Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 28s (2025)
https://www.jneonatalsurg.com

Sustainable Mushroom Cultivation and Development of Value-Added Products from Mushroom Powder in Raipur, Chhattisgarh

Barsha Saraogi[1*], Dr. Sushma Dubey[1]

[*1] PG Scholar Department of Biotechnology, Kalinga University Naya Raipur, (C.G)

[1]H.O.D Department of Biotechnology, Kalinga University Naya Raipur, (C.G)

[*]Corresponding author:

Barsha Saraogi

Email ID: saraogibarsha2000@gmail.com

Cite this paper as: Barsha Saraogi, Dr. Sushma Dubey, (2025) Sustainable Mushroom Cultivation and Development of Value-Added Products from Mushroom Powder in Raipur, Chhattisgarh. *Journal of Neonatal Surgery*, 14 (28s), 648-655.

ABSTRACT

Mushroom cultivation is gaining attention for its nutritional, medicinal, and economic value. This study investigates the feasibility of cultivating Pleurotus ostreatus (oyster mushroom) in Raipur, Chhattisgarh, using locally available substrates. The harvested mushrooms were processed into powder through sun-drying and grinding. Various value-added products—such as natural fabric dyes, skincare formulations, and protein powders—were developed and evaluated for their nutritional and functional properties. Optimal cultivation conditions included 75–80% humidity and temperatures of 18–22°C. Biochemical analysis showed high protein and carbohydrate content. The formulated products were eco-friendly, non-toxic, and showed promise for commercialization. This research supports sustainable agriculture and rural entrepreneurship through mushroom-based innovations.

Keywords: *Mushroom cultivation, mushroom powder, sustainable agriculture, value-added products, Raipur, Chhattisgarh*

1. INTRODUCTION

Mushrooms have long been valued not only as a gourmet food but also for their medicinal and nutritional properties. In recent decades, their role in sustainable agriculture and functional food development has gained significant global attention. The cultivation of edible mushrooms using agricultural residues such as paddy straw, wheat straw, and other lignocellulosic wastes represents one of the most efficient and eco-friendly biotechnological approaches to converting agro-waste into high-value human food (Madan et al., 1987). This method not only promotes circular economy principles by minimizing waste and contributes to rural livelihoods and food security.

Mushrooms are rich in high-quality protein (20–35% dry weight), essential amino acids, dietary fiber, vitamins (particularly B, C, and D), and minerals, while being low in fat and calories (Kalac, 2009; Panjikkaran & Mathew, 2013). Owing to their pleasant taste and characteristic texture, they are widely consumed across cultures. Beyond their culinary appeal, mushrooms have attracted growing interest from the pharmaceutical and nutraceutical industries due to the presence of various bioactive compounds with antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties (Sheu et al., 2007; Mariga et al., 2014).

Processing mushrooms into powder form not only extends their shelf life but also enhances their functional versatility. Mushroom powder can be easily incorporated into a wide range of food products, including baked goods, beverages, and dietary supplements. Studies have shown that mushroom powder can significantly improve the nutritional profile of products by increasing protein, fiber, and mineral content (Sangeeta et al.). It can also serve as a partial substitute for wheat flour or sweet potato flour in biscuits and pastries, improving their sensory and nutritional characteristics. Moreover, such products align with the growing consumer preference for health-promoting, plant-based, and natural foods (Wakchaure et al., 2010; Carrasco Gonzalez et al., 2017; Aishah & Wan Rosli, 2013). Antepartum hemorrhage (APH) has been a leading cause of maternal mortality worldwide, especially in developing countries like India. Its early diagnosis and timely management can APH is defined as bleeding from the genital tract after 28 weeks of gestation to delivery of the baby.[1,2]

Chhattisgarh, known as the "rice bowl of India," offers a unique ecological and agricultural landscape for mushroom cultivation. With 44% of its geographical area covered by forests, the state boasts a rich diversity of macrofungal species, many of which remain underexplored (Singh et al.). The region's favourable climatic conditions, coupled with abundant availability of agricultural residues, make it an ideal location for the sustainable cultivation of mushrooms such as *Pleurotus ostreatus* (oyster mushrooms), *Agaricus bisporus* (white button mushrooms), and *Ganoderma lucidum* (medicinal mushroom). Among these, oyster mushrooms are particularly popular due to their adaptability, rapid growth cycle, and high yield potential.

The Raipur district of Chhattisgarh is witnessing a growing interest in mushroom farming as an eco-friendly and economically viable agribusiness model. With increasing awareness of organic practices and sustainability, mushroom cultivation has the potential to empower smallholder farmers, reduce environmental impact, and generate income through low-cost inputs and high-value outputs.

This study aims to explore the full potential of mushroom cultivation and the development of innovative, value-added products from mushroom powder. By integrating sustainable farming practices with food product development, the research contributes to multiple Sustainable Development Goals (SDGs), including zero hunger, responsible consumption and production, and climate action.

Objectives of the Study-

1. Conduct a survey and collection of mushroom samples in and around Raipur.
2. Develop a sustainable model for mushroom cultivation using locally available agricultural residues.
3. Analyse the biochemical and physicochemical properties of cultivated mushrooms.
4. Produce eco-friendly, non-toxic value-added products from mushroom powder.
5. Optimize production processes for functional food products derived from mushroom powder.

This research contributes to the growing body of knowledge in sustainable agriculture, food science, and biotechnology. By harnessing the potential of mushroom cultivation and powder-based innovations, the study aims to open new avenues for food security, rural entrepreneurship, and environmental sustainability. The findings will be valuable for farmers, researchers, food technologists, and policymakers seeking to promote mushroom farming and value-added agro-industrial products in India.

2. MATERIALS AND METHODS

Study Area

The research is conducted in Tendua, Naya Raipur, Chhattisgarh, which has favourable climatic conditions favourable for mushroom cultivation. The study involves controlled field-based cultivation trials to assess mushroom species growth performance.

Materials

1. Mushroom Species Used: *Pleurotus ostreatus* (Oyster Mushroom)
2. Substrate Preparation: Straw is used as the primary substrate.
3. Spawn Preparation: Pure mycelium cultures of the selected mushrooms are obtained from local agricultural research centres.
4. Cultivation Setup: Polybags are used for substrate filling. Humidity and temperature-controlled rooms are used to maintain optimum growing conditions.

Methodology

1. <u>Mushroom Cultivation</u>: The substrate is washed with formalin and Bavistin to eliminate contaminants. Let it dry until it is partially dry. The bags are incubated in a dark room at optimal temperature(18-22°c) and humidity (75-85%). Mycelial growth is monitored, and after full colonization, the bags are transferred to the fruiting chamber. Regular misting and aeration are provided to promote fruiting. Harvesting is done at different growth stages.

2. <u>Mushroom Powder Production</u>: Fresh mushrooms are cleaned, sliced, and dried in a hot air oven. The dried mushrooms are ground into a fine powder using a mortar and pestle. The powder is sieved and stored in airtight containers to prevent moisture absorption.

3. <u>Product Development</u>: The mushroom powder is used in various innovative food products. Mushroom-based fabric dye is formulated as per Kumar, R., Kumar A. Ramratan, and D. Uttam. Mushroom-Enriched skincare (toner, moisturizer) -these are formulated as per Mohiuddin, Abdul Kader. Innovation is done on the formulation for preparing natural skincare products. Natural ingredients such as glycerine, tea tree essential oil, coconut oil, etc, are used. Mushroom-infused protein powder is dried (sundried) depending on availability and ground into fine powder.

4. <u>Biochemical and physicochemical estimation</u>: Proximate analysis (moisture, protein, and carbohydrate content) was

conducted.

- Protein estimation- Pipette mushroom extract or BSA standard into test tubes and add Reagent C and Folin–Ciocalteu reagent, mix, and incubate. Measure absorbance using a spectrophotometer. Determine the protein content from the standard curve.
- Carbohydrate estimation - Take mushroom extract (or glucose standard) into test tubes and add Anthrone reagent to each tube. Vortex and incubate in a boiling water bath. Cool the tubes. Measure absorbance using a spectrophotometer.
- Moisture estimation- Measure the fresh weight and final weight of the mushroom after drying in a hot air oven. Calculate the moisture content.

3. RESULT

1. Mushroom cultivation: The cultivation of *Pleurotus ostreatus,* commonly known as oyster mushroom, was successfully carried out using locally available wheat and paddy straw as substrates under controlled environmental conditions of Raipur. Optimal mycelial growth was observed within 10–12 days of inoculation, and fruiting bodies were harvested within 21–25 days. The average yield recorded per bag was 1.5 -2kg, which indicates favourable conditions for mushroom growth in the region.
2. Nutritional analysis: The mushrooms were processed into fine powder using the sun drying technique, followed by grinding and sieving. Proximate analysis of the mushroom powder revealed that it contained approximately 25% protein, o.3% fat, and 90% moisture. These values support its application as a high-protein food ingredient.
3. Product development: The mushroom powder was used to develop four innovative products, namely facial toner, moisturizer, fabric dye, and protein powder. The toner showed a skin-friendly pH of 5.4 and exhibited no microbial growth after 30 days of storage & the moisturizer showed good spreadability and moisturizing effect with no signs of irritation in patch tests. The natural fabric dye produced earthy shades on cotton when used with copper sulphate as mordants, with moderate colourfastness, which was observed in wash and light tests. It showed the presence of melanin when qualitatively analysed. The protein powder had a pleasant nutty flavor and can serve as an abundant source of protein when consumed along with a variety of drinks. Comparative evaluation of the developed products with commercial equivalents highlighted the safety and efficacy of the formulations of mushroom-based products. Commercial products contain synthetic additives and preservatives, whereas mushroom-based versions were entirely natural and biodegradable. However, the shelf life of mushroom-based products was slightly shorter due to the absence of chemical stabilizers.

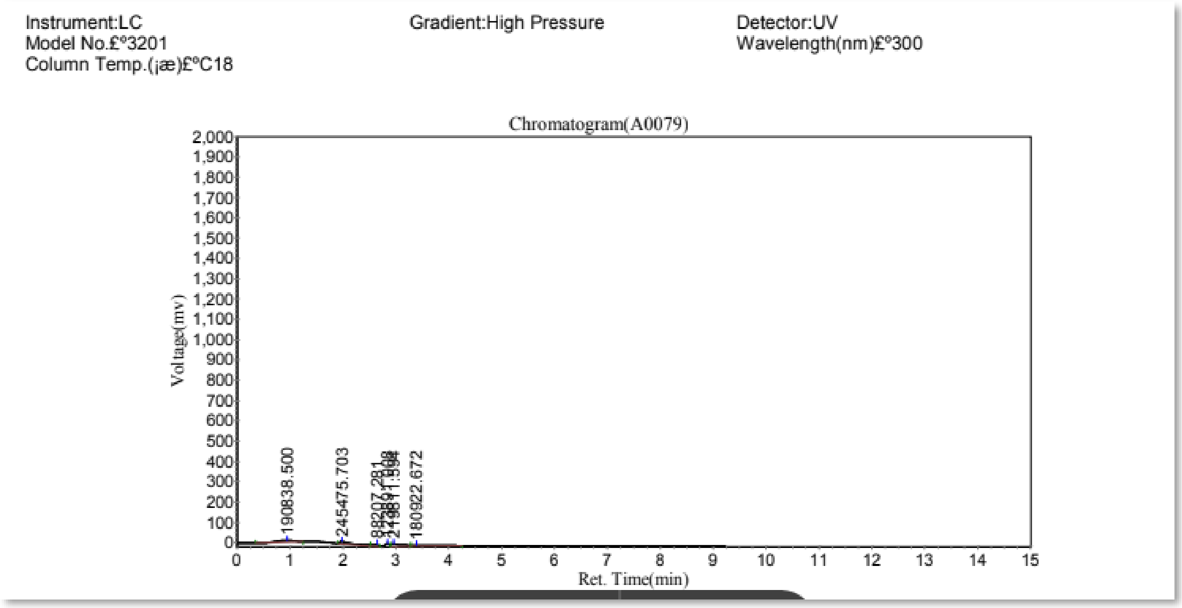

Figure 1. High-Performance Liquid Chromatography (HPLC) chromatogram of the sample recorded using a C18 column at 30°C with UV detection at 300 nm. The chromatogram was obtained under high-pressure gradient conditions, showing multiple peaks between 2 to 4 minutes retention time, indicating the presence of various compounds in the sample.

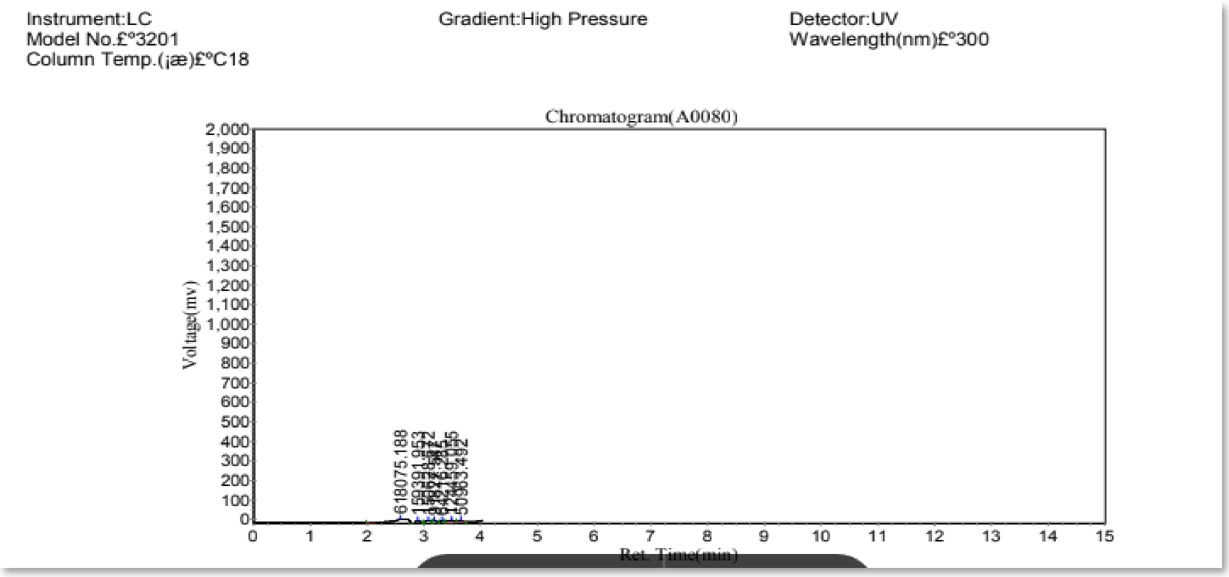

Figure 2. High-Performance Liquid Chromatography (HPLC) chromatogram of the analysed sample obtained using a C18 column at 30°C, with UV detection at 300 nm. The chromatogram was recorded under high-pressure gradient conditions. Multiple peaks were detected between 2.5 to 4 minutes retention time, indicating the presence of several constituents within the sample matrix.

4. Analytical testing (HPLC): Figure 1 and 2 shows HPLC analysis to identify and quantify the dye components. The graph of Sample 1 showed six distinct peaks. Peak 2 with Rt 1.982 min is the major component showing 23.39% of total concentration, likely a dominant dye compound or pigment molecule. Peak 5 with Rt 2.957 min and Peak 1 with Rt 0.948 min are also significant showing around 21% and 18%, respectively. All peaks elute in under 4 minutes suggests that these are small to moderately polar molecules which are typical for bioactive or pigment compounds from mushrooms & the method is fast and efficient which is suitable for rapid screening. The relatively high area values suggest good UV absorbance which is consistent with colored compounds in dye formulations. Graph of Sample 2 showed seven distinct peaks. Peak 1 with Rt = 2.590 min is the dominant component of the dye that comprised approx. 49% of the total area indicating the main pigment or active phenolic compound likely. Retention times between 2.6–3.5 min is typical for compounds like Phenolic acids (caffeic, ferulic, gallic, and p-coumaric acid) & Flavonoids (quercetin, kaempferol). Peaks 2 and 3 with Rt 2.890 and 3.073 respectively are significant minor components that comprised 12.65% and 11.96% supporting colorants or bioactives. The presence of two peaks at 3.490 min suggests either a co-elution of two compounds or a partially separated peak.

5. Analytical testing (FTIR): Figure 3 and 4 shows FTIR analysis to identify compounds in the mushroom-based fabric dye. Analysis report of sample 1 shows peak at nearly 3106 cm^{-1} and 1068 cm^{-1}. Broad peak at nearly 3106 cm^{-1} shows the presence of hydroxyl (O-H) group from phenols or alcohols, or due N-H from amines or amides due to polysaccharides or proteins present in the mushroom extract. Strong and sharp peak at nearly 1608 cm^{-1} characterizes C-O bond in polysaccharides, glycosidic linkages, or ester bonds indicating carbohydrate structure which is common in mushroom derived compounds. There was absence of sharp peak between 1700-1600 cm^{-1} suggesting low or absent carbonyl group(C=O). There is a smooth curve in the 2800-3000 cm^{-1} indicating little C-H stretch typical in organic compounds which is non dominant here. Thus, it can be said that bioactive compounds like polysaccharides, proteins, and phenolic compounds are responsible for color and functional properties of dye. Analysis report of sample 2 shows peak at 3147.06 cm^{-1}, 1598.62 cm^{-1} & 1028.35 cm^{-1}. Broad peak at 3147.06 cm^{-1} shows the presence of hydroxyl group due to alcohols, phenols or water content, or N-H stretch common in natural dyes with plant derived compounds. Peak at 1598.62 cm^{-1} shows some C=C stretch in aromatic rings, N-H bends or C=O stretch in amides suggesting presence of aromatic compounds, proteins, or flavonoid-like structure which is common in mushroom-based dyes. Peak at 1028.35 cm^{-1} is assigned to C-O stretch vibration indicating alcohols, esters, ethers, or polysaccharides. Thus, it can be said that hydroxyl group indicates water soluble compounds, aromatic compounds or amides suggests pigment like phenolics and carbohydrate or polysaccharide content reflects fungal origin.

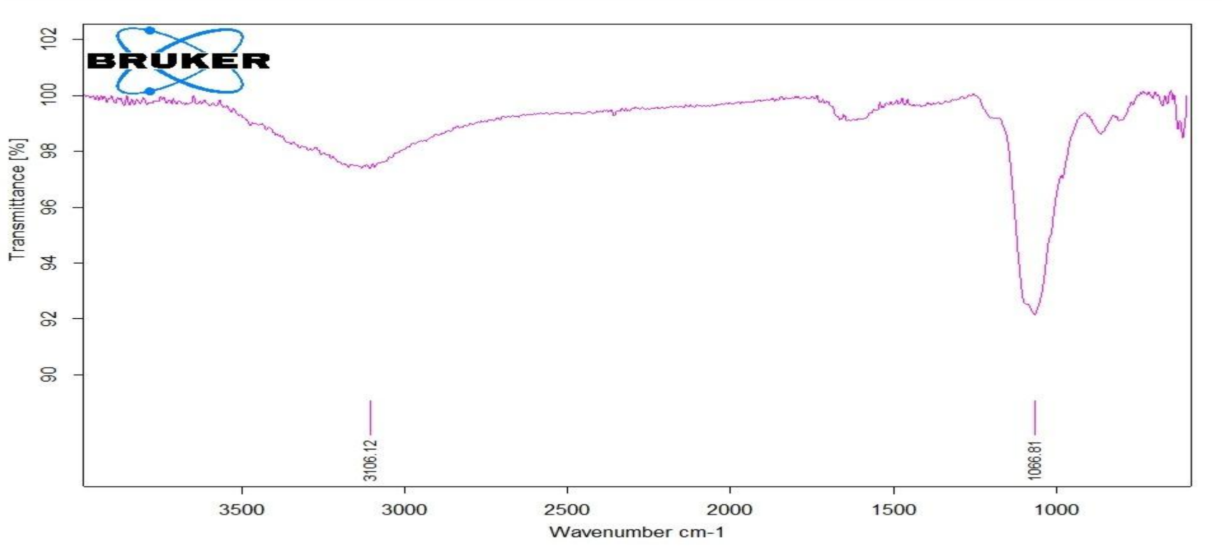

Figure 3. Fourier Transform Infrared (FTIR) spectrum of the sample recorded using a Bruker instrument. The spectrum displays characteristic absorption bands at 3106 cm⁻¹ and 1068 cm⁻¹, indicating the presence of functional groups such asO–H/N–H stretching and C–O/C–N stretching vibrations, respectively. The analysis helps in identifying the molecular components and functional groups present in the sample.

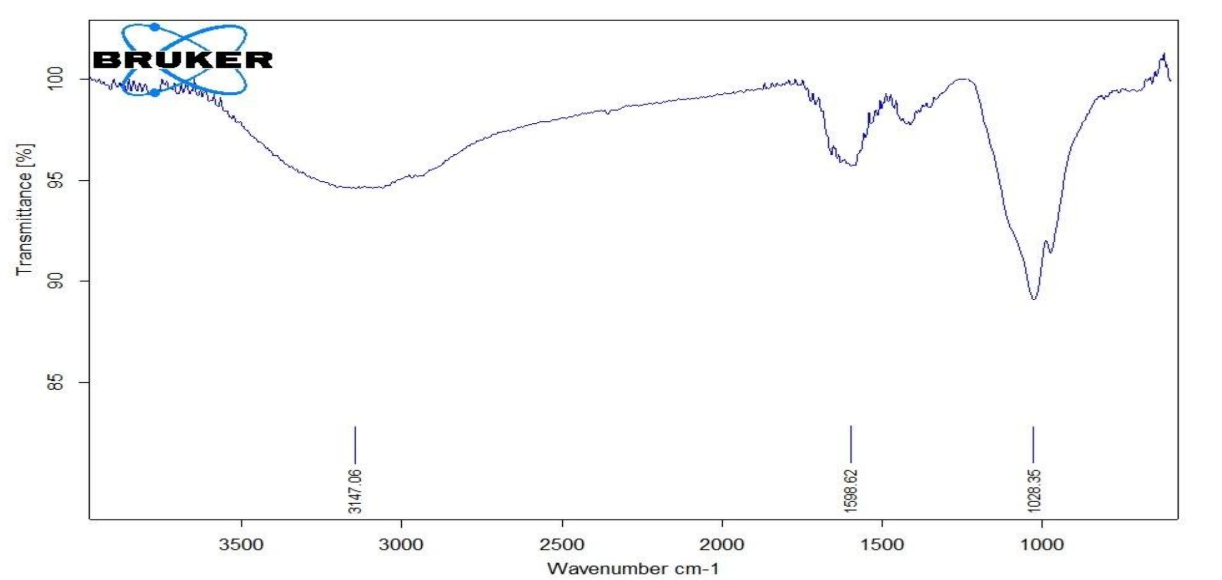

Figure 4. Fourier Transform Infrared (FTIR) spectrum of the analysed sample using a Bruker instrument. Prominent absorption peaks were observed at 3447 cm⁻¹ (O–H/N–H stretching), 1638 cm⁻¹ (C=C or N–H bending), and 1028 cm⁻¹ (C–O or C–N stretching), indicating the presence of hydroxyl, amine, and ether or amide functional groups. The spectrum provides insights into the chemical composition and functional groups of the sample.

Discussion:

The study presents valuable understanding into sustainable mushroom farming, nutritional analysis, eco-friendly applications, and value-added product development. This discussion analyses the findings from different aspects of the study, including cultivation efficiency, nutritional benefits, and commercial viability of mushroom-based products.

1. Sustainable Mushroom Cultivation and Powder Production: Mushroom cultivation using agricultural waste substrates (straw) proved to be an eco-friendly and cost-effective approach. The results demonstrated that Oyster mushrooms (*Pleurotus ostreatus*) exhibited the highest biological efficiency& the controlled temperature (22–28°C) and humidity (75–85%) positively influenced fruiting body development. The conversion of fresh mushrooms into powder was effective in

prolonging shelf life as well as enhancing usability in food formulations. The low moisture content (4-5%) in the powder ensured stability and microbial safety.

2. Biochemical and physiochemical Properties: The biochemical analysis revealed that mushroom powder is a rich source of proteins and carbohydrate. The physiochemical analysis revealed mushroom has abundant moisture (90%).

3. Optimization of Mushroom-Based Products (Dye and Cosmetics): The study explored innovative applications of mushroom powder in product formulations.

- Mushroom-Based Natural Dye: - *Pleurotus ostreatus* extract produced a yellow pigment, which was successfully used as a natural dye. The dye exhibits good wash-fastness and UV protection when applied to fabrics.
- Mushroom-Enriched skincare: -Oyster mushroom-based skincare is gentle, non-irritating, and free from harsh chemicals which makes it suitable for all skin types. Mushroom-infused toners can help to remove toxins and impurities balancing the skin's pH levels that, in turn, makes them great for people exposed to pollutants and stress. Mushroom extracts have natural antibacterial and antifungal properties, in turn, helping to reduce acne-causing bacteria and prevent breakouts. Oyster mushrooms contain kojic acid which is a natural skin-brightening agent. It can help to fade dark spots, pigmentation, and acne scars, in turn, promoting an even skin tone. Mushroom-infused moisturizer provides long-lasting hydration due to presence of beta-glucans, which act like humectants, in turn, drawing moisture into the skin. This is beneficial for dry and dehydrated skin.
- Mushroom-Infused protein powder: - Oyster mushroom (*Pleurotus ostreatus*) as a valuable ingredient in protein powders is gaining popularity due to its rich nutritional profile and numerous health benefits. Oyster mushrooms contain a significant amount of protein (approx. 25% of their dry weight) that makes them an excellent plant-based protein source. They provide essential amino acids crucial for muscle repair, immune function, and overall health. Oyster mushroom powder is packed with bioactive compounds such as Beta-glucans, Ergothioneine & Glutathione, and Polysaccharides & Lectins. Oyster mushrooms are naturally rich in dietary fibre and prebiotics promoting healthy digestion. Oyster mushrooms grow on agricultural waste like straw that makes them a sustainable choice for protein production. Thus, mushroom farming has a low environmental impact when compared to animal-based protein sources. Oyster mushroom protein powder can be easily added to various foods and beverages, such as Smoothies, shakes, Protein bars, Baking, Soups, and stews. Oyster mushroom has abundance of B-vitamins (B1, B2, B3, B5, B9), Vitamin D2, Iron, Zinc, Potassium, and Selenium.

4. Market Potential and Consumer Acceptance: Consumer perception and market viability play an important role in the adoption of mushroom-based products. Key findings include that Mushroom-based cosmetics, textile dyes, protein powder, and edible tablets have strong potential in the organic and sustainable product market. Challenges include a lack of awareness among farmers about mushroom cultivation opportunities & need for better storage and processing infrastructure in rural areas.

5. Future Prospects and Recommendations: Based on the study findings, future research directions and recommendations are suggested includes enhancing yield and quality through advanced substrate optimization and genetic selection of mushrooms, scaling up production with better drying techniques to improve the functional properties of mushroom powder, developing mushroom-based bioplastics for sustainable packaging solutions & improving distribution and market strategies to promote mushroom-based products among rural farmers and urban consumers.

4. CONCLUSION:

This study confirms the potential of oyster mushroom cultivation in Raipur, Chhattisgarh, using locally available substrates. The resulting mushroom powder demonstrated significant nutritional value and was successfully integrated into various eco-friendly products, such as natural dyes, skincare formulations, and protein powders. These innovations offer promising avenues for sustainable entrepreneurship, rural development, and value addition in the food and cosmetic industries. Future work should focus on scale-up, advanced processing techniques, and broader market integration.

REFERENCES

[1] Achinna, P., Malleboina, P., & Joshi, A. A. (2024). Plant-based meat analogs: Composite blend of pulse protein reinforcing structure with fibrous mushroom, jackfruit seed powder, and carboxymethyl cellulose. Food Science & Technology, SAGE Journals.

[2] Aishah M.S., Wan Rosli W.I., 2013. The effect of the addition of oyster mushroom (Pleurotus sajor-caju) on nutrient composition and sensory acceptability of selected wheat- and rice-based products. Intern. Food Res. J. 20(1), 183-188.

[3] Carrasco-Gonzalez J.A., Serna-Saldivar S.O., Gutierrez-Uribe J.A., 2017. Nutritional composition and nutraceutical properties of the Pleurotus fruiting bodies: Potential use as food ingredient. J. Food Comp. Anal. 58, 69-81.

[4] Chang, S. and G.P. Miles. 2004. Mushrooms: Cultivation, nutritional value, medicinal effects, and environmental impact. CRC Press, USA. 436 pp.

[5] Cowan, A. 2001. Fungi – Life Support for Ecosystems Essential ARB 4: 1-5.

[6] Dhanapal, D., & Rajoo, B**.** (2023). Value addition of mushrooms by incorporation in food products: An overview. International Journal of Food Engineering. De Gruyter.

[7] Gates, G.M., D.A. Ratkowsky and S.J. Grove. 2005. A comparison of macrofungi in young silvicultural regeneration and mature forest at the Warra Letersiet in the southern forests of Tasmania. Tasforests 16: 127.

[8] Gopal, J., Sivanesan, I., & Muthu, M. (2022). Scrutinizing the nutritional aspects of Asian mushrooms, their commercialization, and scope for value-added products. Nutrients, MDPI.

[9] https://www.researchgate.net/publication/364070549_The_role_of_emerging_technologies_in_the_dehydration_of_berries_Quality_bioactive_compounds_and_shelf_life

[10] Hunt, G.A. 1999. Assessing Macrofungi of Special Concern for Conservation in Forested Ecosystems. In: Proc Biology and management of species and habitats at risk. 2, 15-19 Feb 1999, University College of the Cariboo, Kamloops. 779 pp.

[11] Itubochi, C. O., Ugwuanyi, J. O., & Ezea, I. B. (2025). Advancing sustainable mushroom production in developing countries: A pathway to nutritional security and economic growth. EAS Journal of Food Science & Nutrition.

[12] Jahan, A., & Singh, B. K. (2019). Mushroom value chain and role of value addition. International Journal of Botany and Research. Academia.edu.

[13] Kalac, P., 2009. Chemical composition and nutritional value of European species of wild-growing mushrooms: a review. Food Chem. 113, 9–16.

[14] Keizer, G.J. 1998. The Complete Encyclopedia of Mushrooms. Rebo Publishers, Netherlands. 268 pp.

[15] Kumar, H., Bhardwaj, K., & Sharma, R. (2021). Potential usage of edible mushrooms and their residues to retrieve valuable supplies for industrial applications. Journal of Fungi, MDPI.

[16] Kumar, R., Kumar A. Ramratan, and D. Uttam. "To study natural herbal dyes on cotton fabric to improve the colour fastness and absorbency performance." J. Text. Eng. Fash. Technol 7 (2021): 51-56.

[17] M. Madan et al.Cultivation of *Pleurotus sajor-caju* on different wastes

[18] Manoharachary, C., K. Sridhar, R. Singh, Adholeya, T.S. Suryanarayanan, S. Rawat and B.N. Johri. 2005. Fungal Biodiversity: Distribution, Conservation and Prospecting of Fungi from India. Current Science 89(1): 58 71.

[19] Mariga, A.M., Yang, W.J., Mugambi, D.K., Pei, F., Zhao, L., Shao, Y., et al, 2014. Antiproliferative and immunostimulatory activity of a protein from Pleurotus eryngii. J. Sci. Food Agric. 94, 3152 3162.

[20] Mishra, N., & Mani, A. (2019). Post-harvest management, processing, and value addition of mushrooms. ResearchGate.

[21] Mohiuddin, Abdul Kader. "Skin care creams: formulation and use." Dermatol Clin Res 5.1 (2019): 238-271.

[22]Naskar, A., Saha, R., Basak, G., & Acharya, K. (2025). Therapeutic Scrutiny of Lentinus polychrous with Attention to Its Antioxidant, Antimicrobial, and Anticancer Attributes. Applied Biochemistry and Biotechnology, Springer.

[23] Panjikkaran, S.T., Mathew, D., 2013. An environmentally friendly and cost-effective technique for the commercial cultivation of oyster mushroom [Pleurotus florida (Mont.) Singer]. J. Sci. Food Agric. 93, 973–976.

[24] Pattanayak, S., & Das, S. (2022). Value addition and nutritional enrichment of wonder food mushroom. Journal of Mycopathological Research.

[25] Piska K., Sułkowksa-Ziaja K., Muszyńska B., 2017. Edible mushroom Pleurotus ostreatus (oyster mushroom) – its dietary significance and biological activity. Acta Sci. Pol., Hortorum Cultus 16(1), 151 161.

[26] Priyadarsini, P., & Mishra, A. (2020). A storage study of value-added oyster mushroom products. International Journal of Current Science (IJCS). Academia.edu.

[27] Rai, R. D., & Arumuganathan, T. (2007). Value addition in mushrooms. Mushroom Biology and Biotechnology. ResearchGate.

[28] Saini, R. K., Chawla, P., & Kaushik, R. (2025). Mushrooms as nutritional powerhouses: A review of their bioactive compounds, health benefits, and value-added products. Foods, MDPI.

[29] Sangeeta, Dhriti Sharma, Seema Ramniwas, Robert Mugabi, Jalal Uddin, Gulzar Ahmad Nayik, Revolutionizing Mushroom processing: Innovative techniques and technologies, Food Chemistry: X, Volume 23, 2024,101774, ISSN 2590-1575

[30] Sangeeta, S., Sharma, D., & Ramniwas, S. (2024). Revolutionizing mushroom processing: Innovative techniques and technologies. Food Chemistry: X, Elsevier.

[31] Sangeeta, Sangeeta, et al. "Revolutionizing Mushroom processing: Innovative techniques and technologies." Food Chemistry: X (2024): 101774.

[32] Sheu, F., Chien, P.J., Wang, H.K., Chang, H.H., Shyu, Y.T., 2007. New protein PCiP from edible golden oyster mushroom (Pleurotus citrinopileatus) activates murine macrophages and splenocytes. J. Sci. Food Agric. 87, 1550–1558.

[33] Singh, K., & Thakur, M. (2016). Formulation, organoleptic, and nutritional evaluation of value-added baked products incorporating oyster mushroom (Pleurotus ostreatus) powder. International Journal of Food Science & Nutrition. Academia.edu.

[34] Sohane, R. K., & Sahu, R. (2025). Mushroom value chain: A novel approach empowering women through production and value addition. ResearchGate.

[35] Sood, A. (2022). Studies on the preparation and preservation of value-added products from specialty mushrooms. Krishikosh (e-Granthalaya).

[36] Sushma, N. (2024). Development and nutritional evaluation of value-added mushroom products. KrishiKosh.

[37] Taofiq, O., Antunes, F., & Morais, A. M. B. M. (2020). Valorization of mushroom by-products as a source of value-added compounds and potential applications. Molecules, MDPI.

[38] Thakur, M. P. (2018). Advances in post-harvest technology and value additions of edible mushrooms. Indian Phytopathology, Springer.

[39] Wakchaure G.C., Shirur M., Manikandan K., Rana L., 2010. Development and evaluation of oyster mushroom value-added products. Mushroom Res. 19(1), 40-44Instrument:LC