International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

IJEP November 2024, 11(4): 387-393

Crossref

Article IJEP5725a

Review Article

Doi: HTTPS://DOI.ORG/10.23910/2/2024.5725a

Cultivation of Oyster Mushroom could be a Viable Option for Doubling the Farmer's Income - An Overview

Anita Chauhan[1], Shivangi Negi[2*], Rupinder Kaur[2], Manish Chauhan[3], Rekha Dhanai[2] and Pankaj Singh Negi[2]

[1]Dept. of Horticulture and Forestry, BFIT Dehradun, Uttarakhand (248 007), India
[2]Dept. of Agriculture, Tula's Institute Dehradun, Uttarakhand (248 001), India
[3]Dept. of Agriculture, Abhilashi University, Mandi, Himachal Pradesh (175 008), India

Corresponding Author

Shivangi Negi
e-mail: shivanginegi002@gmail.com

Article History

Received on 20th August, 2024
Received in revised form on 15th October, 2024
Accepted in final form on 05th November, 2024

Abstract

Our country is celebrating 75th year of Azadi ka Amrit Mahotsava and our Government is very much focused on how to double the farmer's income, it is the utmost duty of every researcher, educationist and agriculture scientist to explore the ways and means to achieve this target. The cultivation of oyster mushrooms has the potential to significantly increase the income of farmers. Oyster mushrooms are easy to grow, require minimal resources, and have a high market demand. By cultivating oyster mushrooms, farmers can diversify their income streams and increase their profits. This abstract suggests that oyster mushroom cultivation could be a viable option for farmers looking to double their income. Indian economy is primarily agriculture based and where the average income from Agriculture Sector ha^{-1} is very less in comparison to the other developed nations of the world. This is a call of time to enhance the farmer's income so they can live their lives in a lucrative manner. Present objective cannot be achieved merely by enhancing the price of the different agricultural produce which the farmers grow on their farm lands, but we should include certain other practical implications to increase the existing productivity level of different agricultural and allied ventures by diversifying farm enterprises. Mushroom culture is one of such enterprises with particular reference to oyster mushroom which has the vast potential to double the existing income level of farmers and this enterprise can easily be adopted by any category of farmers even having marginal landholding.

Keywords: Dhingri mushroom, health benefits, nutritional quality, oyster mushroom

1. Introduction

Mushrooms are an essential component of a typical human diet, and in recent years, the number of mushrooms being consumed by humans has increased substantially. This trend applies to a wide range of mushroom species. We are celebrating 75th year of Azadi ka Amrit Mahotsava and our Government is very much focused on how to doubled the farmer's income, it is the utmost duty of every researcher, educationist and agriculture scientist to explore the ways and means to achieve this target. Indian economy is primarily agriculture based and where the average income from agriculture sector ha^{-1} is very less in comparison to the other developed nations of the world (Negi and Bharat, 2021).

This is a call of time to enhance the farmer's income so they can live their lives in a lucrative manner. Present objective cannot be achieved merely by enhancing the price of the different agricultural produce which the farmers grow on their farm lands, but we should include certain other practical implications to increase the existing productivity level of different agricultural and allied ventures by diversifying farm enterprises (Chang and Buswell, 1996; Chauhan et al., 2023). Mushroom cultivation in India has gained popularity in recent years due to its high profitability and low investment requirements. In India, the cultivation of mushroom started in the early 1960s, and now it has become a major source of livelihood for many people. Mushroom cultivation is mostly done in small-scale units in India, and it has created many employment opportunities for rural people. The government has also taken various initiatives to promote mushroom cultivation and provide training to farmers for the same.

Mushroom cultivation requires ideal conditions for best

development and output. Diverse environmental conditions are required for the production of diverse mushroom species (Carrasco et al., 2016). Several types of mushrooms are produced for commercial reasons in the mushroom business, including oyster mushrooms, which are sold in markets and readily farmed in the lowlands, and button mushrooms, which are cultivated in the highlands and cold climate (Doroski et al., 2022). Mushrooms have antitumor, antioxidant, antigen toxic, antiplatelet aggregating, antihyperglycemic, antimicrobial and antiviral compounds, which are beneficial for curing different types of diseases (Gea et al., 2017; Khare et al., 2018). Oyster mushroom cultivation is a strong means to diversifying livelihoods which strengthen the resilience of farmers. It can be grown at a very low cost and in relatively short period as compared to conventional crops. For taking up this enterprise, farmers need very less investment, meager inputs but compulsory training and commitment to work. These resources for oyster mushroom cultivation are easily available and even sometimes provided by concerned agencies with low investment. Now a days oyster mushroom cultivation is gaining popularity in India as it is a cost friendly, low-labor and high-yielding crop that can be grown throughout the year. Oyster mushroom cultivation has increased throughout the world because of its medicinal properties and its potential to grow at wide range of temperature and different agro based residues (Rana et al., 2015; Nongthombam et al., 2021). It also has wide adaptability to various agro-climatic conditions on different agricultural waste. Mushroom culture is one of such enterprises with particular reference to Oyster mushroom which has the vast potential to double the existing income level of farmers and this enterprise can easily be adopted by any category of farmers even having marginal landholding (Caz et al., 2015).

2. Oyster Mushroom- An Overview

Mushroom cultivation not only imparts diversification of agriculture but also helps in addressing the problems of quality food, health and environment related issues. Among Mushroom cultivation, Oyster mushroom (*Pleurotu*s sp.) gaining popularity in masses, it is popularly known as 'dhingri' belongs to Class Basidiomycetes and Family *Agaricaceae.* In India it grows naturally in the temperate and tropical forests on dead and decaying wooden logs or sometimes on dying trunks of deciduous or coniferous woods (Sharma et al., 2013; Tesfaw et al., 2015). The fruiting bodies of this mushroom are distinctly shell or spatula shaped with different shades of white, cream, grey, yellow, pink or light brown depending upon the species (Dunkwal et al., 2007, Ghaly et al., 2011). Among all the cultivated mushrooms genus *Pleurotus* has maximum number of commercially cultivated species suitable for round the year cultivation. Cultivation of this mushroom on commercial basis would be more profitable as compared to white button mushroom at very low capital cost (Nongthombam et al., 2021). The cultivation of this variety of mushroom is very simple and economical in rural areas where raw materials and facilities required are easily available (Masevhe et al., 2016). Its cultivation is very profitable for the marginal farmers and thereby becomes one of the low-cost employable units for the Indian Farmers**.** It is one of the most suitable fungal organisms for producing protein rich food from various agro-wastes or forest wastes without composting. Cultivation of different varieties of oyster mushroom was initiated in India in the early sixties. Commercial cultivation began in mid-seventies.

The oyster mushroom (*Pleurotus ostreatus*) is a type of edible mushroom that is commonly found in the wild or can be cultivated commercially. It gets its name from its shell-like appearance, similar to that of an oyster (Sharma et al., 1996). Oyster mushroom can grow at moderate temperature ranging from 20° to 30°C and humidity 55–70% for a period of 6 to 8 months in a year (Wongamthing et al., 2022). The economic importance of the mushroom lies primarily in its use as food for human consumption (Hassen et al., 2011).

The oyster mushroom has three distinct parts- a fleshy shell or spatula shaped cap (pileus), a short or long lateral or central stalk called stipe and long ridges and furrows underneath the pileus called gills or lamellae. The mycelium of *Pleurotus* is pure white in colour (Gu and Sivam., 2006, Ram et al., 2022). Oyster mushrooms have a delicate, slightly nutty flavor and a tender texture. They are commonly used in Asian cuisine and are often added to stir-fries, soups, and noodle dishes. Oyster mushrooms are also a popular meat substitute for vegetarians and vegans due to their meaty texture. Oyster

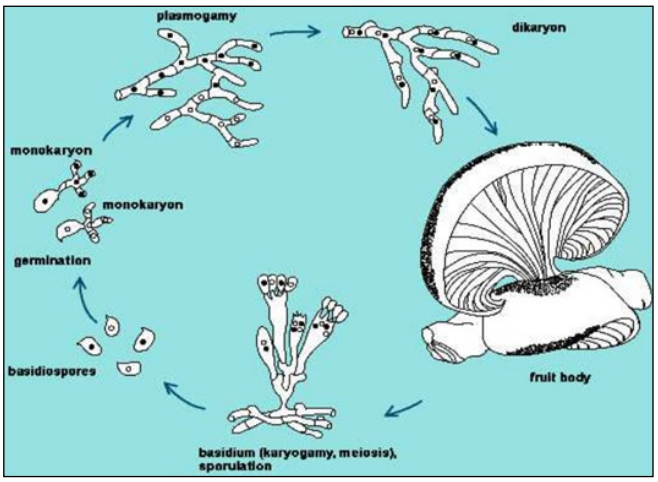

Figure 1: Picture depicting different growing states of Oyster mushroom (*Pleurotus ostreatus*) Source: Adebayo and Martinez-Carrera, 2015, Oloke and Adebayo, 2015

mushrooms are low in calories and high in nutrients, such as fiber, protein, and vitamins B and D. They also contain antioxidants and anti-inflammatory compounds that may have health benefits. Oyster mushrooms can be grown at home using kits or by following certain cultivation methods. They are relatively easy to cultivate and can be grown on a variety of substrates, including straw, sawdust, and coffee grounds (Adebayo and Oloke, 2017).

Among all the cultivated mushrooms *Pleurotus* has maximum

number of commercially cultivated species suitable for round the year cultivation. All the species of oyster mushroom are edible except *P. olearius* and *P. nidiformis* which are poisonous. Species commercially cultivated all over the world during summer months includes *P. flabellatus*, *P. sajor caju*, *P. sapidus*, *P. membranaceous*, *P. citrinopileatus*, *P. eous* etc. and those produced during winter are *P. ostreatus*, *P. florida, P. cornucopiae*, *P. fossulatus*, *P. eryngii* etc.

3. Economic Importance of Oyster Mushroom

Mushrooms have considerable importance in the human diet as they are rich in protein, non-starchy carbohydrates, dietary fiber, minerals, and vitamin-B and have no cholesterol, and negligible amount of fat. Mushroom proteins are of high quality and they contain an abundance of essential amino acids (Sadler, 2003). It is rich in Vitamin C and B complex and the protein content varies between 1.6 to 2.5%. The use of mushrooms may contribute significantly to overcome protein deficiency in the developing countries where good quality proteins from animal sources are either unavailable or unacceptable because of religious beliefs (Dunkwal et al., 2007, Singh et al., 1995). Mushrooms can be a good supplement to cereals (Chang and Buswell, 1996) in enriching one's diet. Owing to their good nutritional and high digestibility values mushrooms are gaining importance in today's healthy diet.

Pleurotus as health promoter and environmental restorer is gaining more importance as compared to other medicinal mushrooms resulting in an upsurge in their research and development activities during the past two decades (Patel et al., 2012). The chemical nature of the bioactive compounds present in this mushroom includes: polysaccharides, lipopolysaccharides, proteins, peptides, glycoproteins, nucleosides, triterpenoids, lectins, lipids, and their derivatives. In certain systems of medicine, such as traditional Chinese medicine (TCM), oyster mushrooms are used to treat a variety of health conditions (Lee, 2012). Oyster mushrooms provide dietary fiber, beta-glucan, and other ingredients that may boost health. They have a delicate taste and can be used to add flavor to a wide variety of savory dishes (Minato et al., 2017).

4. Nutritional Values of Oyster Mushroom

One cup of raw, sliced oyster mushrooms (86 g) provides 28 calories, 2.9 g of protein, 5.2 g of carbohydrates, and 0.3 g of fat. Oyster mushrooms are an excellent source of niacin, fiber, and riboflavin. This nutrition information is provided by the Anonymous, 2019. Oyster mushrooms also contain antioxidants and anti-inflammatory compounds that can help to protect against chronic diseases (Lindequist et al., 2005, Khan, 2010). In particular, oyster mushrooms are a good source of ergothioneine, a powerful antioxidant that has been linked to reduced risk of cancer, cardiovascular disease, and neurodegenerative diseases (Manzi et al., 2001).

Table 1: Nutrient present in oyster mushroom 100 g^{-1} of edible portion (USDA, 2019)

Sl. No.	Nutrient	Oyster Mushroom
1.	Moisture (g 100 g^{-1})	89.18
2.	Energy (kcal 100 g^{-1})	33.00
3.	Protein (g 100 g^{-1})	3.31
4.	Fat (g 100 g^{-1})	0.41
5.	Ash (g 100 g^{-1})	1.01
6.	Carbohydrate (g 100 g^{-1})	6.09
7.	Dietary fibre (g 100 g^{-1})	2.30
8.	Ergosterol (mg 100 g^{-1})	64.00
9.	Calcium (mg 100 g^{-1})	3.00
10.	Copper (mg 100 g^{-1})	0.24
11.	Iron (mg 100 g^{-1})	1.33
12.	Magnesium (mg 100 g^{-1})	18.00
13.	Manganese (mg 100 g^{-1})	0.11
14.	Phosphorus (mg 100 g^{-1})	120.00
15.	Potassium (mg 100 g^{-1})	420.00
16.	Selenium (µg 100 g^{-1})	2.60
17.	Sodium (mg 100 g^{-1})	18.00
18.	Zinc (mg 100 g^{-1})	0.77
19.	Thiamin (mg 100 g^{-1})	0.125
20.	Riboflavin (mg 100 g^{-1})	0.35
21.	Niacin (mg 100 g^{-1})	4.96
22.	Pantothenic acid (mg 100 g^{-1})	1.29
23.	Pyridoxine (mg 100 g^{-1})	0.11

It is rich in Vitamin C and B complex and the protein content varies between 1.6 to 2.5%. It contains most of the mineral salts required by the human body. The niacin content is about ten times higher than any other vegetables. The folic acid present in oyster mushrooms helps to cure anemia (Shamtsyan et al., 2004, Negi et al., 2019). It is suitable for people suffering with hyper-tension, obesity and diabetes due to its low sodium: potassium ratio, starch, fat and calorific value (Akyuz and Kirbag, 2010). Alkaline ash and high fiber content makes it suitable for consumption for those having hyperacidity and constipation (Michael et al., 2011). A polycyclic aromatic compound pleurotin has been isolated from *Pleurotus griseus* which possess antibiotic properties.

5. Health Benefits of Oyster Mushroom

Oyster mushrooms contain several substances thought to influence health benefits. These substances include dietary fiber, beta-glucan, and several other polysaccharides affecting The immune function (Minato et al., 2017). Scientific

studies on the health benefits of oyster mushrooms are emerging. Evidence shows that the dietary fiber component of oyster mushroom (*Pleurotus ostreatus*) may be useful in reducing triglyceride accumulation in the liver (Caz et al., 2015). Research shows that whole foods with fiber, such as mushrooms, provide several health benefits with few calories, making them a good choice for a healthy eating pattern (Daba and Ezeronye, 2003; Marcelo et al., 2018). Several studies have shown that a higher intake of fiber gives better heart health. Fiber in vegetables and other foods "makes them attractive targets for disease prevention and reduction of risk of atherosclerosis and cardiovascular disease (Soliman, 2019).

According to a study published in 2016, Oyster mushrooms may enhance immune function, (Tanaka et al., 2016). In a study, participants ingested an oyster mushroom extract for eight weeks and at the end of study researchers found evidence that the extract might have immune-enhancing effects. Some preliminary research indicates that oyster mushrooms may possess cancer-fighting properties. (Martin and Brophy, 2010). In 2012 a study demonstrated that an oyster mushroom extract might suppress breast cancer and colon cancer growth and spread in human cells. Researches are ongoing, with scientists, suggesting that more studies are needed to understand the relationship fully (Xu et al., 2012).

6. Economic Importance of Cultivation of Oyster Mushroom

The present production of this crop in India is only around 1500 t due to low levels of awareness and low domestic demand. Dhingri cultivation is much easier for farmers to grow as Dhingri takes lesser labour, lesser space, lesser time and minimal care. The compost making in Dhingri takes about 2 days. In the process of Dhingri cultivation, the inputs needed are Spawn (Seed), Wheat Straw (Bhusa), formaline and bavistin as disinfectants. Spawn is available in the price range of ₹ 100–120 kg^{-1}, while straw is mostly available with the farmers. The temperature requirements for the Dhingri cultivation are around 20–30°C, although it may vary depending upon the altitude. Its economics is very simple, for every kg of spawn cultivated, around 8 plastic bags of straw compost can be made which yield around 24 kg of Dhingri mushroom over a period of 3 months under suitable management practices. The market price of one kilogram of mushroom is about ₹ 150. So, from 1 Kg spawn an income of ₹ 3600 can be made, with an input cost around ₹ 600 (with own family labor), that too in a short span of three months. The cost benefit ratio is around 1:6. The income may be higher depending upon the scale of commercialization. The production process has started and the farmers have started selling their produce in the local market with suitable marketing intervention being made by the implementing agency. The aim of the program is to create suitable skill development and interest among the farmers, especially women so that they learn the best techniques and take on commercial production of Oyster cultivation to fulfill the demand.

The adoption of Dhingri as an allied agricultural activity by our small and marginal farmers will provide an additional source of income and livelihood it will certainly contribute towards the aim of doubling of farmer's income. Further, besides selling Dhingri directly, it may also be processed to make pickle, sold in dried and can also be made in powder form which will fetch even higher prices.

Oyster mushroom is the third largest cultivated mushroom. China, the world leader in Oyster production, contributes nearly 85% of the total world production of about 1 mt. The present production of this crop in India is only around 1500 t due to low domestic demand. Another inhibiting factor is that export demand orders are large and can be met only if a linkage is developed between producer, cooperatives and exporters.

The spent straw can be re-cycled for growing oyster mushroom after supplementing with wheat or rice bran @ 10–15% and also for preparing compost of white button mushroom after suitable supplementation with nitrogen rich horse or chicken manure (sun-dried before use). The spent straw can be used as cattle feed and also for bio-gas production. The biogas slurry obtained, can be used as manure. Oyster mushroom can grow at moderate temperature ranging from 20^0 to 30^0 C and humidity 55–70% for a period of 6 to 8 months in a year. It can also be cultivated in summer months by providing the extra humidity required for its growth in hilly areas above 900 m amsl, the best growing season is during March/ April to September/October and in the lower regions from September/October to March/April.

This mushroom is not as popular as white button mushroom in the domestic market. A few units are cultivating it commercially for export market. Cultivation of this mushroom on commercial basis would be more profitable as compared to white button mushroom as capital cost is low. The cultivation of this variety of mushroom is very simple and economical in rural areas where raw materials and facilities required are easily available.

Marketing of fresh oyster mushroom does not pose any problem at present due to very low production. However, as production increases linkage of producers with domestic markets and export-oriented processing units will need to be developed to ensure remunerative prices to the producers. Generally, export orders are too big to be met by a single grower and as such co-operatives have to be encouraged to pool their produce for trading the crop after canning as well as in a dried powder form in international markets. The quantity of oyster mushroom exported is much lower than that of button mushrooms which constitute the major share of exports.

Species of *Pleurotus* is cheapest and easiest to grow among all the cultivated edible mushrooms. Cultivation does not require complicated substrate preparation technique as in case of button mushroom. The former can be grown on

non-fermented, almost fresh plant residues (agro-wastes containing lignin and cellulose). Substrate preparation does not require controlled environmental conditions as in case of button mushroom (Krishna and Usha, 2009). The crop has got a number of varieties varying in shape, colour, texture and aroma which can be cultivated throughout the year under varied agro-climatic conditions. Faster growth rate and early cropping is observed. About 5 to 6 crops can be taken in a year as the total cropping period is 60 days.

High quality commercial cultivation of the crop even on a small scale is a viable proposition as it is in good demand both in domestic and foreign markets. The facts and figures which facilitates the cultivation of *Pleurotus florida* are: The cost of spawn is to be ₹ 100 kg^{-1}, whereas that of the wheat straw is ₹ 7 kg^{-1}. A bag containing 2–3 kg straw is produced 2-3 kg of mushroom on three harvests. Polythene covering is left intact till second harvest, thereafter, it is removed prior to third harvest. Life span from inoculation to the final harvest is observed to be sixty days. The total cost incurred, ₹ 30,000 could be earned as profit if the number of bags is 400. Dhingri mushroom could be raised either in a low-cost bamboo hut costing not more than ₹ 35,000 or in a dark, moist and humid room.

7. Future Prospects of Cultivation of Oyster Mushroom

The future prospects of cultivation of oyster mushrooms are quite promising. Oyster mushrooms are becoming increasingly popular due to their nutritional and medicinal properties, as well as their delicious taste. The demand for oyster mushrooms is growing in both domestic and international markets, creating new opportunities for farmers and entrepreneurs. In addition, oyster mushroom cultivation is a sustainable and environmentally friendly practice that can contribute to the development of a circular economy. Oyster mushrooms can be grown on a variety of substrates, including agricultural wastes, making them a valuable tool for waste management and resource recovery (Aishah and Wan Rosli, 2013).

Moreover, advances in technology and scientific research are helping to improve the yield and quality of oyster mushrooms, making them more competitive in the market. New cultivation techniques and innovative business models are also emerging, creating new avenues for entrepreneurship and job creation.

8. Conclusion

The cultivation of dhingri mushroom will open a plethora of opportunities for the young brains and for the marginal and even poor farmers by making them employable. In summary, the cultivation of oyster mushrooms has a bright future ahead, offering numerous economic, environmental, and social benefits for farmers and society as a whole.

9. References

Adebayo, E.A., Martínez-Carrera, D., 2015. Oyster mushrooms (*Pleurotus*) are useful for utilizing lignocellulosic biomass. African Journal of Biotechnology 14(1), 52–67.

Adebayo, E.A., Oloke, J.K., 2017. Oyster Mushroom (*Pleurotus* Species); A Natural Functional Food. Journal of Microbiology, Biotechnology and Food Sciences 7(3), 254–264.

Aishah, M., Wan Rosli, W., 2013. Effect of different drying techniques on the nutritional values of oyster mushroom (*Pleurotus sajor-caju*). Sains Malaysiana 42, 937–941.

Akyuz, M., Kirbag, S., 2010. Nutritive value of wild edible and cultured mushrooms. Turkis Journal of Biology 34(1), 97–102.

Anonymous, 2019. USDA, 2019. Mushrooms, oyster, raw. Food Data Central. U.S. Department of Agriculture (https://fdc.nal.usda.gov).

Carrasco, J., Navarro, M. J., Santos, M., Dianez, F., Gea, F. J., 2016. Incidence, identification and pathogenicity of *Cladobotryum mycophilum*, causal agent of cobweb disease on *Agaricus bisporus* mushroom crops in Spain. Annals of Applied Biology 168(2), 214–224.

Caz, V., Gil-Ramirez, A., Largo, C., 2015. Modulation of cholesterol-related gene expression by dietary fiber fractions from edible mushrooms. Journal of Agriculture and Food Chemistry 63(33), 7371–7380.

Chang, S., Buswell, J., 1996. Mushroom nutraceuticals. World Journal of Microbiology and Biotechnology 12, 473–476.

Chauhan, M., Negi, S., Vij, S., Bijalwan, P., 2023. Gene pyramiding to increase the sustainability of vegetables under biotic and abiotic stresses. Biological Forums- An International Journal 15(2), 954–960.

Daba, A.S., Ezeronye, O. U., 2003. Anti-cancer effect of polysaccharides isolated from higher Basidiomycetes mushrooms. African Journal of Biotechnology 2, 672–678.

Doroski, A., Klaus, A., Rezek, A.J., Djekic, I., 2022. Food waste originated material as an alternative substrate used for the cultivation of oyster mushroom (*Pleurotus ostreatus*): a review. Sustainability 14, 12509.

Dunkwal, V., Jood, S., Singh, S., 2007. Physico-chemical properties and sensory evaluation of *Pleurotus sajor caju* powder as influenced by pre-treatments and drying methods. British Food Journal 109, 749–759.

Gea, Francisco, J., Carrasco, J.M., Suz, L., Maria, J., Navarro, 2017. Characterization and pathogenicity of *Cladobotryum mycophilum* in Spanish *Pleurotus eryngii* mushroom crops and its sensitivity to fungicides. European Journal of Plant Pathology 147(1), 129–139.

Ghaly, I.S., Ahmed, E.S, Booles, H.F., Farang, I., Nada, S.D., 2011. Evaluation of antihyperglycemic action of oyster mushroom (*Pleurotus ostreatus*) and its effect on

DNA damage, chromosome aberrations and sperm abnormalities in streptozotocin-induced diabetic rats. Global Veterinaria 7, 532–544.

Gu, Y.H., Sivam, G., 2006. Cytotoxic effect of oyster mushroom *Pleurotus ostreatus* on human androgen-independent prostate cancer PC-3 cells. Journal of Medicinal Food 9(2), 196–204.

Hassen, S., Mohammad, A.Y., Kiramat, K., 2011. Cultivation of the oyster mushroom (*Pleurotus ostreatus* (jacq) P. Kumm) in two different agro-ecological Zone of Pakistan. African Journal of Biotechnology 10, 183–188.

Khare, Behari, K., Jongman, M., Loeto, D., 2018. Oyster mushroom cultivation at different production systems. European journal of Biomedical and Pharmaceutical Sciences 5(5), 72–79.

Khan, M.A., 2010. Nutritional composition and Hypocholesterolemia effect of mushroom: *Pleurotus* sajor-caju and *Pleurotus florida*: LAP Lambert Academic publishing Gmbh & co. KG: Saarbrucken, Germany, 1–11.

Krishna, S., Usha, P.T.A., 2009. Hyoglycaemic effect of a combination of *Pleurotus ostreatus,* Murray Koenigii and Aegle marmelos in diabetic rats. Indian Journal of Animal Science 79, 986–987.

Lee, K.H., Morris-Natschke, S.L., Yang, X., 2012. Recent progress of research on medicinal mushrooms, foods, and other herbal products used in traditional Chinese medicine. Journal of Traditional Complement Medicine 22(2), 84–95.

Lindequist, U., Niedermeyer, T.H.J., Julich, W.D., 2005. The pharmacological potentials of mushrooms. Evidence Based complementary and Alternative Medicine 2, 285–299.

Manzi, P., Aguzzi, A., Pizzoferrator, L., 2001. Nutritional values of mushrooms widely consumed in Italy. Food Chemistry 73(3), 321–325.

Marcelo, B.B., Bellettini, S., Fiorda, F.A., Pedro, A.C., Bach, F., Fabela-Moron, F.M., Hoffmann-Ribani, R., 2018. Diseases and pests noxious to *Pleurotus* spp. mushroom crops. Revista Argentina de Microbiologia 50(2), 216–226.

Martin, K.R., Brophy, S.K., 2010. Commonly consumed and specialty dietary mushrooms reduce cellular proliferation in Mcf-7 human breast cancer cells. Experimental Biology and Medicine 235(11), 1306–1314.

Masevhe, M.R., Taylor, N.J., Soundy, P., 2016. Alternative substrates for cultivating oyster mushrooms (*Pleurotus ostreatus*). South African Journal of Plant Soil 33(2), 97–103.

Michael, H.W., Bultosa, G., Pant, L.M., 2011. Nutritional contents of three edible oyster mushrooms grown on two substrates at Haramaya, Ethiopia, and sensory properties of boiled mushroom and mushroom sauce. International Journal of Food Science & Technology 46, 732–738.

Minato, K.I., Ohara, A., Mizuno, M.A., 2012. Proinflammatory effect of the -glucan from mushroom on macrophage action. Mediators of Inflammation, 8402–405.

Negi, S., Bharat, N.K., Sharma, M., 2019. Effect of seed biopriming with indigenous PGPR, Rhizobia and Trichoderma sp. on growth, seed yield and incidence of diseases in French bean (*Phaseolus vulgaris* L.). Legume Research- An International Journal 44(5), 593–601.

Negi, S., Bharat, N.K., 2021. Seed defense biopriming. In plant-microbial interactions and smart agricultural biotechnology, CRC Press: Boca Raton, FI, USA, pp. 129–146.

Nongthombam, J., Kumar, A., Ladli, Manikanta, B., Madhushekhar, M., Patidar, S., 2021. A review on study of growth and cultivation of oyster mushroom. Plant Cell Biotechnology and Molecular Biology 22(5&6), 55–65.

Oloke, J.K., Adebayo, E.A., 2015. Effectiveness of immunotherapies from oyster mushroom (*Pleurotus* species) in the management of immuno compromised patients. International Journal of Immunology 3(2-1), 8–20.

Patel, Y., Naraian, R., Singh, V., 2012. Medicinal properties of *Pleurotus* species (oyster mushroom): a review. World Journal of Fungal and Plant Biology 3, 1–12.

Ram, R.M., Debnath, S., Negi, S., Singh, H.B., 2022. Use of microbial consortia for broad spectrum protection of plant pathogens: regulatory hurdles, present status and future prospects. Biopesticide 2, 319–335.

Rana, G.L., De Luca, P., Pipoli, V., Lops, R., Luca, L., Scarola, Mannerucci, F., Piscitelli, L., Cariddi, C., 2015. Suppressiveness of white vinegar and steam-exploded liquid waste against the causal agents of *Pleurotus eryngii* yellowing. Crop Protection 70, 61–69.

Sadler, M., 2003. Nutritional properties of edible fungi. Nutrition Bulletin 28, 305–308.

Shamtsyan, M.M., Konusova, V.G., Goloshchev, A.M., Maksimova, Y.O., Panchenko, A.V., Petrishchev, N.N., 2004. Immunomodulating and anti-tumor effects of basidiomycetes *Pleurotus ostreatus* (Jacq.: fr) *P. Kumm* and *P. conucopiae* (Pau. Ex Pers.) Rollan. Journal of Biology, Physics and Chemistry 4(3), 157–161.

Sharma, S.G., Fatma, M., Singh, V.K. 1996. Biochemical changes during solid substrate fermentation of water hyacinth with *Pleurotus sajorcaju*. Mushroom Research 5, 89.

Sharma, S., Yadav, R.K.P., Pokhrel, C.P., 2013. Growth and yield of oyster mushroom (*Pleurotus ostreatus*) on different substrates. Journal on New Biological Reports 2(1), 3–8.

Singh, C.S., Sharma, R., Patel, Y., Singh, V.K., 2010. Management of agricultural solid wastes by locally isolated *Pleurotus*

species, a white rot fungi. Asian Journal of Microbiology, Biotechnology and Environment Science 13, 561–564.

Singh, S., Kumar, C.G., Singh, S., 1995. Production, processing and consumption patterns of mushrooms. Indian Food Industry 14, 38–47.

Soliman, G.A., 2019. Dietary fiber, atherosclerosis, and cardiovascular disease. Nutrients 11(5), 1155–1166.

Tesfaw, A., Tadesse, A., Kiros, G., 2015. Optimization of oyster (*Pleurotus ostreatus*) mushroom cultivation using locally available substrates and materials in Debre Berhan, Ethiopia. Journal of Applied Biology and Biotechnology 3(1), 15–20.

Wongamthing, R., Nandi, A., Devi, M.R., Babu Y.M., Chowdhury, A.K., 2022. Strategies for improvement in cultivation practices of oyster mushrooms in North Bengal, India. International Journal of Environment and Climate Change 12(11), 1863–1879.

Xu, T., Beelman, R.B., Lambert, J.D., 2012. The cancer preventive effects of edible mushrooms. Anti-Cancer Agents in Medicinal Chemistry 12(10), 1255–1263.