and its devastating consequences, finding sustainable solutions is imperative. Conventional agriculture often entails deforestation, excessive water consumption, and the use of chemical fertilizers and pesticides(Okuda, 2022). In contrast, mushroom cultivation offers a sustainable alternative that can alleviate some of these environmental burdens.Mushrooms can be grown on various waste materials, including agricultural residues, sawdust, and spent coffee grounds, effectively converting these organic wastes into nutritious food(Grimm & Wösten, 2018; Okuda, 2022). Their cultivation requires less land and water compared to traditional crops, making them an environmentally friendly option. Additionally, the process of myco-remediation, wherein certain mushrooms can help clean up contaminated soils, presents an innovative way to address environmental pollution.

**6. Empowering Rural India:**

Mushroom Cultivation as a Livelihood Opportunity: One of the most significant advantages of mushroom cultivation lies in its ability to empower rural communities. India's agrarian landscape hosts a vast workforce, and yet, many farmers struggle to earn a sustainable income. Integrating mushroom cultivation into traditional farming practices can provide an additional source of revenue while reducing dependence on unpredictable weather conditions and crop failures.Mushroom cultivation is relatively simple and requires minimal investment, making it accessible to small-scale farmers and marginalized groups. Women, in particular, can benefit from mushroom farming as it can be carried out at or near their homes, allowing them to balance household responsibilities while contributing to the family income.

**7. The Roadmap to 2047: Nurturing the Mushroom Industry:**

To realize the full potential of mushrooms in achieving self-reliance by 2047, India must undertake a strategic roadmap that fosters the growth of the edible mushroom industry. This entails several key components:

**a) Research and Innovation**

**b) Infrastructural Development**

**c) Education and Training**

**d) Policy Support**

**e) Market Development**

**a) Research and Innovation:** Research and innovation are crucial in unleashing the full potential of edible mushrooms for India's future and achieving self-reliance by 2047 (. India's diverse regions offer a rich biodiversity of mushrooms, yet many indigenous species remain untapped in terms of commercial viability. Investing in R&D enables scientists to study and identify native mushrooms suitable for cultivation.Systematic research evaluates the nutritional content, flavor profiles, and cultivation suitability of these native species. Identifying mushrooms suitable for specific agro-climatic zones optimizes resource utilization and empowers farmers with locally available species. R&D also improves cultivation techniques, substrate formulations, and environmental conditions for better yields and quality.Innovations in cultivation techniques enhance productivity and cost-effectiveness, making mushroom farming financially viable for small-scale farmers and aiding rural development. Moreover, R&D uncovers bioactive compounds in mushrooms with potential medicinal benefits, such as immunomodulatory and antioxidant properties, enhancing public health and pharmaceutical development.Investment in R&D also addresses industry challenges, like disease resistance and post-harvest handling. Additionally, R&D contributes to value-added mushroom products, expanding the industry and creating new markets (Udheer et al., 2021). Emphasizing research and innovation is pivotal in propelling India's mushroom sector towards self-reliance and prosperity.

**b) Infrastructural Development:** Infrastructural development is a crucial aspect in India's journey towards achieving self-reliance, especially in the mushroom industry. By establishing modern mushroom farms and processing units across the country, India can create a robust supply chain that ensures the consistent delivery of high-quality mushroom products to consumers (Udheer et al., 2021). Modern mushroom farms equipped with advanced technology can boost yield and efficiency, strategically located in different regions with favorable agro-climatic conditions for specific mushroom species.Decentralizing mushroom farming reduces transportation costs, minimizes post-harvest losses, and ensures fresher produce. Coupled with processing units near the farms, value-added mushroom products like dried mushrooms, canned mushrooms, and medicinal extracts can be prepared, enhancing shelf life and generating higher returns (Udheer et al., 2021). A well-developed mushroom infrastructure also maintains a steady supply of mushrooms throughout the year, overcoming seasonal fluctuations and promoting better nutrition and health by encouraging their integration into daily diets.The growth of the mushroom industry can have a cascading effect on other sectors, creating demand for raw materials and generating employment opportunities in rural areas, thus contributing to social and economic development (Salmones et al., 2018). To facilitate infrastructure development, India can consider public-private partnerships, government subsidies, and financial support.Learning from successful models in other countries like China, the United States, and the Netherlands can provide valuable insights into how strategic investments in mushroom farming and processing facilities can stimulate economic growth and enhance food security (Li & Xu, 2022). Prioritizing the expansion and modernization of mushroom infrastructure will not only strengthen India's position in the global mushroom trade but also reduce import dependency and generate export revenue. In this way, India can propel itself towards self-reliance, leveraging the transformative potential of the mushroom industry.

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| **Country** | **Per capita consumption/annum (Kg/annum)** | **Reference** |
| Australia | 3.0 | (*No Title*, n.d.-a) |
| Belgium | 3.3 | (Desrumaux, 2001) |
| Canada | 1.6 | (*No Title*, n.d.-b) |
| Germany | 2.9 | MFPI (India) –report |
| India | 0.05-0.075 | (B. L. D. and R. N. Verma, 2001) |
| Iran | 0.250 | Iran Daily, Sept 8, 2005 |
| Japan | 0.674 | Mushworld.com, Feb 2006 |
| Latin Amercia | 0.125 | (Martinez-Carrera, 2002) |
| Mexico | 4.80-7.53 | (Martinez-Carrera,-D;Aguilar,-A; Martinez,-W; Morales,-P; Sobal,-M; Bonilla, 1998) |
| New Zealand | 2.0 | Peter K Buchanan and John Barnes. The Mushroom Industry in New Zealand –ISMS 2001 |
| South Cameroon | 1.1-1.4 | (Dijk,-H-yan; Onguene,-N-A; Kuyper, 2003) |
| Spain | 1.0 | Strategic Plan of the Mushroom Sector in the Region of 'La Manchuela' ISMS-2001 |
| USA | 1.78 (2003) | [www.ers.usda.gov](http://www.ers.usda.gov) |
| Western Europe | 3.0 | Hans Megens. Western fresh mushroom market key drivers and impact on chain value. ISMS-2001 |
| Zimbabwe | 1.8 (wild) | [www.fao.org](http://www.fao.org) |

Table 2: Mushroom consumption data

**c) Education and Training:** Education and training are integral to achieving self-reliance in India's mushroom industry. By imparting knowledge and skills in cultivation, processing, and marketing, education empowers farmers and entrepreneurs to adopt sustainable practices, drive innovation, and explore economic opportunities (NAYAK et al., 2022). Educating farmers about mushroom cultivation techniques enables them to diversify income sources and utilize marginal land. With a short cultivation cycle, mushrooms provide a quicker income turnaround compared to traditional crops, reducing reliance on single-crop farming and mitigating market risks. Training programs also nurture entrepreneurship in the mushroom sector. Aspiring entrepreneurs can benefit from specialized training in cultivation, business management, and marketing, leading to job creation, especially in rural areas. Successful mushroom businesses contribute to local economic development and empower communities by providing livelihood opportunities. Education drives innovation and research, keeping farmers and entrepreneurs updated withadvancements in cultivation, processing, and product development. This culture of continuous learning enhances industry efficiency and competitiveness. Research on using agricultural waste materials as substrates for cultivation addresses waste management challenges and lowers production costs. Promoting sustainable practices is another crucial aspect of education and training. Emphasizing resource conservation, waste reduction, and eco-friendly technologies aligns with India's commitment to environmental conservation and climate change mitigation. Adopting sustainable methods enhances the reputation of Indian mushroom products in the global market, attracting environmentally conscious consumers. By investing in education and training, India paves the way for a self-reliant and sustainable future in the mushroom industry.

**Technological Advancements in Mushroom Cultivation:** Technological innovations are revolutionizing mushroom cultivation, making it more efficient and sustainable. **Modern cultivation technologies have greatly improved the yield, efficiency, and sustainability of the mushroom industry. By controlling temperature, humidity, CO₂ levels, and light using automated HVAC systems** (Subashini et al., 2024)**, Internet of Things-based monitoring, and fogging systems, climate-controlled farming guarantees year-round output, avoiding crop failures caused by climate change and enhancing quality control. Through the use of multi-tier racks, LED-based light optimisation, and automated nutrient delivery, vertical farming optimises space efficiency, minimising land requirements and enabling urban farming. By substituting nutrient-rich water solutions, fortified bioactive compounds, and microbial bioreactors for conventional substrates, hydroponic and substrate-based techniques further maximise growth while enhancing scalability and nutritional value** (Irwanto et al., 2024)**. AI-powered robotic arms, sorting devices, and cold chain logistics are examples of automation in harvesting and processing that lowers labour costs, minimises post-harvest losses, increases shelf life, and improves marketability** (Sangeeta et al., 2024). Adopting these technologies can significantly boost India's mushroom production, ensuring consistent quality and higher profitability.

**While large-scale mushroom farming is widely regarded as sustainable, it presents several environmental challenges that must be managed effectively. The high demand for organic substrates such as straw and sawdust leads to significant waste generation, and improper disposal of spent mushroom substrate (SMS) can cause soil degradation and water contamination** (Jayaraman et al., 2024)**. Additionally, large-scale indoor farming requires substantial water and energy inputs, with HVAC systems, humidifiers, and artificial lighting increasing carbon footprints. The excessive use of pesticides, fungicides, and chemical disinfectants in commercial production poses risks of soil and water contamination, necessitating eco-friendly alternatives like integrated pest management (IPM) and biological control agents. Moreover, organic decomposition in mushroom farms emits greenhouse gases such as methane (CH₄) and carbon dioxide (CO₂), impacting air quality and contributing to climate change, which can be mitigated by aerated composting and carbon sequestration techniques. Large-scale expansion may also lead to deforestation, biodiversity loss, and habitat destruction, which can be minimized by vertical farming and agroforestry integration. Furthermore, dense cultivation environments increase the risk of pathogen proliferation and contamination, affecting surrounding ecosystems and agricultural lands, requiring strict biosecurity measures, controlled airflow systems, and sanitation protocols. Addressing these risks with sustainable practices and regulatory policies is crucial to ensuring that large-scale mushroom farming remains both economically viable and environmentally responsible.**

**Economic Impact and Success Stories in Mushroom Farming: Mushroom growing has grown as a viable enterprise in India, with considerable benefits for rural employment, economic growth, and food security** (Jayaraman et al., 2024)**. The worldwide mushroom market is predicted to reach $90 billion by 2028, with India's sector expanding at a CAGR of 9-10%, driven by rising demand for medicinal mushrooms and functional foods. Due to low input costs and short growing cycles, small-scale farmers that cultivate mushrooms can earn 30-40% more than conventional crops. India's mushroom exports, worth at ₹50-60 crore yearly, are gaining popularity in countries such as the US and Europe. Real-world examples demonstrate the industry's effect. Solan, Himachal Pradesh—known as "The Mushroom City of India"—produces over 25,000 metric tonnes each year, creating thousands of jobs and bolstering the local economy. In Odisha, government-sponsored training programs have allowed rural women to create oyster mushroom farms, raising household earnings by 40-50% and promoting financial independence** (Dagar & Tewari, 2017)**. Tamil Nadu farmers have effectively combined climate-controlled farming with IoT-based monitoring systems, resulting in 20% greater yields and lower post-harvest losses** (K. et al., 2025)**. Furthermore, China, the world's largest mushroom grower, provides a model for India to follow, emphasising government-supported cooperative arrangements and financial incentives to increase output and improve rural lifestyles** (Zhang et al., 2014)**. These success stories demonstrate the enormous potential for mushroom cultivation to revolutionise India's agricultural and economic environment.** Learning from these examples, India can adopt best practices and tailor them to local conditions, ensuring sustainable growth and self-reliance in the mushroom industry.

**Raising public awareness about mushroom farming is essential for boosting consumption, encouraging entrepreneurship, and promoting its environmental and economic benefits. Educational campaigns through social media, television, and print media can highlight the nutritional and medicinal advantages of mushrooms, making them more appealing to consumers** (Khan et al., 2024)**. Incorporating mushroom cultivation into school and college curriculums can inspire young entrepreneurs and future farmers to explore mushroom farming as a viable business. Hosting workshops, training programs, and farmer awareness drives in rural areas can provide hands-on learning experiences, demonstrating the ease and profitability of mushroom cultivation** (Kavitha et al., 2019)**. Government and NGO-led initiatives, such as subsidized training programs and financial incentives, can motivate small-scale farmers to adopt mushroom farming. Engaging influencers, chefs, and nutritionists to promote mushroom-based recipes and dietary benefits can further drive consumer interest. Organizing mushroom festivals, exhibitions, and farm visits can familiarize the public with different varieties and cultivation techniques. Additionally, leveraging e-commerce and digital platforms to educate consumers about mushroom products through blogs, videos, and live demonstrations can help expand market reach. Mushroom growing in India presents major storage and transportation issues due to the perishable nature of mushrooms, insufficient cold chain infrastructure, and logistical inefficiencies. Fresh mushrooms have a shelf life of about 1-3 days at room temperature, thus they must be refrigerated right away to retain freshness** (Sharma et al., 2024)**. However, restricted availability to cold storage facilities, particularly in rural regions, causes significant post-harvest losses. Small-scale producers face significant expenditures for refrigeration and processing machines, making it difficult to extend shelf life or transport mushrooms across vast distances. The lack of adequate cold chain logistics causes severe spoiling during transportation, particularly in hot and humid climates. Poor road infrastructure and transit delays compound the situation, lowering mushrooms' marketability in big cities. To address these challenges, investments in affordable, decentralized cold storage units, mobile refrigeration solutions, and government-supported cold chain networks are crucial. Additionally, the adoption of value-added processing techniques such as drying, freezing, and canning can help extend shelf life and reduce wastage. Strengthening cooperative farming models and supply chain integration can improve bulk transportation efficiency, reducing costs for small-scale producers. By addressing these storage and transport limitations, India can enhance the profitability and sustainability of its mushroom industry while ensuring a steady supply to domestic and international markets. By implementing these strategies, mushroom can gain broader acceptance, driving both production and consumption while contributing to sustainable agriculture.**

**d) Policy Support:** The Indian government has introduced several policies and support programs aimed at promoting mushroom cultivation, recognizing its potential for economic growth and food security. These include subsidies on spawn, compost, and equipment, as well as low-interest loans for setting up mushroom farms. The National Horticulture Board and the Ministry of Agriculture and Farmers' Welfare have been instrumental in providing training and resources to farmers. However, there is a need for more targeted policies that address regional challenges and provide better market linkages. Enhancing the availability of quality spawn, establishing cold storage facilities, and incentivizing research on indigenous mushroom species could further accelerate the industry's growth.

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| **Year** | **Policy/Initiative** | **Description** |
| 1886 | Initial Cultivation Trials | N.W. Newton exhibited mushroom specimens at the annual show of Agriculture, Horticulture Society of India. |
| 1921 | Research on AgaricusSpecies | Bose successfully cultured two Agaricus species on sterilized dung media, published in the Indian Science Congress in 1926. |
| 1939-1945 | Experimental Cultivation of Paddy Straw Mushroom | The Department of Agriculture, Madras, began experimental cultivation of Volvariella mushrooms. |
| 1947 | Improved Cultivation Techniques | Thomas and colleagues detailed cultivation methods for paddy straw mushrooms in Madras, enhancing yield by adding red powdered dal to beds. |
| 1961 | Development of Mushroom Cultivation in Himachal Pradesh | Himachal Pradesh government, in collaboration with ICAR, initiated a scheme for cultivating Agaricusbisporus at Solan. |
| 1965 | Modernization of Mushroom Cultivation | Dr. EFK Mantel guided the Department of Agriculture in constructing a modern spawn laboratory and air-conditioned mushroom house, improving compost preparation and environmental control. |
| 1977-1982 | UNDP Mushroom Development Project | The Department of Horticulture (H.P.) launched a project with UNDP, constructing a bulk pasteurization chamber and providing ready compost and casing soil to growers. |
| 1982 | Establishment of National Centre for Mushroom Research and Training (NCMRT) | ICAR established NCMRT to conduct research on mushroom production, preservation, and utilization, and to train scientists, teachers, extension workers, and growers. |
| 1983 | All India Coordinated Mushroom Improvement Project (AICMIP) | ICAR sanctioned AICMIP with centers in various states to improve mushroom cultivation techniques and production. |
| 2000 | National Horticulture Mission | The mission included mushroom cultivation as a high-value crop, providing subsidies and support for mushroom growers. |
| 2005 | National Mushroom Development and Training Centres | Establishment of training centers across states to promote mushroom cultivation and provide technical training to farmers. |
| 2010 | Rashtriya Krishi Vikas Yojana (RKVY) | Funding and support under RKVY for mushroom cultivation projects to boost rural incomes and agricultural diversification. |
| 2013 | National Food Security Mission (NFSM) | Included mushroom cultivation under its initiatives to improve food security and provide additional income sources for farmers. |
| 2016 | Pradhan Mantri Kaushal Vikas Yojana (PMKVY) | Skill development programs for youth in mushroom cultivation techniques, aimed at creating employment opportunities in agriculture. |
| 2020 | Atmanirbhar Bharat Abhiyan | Focused on promoting local industries, including mushroom farming, through financial incentives, training programs, and infrastructure development to enhance self-reliance and reduce dependency on imports. |

Table 3: Market Development and Policy Support

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| **Year** | **Private Sector Role** | **Description** |
| 1920s | Initial Cultivation and Marketing | Early private growers in India began cultivating and marketing mushrooms locally, laying the foundation for commercial mushroom farming. |
| 1950s | Introduction of Modern Techniques | Private companies started adopting and promoting modern cultivation techniques, including the use of pasteurized compost and controlled environment facilities. |
| 1960s | Spawn Production and Supply | Private sector firms began producing and supplying quality mushroom spawn, reducing dependency on government laboratories. |
| 1970s | Commercial Mushroom Farms | Establishment of large-scale commercial mushroom farms by private entrepreneurs, particularly in states like Himachal Pradesh and Haryana. |
| 1980s | Processing and Export | Private companies ventured into mushroom processing (canning, drying) and export, expanding the market beyond domestic consumption. |
| 1990s | Collaboration with Research Institutions | Private sector collaborated with research institutions like ICAR for developing high-yielding strains and improved cultivation practices. |
| 2000s | Retail and Supermarket Chains | Growth of retail chains and supermarkets led to increased demand for fresh mushrooms, encouraging private growers to expand production. |
| 2010s | Innovation and Technology Adoption | Introduction of advanced technologies like automated climate control, improved packaging, and logistics by private companies to enhance quality and shelf-life of mushrooms. |
| 2020s | E-commerce and Direct-to-Consumer Models | Rise of e-commerce platforms and direct-to-consumer sales channels facilitated by private companies, providing consumers with easier access to a variety of mushroom products. |
| Ongoing | Sustainable Practices and CSR Initiatives | Private sector focusing on sustainable cultivation practices and corporate social responsibility (CSR) initiatives to support rural communities and promote environmental sustainability. |

Table 4: Role of private sector in mushrooms industry

Achieving self-reliance in India's mushroom industry hinges on policy support that incentivizes cultivation and promotes sustainable practices . Supportive policies create an environment for the industry to thrive, leading to increased production, improved quality, and a flourishing market for mushroom products. Financial incentives play a crucial role in encouraging mushroom cultivation. Subsidies on inputs such as spawn, substrate, and equipment reduce production costs, making mushroom farming financially viable. Low-interest loans and grants for setting up mushroom farms attract investments, especially from small farmers. Government support for research and development (R&D) drives innovation in cultivation techniques, product development, and post-harvest handling. Funding research projects and collaborations between institutions and the private sector lead to improved varieties and sustainable methods. Capacity building and training programs are vital for the widespread adoption of modern and sustainable practices. Such programs provide stakeholders with technical knowledge and skills in cultivation and marketing. Creating market linkages for mushroom producers and processors ensures steady demand and fair prices for their products. Direct connections between producers and consumers, as well as linkages with food processing industries, expand the market reach of Indian mushrooms. Implementing policies that enforce environmental and quality standards ensures industry sustainability and safety. Regulations related to waste management, water usage, and pesticide usage promote environmentally friendly practices. Quality standards for mushroom products enhance consumer confidence. Through strategic policy support, India can nurture a self-reliant and sustainable mushroom industry, bolstering economic growth and contributing to food security and environmental conservation.

**e) Market Development:** Market development is a pivotal aspect in achieving self-reliance for India's mushroom industry, as it opens up economic opportunities, enhances income generation, and strengthens the nation's position in the global mushroom trade.To sustain growth in the domestic market, increasing awareness about the nutritional benefits and culinary versatility of mushrooms is crucial. Organizing marketing campaigns and promotional activities can educate consumers about the value of mushrooms in their diet. Diversifying the range of mushroom products available, such as fresh mushrooms, processed items, and value-added products, caters to diverse consumer preferences. Collaborating with retail chains, supermarkets, and food processors facilitates wider distribution and accessibility of mushroom products across the country (Maity et al., 2020).Exploring international markets presents significant revenue opportunities for India's mushroom industry. The nation's diverse mushroom varieties and favorable agro-climatic conditions can cater to global consumer demands. To penetrate international markets successfully, adherence to international quality standards and certifications is crucial. Implementing food safety and quality assurance practices instills consumer trust and confidence(Birwal, P., Singh, S., & Singh, 2020).Promoting the export of Indian mushroom products contributes to self-reliance by generating foreign exchange earnings. Government policies and support can facilitate export-oriented initiatives through financial assistance for export promotion, market research, and participation in international trade events. Establishing strategic partnerships with importers, distributors, and food service companies in target countries opens new avenues for exporting Indian mushrooms (Phull, S. S., & Sharma, 2017).Developing value-added mushroom products tailored to specific consumer demands is also vital for market development. This includes processed mushroom products like dried mushrooms, canned mushrooms, mushroom powders, and medicinal extracts. Value-added products not only have longer shelf lives but also offer higher economic returns for farmers and processors. The global mushroom market is projected to grow at a CAGR of 9.5% from 2021 to 2028, driven by increasing consumer awareness of their nutritional and medicinal benefits. In India, the mushroom industry is still nascent but rapidly expanding, with a market size of approximately INR 1,200 crore in 2023. Domestic consumption is rising, particularly in urban areas where health-conscious consumers are incorporating mushrooms into their diets. Internationally, Indian mushrooms have potential in markets like the USA, Europe, and Southeast Asia. To capitalize on this, India needs to enhance its production capacity, improve quality standards, and establish strong export channels. By strategically focusing on market development, India's mushroom industry can thrive domestically and globally, contributing significantly to the nation's journey towards self-reliance and prosperity.

**8. Opportunities**:

1. Mushrooms can contribute significantly to the livelihoods of rural and peri-urban dwellers, providing food security and income generation opportunities.
2. Mushroom cultivation offers valuable dietary additions due to their protein content and various micronutrients, and their medicinal properties make it a viable small-scale enterprise option.
3. Mushroom cultivation does not require land access and can provide a steady income throughout the year.
4. Cultivating mushrooms helps overcome challenges faced by wild fungi collectors, such as species identification, access and permits for collecting, and sustainable harvest practices. It is also independent of weather conditions and allows for recycling agricultural by-products as composted substrate and organic mulch.
5. Mushroom cultivation can be combined with traditional agricultural and domestic activities, particularly benefiting disabled individuals, women, and the landless poor, fostering independence and self-esteem through income generation.
6. Successful mushroom cultivation for trade requires good individual or collective organization, and while it can be a viable small-scale business, it entails some investment risks.
7. Cooperatives and community groups can collaborate in setting up and production costs, harvesting, and marketing, reducing vulnerability. Partnerships with agro industries, universities, or wholesalers can also be beneficial.

**9. Constraints/Challenges:**

1. Lack of awareness about the nutritional and medicinal values of mushrooms through mass media.
2. Insufficient awareness of incorporating mushrooms into various programs and meals to address undernourishment and malnourishment.
3. Lack of good quality mushroom spawn laboratories, cold storage facilities, and small-scale processing units in district areas to facilitate mushroom production, processing, and marketing.
4. Low consumer awareness and limited availability for trials, with adverse comparison to more aggressively promoted temperate mushrooms like button mushrooms.
5. Larger scale mushroom cultivation systems can be labor and management intensive and vulnerable to sporadic yields, weed fungi invasions, insect pests, and unreliable market prices.
6. Challenges in transitioning from subsistence mushroom cultivation to commercial production and marketing.
7. Difficulty in maintaining a continuous supply for chosen market outlets, and producers needing to become multi-skilled to manage several enterprises successfully.

**10. Discussion:**

The edible mushroom industry in India has enormous potential to increase self-reliance by 2047, providing several nutritional, medical, and environmental benefits. Mushrooms can assist battle hunger, improve public health, and provide bioactive chemicals for medicinal use. From an environmental standpoint, mushroom farming recycles agricultural waste, uses less land and water, and promotes sustainability. Economically, it strengthens rural communities by increasing revenue and lowering reliance on traditional crops. However, obstacles such as a lack of knowledge, inadequate infrastructure, and restricted market growth must be overcome by strategic investments in research, infrastructure, education, and governmental assistance. **This paper is particularly important to the scientific community since it emphasises the importance of edible mushrooms in sustainable agriculture, food security, and economic development. It lays the groundwork for future study and policy creation by investigating the effects of government policies, technological breakthroughs, and novel agricultural practices. This study, which encourages multidisciplinary collaboration, highlights the importance of incorporating mushroom growing into global sustainability initiatives, contributing to both scientific information and practical applications for a self-sufficient future.**

**11. Conclusion:**

**The edible mushroom business offers considerable opportunities for India's self-reliance and long-term growth. Mushrooms, as a highly nutritious and environmentally friendly food source, help to improve food security, public health, and economic growth, especially by empowering rural people and promoting inclusive development. This study discusses how edible mushrooms might help India achieve self-sufficiency by 2047 by combining sustainability, technical breakthroughs, and policy assistance. To fully realise the potential of this business, it is critical to increase research funding, use new agricultural practices, and provide farmers with education and training. Furthermore, stimulating innovation, establishing strong market links, and enacting supporting government policies will assure long-term success. By embracing the mushroom business as a transformational force, India may develop new economic possibilities, promote environmental sustainability, and increase its agricultural resilience, making a significant contribution.** India can strengthen its path toward self-sufficiency and prosperity, making a significant contribution to the nation's development goals as it approaches the milestone year of 2047 and beyond.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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