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Cultivation of Oyster Mushroom: A Review

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ABSTRACT: Mushrooms are rich in nutrients, minerals, vitamins, proteins, and bioactive substances such polysaccharides, steroids, phenolic compounds, and terpenes. The demand for mushroom cultivation is increasing daily as more people become aware of its high nutritional value and gustatory appeal. This review study aims to provide a comprehensive view of mushroom farming technologies. The expression of non-traditional crops in the farming system enhances the profitability of the farmer. Mushroom farming is a successful agricultural enterprise. It is a limited-space technique that only needs a small expenditure. Cultivation of oyster mushroom is a source of national income and helps to reduce poverty. Pleurotus species are capable of growing on a variety of agro-wastes and lignocellulosic materials, and a number of different culture substrates and growth conditions have been explored. The use of wastes in mushroom production offers an added benefit: tackling environmental, economic, and global problems while managing food waste sustainably and producing high-quality food from low-quality waste. *Pleurotus* species of mushrooms have medicinal potential because of their nutritional or chemical composition. Mushrooms can be utilized to empower women. In a small village, women can grow oyster mushrooms at home to meet their nutritional needs and make money.

Keywords: *Pleurotus* spp., Agro-wastes, Temperature, Relative humidity, Nutritional value, Yield.

INTRODUCTION

Mushroom is a macro fungus, mushrooms have characteristic fruiting bodies that can be either epigeous or hypogeous (Nongthombam *et al.*, 2021). Mushroom lacks chlorophyll. Therefore, because it is unable to synthesis food on its own, so it depends on dead and decay materials to utilize food materials as ectomycorrhizal association. There are about 2,000 species in nature, but only about 25 are commonly used as food (Chatterjee and Patel 2016). Edible mushrooms are a large and fascinating group of fungi, which include 3283 mushroom species as edible or conditionally edible, accounting for about 20% of all mushroom taxa recorded in the global sources (Zhang *et al.*, 2021). China alone produces 87% of the global production of *Pleurotus spp.* (Barh *et al.*, 2019). The most widely farmed fungus in India is *Agaricus bisporus*, followed by *Pleurotus* spp.

One of the most popular edible mushrooms grown in the tropics is the *Pleurotus* species (Quimio *et al.*, 1990). Due to the temperature range in which they thrive, oyster mushrooms can be produced in both temperate and tropical regions. Lately, a commonly used substrate for oyster mushroom cultivation—wheat straw, is more often replaced by alternative cellulose substrates originated from the agricultural and food industry. Recycling food waste has several advantages, including addressing important global concerns relating to the environment (Djekic *et al.*,2019), society (Van *et al.*, 2019), and the economy (Philippidis *et al.*, 2019) unemployment, food demand, environmental pollution etc. (Nongthombam *et al.*, 2021). Mushroomis one of the most promising resources to promote rapid socioeconomic development (Martinez-ibarra, 2019). It is an indoor setting, in which it is possible for rural women to start mushroom farming in their homes with little start-up cost (Shaker, 2015). Thus, mushroom farming not only gives rural women empower but also eradicates poverty at the grass root level.

Mushrooms cultivation is the most cost-effective biotechnology available today for recycling lignocellulose organic waste which they combine the production of food high in protein with pollution prevention. The nutritional value of mushrooms and their potential health benefits are becoming widespread awareness around the globe. Edible mushrooms are regarded as a significant source for the human diet worldwide, along with fruits and vegetables. Proteins, carbohydrates, dietary fiber, water-soluble vitamins, vital amino acids, and minerals are abundant in *Pleurotus* (Raman *et al.*, 2021). Mushroom species are known to have wide range of metabolites such as antitumor anti-cholesterol and anti-cancerous properties (Shah *et al.*,2004), antioxidant, antigen toxic,

antiplatelet aggregating, antihyperglycemic, antifungal, antibacterial, and antiviral activities (Nongthombam *et al.,* 2021), anti-inflammatory, hepatoprotective, antidiabetic, hypolipidemic, hypotensive and cytotoxic properties (Zawadzka *et al.*, 2022) boosts immune-balancing and immunomodulation (Wasser, 2002). This makes it a good dietary source for human nutrition (Strmiskova *et al.*,1992). During pandemic SARS-COV -2 consumption of mushroom was increased because there was no any specific treatment available for it but only by regular consuming of mushrooms species like *Lentinula edodes, Inonotus obliqus and Grifola frandosa* having antiviral and anti-inflammatory properties can be prove to be very effective in reducing the deleterious effects Covid – 19 (Shahzad *et al.*,2020).

Pleurotus mushrooms and its strains are somewhat new and recent move towards, and because of its nutritional advantages, this mushroom needs to be popularized in India. The cultivation technology adopted for growing this mushroom is much simpler than growing the button mushroom. This review paper tries to give a comprehensive perspective on environmentally responsible farming practices. In general, this article informs the reader about the oyster mushroom cultivation technology their production potential along with nutritional and health benefits of Pleurotus mushrooms.

Scientific classification

1. Kingdom- Fungi
2. Division-*Basidiomycota*
3. Class-*Agaricomycetes*
4. Order-*Agaricales*
5. Family-*Pleurotaceae*
6. Genus-*Pleurotus*
7. Species-*P. ostreatus, P. florida, P. sajor-caju, P. sapidus, P. eous, P. flabellatus*

Parts of oyster mushroom. The external appearance of oyster mushroom has been characterized by the presence of a spatula shaped cap called pileus. This is fleshy part. An oyster mushroom's fruiting body has a stem that can be short, long, lateral or central and thick (Shukla and Jaitly 2011). This stalk is called stipe. An interesting and attractive feature of oyster mushroom is presence of long ridges and furrows underneath the pileus which is called gills or lamellae. The oyster mushroom's gills contain the spores that help in reproduction. These spores are characterized as smooth and cylindrical which can germinate on any type of mycological media within incubation period of 48 to 96 hrs. The mycelium colour of *Pleurotus florida*, is purely white (Chitra *et al.*, 2018). Mostly, the colours of mushrooms are white, brown, or yellow. Sometimes, it can be very colourful. The spore print of the mushroom is white to lilac-grey, and best viewed on dark background.

Agroclimatic Requirement. Optimizing the growth conditions, which include temperature, humidity, and light levels, is one of the most critical elements for generating optimum yields (Bumanlag *et al.*, 2018). Although oyster mushrooms can be grown all year long, for commercial purposes they need particular environmental factors including temperature and relative humidity. The optimum temperature and relative humidity for maximum mycelial growth is 25-30ºC and 75-90 per cent respectively (Ragupathi *et al.*, 2016). Variations in any of the factors directly affect the primordial initiation, yield and biological efficiency. Thakur *et al.* (2000) conducts their experiment for ten successive months (January to October) and noticed that January to March were the most favourable months for early spawn run, pin head initiation and maximum biological efficiency (58.54-63.62%). In the months of May and June there was no spawn run observed. This denotes that high temperature with low relative humidity slow down the growth of mycelium. Uddin *et al.* (2011); Chitra *et al.* (2018); Deora *et al.* (2021) reported that the most favourable months for higher production and best biological efficiency were during the winter (December to February). The cultivation practices during the summer months can be done by delivering redundant moisture needed for its growth and development.

Cultivation technology of oyster mushroom. Mushroom culture involves several different, each of which must be carefully performed. The first step is to obtain pure mycelium of the specific variety of mushroom. Poppe (2000) reported that Edible mushrooms can be cultivated in 200 different types of waste. Substrate preparation, inoculation, incubation, and production conditions depend on the mushroom species to be cultivated. The subsequent steps can be carried out during oyster mushroom cultivation are:

i. Preparation of spawn
ii. Preparation of substrate
iii. Spawning of substrate
iv. Crop management and harvesting of mushroom

Preparation of spawn. Mycelium can be gathered from spores or a tiny piece of a particular mushroom. Two percent malt extract agar medium was used to multiply the and pure culture maintained in test tube slants having two per cent malt extract agar medium by frequent sub culturing. After inoculation, the slants should be kept in an incubator at a temperature of 25°C upon inoculation until the desired growth is obtained. Mother spawn and planting spawn are raised on grains once pure culture has been obtained. Mycelium of mushroom is grown on grains and these grains are using for seeding, which is usually called the spawn (Chang and Hayes 1978; Chang and Miles 1989). Spawn is referred as seed of mushroom.

For the preparation of spawn, cereal grains are used as the substrate. Good quality grains are soaked in water over night and then boiled for 20 to 25 minutes the following morning. Excess water is decanted off after boiling. The grains are then spread out on a bloating sheet to surface drying for 30 minutes. On a wet weight basis, 1% calcium carbonate is added to these semi-cooked grains. $CaCO_3$ is used to control the pH of grains and prevent clumping of the grains. The ideal substrate pH range is 7.5–7.8. Grain is thoroughly mixed before being placed into glass bottles and polypropylene bags up to two-thirds full. The mouth of the container is then tightly sealed with a cotton plug, covered with aluminium foil or paper and secured with a rubber band to hold it in place. For 30 minutes, these

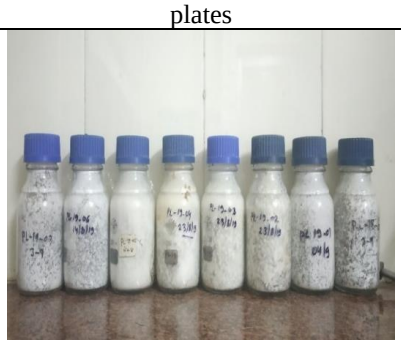
bottles and bags are sterilized at 20 pressure (126.5°C) in an autoclave. After sterilization these bags are kept for cooling. After cooling at room temperature, each bag and bottle should be violently shaken and transferred in a laminar air flow chamber. These bags and bottles undergo a 20-minute UV exposure process to remove surface contaminants (Netam *et al.*, 2018).

Mother spawn. Bottles are inoculated with fully grown pure culture tube or mother grain spawn. Inoculation should be done under aseptic condition inside the laminar air flow. One pure culture tube or 8-10 g mother spawn grains are poured into the bottles. One fully grown mother grain spawn bottle is able to inoculate 14-15 bottles ((Monmoon *et al.*, 2010; Netam *et al.*, 2018; Sarita *et al.* 2021).

Planting/ commercial spawn. The planting spawn is used for seeding. The sterilized bags are inoculated same as mother spawn. Fully grown mother grain spawn is used for inoculation of these bags. 15-20 g of mother spawn grains are poured into the sterilized bags and bags are shaken gently to spread the inoculums uniformly. Within the 10-12 days spawn run completed and bags are full of white coloured mycelium. Spawn is usually stored in a controlled environment to maintain its viability until it is used for inoculating the growing substrate (Knop *et al.*, 2015). The success of mushroom production depends in great part on the quality of the spawn, which must be prepared under sterile conditions to diminish contamination of the substrate.

Mushroom mycelium growth in Petri plates

Pure culture tubes



Master spawn

Commercial spawn

Plate 1. Steps in spawn preparation.

Substrate for oyster mushroom cultivation. *Pleurotus* spp. are able to degrade and convert lignocellulosic compounds into protein rich biomass (Mamiro and Mamiro 2011), and help in managing agro-wastes whose disposal has become a problem (Das and Mukherjee 2007). It demonstrated higher colonization rates, improved earliness, and sporophore yield on different agro wastes compared to other cultivated mushroom genera (Philippoussis *et al.*, 2001). *Pleurotus* spp. are usually grown on a wide range of lignocellulosic materials (Khan and Tania 2012; Poppe, 2000). The materials are generally not composted prior to mushroom inoculation. *Pleurotus spp.* is characterized by its rapid growth on agro-wests such as paddy straw (Maheshwari *et al.*, 2007), wheat straw (Gregori *et al.*, 2007; Deora *et al.*, 2021), wheat straw- cotton straw (Akyuz and Yildiz 2007), cotton waste (Oh *et al.*,2000), cotton seed (Girmay *et al.*, 2016), grasses (Singh and Singh 2011; Bumanlag *et al.*, 2018); Maize stover (Fanadzo *et al.*, 2010). When *Pleurotus ostreatus* grows on 40-60% tea leaf waste resulted in high yield and biological efficiency (Yang *et al.*, 2016).

Sterilization of Substrate. Sterilization of the substrate is an essential step in the production of mushrooms because it prevents pathogens like Molds, bacteria, other fungi like *Coprinus, Aspergillus* etc. to colonize the substrate. Chemical treatments resulted in a higher yield because the fungicides and insecticides used to control saprophytes and fungal insect attacks. When compared to alternative straw treatments like steam treatment, chemical treatment, or untreated wheat straw, yields when treating substrate with IHW (immersion in hot water) treatment are lowered by at least 20%. The decrease in yield would be caused by the loss of these nutrients (Mejía and Albertó 2012).

Straw should be chopped into 1-3 cm pieces and soak in clean water for 16-24 hours. After soaking and disinfecting, excess water should be removed from the straw by spreading it on a high wire mesh frame (Peng,

1996). When the excess water decanted, spread the straw on a poly sheet by weighing 3-4 kg of wet straw. The optimum level of water is indicated when water does not drip down the palm of the wet straw when pressed in the hand. Excess moisture causes rotting of the straw and low moisture slows down thespawn run. Techniques for preparing the substrate are intended to produce an environment that is sterile or semi-sterile and favourable for the colonization and growth of mushrooms. (Feeney *et al.,* 2014).

Spawning. Rate of spawn and substrate quantity also affect the yield and biological efficiency of oyster mushroom. The yield increase is directly proportional with the increase in spawn rate up to certain level. For higher yield and biological efficiency 3 kg and 4 kg substrate (Kumar 2005, Patel and Trivedi 2014; Deora *et al.,* 2021) with five percent spawn rate (Ram and Pant 2004; Chauhan, 2013; Kumar *et al.,* 2021; Deora *et al.,* 2021) is optimum. Spawning should be done in neat and clean place. Polybags (14×20 inches) used for filling 3 kg wet substrate. 10-12 small holes should made in the bags as facilitate respiration by the mycelium. Spawning can be done by mixed spawning or layer spawning. The commonly used method is the mixed spawning method where sterilized straw thoroughly mixed with healthy spawn and fill in the polybags. For layer spawning a 4 cm thick layer of substrate is made in bag and press slightly and then spawn is spread uniformly over it which is again covered with a 4 cm thick layer of straw. This process is repeated 4-5 times and the mouth of the poly bag is tied with rubber bands.

Crop management and harvesting of mushroom. In the traditional method of mushroom cultivation, humidity is maintained by hanging gunny sheets or coir mats along the walls and kept wet by watering it frequently during the cropping phase. In addition, during summer, the loss of water due to evaporation is more, and it becomes very difficult to maintain the required humidity and moisture in the substrate. In such a period, sand is spread on the floor and drenched with water. The average yield gained is 60% of the substrate, as there is no fixed controlling mechanism for maintaining mushroom house temperature and humidity, but it can be achieved 100% under proper environmental conditions and crop management (Pandey *et al.,* 2022).

Spawned bags are stacked in racks in closed position and temperature (24±2 °C) and humidity (80-85%) is maintained by spraying water twice in a day on walls and floor. The length of the spawn run period varies depending on the mushroom species and environmental conditions, but typically ranges from a few weeks to a couple of months (Singh and Singh 2011). After spawn run completion and bags fully covered with white mycelium. Polybags are removed carefully, and one day after the removal of polythene cover watering is started. The first primordia appears 3-4 days after removal of polybags. These primordia matured generally in 1-2 days. Matured mushroom is identified by curl margin of cap and harvested by twisting it clock wise to uproot from the base. In a single life cycle of mushroom 3-4 flushes appeared.

Removal of excess water by air drying

Layered spawning

Completion of Spawn run

Spawned bags

	
Pin head initiation after opening the bag	After pin head initiation fruit-bodies are ready for harvesting in 1-2 days.

Plate 2. Steps in oyster mushroom cultivation.

CONCLUSIONS

Management from 'waste-to-wealth' is essential for more sustainable farming globally, and increasing mushroom production in India seems a viable and attractive option. By educating people and raising awareness about the nutritional and health potential of mushrooms, adding these mushrooms to our diet can enrich our culinary experience while providing an array of health benefits. It is also important to draw attention towards the integration of mushroom technology into successful Agri-residue management programs, livelihood programs, national nutrition programs, and women's empowerment and rural development initiatives.

From this review paper it is concluded that to increase the productivity of Pleurotus mushroom, it is necessary to understand its production technology as well as favourable environmental condition such as room temperature, relative humidity dark period and appropriate aeration. Bacterial and fungal diseases are most commonly occurred due to unfavourable temperature, relative humidity and inappropriate aeration. In mushroom cultivation it entirely depends on the environment where it is cultivated and the room needs to be in proper sanitation in order to avoid contamination. The grower engaged in mushroom cultivation should also have knowledge of substrate quantity and spawn rate.

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