**In India's northwestern region Oyster mushrooms may be a new superfood, and oyster mushroom cultivation method and disease management**

**Prdeep Singh Shekhawat1, Udai Pal Singh2 and Jyotsana Rathore3**

1Ph. D. (Research Scholar), Department of Plant Pathology Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan

2Ph. D. (Research Scholar), Department of Entomology, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan

3M. Sc. Student, Department of Genetics and Plant Breeding, Maharana Pratap University of Agriculture and Technology, Rajasthan

**Abstract**

In India's northwestern region, oyster mushrooms are gaining recognition as a potential superfood due to their nutritional value and ease of cultivation. Oyster mushroom cultivation is relatively straightforward and can provide a sustainable source of protein and other essential nutrients. oyster mushrooms are being promoted as a new protein source in the northern part of India. Oyster mushrooms have gained attention in various regions as a nutritious and sustainable food source due to their high protein content and potential health benefits. They are relatively easy to cultivate, making them a viable option for local food production. Oyster mushrooms are considered a good source of protein, vitamins (such as B vitamins), minerals (like potassium, phosphorus, and zinc), and dietary fiber. They are low in fat and calories, which can be beneficial for those looking to maintain a healthy diet. Additionally, they have a unique texture and flavor that make them a popular choice for various culinary applications. If oyster mushrooms are being introduced as a protein source in the northern part of India, it's likely that local initiatives are promoting their cultivation and consumption to address nutritional needs and sustainability challenges. It's important to ensure that proper cultivation practices are followed to ensure the safety and quality of the mushrooms.

**Introduction**

Mushrooms are large reproductive structures of edible fungi which acts as a major group of lower plant kingdom. Mushrooms are highly nutritive, being low-calorie and stuffed with good amount of proteins, vitamins and minerals, hence regarded as a holistic food preferable for all age groups. It provides high quality protein that can built greater biological efficiency than animal protein. Mushroom so often called as “Queen of vegetables” and table delicious from ancient as well it is a nature's hidden treasures of nutrition. Mushrooms are typically composed of 90% water, 2-40% protein, 2-8% fat, 1-55% carbohydrate, 3-32% fiber and 8-10% ash. Mushroom has a great potential for reducing malnutrition (Varghese and Pavitra, 2020).

Approximately 0.3 million varieties of mushrooms are identified, among them, some are fully edible and have no toxic effect hence they are considered as edible mushroom. Out of 2000 species of mushrooms, about 151 have been grown experimentally, 20 are cultivated commercially and 4- 5 are produced on industrial scale throughout the world. However, nearly 30 species are poisonous mushrooms and further a small number of them are lethal (Hasan *et al*., 2015).

Mushroom farming is becoming profitable because of its very low inputs. It is determined that about 300 million tons of fresh mushrooms can be brought from just one-fourth of words annual yield straw (2.325 million tons). It was calculated that approximately 317 million metric tons of fresh mushroom could be supplied annually that would provide 197g of fresh mushroom daily to each person in the world (Somashekar *et al*., 2020).

Mushroom cultivation is one of the most commercially important step towards assortment of agriculture. Microbial technology can help in large scale recycling of agriculture waste. This is being considered as one of the profitable and eco-friendly technology, and is most relevant for converting wastes into wealth (Biswas, 2014). Mushroom cultivation is easily done as it doesn’t required skilled persons for production.

Mushroom was first cultivated in 1917 in Germany by Flank. Oyster mushroom consists of several species of genus Pleurotus. It is commonly referred to as ‘Dhingri’ in India. The cap of Pleurotus is normally shell like and about 5-9 cm in diameter. Cap is fleshy having eccentric or lateral stripe. Colour of Pleurotus can be white, yellow, cream, pink and brown or dark grey. Fungal populations are developed through sexual and asexual reproduction (Naraian *et al*., 2016). It is reported as the third largest commercially produced mushroom in the world market. Thirty-nine species of these mushrooms have been recorded (Garcha *et al*., 1997), of which 9 are grown commercially world- wide. China alone accounts for 80% of the total world produce. Oyster mushrooms have a wide range of temperature tolerance (15-30oC) so; these are ideally suitable for cultivation under both temperature and tropical climatic condition. Oyster mushrooms are cultivated and harvested throughout the year (Ogundele *et al*., 2014).

It is an ideal food for diabetic and heart patients due to its low calorie, high protein and high fibre value and has high medicinal properties (Lavi *et al*., 2010). It also has antihypertensive and anti- hypercholesterolemia property, fully packed with vitamins (mainly B complex and C) and anti- oxidants. These mushrooms show anti-tumour properties (Jayakumar *et al*., 2009). The methanol extract from fruiting bodies of *P. florida* shows OH- radical scavenging and lipid catabolism inhibiting activities.

Natural plant wastes or agro-wastes are the basic substrate for production of all edible mushrooms, able to utilize high C/N ratio organic matter such as lignin, cellulose and hemicelluloses, require minimum space and low speculation cost and has short gestation period.

Oyster mushroom creates proper enzymatic mechanism for the transformation of complex organic macromolecules into simple compounds which have been utilized as the means for bio-degradation of a wide range of agro-wastes due to their ability of selective delignification. They can be grown in cultivation media of any lignocellulosic material such as rice straw, wheat straw, cereal straws, sawdust, sugarcane bagasse, maize cobs, cereal straw, corn cobs, sawdust, wood pulp, cotton and oil palm waste, banana leaves, coconut husks, poultry wastes, tree bark, leaves, paper, cotton seed hull and aquatic weeds with varying yield and performance (Sadh *et al*., 2018).

**Life cycle of white oyster mushroom (*Pleurotus florida*)**

Spore to spore stage, which defines the term life cycle of Pleurotus, is similar to any pileate basidiomycete, a major fungal group. It occurs with the germination of a basidiospore in a suitable substrate, which develops a monokaryotic mycelium with genetically identical nuclei (n) and capacity to develop indefinitely by itself and mate to produce in turn the dikaryotic mycelium; the dikaryotic mycelium expands and passes through the natural substrate with its genetic power, developing fruiting primordia, which grow into larger fruit bodies under optimum climatic conditions (temperature, light, relative humidity), followed by the creation and discharging of basidiospores (Adebayo and Martínez, 2015; Maurya *et al.,* 2022 a).

**Mushroom crop room cleaning and sterilization:**

The mushroom crop room was properly cleaned and washed with water. White washing of the mushroom crop room was done on the next day. The crop room was properly sprayed with the insecticide chlopyriphos 50% + cypermethrin 5% EC @ 30ml in 10 liters of water with a fungicide carbendazim 12% WP @ 10 g in 5 liters of water. The mushroom room was closed for one day. On the following day, a solution consisting of 10 g potassium permanganate and 100 ml formalin was kept in four corners of the mushroom room. The doors and windows were closed for 2 days. On the third day, spawning was done and the mushroom bags were kept inside the crop room for incubation (Maurya *et al.,* 2019 c and Maurya *et al.,* 2020).

**Substrates:**

Maize leaves, corn flour, banana leaves, sugarcane bagasse, wheat bran, paddy straw and other agriculture waste (Maurya *et al.,* 2022 b).

**Sterilization of substrates**:

All five substrates viz., wheat straw, paddy straw, sugarcane bagasse, maize leaves, and banana leaves were collected from various locations in Prayagraj and sun dried prior to cutting into small pieces (2-3 inches). A clean 200-liter drum was filled with 150 litres of water. Chemical sterilization method was used for decontamination of the substrates. 3 g of 75 ppm carbendazim (12% WP), 2 ml of insecticide (chlorpyriphos 50% + cypermethrin 5% EC), and 9 ml of 500 ppm formalin (40%) solution were mixed in the water and stirred together with a clean stick, then all five five substrates were soaked separately in the 15 litres bucket for 18 hours (Singh *et al*., 2019). The mouth of the plastic bucket was covered or sealed shut with a plastic sheet. Excess water was decanted onto a sloppy concrete floor which was pre-cleaned with formalin 2% water solution and dried for 3-4 hours in the shed to maintain 65–70% moisture (Kumar *et al*., 2020; Maurya *et al.,* 2020; Murmu *et al*., 2020).

**Surface sterilization:**

**Formalin:**

4 % of formalin solution was prepared by diluting 100ml of commercial formalin (40%) with 900 ml of distilled water to sterilize the polythene sheet on which the substrates were shade dried

**Preparation of mushroom bed:**

For bed preparation, standard compact polybag approach was followed by using sterilized organic substances. Prior to usage, the polyethene bags of size 13×18" with 100 gauge thicknesses were disinfected by soaking them in @ 2% formalin, and the lower corners of the bags were knotted with string to form a round bed. Spawning was done @ 3% per 1kg of wet substrates (Patil *et al*., 2014; Maurya *et al.,* 2016).The spawn was thoroughly mixed with the substrates and packed into the polythene bags by layering methods. Rubber bands were used to tie the openings of the bags once they were filled with the substrate containing spawn. 10-12 holes were made all-around the filled bags by using a sterile needle to facilitate aeration. Each 1 kg bag of agricultural waste was maintained for six treatments and six replications. The bags were kept in the sterilized crop room. All the spawned bags were kept at 20-25cm distance from each another. The spawned bags were incubated in a dark (Chauhan and Gupta, 2017) at temperature ranging from 200C-250C and humidity levels of 70 to 85%. Water was sprinkled twice a day on the walls and floor of the mushroom crop room to maintain temperature and humidity (Maurya *et al.,* 2019 b).

**Care after spawning:**

The spawned bags were moved inside the crop room and placed on a flat surface at room temperature. During the spawn run, there was no light or cross ventilation. The spawn run was observed carefully in the bags. When the fungus mycelium had fully covered the substrate, the polythene covering was carefully removed with a sterile needle to expose the substrate's surface for pinhead initiation. At least twice a day, the substrate was sprayed with water using hand sprayer. In 3-5 days, small pinheads appeared on the side of the blocks after the polythene bags were removed. With the use of a sprayer, the humidity of the cropping room was maintained by sprinkling tap water over the walls, roof, floor and beds. 2-3 hours of light and 2-3 hours of cross ventilation per 24 hours was provided for cropping (by opening doors and windows). The temperature was maintained between 20-30°C and the moisture level in the crop room was maintained between 72 and 75% (Biswas and Kuiry, 2013; Maurya *et al.,* 2019 a).

**Harvesting**

Mushrooms were harvested when the fruiting bodies reached maturation. Harvesting was done in the morning hours before 10 a.m. to minimize transpiration loss and before spore shedding. Watering was withheld a day before harvesting (Biswas and kuiry, 2013). The mature fruiting bodies were harvested by twisting them in clock wise or anti-clock wise direction with hand picking. The harvested fruiting bodies were weighed and observations were recorded treatment wise (Bhuvanesh *et al*., 2020)

**Table 1: List of mushroom infectious diseases and moulds with their causal**

**organisms**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Diseases Name** | **Causal Agents** |
| 1 | Olive Green Mould | *Chaetomium olivaceum* and other species |
| 2 | Green Moulds | *Trichoderma aggressivum* |
| 3 | Black Moulds | *Mucor* spp., *Rhizopus* spp., *Fusarium* spp.,  *Cephalosporium* spp., *Gliocladium* spp.,  *Papulospora* spp. |
| 4 | White Plaster mould | *Scopulariopsis fimicola* |
| 5 | Brown Plaster mould | *Papulospora byssina* |
| 6 | Lipstick mould | *Sporendonema purpurascens* |
| 7 | False truffle | *Diehliomyces microsporus* |

**Green mould** *(Trichoderma viride)*: It is the most common disease in oyster mushroom where green coloured patches are observed on cubes.

**Control:** Dip a cotton swab in formalin solution (4%) and scrapped off the affected area. If the fungus attacks more than half of the cube then the entire cube should be discarded. Care should be taken that the contaminated cube is burnt or buried in a place far from the cropping room to avoid re- infection.

**Bacterial Soft Rot**(*Pseudomonas spp.*):

**Symptoms:** Soft, slimy, and water-soaked spots on the mushrooms, often with an unpleasant odor. The affected areas can quickly degrade.

**Control:** Maintain proper hygiene, sterilize substrate, and ensure good air circulation to reduce moisture on mushrooms.

**Cobweb Mold** (*Hypomyces perniciosus*):

**Symptoms:** Grayish-white, cottony growth on the substrate or mushrooms, often spreading rapidly.

**Control:** Maintain proper hygiene, ensure good ventilation, and avoid high humidity conditions.

**Brown Blotch** (*Pseudomonas tolaasii*):

**Symptoms:** Brown to reddish-brown blotches on the mushroom cap, causing aesthetic and economic damage.

**Control:** Avoid overhead watering, maintain proper air circulation, and practice good sanitation.

**Virus Diseases:**

**Symptoms:** Stunted growth, irregular fruiting, and abnormal mushroom shapes.

**Control:** Use certified disease-free spawn, avoid cross-contamination, and practice strict hygiene.

**Wet Bubble Disease** (*Mycogone perniciosa*):

**Symptoms:** Small, watery blisters on the mushroom cap, often causing distortion.

**Control:** Maintain proper humidity, avoid overcrowding, and use disease-free substrate and spawn.

**Dactylium Disease:**

**Symptoms:** White, fluffy mycelial growth on the mushrooms, leading to deformities.

**Control:** Maintain proper ventilation, avoid overcrowding, and practice good sanitation.

**To prevent and manage these diseases, it's essential to follow good cultivation practices:**

Use clean and disease-free substrate and spawn.

Maintain proper hygiene throughout the cultivation process.

Provide adequate air circulation and ventilation to reduce humidity.

Avoid over-watering and maintain consistent moisture levels.

Monitor for early signs of disease and act promptly if detected.

Maintain optimal temperature and humidity conditions for oyster mushrooms.

Practice crop rotation and avoid reusing contaminated substrate.

If you suspect a disease outbreak, it's recommended to consult with experienced growers, agricultural extension services, or mycologists for proper identification and advice on management strategies specific to your region and conditions.

**Conclusion:**

Oyster mushroom cultivation offers a sustainable and nutritious source of protein. The cultivation process involves substrate preparation, inoculation, incubation, and controlled fruiting conditions. By following these steps, growers can enjoy multiple harvests of these delectable and versatile mushrooms.

For detailed and region-specific guidance, it's recommended to refer to comprehensive cultivation guides or seek advice from experienced cultivators or agricultural experts.

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