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TRAINING MANUAL
ON

CULTIVATION OF OYSTER MUSHROOM

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Preface

Visit to nearby hills, mountains for picking up of edible mushroom during onset of monsoon is one of the common hobbies among the villagers. Such hobby has become the customary practices among the tribal people in North East India. This is helping them to spend their leisure time, free from cities 'pollution, ensures relaxing in the midst of clean air giving them a peaceful environment, thereby improving their overall health in all spheres-mind, body and soul. Mushroom is one of the favourite food items of the people. This food item is very beneficial, it boosts the human health by providing the essential proteins, carbohydrates, low in fat and thus nutritious to the human body. As we know, mushroom is one of the oldest food items known since ages and are now preferred by the people with obesity, high blood pressure especially for those who could not take meat anymore in their daily diet. Not only this, for some people, such hobby has become a livelihood means, a source of income to the family.

In the North Eastern region of India mushrooms needs no introduction which have been a coveted food item for the predominant ethnic tribal population here since ages. The ethnic groups with their traditional knowledge as legacy are engaged in mushroom collection and consumption. Mushrooms are known by different names in the local dialects of the North Eastern states like *'Tit'* (Meghalaya) *'Kathphula'* (Assam and Tripura), *'Cheaoe'* (Sikkim), *'Chenggum'* (Manipur), *'Pa'* (Mizoram), *'Konger'* (Ao dialect, Nagaland) and *'Indeo'* (Galo dialect, Arunachal Pradesh). Mushroom picking especially with the onset of monsoon from the wild is still rampant in the remote areas. Most of the edible and non-edible mushrooms grow wild in the region. In nature, a number of species of mushrooms are found mainly during the rainy season, on almost all types of soils, on decaying organic matter, wooden stumps etc. But sometimes, picking of mushroom from the wild forest poses a great danger for consumption and is such a risky, life threat activity when we are not cautious enough. Consumption of wild mushrooms have led to loss of precious lives which is evident in the reports of the local dailies time and on. So utmost care with good knowledge about mushrooms is needed from time to time. To continue reaping the benefits from mushroom, the Government is encouraging the farmers to cultivate oyster mushroom instead, which is free from all the life-threatening consequences. This calls for promoting mushroom cultivation on mass scale to ensure nutritional security, livelihood improvement and empowering the unemployed and farm women. This manual would provide all the essential information, insight for production of oyster mushroom at the farmers' level so as to double their livelihood income and make use of the available farm resources.

Chapter 1: About Oyster mushroom

Objectives of the session

- To educate the farmer about oyster mushroom and its importance.
- To enhance awareness of farmers about the varieties of growing Oyster Mushroom and its advantages

Introduction

Mushrooms are primitive organisms known as fungi (macro fungi). They lack the green matter content (chlorophyll) and grow saprophytically on dead decomposed matter. They derive their nutrition with the help of the mycelium that penetrate into the substratum (decaying organic matter, rotting wood or soil) where conditions are favorable for their growth. When the mycelium has grown profusely by absorbing sufficient food materials, it develops the spore bearing reproductive structure or fruiting body, generally referred to as 'Mushroom'. The basic structure of mushroom consists of an umbrella like cap or technically called pileus, bearing gills and a stalk or stipe. In 1992, Chan and Miles defined mushrooms as macrofungi with outstanding fruiting body that can be hypogeous or epigeous, large enough to be seen with naked eye and can be picked by hand. All fungi are not mushrooms and all mushrooms are not edible. There are 14,000 species of mushrooms reported in the world including 1200 species belonging to three orders Agaricales, Boletales and Russulales are described from India which contributes 10 percent of the global mushroom diversity. More than 2000 species are considered to be edible, less than 25 species are widely accepted as an item of food and only about a dozen of them have been domesticated and artificially cultivated. In the north eastern region, a huge diversity of macrofungi is found growing on the forest-floor, twigs and branches, rotting plants etc.

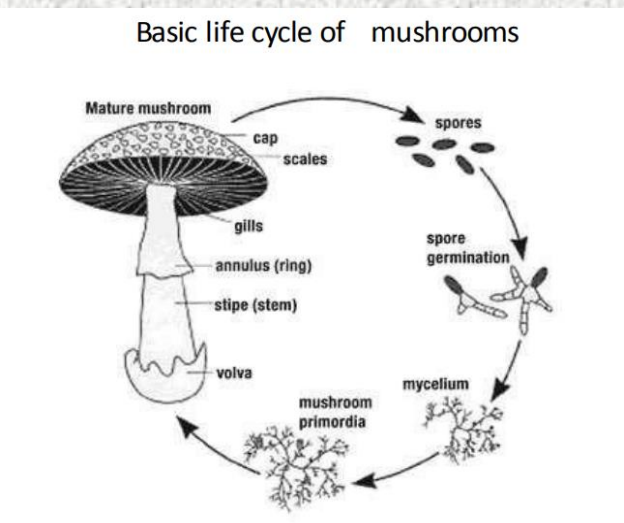


Fig 1: Few common edible wild mushrooms found in Khasi Hills

Fig 2: Few wild mushrooms found in NE region

Pleurotus sp.

Lentinula sp.

Termitomyces sp.

Ganoderma sp.

Some unknown species

Oyster mushroom

Oyster mushroom commonly referred as 'Dhingri' in India, is a basidiomycetes and belongs to the genus 'Pleurotus'. It is lignocellulolytic fungus that grows naturally in the temperate and tropical forests on dead, decaying wood logs, sometimes on drying trunks of deciduous or coniferous trees. It can also grow on decaying organic matter. The fruit bodies of this mushroom are distinctly shell, fan or spatula shaped with different shades of white, cream, grey, yellow, pink or light brown depending upon the species. However, the colour of the sporophores is extremely variable character influenced by the temperature, light intensity and nutrients present in the substrate.

The name Pleurotus has its origin from Greek word, 'Pleuro' that means formed laterally or lateral position of the stalk or stem. The oyster mushroom is one of the most suitable fungal organisms for producing protein rich food from various agrowastes without composting. This mushroom is cultivated in about 25 countries of far-east Asia, Europe and America. It is the third largest cultivated mushroom in the world. China alone contributes 88.00 percent of the total world production. The other major oyster producing countries are South Korea, Japan, Italy, Taiwan, Thailand and Philippines. At present India produces annually about 10,000 tons of this mushroom. It is popularly grown in the states of Orissa, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh, West Bengal and in the North-Eastern States of Meghalaya, Tripura Manipur, Mizoram and Assam.

Visually the basidiocarps or fruit bodies of an oyster mushroom have 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 gills stretch from the edge of the cap down to the stalk and bear the spores. If a fruit body is kept on a paper directly (gills facing the paper) a dirty white or lilac deposition of powdery spores can be seen. The spore print colour may be whitish, pinkish, lilac or grey. The spores are hyaline, smooth and cylindrical. The spores are heterothallic and germinate very easily on any kind of mycological media and within 48-96 hrs whitish thread like colonies could be seen. The mycelium of most *Pleurotus spp.* is pure white in colour. *P. cystidiosus and P. columbinus* forms coremia like stalked structures (asexual spores). Basidiospores on germination forms primary mycelium. Fusion between two compatible primary mycelia develops into secondary mycelium, which is having clamp connections and is fertile. Primary mycelium is clampless and non-fertile.

Fig 3: Different species of oyster mushroom

Table 1: Types of Oyster mushroom with required optimum temperature		
Common Name	**Scientific Name**	**Optimum Temperature Range**
Grey Oyster	*Pleurotus sajor-caju*	20-28^{o} C
Black Oyster	*Pleurotus ostreatus*	18-22^{o} C
White Oyster	*Pleurotus florida*	20-28^{o} C
Pink Oyster	*Pleurotus djamor*	20-26^{o} C

A. Advantages of Growing Oyster Mushroom

1. Variety of substrates

Pleurotus mushroom can degrade and grow on any kind of agricultural or forest wastes, which contain lignin, cellulose and hemicellulose.

2. Choice of species

Among all the cultivated mushrooms Pleurotus has maximum number of commercially cultivated species suitable for round the year cultivation. Moreover, variation in shape, colour, texture, and aroma are also available as per consumer's choice.

3. Simple cultivation technology

Pleurotus mycelium can grow on fresh or fermented straw and it does not require composted substrate for growth. Substrate preparation for oyster mushroom is very simple. Further this mushroom does not require controlled environmental conditions like *A. bisporus* as most of the species have very wide temperature, relatively humidity and CO2 tolerance.

4. Longer shelf life

Unlike white button mushroom, the oyster mushroom fruit bodies can be easily dried and stored. Dried oyster mushrooms can be instantly used after soaking in hot water for 5 to 10 minutes or it can be used in powdered form for several preparations. Fresh mushrooms have a shelf life of 24-48 hr even at room temperature.

5. Highest productivity

The productivity of oyster mushroom per unit time is very high as compared to all other cultivated mushrooms. One can harvest minimum of about 500 to 700 kg of fresh oyster mushroom from one ton of dry wheat or paddy straw in 45-60 days, while with the same quantity of straw only about 400-500 kg of white button mushrooms are obtained in 80-100 days (including period needed for compost preparation). Yield of this mushroom can further be increased by supplementing the substrate with suitable nitrogen source viz., soybean and cotton-seed meal or by introducing high yielding cultures/strains.

The present-day cultivation technology of oyster mushroom is a result of various successive steps evolved throughout the world during 20th century. A very primitive form of growing Pleurotus spp. was adopted by Lumberman in Europe during 19th century that involved collection of wood logs and stumps showing fructification in nature and keeping them in cool and moist places. First successful experimental cultivation of Pleurotus ostreatus was achieved in Germany by Falck in 1917. In India cultivation of *P. flabellatus* on paddy straw was reported by Bano & Srivastava in 1962 at CFTRI, Mysore. Kaul and Janardhanan (1970) cultivated a white form of *P. ostreatus* on dried Euphorbia royleana (Thor) stems. Jandaik and Kapoor in 1974 could grow *P. sajor-caju* on various substrates including wheat and banana pseudostems.

Almost all the species *Pleurotus florida, P. cornucopiae, P. citrinopileatus, P. flabellatus, P. ostreatus, P. sapidus, P. sajor-caju along* with *H. ulmaris* can be successfully grown in the region. *P. sapidus* and *P. sajor-caju* do better during the warmer part of the year (May – August). *P. eous* with attractive pink colored fruit bodies is most beautiful but has no commercial implications due to less yield potential and leathery texture.

Table 2: Required characteristics of different oyster mushroom species

Characters	**Oyster mushroom**	**Button mushroom**	**Milky mushroom**	**Paddy straw mushroom**
Species	*Pleurotus spp.*	*Agaricus spp.*	*Calocybe indica*	*Volveriella spp*
Substrate use	Paddy straw	Compost	Paddy straw	Paddy straw
Growing Temperature	20-25^{0}C	15-20^{0}C	30-35^{0}C	30-35^{0}C
Relative humidity	85%	85-95%	85%	85-95%
Total life cycle	35-45 days	90 days	45-50 days	90 days
Days for first interval	15-25 days	60-70 days	24-28 days	10-15 days
Yield	635g (500g paddy straw)	800-900g/bed (4 kg compost)	720g (500 g paddy straw)	800-900g/bed (4 kg compost)
Shelf life (days)				
a) Normal conditions	2	2	3	1
b) Refrigerated	3	3	5-7	2
Protein	23.6%	23.9%	32%	23.9%
Production cost/kg (Rs)	60-75	90-120	60-80	45-55

Chapter 2 Nutritional and Medicinal Value of Oyster Mushroom

Objectives of the session

• To enhance awareness of farmers about the medicinal and nutritional value of oyster mushroom

Indian diet is primarily based on cereals (wheat, rice and maize), which is deficient in protein. Supplementation of mushroom recipe in Indian diet will bridge protein gap and improve the general health of socio-economically backward communities. Earlier mushrooms were considered as an expensive vegetable and were preferred by affluent peoples for culinary purposes. Currently common populace also considers mushroom as a quality food due to its health benefits. Mushroom is considered to be a complete, health food and suitable for all age groups, child to aged people. The nutritional value of mushroom is affected by numerous factors such as species, stage of development and environmental conditions. Mushrooms are rich in protein, dietary fibre, vitamins and minerals. The digestible carbohydrate profile of mushroom includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols and sugar acids. The total carbohydrate content in mushroom varied from 26-82% on dry weight basis in different mushrooms. The crude fibre composition of the mushroom consists of partially digestible polysaccharides and chitin.

Edible mushrooms commonly have insignificant lipid level with higher proportion of polyunsaturated fatty acids. All these result in low calorific yield from mushroom foods. Mushrooms do not have cholesterol. Instead, they have ergosterol that acts as a precursor for Vitamin D synthesis in human body. Similarly, ergosterol in button mushroom is converted in to vitamin D2 when exposed to UV radiation or sunlight. The protein content of edible mushrooms is usually high, but varies greatly. The crude protein content of mushrooms varied from 12-35% depending upon the species. The free amino acids composition differs widely but in general they are rich in theronine and valine but deficient in sulphur containing aminoacids (ethionine and cysteine). Nutritive values of different mushroom are given in Table 3. Mushrooms comprise about 80-90% of water, and 8-10% of fiber. In addition to these, mushroom is an excellent source of vitamins especially C and B (Folic acid, Thiamine, Riboflavin and Niacin). Minerals viz., potassium, sodium and phosphorous are higher in fruit bodies of the mushroom. It also contains other essential minerals (Cu, Zn, Mg) in traces but deficient in iron and calcium.

Oyster mushrooms are 100% vegetarian and the nutritive value of oyster mushroom is as good as other edible mushrooms like white button mushroom (*A. bisporus*), shiitake (*Lentinula edodes*) or paddy straw mushroom (*Volvariella spp.).* They are rich in vitamin C and B complex. Protein content varies between 1.6 to 2.5% on fresh weight basis. It has most of the mineral salts required by the human body such as potassium, sodium, phosphorus, iron and calcium. The niacin content is about ten times higher than any other vegetables. A polycyclic aromatic compound pleurotin has been isolated from *P. griseus*, which possess antibiotic properties.

Table 3: Nutritive values of different mushrooms (dry weight basis g/100g)

Mushroom	Carbohydrates	Fibre	Protein	Fat	Ash	Energy k cal
Oyster mushroom (*Pleurotus sajor-caju*)	63.40	48.60	19.23	2.70	6.32	412
Oyster mushroom (*Pleurotus ostreatus*)	57.60	8.70	30.40	2.20	9.80	265
White-button mushroom (*Agaricus bisporus*)	46.17	20.90	33.48	3.10	5.70	499
Auricularia auricula	82.80	19.80	4.20	8.30	4.70	351
Milky mushroom *(Calocybe indica)*	64.26	3.40	17.69	4.10	7.43	391
Shiitake mushroom (*Lentinula edodes*)	47.60	28.80	32.93	3.73	5.20	387
Flammulina velutipes	73.10	3.70	17.60	1.90	7.40	378
Paddy straw mushroom (*Volvariella volvaceae*)	54.80	5.50	37.50	2.60	1.10	305

Table 4: Medicinal values of important mushrooms

Mushroom	Compounds	Medicinal properties	Source
Ganoderma lucidum	Ganoderic acid Beta-glucan	Augments immune system, liver protection, Antibiotic properties, inhibits cholesterol synthesis	Lin & Zhang,2004 Wang et. al.,2007 Moradali et. al.,2006 Komoda et. al.,1989
White-button mushroom (*Agaricus bisporus*)	Lectins	Enhance insulin secretion	Ahmad, 1984
Oyster mushroom (*Pleurotus sajor-caju*)	Lovastatin	Lower cholesterol	Gunde & Cimerman,1995
Shiitake mushroom (*Lentinula edodes*)	Eritadenine Lentinan	Lower cholesterol, Anti cancer agent	Enman et. al.,2007
Flammulina velutipes	Ergothioneine Proflamin	Antioxidant Anticancer activity	Bao,2008, lkekawa et. al.,1985
Auricularia auricula	Acidic polysaccharide	Decrease blood sucrose	Yuan et. al.,1998

(a)

(b)

(c)

Fig 4: Different types of mushroom:

(a) Oyster mushroom (b) *Ganoderma lucidum* (c) Button mushroom

Chapter 3: Low-Cost Production of Oyster Mushroom

Objectives of the session

• To teach the farmers about the polybag cultivation method adopted for growing of oyster mushroom at small scale production level

It is reported that there are about 50,000 known species of fungi and about 10,000 are considered as edible ones. Of which, about one hundred and eighty mushrooms can be tried for artificial cultivation and seventy are widely accepted as food. The cultivation techniques were perfected for about twenty mushrooms and about dozen of them have been recommended for commercial cultivation. However, only six mushrooms are widely preferred for large-scale cultivation. They are

1) Oyster mushroom - *Pleurotus spp*
2) Paddy straw mushroom - *Volvariella spp.*
3) Button mushroom - *Agaricus spp.*
4) Milky mushroom - *Calocybe spp.*
5) Shiitake mushroom - *Lentinus spp.*
6) Jew's ear mushroom - *Auricularia spp.*

Cultivation technology of oyster mushroom is very simple which does not require costly infrastructure facilities. The cultivation of oyster mushroom in India is mainly done in seasonal low cost growing rooms with very less expenditure. This simple cultivation technology, low production cost and adaptability attributes make this mushroom most widely cultivated throughout the country. Bioconversion ability is highest i.e. more than 60%. Moderate range of temperature 20-3^{0}C and 80-85% humidity supports good growth of this mushroom. Especially in the North East region the growing season of oyster mushroom is longer. It can be grown for ten months or almost throughout the year. One can hardly find a big oyster mushroom growing unit in India having round the year production. There is no organized market where one can sell his produce or purchase fresh or dry oyster mushroom throughout the year. Therefore, the production of oyster mushroom on a commercial scale is rare in our country as compared to *Agaricus bisporus* (button mushroom). Theoretically each crop takes 45 days and under controlled conditions and hence there can be 8 crops per year.

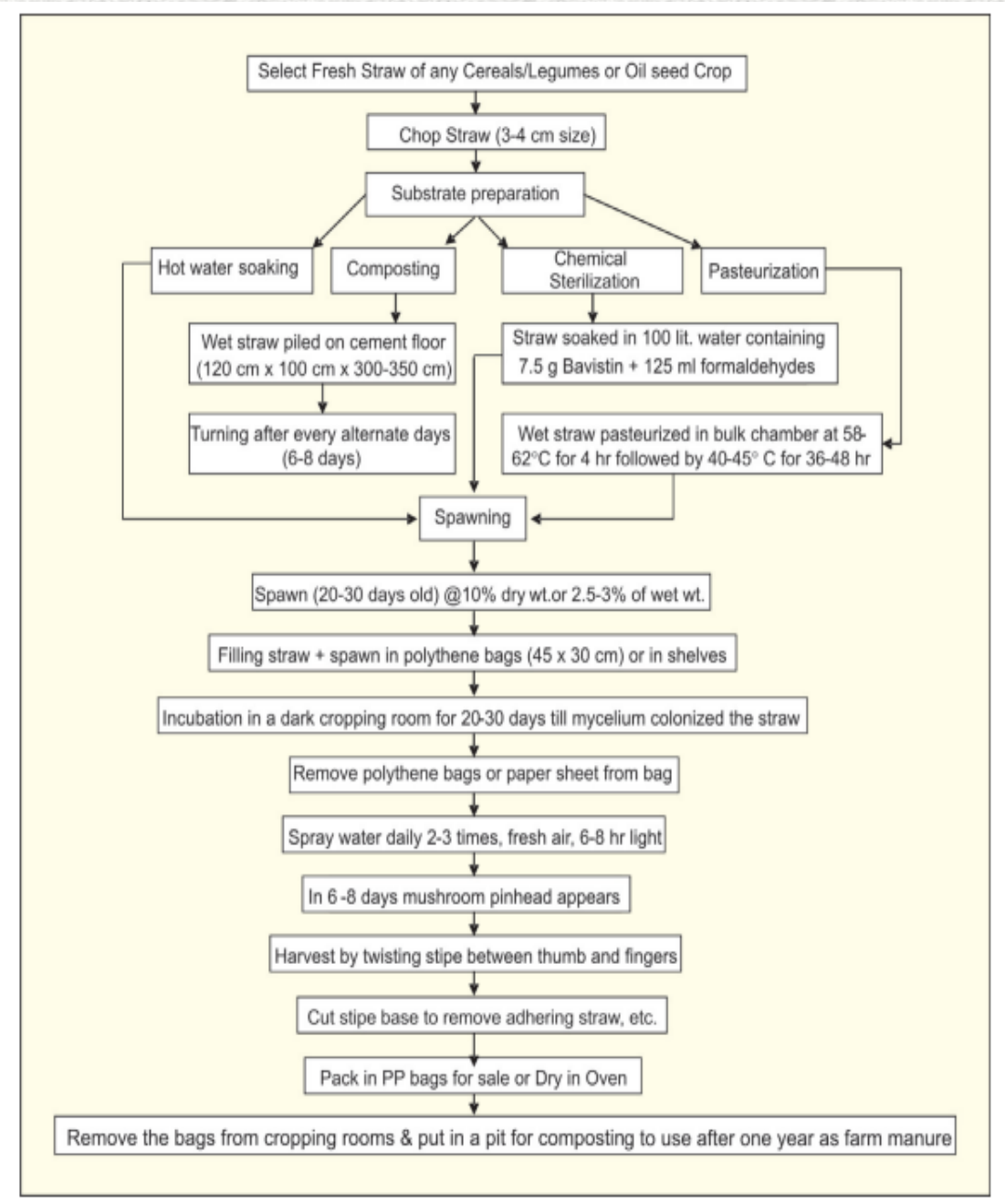


Fig 5. Different types of spawn preparation techniques for oyster mushroom production

Polybag culture / Polythene bag method is one of the cultivation methods adopted by the farmers for small scale production at the field level. It is very much adopted by the farmers as majority of them are paddy growers. In this method, no such machines or any sophisticated instruments, chemicals are needed but only with the local materials available at home. Hot water treatment makes the hard substrate like paddy straw, maize cobs, stems, etc. soft so that

the growth of mycelial takes place easily. This method thus is quite economical and not suitable for large-scale commercial cultivation.

Site selection

For successful production and better return of mushroom, the site should be selected after consideration of the following points:

i) Nearer to the residence of grower for easy monitoring and supervision of the farm.

ii) Site should be easy to access by vehicle for transportation of critical inputs (Straws, construction materials) and farm products

iii) Available of resources such as paddy straw, water, cheap labours, power supply for installing motor operated chaff cutter, exhaust fan, water pump, light, etc.

iv) Provision of disposal site to convert of spent mushroom substrate (SMS) to compost.

v) Sufficient areas should be available for storage of raw materials, chopping of raw materials, boiling and spawning areas and post-harvest handling.

Materials required: (i) Paddy straw (ii) Trays (iii) Spawn (Mushroom seed) (iv) Water boiling drum (v) Chaff cutter/dao or Hachette (vi) Sprayer/ hand spray (vii) Transparent poly bags (Size: 40- 45 cm X 20 cm) (viii) Single hole punch machine/Pointed stick (ix) Garlic extract (x) Jute thread/Rubber band.

The method consists of the different steps which is given as below:

1. Preparation of substrate
2. Spawning
3. Spawn running
4. Cropping
5. Post Harvest Management

1. Preparation of substrate

Oyster mushroom is one of the most suitable fungal organisms for producing protein rich food from various agro-wastes without composting. The best temperature for oyster mushroom is 23^0C to 25^0C. *Pleurotus* mushroom can degrade and grow on any kind of agricultural or forest wastes. Paddy straw is the best substrate among all the cellulosic materials. The straw should be of good quality-golden yellow in colour and free from diseases. It is chopped to a length of 5 cm and then boiled in hot water at 85°C for 30 minutes. Boiling makes straw free from all contaminants and the cellulose is easily broken down by the mushroom fungus. About 2 kg of straw is needed for a polythene bag of 40-45×20 cm size.

2. Spawning

After draining excess water, spread the straw on a clean floor for cooling. We then squeeze the straw to remove excess water. We also need to maintain the moisture in straw, the moment when straw is squeezed in palm, no more water comes out. This indicates that the straw is ready for spawning and we stop further cooling. Spray garlic extract (stock solution) mixed with water (3-5 ml/ litre of water) on the boiled straw. One litre of garlic solution is sufficient for 5 kg of boiled straw.

Materials preparation required during spawning

i) **Garlic extract:** Paste of 50 g (approx. 10 big size cloves) peeled garlic is made by adding 50ml of water (approx. 10 teaspoonful). The paste is squeezed through muslin cloth to get the stock solution. Spraying garlic extract prevents contamination of mushroom beds with green moulds especially during summer months. Spraying the soaked/boiled straw with garlic extract can be an optional practice during winter months.

ii) **Polybags:** Fold the poly bags (mushroom bags) length wise twice and perforate with a punch machine at a distance of about 10 cm between the holes. The sizes of the holes are about 5 mm in diameter. A polybag should have 15-20 no. of holes for proper ventilation. Polythene bag of 40×60 cm size is used for spawn running.

iii) **Spawn:** It is used at the rate of 2 % i.e.20g per kg of straw. The whole packet of 200g spawn is used in making one bed with 2kg of straw. Break the lumps of planting spawn on a plate and divide into four equal parts of 50g each. Freshly prepared 20-30 days old spawn is best for spawning.

Further, fill the bag with a layer of 10 cm straw. Make the layer compact by pressing with the palm and to a height of about 4-5 cm. Spawn the straw layer with 50 gm of the spawn, sprinkle more amount of spawn towards the sides and little less in the centre. Likewise with a total of five layers of straw and four layers of spawn in between, fill up the polythene bag. Once the bag is filled up, tie the open end of the bag with a piece of jute thread. A label with the species name and date of spawning or preparing the bed should be tagged to the bed for record.

3. Spawn Running:

Bamboo racks or wooden shelves are built to accommodate maximum number of beds. During mycelia growth the bags are not to be opened and no ventilation is and light is required. Place the mushroom bag in a cool and dark place, safe from rodents and other insects, for spawn run. The best temperature for spawn run is 25^0C which is completed within 15-18 days. Once the mycelium has fully colonized the substrate, it forms a thick mycelia mat and is ready for fruiting and polythene can be removed with white to cream coloured mycelium mat covering the entire straw.

4. Cropping

Preparation of cropping room: A cropping room of size 22 x 11 x 9 feet (length x breadth and height) can accommodate about 250 to 300 bags of 4kg each (wet basis). The spawning bags may be kept either by hanging or shelves. Spawned bags are kept on a raised platform in shelves in thatched shed of with a minimum distance of 15-20 cm between each bag in the tier. The air ventilator or opening which air is either blown in or out of the rooms should have at least a simple filter or cloth as barrier. The wooden made shelves can also be arranged in 4 to 5 tiers system and length can be adjusted according to size of the house. The distance between two tiers may be maintained of 45 cm, the tier height from floor may be 45-50 cm and the shelves should be placed preferably 45-50 cm away from the walls.

After completion the spawn run, the bags are removed using a blade to allow space for fruiting. The beds after opening are kept inside the cropping room having a minimum size of 22x11x9 ft. There should be a diffused light and ventilation. Best

temperature for fruiting is 23^0C. The floors and walls are watered, usually twice a day to maintain sufficient humidity. Water should not be sprayed on the beds for first two days after removing the polythene. Mushroom fruit bodies come up after 5-7 days in clusters after the beds are placed in the cropping room. In the initial stage these tiny fruit body clusters are known as pinheads. Pinheads grow into fully developed fruit bodies after 3-5 days of their appearance. These fruit bodies should be harvested just before they attain maturity i.e. when the caps start to open outward.

5. Post Harvest Management of mushroom

It is possible to obtain complete food value, medicinal values and taste by consuming mushroom in fresh condition and when harvested at the right stage. The right stage for picking can be judged by the shape and size of fruit body. Pileus margin when starts to curl upward or down ward indicates that the fruit bodies have become over maturity. Mushrooms should always be harvested before water spray. The margin of some fruit bodies starts curling upward and downward. This is the right stage for harvesting. Fruit bodies are harvested by holding the stipe between the thumb and forefingers and twist it clockwise. Scoop out any portion of the stipe left in the bed to prevent saprophytic growth of other fungi and bacteria. Flushes of mushroom fruit bodies appear at 15-20 days interval and the harvest from first three flushes is considered as economic harvest in commercial cultivation in terms of time and space. Trim stipe/stalk of the fruit bodies to remove the adhering straw particles. Stipe is kept short or almost non-existent, as it is hard and not liked by many consumers. Fresh mushrooms should be packed in perforated polythene bags for marketing. They can also be sundried by spreading on a cotton cloth in bright sunlight or diffused light. In young mushrooms, the edge of the cap is thick and cap margin is enrolled while the cap of mature mushroom is flat and inward curling starts. It is advisable to harvest all the mushrooms at one time from a bag so that the next crop of

mushrooms starts early. The dried produce with 2-4% moisture can be stored for 3 to 4 months after proper sealing. Pack the fruit bodies in 250 gm or 500 gm packets as per requirement either in perforated poly bags or paper bags. Value addition can be done with attractive packaging, label and recipes.

6. Recycling of spent mushroom beds

Mushroom beds after the harvesting of the crop or continuation of cropping becomes uneconomic the substrates are considered ‘spent’ or ‘used mushroom substrate’. If not handled properly, the ‘spent mushroom substrate’ creates various environmental problems including ground water contamination and nuisance by being the safe home for pathogens. Diversified uses of ‘spent mushroom substrate’ in managing agriculture, environment and recycling energy have come to light.

(i) Used mushroom beds can be broken into pieces and applied in vegetable or flower garden as organic manure.

(ii) Spent mushroom substrate is a better substrate for vermicompost. Usually, 100kg of spent mushroom substrates yield 50 kg vermicompost. The nutrients contents of the vermicompost prepared from spent mushroom substrates are Nitrogen (1.85%), Phosphorus (0.90%) and Potash (1.12%).

(iii) Spent oyster mushroom substrates serve as good livestock feed especially for goats, cattle and pig because the oyster mushrooms have the capability of reducing the organic carbon and increasing the nitrogen content of plant residues. Cattle prefer these when the spent bed is broken in to pieces, boiled with other feed and salt.

Fig 6: Use of Spent Mushroom Substrate in Vermicomposting unit

Chapter 4: Disease and Insect Pests Management

Objectives of the session

• To teach the farmers about the common disease and insect pests found in oyster mushroom.

It is common that the crops are infected with many pathogens, fungus and bacteria, with insect pests' infestation and such cases is also found in oyster mushroom. Few of the common disease and insect pests found in oyster mushroom is discussed herewith with management controls to protect against the crop losses.

A. Diseases

a. Green mould:

Sometimes during spawn run mushroom beds are seen covered with green coloured velvety growth, completely or in patches. This is because of the fungus, *Trichoderma harzianum* that impair mycelial run causing drastic reduction in yield. The contamination occurs due to improper boiling of the straw (sterilization) or due to contaminated spawn. Green mould causes more problems during the warmer period of the year.

Management:

(i) Spray garlic extract before spawning.

(ii) Check the spawn packet for any fungal contamination before spawning.

(iii) Discard contaminated spawn and remove contaminated beds away from mushroom house.

(iv) Wash mushroom bags properly before re-use.

(v) Scooped out the green moulds patches at the initial stage and spray the area with garlic extract.

Fig 7: Green mould- A Common disease in oyster mushroom

b. Ink cap:

Ink cap fungus, *Coprinus spp.* is a weed mushroom. Affected beds turn black to deep blue colour due to excessive spore production of the weed fungus. Contamination of mushroom beds with this weed fungus is mainly due to excess moisture in the straw or decomposed straw used for mushroom bed preparation.

Management:

(i) Use good quality and properly dried straw for bed preparation.

(ii) Avoid decomposed straw or straw exposed to rain.

(iii) Remove at young stage all the ink caps whenever seen on beds.

c. Browning:

Yellow to light brown colour may develop on the margin of the fruit bodies and the stalk, due to the bacterium *Pseudomonas spp.* Accumulation of water on the fruit bodies during watering of the beds leads to the growth of bacteria.

Management:

(i) Avoid direct watering on the mushrooms.

(ii) Shake the beds gently after watering to avoid water droplets deposit on the mushrooms.

B. Pests:

Generally, insect pests in mushrooms do not pose much problems, except during summer months. Insects like Sciarid fly, Phorid fly, Staphylinid beetle, Scaphisoma beetles and Pleasant beetles are common on mushrooms. The adults of Sciarid and Phorid fly lay eggs on the gills but do not cause damage. The maggots emerging from eggs eat away the soft tissues of fruit bodies. They also bore tunnels in the pileus and stipe thereby rendering the fruit bodies unfit for consumption. The adults of the beetles feed on the fruit bodies and also on the mycelium during mycelia run. The grubs make irregular holes in the gills and stipes, where they hide. Infestation by the grubs becomes intense during the months of June to August. Slugs and snails also cause damage by feeding on the mushroom fruit bodies and secrete slimy fluid on the beds.

Management:

(i) Remove over matured fruit bodies at the earliest, to prevent adults from laying eggs.

(ii) Bleaching powder repels the beetles; apply it in the mushroom house and its premises.

(iii) Spray neem-based insecticides (Azadirachtin) like Rakshak, Neemagon, Neemazol, etc. @ 3ml per litre water thrice. The first spray is to be done prior to spawning on the boiled straw. The second after opening of the beds and one more spray after the first harvest.

(iv) To prevent the entry of flies and beetles, nylon net is to be fixed on the ventilations and windows of the mushroom house.

(v) Light traps are made with polythene sheet smeared with a sticky material like mustard oil and placed close to yellow or white coloured bulb. Adult insects are attracted to white light at temperature above 15^0C and to yellow light at lower temperature.

(vi) Smoke daily or at alternate days to get rid of the insect pests from the mushroom house.

Fig 8: Common insect pest in oyster mushroom

Chapter 5: Care and Management of Oyster Mushroom

Objectives of the session

• To teach the farmers about the cultural and physical management practices to be taken during different crop stages of oyster mushroom.

Care and management of oyster mushroom is very crucial during the different stages of crop cultivation. It is found that the arrangement for housing with the required weather parameters viz., temperature, humidity, light ventilation, fresh air, clean and healthy environment is of equally important to get the good harvest. Few of the most important cultural and physical practices are given as below:

A. Cultural practices

The spawned bags or blocks are kept in incubation room for mycelial growth.

a. Incubation

Spawned bags can be kept on a raised platform or shelves or can be hanged in cropping room for mycelial colonization of the substrate. Although mycelium can grow between 10-30°C but the optimum temperature lies between 22-26°C. Higher temperature (more than 30°C) in the cropping room will inhibit the growth and kill the mycelium. Daily maximum and minimum temperature of cropping rooms and beds should be recorded. The bed temperature is generally 2-4°C higher than the room temperature. Mycelium can tolerate very high CO2 concentration of 15-20%. During mycelial growth the bags are not to be opened and no ventilation is needed. Moreover, there is no need for any high relative humidity, so no water should be sprayed.

b. Fruit body induction

Once the mycelium has fully colonized the substrate, it forms a thick mycelial mat and is ready for fruiting. Contaminated bags with mould infestation should be discarded while bags with patchy mycelial growth may be left for few more days to complete the spawn run. In no case bags should be opened before 16-18 days except in case of P. membranaceus and *P. djamor var. roseus*, which forms fruit bodies within 10 days even in closed bags from small holes. Casing is not required in oyster mushroom cultivation. All the bundles, cubes or blocks are arranged on iron/wooden platforms or shelves with a minimum distance of 15-20 cm between each bag in the tier.

They can also be hanged. The cultural conditions required for fruiting are as follows:

i) Temperature

Mycelial growth of all the *Pleurotus spp*. can take place between 20-30°C. However, for fruiting different species have different temperature requirement. Depending upon the temperature requirement of a species, they can be categorized into two groups winter or low temperature requiring species (10-20°C) and summer or moderate temperature requiring species (16-30°C). Summer varieties can fructify at low temperature but the winter varieties will not fruit at higher temperatures. They need a low temperature shock for inducing fruit body formation. Commercial varieties, which can be cultivated during summer are *P. flabellatus, P. sapidus, P. citrinopileatus and P. sajor-caju.* Low temperature requiring species are *P. ostreatus, P. florida, P. eryngii, P. fossulatus and P. cornucopiae.* We have isolated a wild species of *P. cornucopiae*, which is suitable for growing between 15-25°C. The growing temperature not only affects the yield but also the quality of produce. The pileus or cap colour of *P. florida* is light brown when cultivated at low temperature (10-15°C) but changes to white pale to yellowish at 20-25°C. Similarly, fruit body colour of *P. sajor-caju* when cultivated at 15-19°C is white to dull white with high dry matter content while at 25-30°C, it is whitish brown to dark brown with less dry matter.

ii) Relative humidity

All the Pleurotus species require high relative humidity (75-85%) during fruiting. To maintain relative humidity, water spraying is to be done in the cropping rooms. During hot and dry weather conditions daily 2-3 spray are recommended while in hot and humid conditions (monsoon) one light spray will be sufficient. The requirement of water spray can be judged by touching the surface of the substrate. Spraying should be done with a fine nozzle to create a mist or fog in the cropping room. It is desirable that mushrooms are harvested before water spray. Ventilators and exhaust fans should be operated for air circulation so that the excess moisture from the pileus surface evaporates. Sometimes fruit bodies gives offensive smell due to the growth of saprophytic bacteria on the wet pileus surface, under such conditions 0.05% bleaching powder spray at weekly interval is recommended.

iii) Oxygen and carbon dioxide requirements

Oyster mushroom can tolerate high carbon dioxide concentration during spawn run (upto 20,000 ppm or 2%) while it should be less than 600 ppm or 0.06% during cropping. Therefore, sufficient ventilation should be provided during fructification. If the CO2 concentration is high,

the mushrooms will have long stipe and small pileus. Mushrooms will appear like a mouth of trumpet.

iv) Light

Unlike green plants mushrooms do not require light for the synthesis of food. They grow on dead organic plant material. Light is required to initiate fruit body initiation. For primordia formation, light requirement is 200 lux intensity for 8-12 hrs. Inadequate light conditions can be judged by long stalk (stipe), small cap and poor yield. The colour of the pileus is also influenced by the light intensity and its duration. Fruit bodies raised in bright light are dark brown, grey or blackish coloured. If the light intensity is less than 100 lux the mushrooms will be pale yellowish.

v) Hydrogen ion concentration (pH)

The optimum pH during mycelial colonization should be between 6.0 to 7.0 while the pH of the water for spraying should be neither too acidic nor alkaline. Water should not contain harmful salts. Rusted iron drums and tubs used for substrate treatment or storing water for spraying delay fructification due to presence of excess iron in the water.

B. Physical practices

It has been reported that common flies like Sciarid flies, phorid flies, cecids, springtails, mites and nematodes used to disturb the mushroom from spawning to harvesting stages. These flies are important pests of cultivated mushrooms throughout the world. Such files are found mostly when hygienic and sanitation practices is not followed properly. Some of the physical management practices that a mushroom grower could practice at home are as follows:

i) Hygiene and sanitation: Hygiene is the primary method of pest control in mushroom farming. It is the foundation upon which success of all other control techniques depends. The objectives of any hygiene programme include exclusion of pests and diseases from production cycle, elimination of pest and pathogens and destruction of pest and disease present in a crop at its termination. Such measures help to reduce the contamination level and ensure clean start for subsequent crops. Sanitation focuses on elimination or killing a pest. Routinely removing stumpage from the rooms, where the crop is growing, is a sound sanitary practice. Sanitary practices are designed not only to remove mushroom pests but to kill significant crop threats.

ii) Screening of doors and ventilators: Mushroom flies can easily pass through ordinary wire screen and enter the mushroom house to breed on spawned compost and mushroom beds. Screening of doors and ventilators with nylon net of 35 meshes or more can effectively check the entry of flies in the cropping rooms. Using of yellow sticky trap is also helpful against flies.

iii) Light trap: Polythene sheets coated with sticky material and attached to a fluorescent tube light in each cropping room help in controlling adult flies. Insects are attracted to white light above 15ºC and to yellow light at lower temperature. Use of light trap (15 W yellow bulb and polythene sheet coated with mustard oil) is very effective for monitoring as well as for the management of the flies.

iv) Poison baiting: Poison baiting with Baygon diluted with water (1:10) with addition of little sugar is an effective method of fly control in cropping rooms. Solution of Leafpep and Electra (1:10) with addition of sugar is also effective. N-rat sticky trap or cake is also suggested to protect against rodents.

v) Cookout: The most heavily contaminated area on a farm is the older crops about to be terminated. Elimination of pests that have built up within the crops is one of the essential step in any effective control programme. Temperature of 70ºC held for 2-3 hours effectively kills all stages of pest and pathogens.

vii) Yellow sticky trap: Use of sticky trap is an effective method against the insect flies like Sciarid fly, Phorid fly.

vi) Disposal of spent compost: The spent compost and casing material contain the insects, mites and nematodes. Dumping the spent compost and casing material in moist and shady places helps it to become ideal substrate for breeding of pests. Putting this material in the compost pit and covering it with at least 10 cm thick layer of manure helps in checking the fly breeding.

Fig 9: Using of Yellow sticky trap against flies during fruiting stage of oyster mushroom

Chapter 6: Production Cost of Oyster Mushroom Cultivation

Objective of the session

• To give an awareness to the farmers about the cost of production of oyster mushroom

Cultivation technology of oyster mushroom is very simple which does not require costly infrastructure facilities. The cultivation of oyster mushroom in India is mainly done in seasonal low cost growing rooms with very less expenditure on infrastructure. One can hardly find a big oyster mushroom growing unit in India having round the year production. There is no organized market where one can sell his produce or purchase fresh or dry oyster mushroom throughout the year. Therefore, the production of oyster mushroom on a commercial scale is rare in our country as compared to *Agaricus bisporus* (button mushroom). Theoretically each crop takes 45 days and under controlled conditions and hence there can be 8 crops per year. In our district condition, on an average upto 5 seasons crop can be produced in a year.

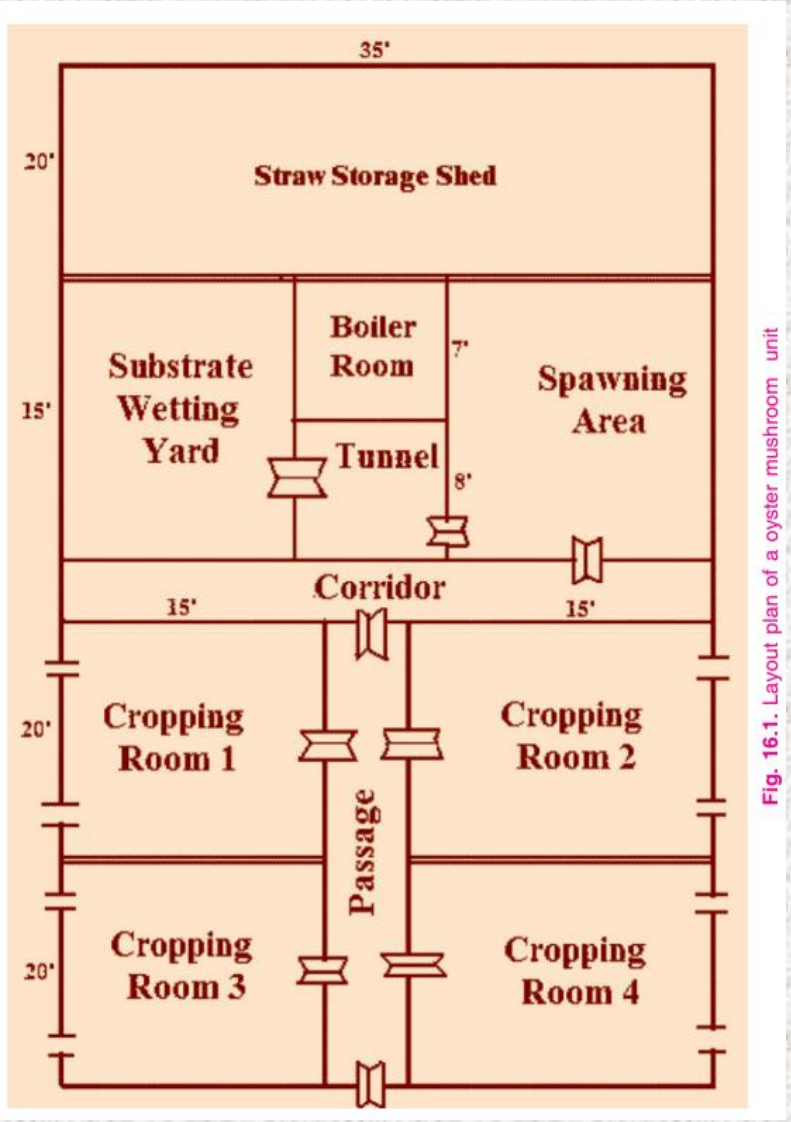


Fig 10: Layout plan of a oyster mushroom unit

Table 5: Economics of Oyster Mushroom Cultivation under low cost			
A.	**Fixed capital**		
1.	Mushroom cropping room	Size: 4m x 7m size with a capacity to hold 500 beds at a time	Rs 75000/-
2.	Chaff cutter	1 No.	Rs 10000/-
3.	Aluminium sauce pan for boiling of straw	3 Nos.	Rs 3000/-
4.	Sprayer pump	1 No.	Rs 2000/-
5.	Firewood	Lumpsum	Rs 5000/-
6.	Annual maintenance		Rs 5000/-
		Total (A)	**Rs. 100000/-**
B.	**Fixed cost**		
1.	Interest @ 10% for crop season		Rs 9500/-
2.	Depreciation on items 1 – 5 @10%		Rs 9500/-
		Total (B)	Rs 19,000/-
C.	**Working capital**		
1.	Paddy straw	4000 kg	Rs 8000/-
2.	Cost of spawn @ 200 gm each pkt	Rs 30 per pkt x500 bags	Rs 15000/-
3.	Cost of polythene bags	20 kg	Rs 2000/-
4.	Labour wages	100 mandays @ Rs 200	Rs 20000/-
5.	Miscellaneous charges		Rs 1000/-
		Total (C)	**Rs. 46000/-**
D.	**Cost of mushroom production**		
1.	Working capital plus fixed cost (B + C)		Rs 65000/-
E.	**Income**		
1.	Average production per bag	1.5 kg	
2.	Selling price	200 per kg	
3.	Sales of oyster mushroom for one crop	1.5 kg x 500 bags x Rs 200	Rs 150000/-
4.	Net income from one crop out of 2 months	Rs 150000- Rs 65000	Rs 85000/-
5.	Net income from 5 crops in a year	Rs 85000 x 5	Rs 4,25,000/-

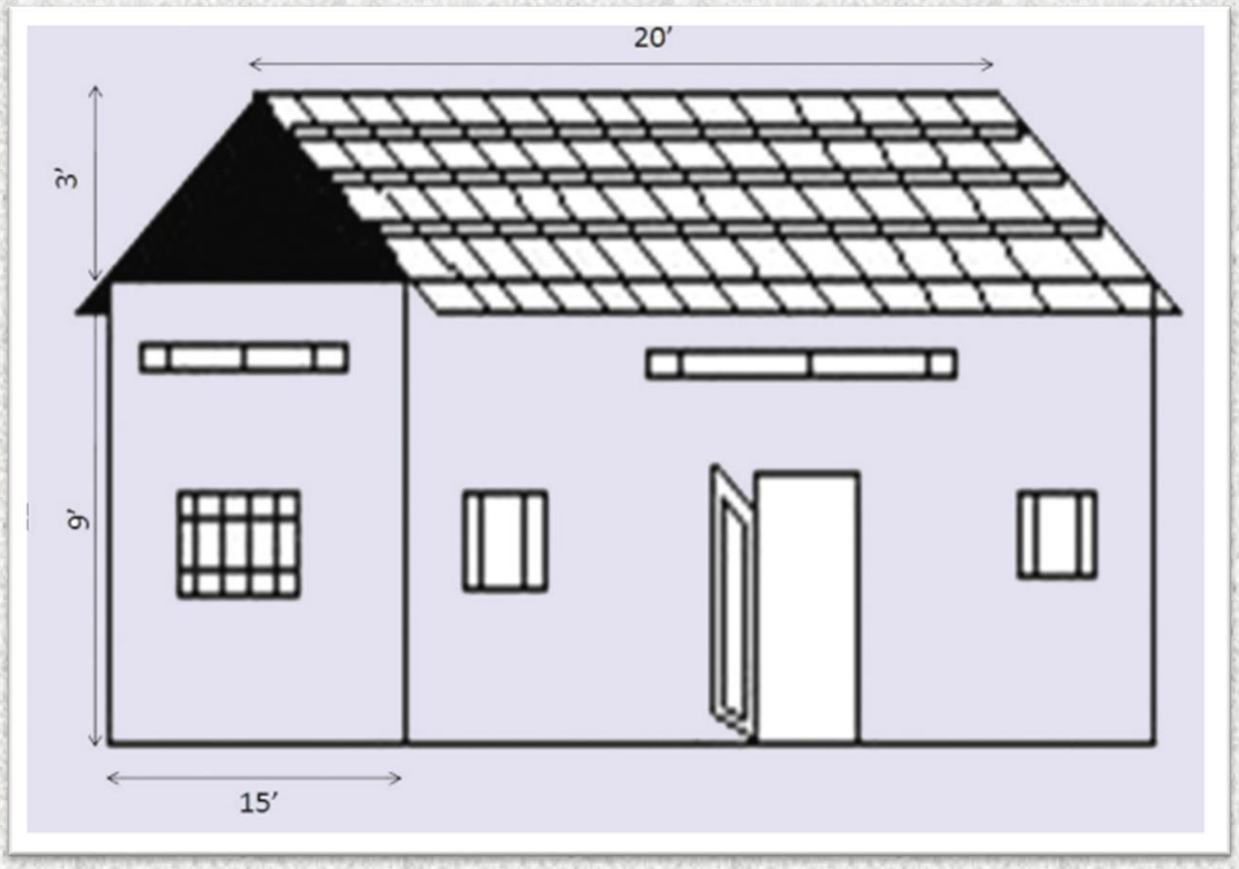


Fig 11: Method demonstration of Oyster mushroom production at Nongshillong village

Chapter 7: Mushroom spawn production cost

Objective of the session

• To give an awareness to the farmers about the equipments required and the techniques for spawn production.

Oyster mushroom is very popular among the farmers of West Khasi Hills and Eastern West Khasi Hills districts and is cultivated widely by the farmers. It is observed that there is a horizontal adoption of technology by the farmers in the district and this happened due to the favourable climatic conditions, easy to cultivate, available of paddy straw as substrate and most importantly of high returns from mushroom. The farmers in the district used to cultivate from the month of March onwards and less during winter season. Mushroom spawn or mushroom seed is one of the main inputs for oyster mushroom cultivation. Spawn, i.e. seed required for growing mushroom, is the vegetative mycelium from a selected mushroom cultured on a convenient medium like wheat, paddy grains, pearl millet, sorghum grains, etc. In simple words spawn is grains covered with mushroom mycelium. It essentially involves preparation of pure culture of mushroom from tissue/spores, evaluation of selected cultures for yield, quality and other desirable traits, maintenance of selected cultures on suitable agar medium, followed by culturing on sterilized grains and further multiplication on grains. The spawn is not available at the market as other vegetable seeds but is only produced in the Government laboratories at Mushroom Development Centre, Upper Shillong, ICAR & CPGS Umiam in this region. As of now, there is no spawn production unit in the entire West Khasi Hills district.

A. Equipments Required:

The equipment required in the spawn laboratory (Fig. 13) are:

1) **Laminar flow** cabinet (normally 4 ft. horizontal) is needed for isolation and multiplication of cultures and spawn inoculation.

2) **Autoclave** for sterilization of spawn medium and oven for sterilization glassware. Two electrically operated autoclaves with 100-145 bottle capacity having a dia. of 2 ½' and 3 ¼' height are sufficient. If boiler is available steam operated autoclaves can be used for better efficiency. A small clinical autoclave can also be kept for sterilization of culture medium.

3) **BOD incubator** is needed to incubate cultures and master cultures.

4) **Refrigerator** is needed for short-term preservation of mycelial cultures.

5) **Air conditioner** (2 tonnes capacity) and **Hot air oven.**

6) **Gas Stove** or steam line for boiling of wheat grains and preparation of medium.

7) **GI racks** in incubation room and cold storage for keeping bags/bottles, exhaust fans, filters, office table, working tables, troughs, sieves, inoculating needles, scalpels, test tubes, petri plates etc. are also required.

8) **Boiling pans/boiling kettle** (vessel) for boiling the grains. Kettle can also be used if baby boiler is available otherwise kettles working on electricity, kerosene or gas can be installed. Pans for preparation of medium are also required.

9) **pH meter** to check pH of the medium.

10) Other items like glassware, weighing balance, chemicals for medium preparation, non-absorbent cotton, polypropylene bags (or bottles), disinfectant (formaldehyde), calcium carbonate, calcium sulphate are also required.

Fig 12: Types of Autoclave-Vertical and Horizontal

Fig.13 : (a) Boiling keetle (b) Agar agar and malt extract (c) Laminar flow (d) BOD incubator

Table 6: Temperature requirement for storage and incubation of different mushrooms

Characters	Oyster mushroom *(Pleurotus spp.)*	Button mushroom *(Agaricus spp.)*	Shiitake mushroom *(Lentinula spp.)*	Paddy straw mushroom *(Volveriella spp.)*	Milky mushroom *(Calocybe indica)*
Days for complete colonisation of mother spawn	8-12	20-21	20-22	6-7	15-17
Days for complete colonisation in commercial spawn	8-10	12-14	15-16	5-6	12-14
Incubation temperature during colonisation	25	25	25	32	25
Storage Temperature	4^0C	4^0C	4^0C	15^0C	15-16^0C
Shelf life of spawn	One month	Two months	Three months	Less than 15 days	15 days

Spawn production cycle

1. Preparation of mother spawn

Step-1 — Select healthy and clean cereal grains

↓

Step-2 — Boil grains in water (15-20 min.)

↓

Step-3 — Remove excess water on sieve

↓

Step-4 — Dry grains in shade (4 h)

↓

Step-5 — Mix $CaCO_3$ (0.5%) and $CaSO_4$ (2%) on dry wt. basis

↓

Step-6 — Fill 300 g grains in glucose/milk bottle

↓

Step-7 — Plug and autoclave at 22 p.s.i. for 1.5 to 2 h

↓

Step-8 — Inoculate growing mycelium of desired strain using laminar flow

↓

Step-9 — Incubate in BOD at 23 ± 2^0C for 20-25 days (shake bottles after 10 days)

↓

Step-10 — Master spawn is ready

2. Preparation of commercial spawn

Step-1 — Use polypropylene bags instead of bottle

↓

Step-2 — Upto autoclaving (Step 1 to 7) is same as of mother spawn

↓

Step-8 — Inoculate with 10-15 grams of mother spawn per PP bags

↓

Step-9 — Incubate at 23 ± 2^0C in incubation room (Shake bags after 7-8 days)

↓

Step-10 — Commercial spawn is ready in 2-3 weeks

(a) Boiling, seiving, autoclaving and inoculation

(b) Method of inserting ring, folding bag and plugging

(c) Preparation of master spawn and commercial spawn

Fig.14: Steps of substrate preparation

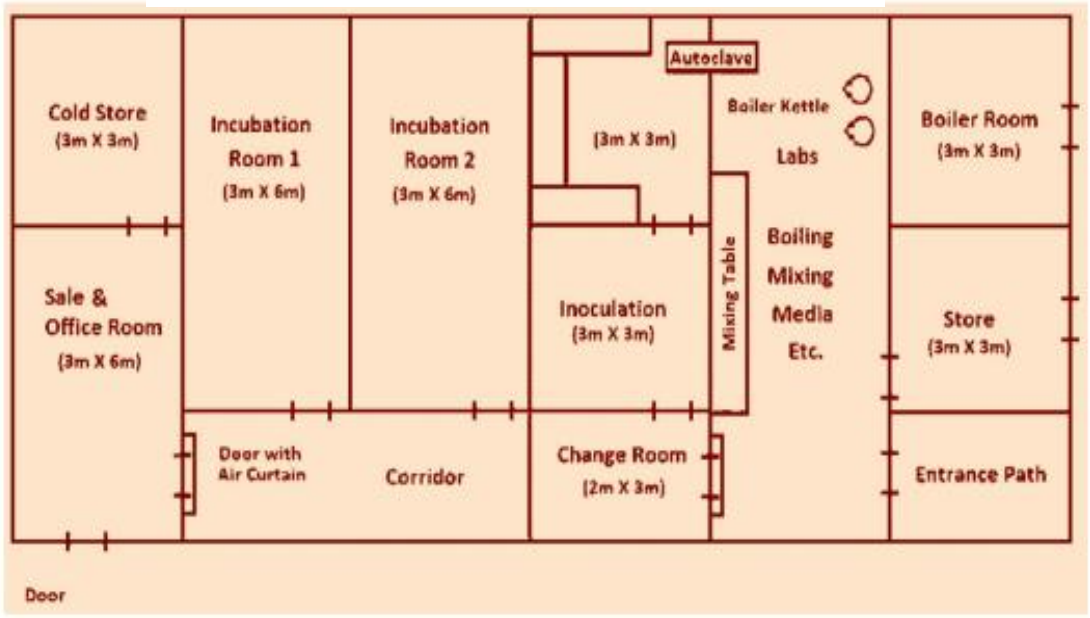


Fig.15 : Layout of mushroom spawn laboratory

Table 7: Economics of Spawn production on commercial scale (10 t/annum)			
Sl. No.	**Particulars**	**Qty (No.)**	**Expected Cost (Rs)**
A. Fixed cost			
a.	**Cost of Machineries**		
1.	Laminar flow	1 No.	1,00,000.00
2.	Autoclave	1 No.	75,000.00
3.	BOD incubator	1 No.	50,000.00
4.	Refrigerator	1 No.	50,000.00
5.	Air conditioner (2 ton capacity)	1 No.	50,000.00
6.	Hot air oven	1 No.	50,000.00
7.	Glass wares & need based materials	lumpsum	50,000.00
8.	GI racks for spawn storage	lumpsum	30,000.00
9.	Gas stove	1 No.	5,000.00
10.	Weighing balance	1 No.	2,000.00
	Total (a) = 4,62,000.00		
b. Cost of housing			
1.	Laboratory and storage rooms Size -24x12 ft	1 unit	400000.00
2.	Electrification		20000.00
3.	Water supply with tank		20000.00
	Total (b) = 4,40,000.00		
	Fixed Cost (A) = (a) + (b) = Rs 4,62,000 + Rs 4,40,000 = Rs 9,02,000.00		
B.	**Recurring Expenditure for 1st yr**		
1.	**Salary & wages**		
i.	Technical Assistant	Rs 15000/- per month	1,80,000/-
ii.	Labour	Rs 5000/- per month	60,000/-
		Total (1)	**Rs 2,40,000/-**
2.	**Raw materials**		
i.	Cost of grains	80 q	1,20,000.00
ii.	Cost of calcium carbonate	1.5 q	7,500.00

iii.	Cost of non-absorbent cotton	1.5 q	9,000.00
iv.	Cost of rubber band	30 pkts	7,500.00
v.	Cost of polypropylene bags	1.0 q	10,000.00
vi.	Readymade PDA & OMA media	1 kg each	30,000.00
vii.	Energy consumption/year		50,000.00
viii.	Refilling of LPG	6 times	9,000.00
ix.	Miscellaneous (cost of disinfectants, gloves etc.)		10,000.00
		Total (2)	**Rs 2,53,000/-**
	Total (B) = (1) + (2) = Rs 2,40,000+ 2,53,000 = Rs 4,93,000.00		
	Total Project Cost = Fixed cost (A) + Recurring expenditure (B) = Rs 9,02,000 + 4,93,000 **= Rs 13,95,000.00**		
C.	**Cost of production**		
1.	Salary & wages	2,40,000.00	
2.	Raw materials	2,53,000.00	
	Total = Rs 4,93,000.00		
D.	**Return**		
	Annual Income from sale of 9600 kg spawn bags @Rs 120 per kg		Rs 11,52,000.00
E.	**Net profit per year** = D-C = Return – Cost of production = Rs 11,52,000 - Rs 4,93,000 = Rs 6,59,000/-		

Chapter 8: Processing and Value Addition of oyster mushroom

Oyster mushroom other than selling as fresh produces, the growers could use them in the form of processed products to fetch a better profit. Mushrooms have become valuable component of diet owing to their attractive taste, aroma and nutritional values. Fresh mushrooms are perishable, has a very short shelf life with high moisture content of more than 90%. Preservation of mushrooms in fresh condition for a longer period is a difficult and costly task. Fruit bodies become soggy as many metabolic activities continue after harvest. High water content of mushrooms also becomes conducive for multiplication of various microbes which cause rot of harvested fresh mushrooms. However, it can be stored for certain time period by adopting the preservation procedures mentioned below.

Selection of mushroom fruit bodies for preservation

i) Too young and over matured fruit bodies should not be selected. The right stage of harvesting in case of oyster mushroom is when the margin of the pileus starts to curl and in case of button mushroom or paddy straw mushroom, harvesting is done at button stage.

ii) Mushrooms of the first flush are considered to be best as the colour and taste remain intact during preservation.

iii) Spotted, deformed, insect damaged fruit bodies are to be discarded.

iv) Fruit bodies should be sorted out based on the size and age to maintain uniformity.

Types and methods of preservation.

The methods of preservation developed for mushrooms can be grouped into two types, they are

1. Short term preservation (for maximum period of 10-15 days only)

i) Room temperature: Keeping in room temperature of around 30-33ºC, the mushrooms remain fresh for 8-12 hours only whereas it is possible for 24-36 hours during winter at lower temperatures.

ii) Refrigeration: Fresh mushrooms can be stored for 7-15 days in a refrigerator depending on the type of package and storage temperature.

iii) Brine solution preservation: In a solution of common salt (in water) in high concentration (10-15%), fresh mushrooms can be kept safe for 6-7 days.

iv) Other methods: Lactic acid fermentation and gamma irradiation. These are tedious, costly and sometimes risky also.

2. Long term preservation

i) Sun drying: Fresh mushrooms after sorting and selection (trim off the hard stalk portions), are thinly spread on a sieve and sun dried for 3-5 days or till when 10Kg mushroom weighs 1Kg. To avoid browning of the fruit bodies, a shade may be provided to the mushrooms by spreading a black cloth at about 1 foot above the sieve. This type of dry mushrooms can be kept in air tight containers up to 5-6 months.

ii) Machine drying: In machine drying method, fresh mushrooms are dried in electrically operated drier within 6-8 hours. It is a costly method.

iii) Blanching: Sorted out mushrooms are steeped in warm water of 80-85^0 C for 1-2 min. only and then sun dried. Sometimes sodium chloride @ 400 ppm and citric acid @ 0.1-0.2% may be added to the water before boiling to retain or improve the natural colour.

iv) Other methods: Freeze drying, canning, pickling etc.

Value added products

Mushrooms not only taste delicious but they are also nutritional powerhouse. Worldwide mushrooms have been consumed since ages in hundreds of different ways, from everyday fare to a costly delicacy. A growing number of brands have come out with mushroom-based coffee, hot chocolate etc. as well as mushroom powder blends that can be mixed into smoothies and juices. Some of the common mushroom recipes are –

I. Mushroom pickle

Ingredients:

Oyster mushroom – 250g , Vinegar – 3 tsp , Garlic and ginger (chopped) – 1 tsp

Mustard seed powder – 20g, Chilli powder – 1tsp., Turmeric powder – 1tsp.

Cumin powder – 1 tsp., Mustard oil – 50 ml., Coriander seed powder – 1 tsp.

Salt to taste, Black pepper powder - ½ tsp.

Method:

i) Let the mushroom pieces dry for 1 hour after blanching.

ii. Heat mustard oil in a cauldron (Kadai), fry the chopped garlic and ginger pieces till light brown colour.

iii. Add cumin powder, coriander powder, chili powder, turmeric powder and the mushroom pieces and fry by stirring.

iv. Add mustard powder, vinegar, salt and cook for 10 minutes.

v. Remove from heat and sprinkle black pepper powder.

vi. When the pickle has cooled down, transfer it to an air tight glass vessel.

II. Mushroom curry

Ingredients:

Mushroom – 250g (wash, cut into pieces), Chopped ginger – 1tsp., Onion (paste) – 2 nos. (big size), Cinnamon – 3 nos., Tomato – 2 nos. (big size), Cardamom – 2 pieces, Turmeric powder – 1 tsp. Oil – 2 tbsp Garlic paste – 1 tsp. Salt to taste.

Method:

i. Cut the tomato into pieces and keep aside.

ii. Heat the oil in a cauldron (kadai), add the cinnamon and cardamom to it.

iii. Add the onion paste, garlic paste and fry these to golden brown colour at low flame.

iv. Add the tomato pieces, chopped ginger and fry till the oil comes out and the contents leave the sides of the kadai.

v. Now put the mushroom pieces and cook at low heat for about 15 minutes.

III. Mushroom chop

Ingredients:

Mushroom – 100g Salt to taste Onion (chopped) – 2 medium size Bread slices – 5 (big size) Ginger/ garlic (finely chopped) – 1tsp. Oil for frying Tomato sauce – 1tbsp

Method:

i. Shred the oyster mushroom after washing into thin pieces.

ii. Heat 1tsp oil in a cauldron (kadai) and fry the chopped onion till light brown, add the chopped ginger /garlic pieces.

iii. Put the shredded mushrooms and salt. Cover and cook at medium flame for about 10 minutes. iv. Add the tomato sauce and remove from heat.

v. Trim off the sides of the bread pieces and dip the slices one at a time in clean cold water.

vi. Now squeeze out the water by pressing the bread slice between the palms.

vii. Put the mushroom stuffing on the bread slice and slightly press it tight to give a round/ oval shape.

viii. Now in deep fry pan, fry the bread chop till it gets crunchy and brownish color.

ix. Garnish with chopped coriander leaves, onion and serve hot.

IV. Sauted mushrooms

Ingredients:

Mushrooms – 200g Turmeric - ½ tsp., Refined oil – two table spoon, Salt to taste

Method:

i) Clean and wash the mushrooms. Shred it in to pieces and keep aside.

ii) Heat the refined oil and add the turmeric, mushrooms and salt.

iii) Cook without cover on low heat till the water evaporates completely and the mushroom pieces become crispy.

iv) Sprinkle black pepper and serve.

V. Mushroom omlette

Ingredients: Mushrooms – 50g, Cooking oil – 2 tsp., Eggs – Two nos., Salt and pepper powder to taste

Method:

i) Clean, cut and fry mushrooms with one tsp. of oil and keep aside.

ii) Beat the eggs until fluffy.

iii) Add salt, pepper and fried mushrooms.

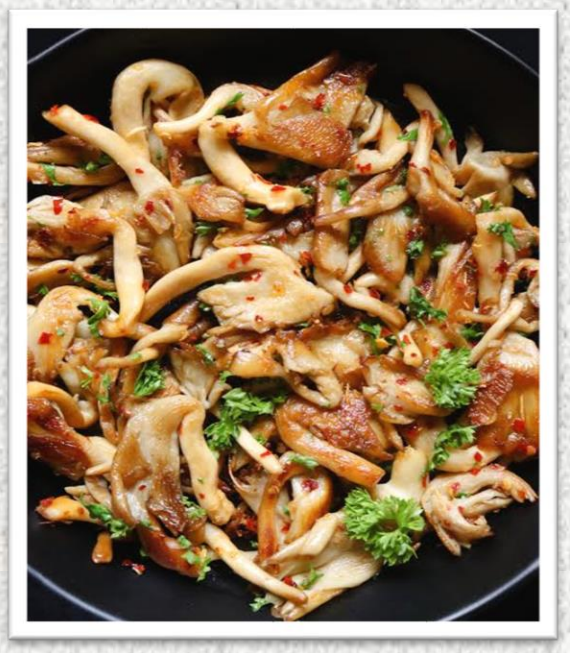
iv) Heat oil in a fry pan, covering till the edge and add the mix spreading over the pan.

v) Turn the omlette upside down to give it a light golden-brown colour.

Other ingredients can also be added to the beaten eggs like onion, green chilli, fresh coriander etc. along with mushrooms. The omlette can be garnished with onion rings, grated cheese or tomato sauce and serve hot.

(a)

(b)



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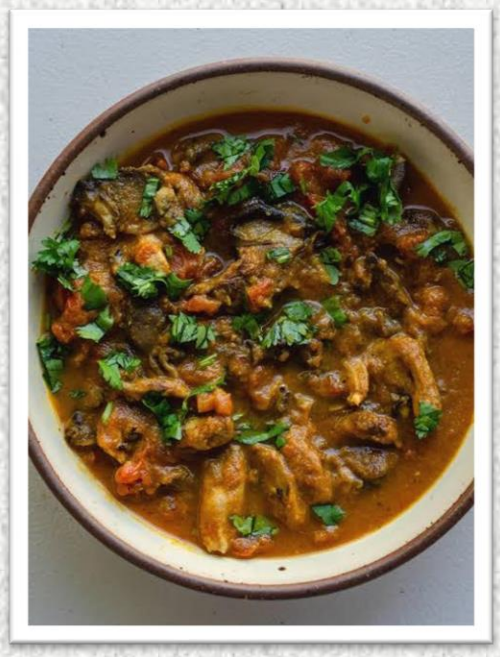

(d)

Fig.16 : Value added products of oyster mushroom (a) Oyster Mushroom cutlet (b) Air fryer oyster Mushroom (c) Garlic butter sauce mushroom (d) Mushroom curry

References:

1. Borah, Tasvina R., Singh, Akoijam Ratankumar, Paul Pampi, Talang, H., Kumar Baghish and Hazarika S. (2019) Spawn production and mushroom cultivation technology, ICAR Research Complex for NEH Region, Meghalaya, India, pp. 46.
2. Quimio, T.H., Chang, S.T. and Royse, D.J. (1990). Technical guidelines for mushroom growing in tropics. FAO, Rome. pp. 153.
3. Rai, R.D., Upadhyay, R.C. and Sharma, S.R. (2005). Frontiers in mushroom biotechnology. NRCM, Solan. pp. 430.
4. Singh, M., Bhuvnesh, V., Kamal, S and Wakchaure, G.C. (2011). Mushrooms Cultivation, marketing and consumption. Directorate of Mushroom Research, Solan.
5. Stamets, P. (2000). Growing Gourmet and Medicinal Mushrooms. 3rd Ed. Berkeley: Ten Speed Press. 574 pp.