

TRAINING MANUAL ON CULTIVATION OF TROPICAL MUSHROOM AND ITS VALUE ADDITION



ICAR- Agricultural Technology Application Research Institute, ZONE-VII

Indian Council of Agricultural Research

JNKVV, Jabalpur – 482004 (M.P.)

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Editors

Anupam Mishra

Director, ATARI, Jabalpur

S.R.K. Singh

Principal Scientist, ATARI, Jabalpur

M.P. Thakur

Director Extension Services, IGKV, Raipur

Compilation

Mrs. Saswati Pattnaik

SMS(Home Science)

KVK, Bhadrak, OUAT

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Training on Cultivation of Tropical Mushrooms

Course module (5 days)

Days	Morning session	Afternoon session	
	10.00 AM-12.00 Noon	1.00 PM-3.00 PM	3.00 PM-5.00 PM
Day-1	Mushroom: concepts, types, uses, food values, edible and poisonous mushroom	Mushroom cultivation : an agribusiness activity, status: world, national and state scenario, opportunities and constraints	Acquaintance with edible, non-edible, medicinal and poisonous mushrooms
Day-2	Importance of mushroom cultivation	Cultivation procedure of paddy straw mushroom (outdoor/ indoor)	Demonstration on raising of beds
Day-3	Cultivation procedure of oyster mushrooms	Cultivation procedure milk mushroom	Demonstration on bag preparation of oyster and milk mushrooms
Day-4	Mushroom processing and preservation (drying/ dehydration, pickling and canning)	Value addition in mushroom	Demonstration on preparation of value added products
Day-5	Mushroom spawn: quality attributes, storage and transport	Establishment of a commercial mushroom production units	Acquaintance with mushroom contaminants

DAY-1 (Theory)

Time-10 AM to 1 PM (3 hours)

Mushroom

Mushrooms are a group of fleshy macroscopic fungi. They lack chlorophyll having heterotrophic mode of nutrition. They synthesize enzymes like cellulose and hemicellulose which bring the substrate to available forms. Mushrooms live on dead matter as they are saprophytes.

Chang and Miles (1992) gave the definition that is now universally accepted. They defined mushroom as a “macro fungus with a distinctive fruiting body which can be either epigeous or hypogeous and large enough to be seen with the naked eye and can be picked with hand.”

Characteristics of mushroom

- Mushroom lacks chlorophyll
- They cannot make their own food
- Mushroom obtain their nutrition either by saprophytic or parasitic or symbiotic means
- They varied widely in size and shape
- Mushrooms may be of edible, non-edible, medicinal, poisonous and miscellaneous in nature

Some mushrooms are parasites, drawing their nutrition from the living matter and some are saprophytes drawing their nutrition from the dead organic matter. Some other still exist in symbiotic association with plants called as mycorrhizae. In nature mushrooms, grow wild on all types of soils, pastures, forest, cultivated fields or waste lands. They appear in all seasons, chiefly during the rainy weather, wherever organic matters or its decomposition products are available. Most of the mushrooms belong to the sub-division Basidiomycotina and a few belong to Ascomycotina. Out of 1.50 million species of fungi, about 10,000 are fleshy macro-fungi. About 2,000 species from more than 30 genera are regarded as prime edible mushrooms, 80 of them are grown experimentally, 40 cultivated economically, 20 cultivated commercially and 4-5 are produced on an industrial scale.

Importance of mushroom cultivation

1. Mushroom possesses unique flavor and exotic taste.
2. It is a rich source of quality proteins (20-35% on dry weight basis), which is higher than the protein content of vegetables and fruits.
3. Have a high percentage of all the nine essential amino acids and are rich in lysine and tryptophan, the two deficient in cereals.
4. They are almost free from fat except for linoleic acid, but are richer in water soluble vitamins; B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic) acid and B12, also contain vitamin C (ascorbic acid), vitamin K and of course vitamin A, D* and E appear to be present in low amounts.
5. They are good source of minerals (P, K, Fe, Na, Ca, and Mg). However, Na and P level decreases as the mushroom matures. K: Na ratio is very high.
6. Low starch content, low in calories with trace of sugar and no cholesterol.
7. Mushrooms are probiotic. They help in keeping our body healthy and ward off diseases by strengthening the immune system, having antibiotic activities, anti-cancer, hypolipidemic, hypocholesteremic and anti-hypertension effects.
8. Mushroom cultivation is easy and simple.
9. Mushrooms have a short crop cycle.

Mushroom	Crop duration (days)	Crop cycle (days)
Paddy straw	15	21
Oyster	21	45
Milky	40	60
Button	60	90

10. Its cultivation is labour intensive and offers vast employment opportunities in rural areas. It can be taken up by farmers as cottage industry and as a source of additional income.
11. It is very good enterprise for small farmers and landless labourers.

12. It is a good enterprise for farm women. About 80% of the work force engaged in mushroom cultivation worldwide constitute of ladies.
13. Farm wastes are recycled to produce additional food in the form of mushrooms. In the process environmental pollution is contained.
14. Absence of crop competition in mushroom.
15. Water productivity can be scaled up through mushroom cultivation.
16. Huge potential of export, as mushrooms are potential foreign exchange earner.
17. The spent mushroom substrate (SMS) can be utilized for manuring, fertilizing the horticultural crops and feed for animals.

Practical

2.00 PM to 5.00 PM (3 hours)

Acquaintance with edible, non edible, medicinal and poisonous mushroom

Constraints:

1. Non availability of suitable raw materials at the door step of the farmers such as quality substrate, spawn and organic supplements.
2. Dissemination of mushroom production technology is at a slower rate.
3. Mushroom spawn production is highly scientific and require more investment.
4. People of rural India possess indifferent attitude towards mushroom.
5. Mushroom is highly perishable, i.e. shelf life is shorter.
6. Environmental fluctuations create problem in successful cultivation of mushroom.
7. Problems associated with post harvest handling, drying, pickling and canning.

DAY-2 (Theory)

Time-10 AM to 1 PM (3 hours)

Importance, climatic conditions, material requirements, cultivation procedure and economics of paddy straw mushroom

Paddy straw mushroom is an edible mushroom of the tropics and subtropics. It was first cultivated in China as early as in 1822. Around 1932-35, the straw mushroom was introduced into Philippines, Malaysia, and other South-East Asian countries by overseas Chinese. In India this mushroom was first cultivated in early 1940's. In India, 19 edible species of *Volvariella* have been recorded but cultivation methods have been devised for three of them only viz; *V. volvacea* (Bull. ex Fr.) Sing., *V. esculenta* (Mass) Sing. and *V. diplasia* (Berk and Br.) Sing. *Volvariella volvacea* is deep grey in colour and number of fruiting body is less per bed whereas *V. diplasia* is whitish or ashy in colour and, fruiting body is more with smaller size.

Taxonomy

Kingdom	:	Fungi
Phylum	:	Basidiomycota
Class	:	Agaricomycetes
Order	:	Agaricales
Family	:	Plutiaceae
Genus	:	<i>Volvariella</i>
Species	:	<i>volvacea</i>

Climatic requirement

Temperature- 25-38°C	Relative humidity-85-90%
Light- 1000 lux	pH- 6.5-7.0
Substrate moisture -65%	Oxygen requirement- more during fruiting stage

Production inputs

Paddy straw-7kg	Spawn-200g (3%)
Additives – 200g (3%)	Standard bed size should be 1.5'x1.5'x1.5'

Photos of alternate substrates



Alternate substrates for straw mushroom Cotton mill waste



Alternate substrates for straw mushroom Banana pseudostem



Alternate substrates for straw mushroom Water hyacinth



Alternate substrates for straw mushroom Sugarcane baggage

Requisites:

Thatched shed	Soaking tank
Sprayer	Chaff cutter
Thermometer	Hygrometer
Self	Polythene sheet
Spawn bottle	Organic additives

Procedure:

Straw bundle of 1.5' length are soaked in clean and cold water for 6 hours. Period of soaking depends upon the stiffness of the straw. Then, substrate is pasteurized physically/ chemically for 1 hour. In physical method, it is treated in boiled water or steam pasteurized at 70-80°C for 1 hour. In chemical method, substrate is soaked in solution containing 125ml of formalin (40%) and 7.5g of Carbendazim (Bavistin) per 90 litre of water. Alternatively, the bundles are soaked in water containing 1-2% CaCO₃ powder for the required period so that the pH of the medium is improved. This suppresses the growth and multiplication of moulds in the substratum. Then bundles are kept in a slanting manner upside down to drain out excess water.

Put 4 bricks at 2ft apart from each other and put bamboo sticks on it to make a platform. Break

the spawn bottle, remove the spawn and divide it into four parts. For preparing a bed of 1.5'x1.5'x1.5' size 200g of spawn is required. Spread 1st layer of straw having 5" thickness. One fourth of the spawn bit is put at 3" apart from the periphery at spacing of 3" also. One-fourth of the organic supplement should be sprinkled on the spawn bits. After the 1st layer is complete, another layer of straw 5" thickness is laid opposite to the 1st layer and spawn along with organic supplement (one fourth part each) are sprinkled. Then the 3rd layer is just as 1st layer.

Photographs of Straw mushroom bed preparation



Preparation of straw mushroom bed Spawning of straw mushroom



Preparation of straw mushroom bed Application of supplement



Straw mushroom bed

Photograph of straw mushroom in shed in outdoor



Straw mushroom beds in coconut orchard



Straw mushroom beds in shed



Straw mushroom bed in fruiting stage

Economics:

Straw (7kg)	:	₹ 14.00
Spawn	:	₹ 12.00
Supplements	:	₹ 4.00
Miscellaneous	:	₹ 10.00
		₹ 40.00

Average yield per bed- 1kg in 2-3 flushes

Minimum sale price- ₹80.00/kg

Net profit-(₹80.00-₹40.00)= ₹40.00 (from 10 ft² area)

Practical

2.00 PM to 5.00 PM (3 hours)

Demonstration on Paddy straw mushroom cultivation

DAY-3 (Theory)

Time-10 AM to 1 PM (3 hours)

Importance, climatic conditions, material requirements, cultivation procedure and economics of Oyster mushroom (*Pleurotus* spp.)

‘Oyster mushroom’ or ‘Dhingri’ as referred in India is a basidiomycetes and belongs to the genus ‘*Pleurotus*’. It is lignocellulolytic fungus that grows naturally in the temperate and tropical forest on dead, decaying wooden logs, sometimes on drying trunks of deciduous or coniferous woods. 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’ means formed laterally or lateral position of the stalk or stem. The oyster mushroom is one of the most suitable fungal organism for producing protein rich food from various agro-wastes without composting.

This mushroom is cultivated in about 25 countries of far-east Asia, Europe and America. It is the 3rd largest cultivated mushroom in the world. The major producing countries are China, South Korea, Japan, Italy, Taiwan, Thailand and Philippines. At present, India produces annually 10,000 tones of this mushroom. It is popularly grown in the states of Odisha, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh, Chhattisgarh and West Bengal and in the North-Eastern States of Meghalaya, Tripura Manipur, Mizoram and Assam.

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.



Pleurotus florida



Pleurotus columbinus



Pleurotus platypus



Pleurotus eous

3. Simple cultivation technology: *Pleurotus* mycelium can grow on fresh and 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, relative 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 h even at room temperature.

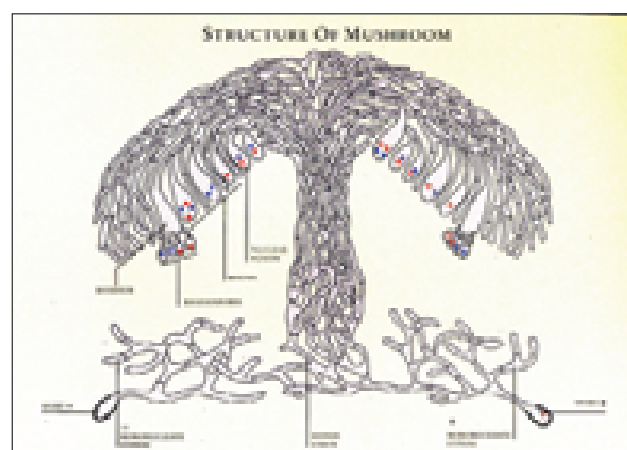
5. High productivity: The productivity of oyster mushroom per unit time is very high as compared to all other cultivated mushrooms. One can harvest minimum of about 500 to 700 kg of fresh oyster mushroom from one ton of dry wheat or paddy

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 cottonseed 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.

B. The biology of oyster mushroom

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 h whitish thread like colonies could be seen. The mycelium of most *Pleurotus sp.* 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 it is fertile. Primary mycelium is clampless and non fertile.

C. Varieties of oyster mushroom:

All the varieties or species of oyster mushroom are edible except *P. olearius* and *P. nidiformis* which are reported to be poisonous. There are 38 species of the genus recorded throughout the world (Singer). In recent years 25 species are commercially cultivated in different parts of the world which are as follows: *P. ostreatus*, *P. flabellatus*, *P. florida*, *P. sajor-caju*, *P. sapidus*, *P. cystidiosus*, *P. eryngii*, *P. fossulatus*, *P. opuntiae*, *P. cornucopiae*, *P. yuccae*, *P. platypus*, *P. djamor*, *P. tuber-regium*, *P. australis*, *P. purpureo-olivaceus*, *P. populinus*, *P. levis*, *P. columbinus*, *P. membranaceus* etc.

D. Climatic requirement

Temperature- 20-30°C	Relative humidity- More than 75%
Light- 200lux	pH- 6.5-7.0
Substrate moisture -65%	

E. Materials required

Straw-2kg	Spawn-200g
Polythene bag-1 (80x40cm)	Supplements-200g (boiled wheat, pulse powder, maize mill, wheat bran, rice bran, vermi-compost etc as optional)

F. Cultivation

The procedure for oyster mushroom cultivation can be divided into following four steps.

1. Preparation or procurement of spawn.
2. Substrate preparation.
3. Spawning of substrate
4. Crop management.

1. Preparation or procurement of spawn:

One should have a pure culture of *Pleurotus* spp. for inoculation on sterilized wheat grain. It takes 10-15 days for mycelia growth on grains. It has been reported that Jowar and Bajra grains



are superior over wheat grains. The mycelium of oyster mushroom grows very fast on wheat grains and 25-30 days old spawn starts forming fruit bodies in the bottle itself. It is therefore, suggested that the schedule for spawn preparation or spawn procurement should be planned accordingly. Sometimes the mushroom farmers are using active mycelium growing on substrate for spawning fresh



new oyster mushroom bags. This method can be used on a small scale. There are always chances of spread of contamination through infested straw by active mycelium spawning method so it is not advisable on large scale commercial cultivation.

2. Substrate preparation:

a. Substrates for oyster mushroom and their nutrition quality:

A large number of agricultural, forest and agro-industrial by-products including straws of wheat, paddy and ragi, stalks and leaves of maize, jowar, bajra and cotton, sugarcane bagasse, jute and cotton waste, dehulled corncobs, pea nut shells, dried grasses, sunflower stalks, used tea leaf waste, discarded waste paper, paper mill sludges, coffee byproducts, tobacco waste, apple pomace and synthetic compost of button mushroom which are rich in cellulose, lignin and hemicellulose useful for growing oyster mushroom. However, yield of oyster mushroom largely depends on the nutrition and nature of the substrate. The substrate should be fresh, dry, free from mould infestation and properly stored. Cellulose rich substrates like cotton waste give better yields as it helps in more enzyme production, which is correlated, with higher yield.

b. Methods of substrate preparation: The mycelia growth can take place on a simple water treated straw but there are number of other cellulolytic moulds already present on straw which compete with *Pleurotus* mycelium during spawn run and also toxic metabolites secreted by these competitors hampers its growth. There are various methods to kill undesirable microorganism present in the straw to favour the growth of *Pleurotus* mycelium. The substrate can be prepared by adopting different methods like steam pasteurization, hot water treatment, chemical sterilization technique, sterile technique and fermentation or composting. The choice of method will depend upon the scale of cultivation envisages and the facilities available. The growers may adopt any one of these method depending upon their need. The details of different methods are given below:

i. Steam pasteurization

In this method, pre-wetted straw is packed in wooden trays or boxes and then kept in a pasteurization room at 58-62°C for four hours. Temperature of the pasteurization room is manipulated with the help of steam through a boiler. Substrate after cooling at room temperature is seeded with spawn. The entire process takes around 3-5 days. This method

is adopted on a commercial scale in Germany. There are various minor variations of this methods adopted in Europe. The tunnel prepared for pasteurizing compost/casing of button mushroom can be used for pasteurizing the straw for oyster. However, adequate boiler facility will be must.

ii. Hot water treatment

The substrate after chopping (5-10 cm) as such in case of wheat straw is soaked in cold water overnight. The substrate is taken out and excess water is drained. Thereafter the straw is soaked in hot water for one hour where the temperature may



be in the range of 65 to 70°C. It will be appropriate to check the temperature and standardize the conditions as per location. Over boiling or over heating may not lead to proper result. Hot water treatment makes the hard substrate

like maize cobs, stems etc. This method is not suitable for large-scale commercial cultivation.

iii. Chemical sterilization technique

Various species of *Trichoderma*, *Gliocladium*, *Penicillium*, *Aspergillus* and *Doratomyces* spp. are the common competitor fungi on the straw during oyster mushroom cultivation which do not allow the growth of mushroom mycelium during mycellial growth and resulting in yield loss or complete crop failure. The technique of chemical sterilisation, which was standardized at DMR, Solan in 1987, is as follows:

Ninety litres of water is taken in a rust proof drum (preferably of galvanized sheet) or G.I. tub of 200 litres capacity. Ten kg of wheat straw is slowly steeped in water. In another plastic bucket, Carbendazim (Bavistin) 7.5 g and 125 ml formaldehyde (37-40%) is dissolved and slowly

poured on the already soaked wheat straw. Straw is pressed and covered with a polythene sheet. After 15 to 18 hour the straw is taken out and excess water drained.

iv. Sterile technique

The chopped substrate after soaking in cold water is put in heat resistant polypropylene bags and sterilize in an autoclave at 22 lb. pressure for 1-2 hours (depending upon the size of the bags) followed by spawning under aseptic conditions. This method is more suitable for research work rather than on large-scale commercial production.

v. Fermentation or composting without pasteurisation

This method is a modification of composting technique used for white button mushroom. It is most suitable for hard substrates like cotton stalks, maize stalks and leguminous stubbles, etc. Composting should be done on a covered area or shed. Chop the substrate into 5-6 cm long pieces. Add ammonium sulphate or urea (0.5-1%) and lime (1%) on dry weight basis of the ingredients. Horse manure or chicken manure (10% dry weight basis) can also be used instead of nitrogenous fertilizers. Addition of lime improves the physical structure and pH of the compost. After wetting of straw, other ingredients are mixed to make a pile. Prepare a heap 75-90 cm high, about one meter wide. After 2 days of fermentation, turning of pile is done and 1% superphosphate and 0.5% lime is added. The compost will be ready after 6 days with three turnings.

vi Fermentation or composting with steam pasteurization

Straw is pre-wetted and made into pile as described above. One per cent lime is added to adjust the pH at the time of stacking. After two turning at two days interval, the substrate is filled in the tunnel and steam pasteurized as described in the steam pasteurization section above.

c. Substrate supplementation: The nitrogen content in most of the substrates ranges between

0.5 to 0.8% and hence addition of organic nitrogen in the straw helps in getting higher yields. Some of the common supplements are wheat bran, rice bran, cottonseed meal, soybean cake, etc. Wheat bran and rice bran should be used at the rate of 10% while cottonseed meal, soybean cake and groundnut cake should be used at the rate of 3-6% on dry weight basis of the substrate. The supplements should be treated with 25 ppm carbendazim (250 mg in 10 litre water) + 500 ppm of formaldehyde for 48 hour. Supplements are thoroughly mixed with straw while spawning. Addition of supplements increases substrate temperature by 2-3°C or even more and hence supplementation during summer season is not advisable. However, during winter months though increased temperature is observed, which helps in quick spawn run. Excess nitrogen can attract mould infestation, which should be taken care of. In many cases, addition of supplements is counterproductive due to the diseases. The better results of supplementation can be obtained in sterile techniques.

3. Spawning of substrate:

Freshly prepared (20-30 days old) grain spawn is best for spawning. The spawning should be done in a pre-fumigated room (48 h with 2% formaldehyde). The spawn should be mixed @ 2 to 3% of the wet weight of the substrate. One spawn bottle of 200 g is sufficient for 8 kg of wet substrate or 2 kg dry substrate. Spawn can be mixed thoroughly or mixed in layers. Spawned substrates can be filled in polythene bags (80 x 40 cm) of 125-150 gauze thickness. Ten to 15 small holes (0.5-1.0 cm dia) should be made on all sides especially two to four holes in the bottom for draining excess water. Perforated bags give higher and early crop (4-6 days) than non-perforated bags. One can also use empty fruit packing cartons or boxes for filling substrate. We can also make a block of the substrate by using compression machine. Polythene sheets of 200-300 gauze thickness of 1.25 x 1.25 m are spread in rectangular wooden or metal box. Spawned substrate is filled and the polythene sheet is folded from all the four sides and compressed to make a

compact rectangular block. It is taken out of the box and tied with a nylon rope. The block is incubated as such and after mycelium growth polythene sheet is removed.

4. Crop management:

The spawned bags or blocks are kept in incubation room for mycelial growth at desirable temperature. Some of the *Pleurotus* species fruit at low temperature around 15°C whereas other species fruit between 20-30°C. However, the incubation temperature is around 25°C for most of the species.

a. Incubation: Spawn bags can be kept on a raised platform or shelves or can be hanged in cropping room for mycelial colonization of the substrate. Higher temperature (more than 30°C) in the



cropping room will inhibit the growth and kill the mycelium. Mycelium can tolerate very high CO₂ concentration of 1.5-2.0%. During mycelial growth the bags are not opened and no ventilation is needed. Moreover, there is no need for any high relative humidity, so no water should be sprayed. However, some chemicals for control of flies can be sprayed on the walls. Similarly, water can be sprayed in the room or on the wall in case the environmental temperature is more than required.

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. djamore 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 wooden platforms or shelves with a minimum distance of 15-20 cm between each bag in the tier. They can also be hanged. Various cultural conditions required for fruiting are as follows.

i. Temperature

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 fruit at low temperature but the winter varieties will not fruit at higher temperature. 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*, *P. sajor-caju* and *P. eous*. Low temperature requiring species are *P. ostreatus*, *P. florida*, *P. eryngii*, *P. fossulatus* and *P. cornucopiae*. 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 grayish brown.

ii. Relative humidity

All the *Pleurotus* species require high relative humidity (70-80%) 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 exhausts fans should be operated for air circulation so that the excess moisture from the cap surface evaporates. Sometimes fruit bodies give offensive smell due to the growth of saprophytic bacteria on the wet cap surface; under such conditions 0.05% bleaching powder spray at weekly interval is recommended.

iii. Oxygen and carbon dioxide requirements

The oyster mushroom mycelium can tolerate high carbon dioxide concentration during spawn run (up to 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, however, required to initiate fruit body formation. For primordia formation light requirement is 200 lux intensity for 8-12 hour. 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. Thus both light and fresh air is necessary for formation of normal fruit body. It is not necessary to give the light and fresh air simultaneously but the required CO₂ concentration and light requirement must be met for getting normal fruit body. It may be a good idea to give the fresh air just after water spray as it helps in removal of excess water from the surface of fruit bodies.

v. Hydrogen ion concentration (pH)

The optimum pH during mycelia colonization should be between 7.0 and 8.0. The pH of the water for spraying should be neither too acidic nor alkaline. Water should not contain harmful salts or heavy metals. The mushrooms tend to accumulate various metals if present in substrate or water used. 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.

Economics:

Straw (2kg)	:	₹4.00
Spawn	:	₹ 12.00
Supplements	:	₹ 4.00
Polythene	:	₹ 3.00
Miscellaneous	:	₹ 7.00
		₹ 30.00

Average yield per bag- 1.5kg in 2-3 flushes

Minimum sale price- ₹ 40.00/kg

Net profit-(₹ 60.00-₹ 30.00)= ₹ 30.00 (from 4 ft² area)

Importance, Climatic conditions, Material requirements, Cultivation procedure and Economics of Milky Mushroom

Milky mushroom (*Calocybe indica*) is second tropical mushroom after paddy straw mushroom and 4th popular mushroom in India. This variety is new introduction to world mushroom family from India. This mushroom is not grown commercially

in Odisha, as mushroom farmers are involved in straw mushroom cultivation in the same season. In south India like AP, Kerla, Karnataka, it is grown commercially.

Advantages and disadvantages:

- This mushroom bears attractive white colour
- It has high biological efficiency (80-100%)
- It has better keeping quality (3-4 days)
- Cultivation process is simple
- Can be cultivated in different agro wastes
- It can be cultivated March-October in India
- It can tolerate high temperature in which straw mushroom fails
- It has only one species in India

Climatic requirement:

Temperature-25-38°C

Humidity- More than 80%

Light- 200lux

Substrate moistuer- 65-70%

Materials required

Straw-1.5kg

Spawn-200g

Polythene bag-1 (60x40cm)

Suppliments-200g (boiled wheat, pulse powder, maize mill, wheat bran, rice bran, vermi-compost etc as optional)

Cultivation

1. Substrate and substrate preparation

Milky mushroom (*Calocybe indica*) can be grown on wide range of substrates as in case of oyster mushroom. It can be grown on substrates containing lignin, cellulose and hemicelluloses. Substrate should be fresh and dry. It can be grown on straw of paddy, wheat, ragi, maize, bajra, cotton stalks and leaves, sugarcane bagasse, cotton and jute wastes, dehulled maize cobs, tea/coffee waste etc.

Straw is chopped in small pieces (2-4 cm size) and soaked in fresh water for 6-8 hours. Main purpose of soaking is to saturate the substrate

with water. It is easier to soak if straw is filled in gunny bag and dipped in water. The substrate can be pasteurized in various ways as incase of oyster mushroom.

2. Spawning and spawn run

Higher spawn dose 4-5% of wet substrate is used. Layer spawning is preferred. After spawning bags are shifted to spawn running room and kept in dark where temperature 25-35°C and relative humidity above 80% are maintained. It takes about 20 days when substrate is fully colonized and bags are ready for casing.

3. Casing

The casing means covering the top surface of bags after spawn run is over, with sterilized casing material in thickness of about 3-4 cm. Casing provides physical support, moisture and allows



gases to escape from the substrate. Casing material (soil 75% + compost 25%) pH adjusted to 7.8-7.9 with chalk powder is sterilized in autoclave at 151b psi for one hour or chemically treated with formaldehyde solution (4%) about a week in advance of casing. Solution should be enough to saturate the soil. It is covered with polythene sheet to avoid escape of chemical and at an interval of 2 days and soil is turned so that at the time of casing, soil is free from formalin fumes. Top of the bag is made uniform by ruffling top surface of the substrate and sprayed with solution of carbendazim (0.1%) + formaldehyde (0.5%). Casing material is spread in uniform layer of 3-4cm thickness. Temperature 30-35°C and R.H. 80-90% are maintained.

4. Cropping

It takes about 10 days for mycelium to reach on top of casing layer when fresh air is introduced while maintaining temperature and R.H. as above. Light should be provided for long time (10-12 hour daily). The changes thus made in environment, result in the initiation of fruiting bodies within 3-5 days in the form of needle shape which mature in about a week. Mushrooms 7-8 cm diam. are harvested by twisting, cleaned and packed in perforated polythene/polypropylene bags for marketing. Mushrooms can also be wrapped in clean film for longer storage.



5. Economics:

Straw (1.5kg)	:	₹ 3.00
Spawn(100g)	:	₹ 6.00
Supplements	:	₹ 4.00
Polythene	:	₹ 3.00
Miscellaneous	:	₹ 9.00
		₹ 25.00

Average yield per bag- 1kg in 2-3 flushes

Minimum sale price- 60.00/kg

Net profit-(60.00-25.00)= 35.00 (from 4 ft² area)

Practical

2.00 PM to 5.00 PM (3 hours)

Demonstration on Oyster and milky mushroom

DAY-4 (Theory)

Time-10 AM to 1 PM (3 hours)

Mushroom processing and preservation

Post-harvest technology involves all treatments or processes that occur from time of harvesting until the foodstuff reaches the final consumer. Efficient techniques for harvesting, conveying/transportation, handling, storage, processing/preservation, packaging, etc are components of the post-harvest chain. It reduces the post harvest and storage losses; adds value to the product, generate employment in village and reestablishes agro-industries in rural sector. Fresh mushrooms need to be properly stored to retard post harvest deterioration till these are consumed. In India only 2% of fruits and vegetables produced are processed as against 65% in the USA, 70% in Brazil etc.

To overcome post harvest losses, specially during peak season, suitable post harvest management/practices are to be followed to retard the deterioration in quality, to increase the shelf life and marketability of mushrooms (Wakchaure, 2011a). There are two important methods of preservation:

Short term preservation (cooling)

Straw mushroom can be stored for 2 days at 10-15°C in polythene bags (100 gauge) with 5% vent area. Other mushrooms like button, oyster and milky mushrooms are preserved at 5°C in 100 gauge polythene bags (button and milky in non-perforated and oyster in perforated). In this condition, button and milky mushroom can be stored for one week where as oyster for 3-4 days. Pre-washing may/may not be taken up before packaging. It leads to decline in shelf life and spoilage of mushroom by bacteria. However, some antimicrobial and reducing agents are used to extend shelf life.

Long term preservation

1) **Brine preservation:** Mushrooms are sorted, washed, trimmed and blanched for 3 minutes in 2% salt solution and 0.1% acetic acid and stored in 5%

slat solution containing 0.2% acetic acid and 0.1% potassium meta bisulphate in glass bottles.



2) **Drying:** Mushroom contains about 90% moisture at the time of harvesting and are dried to maintain 10-12%. Drying at 55-60°C, the





insects and microbes are killed. The dehydrated product at low moisture percentage increases the self life of mushroom. Oyster, shitake, paddy straw and black ear are being dried in sun or in cabinet drier which increases the self life upto 6months.

3) **Canning:** Canning is the technique by which the mushrooms can be stored for longer periods up to a year. The caning process can be divided into various unit operations namely cleaning, blanching, filling, sterilization, cooling, labeling and packaging.

In this process the whole mushrooms are washed 3-4 times in cold running water to remove adhering substances. The mushrooms are blanched with a solution of 0.1% citric acid and 1% common salt from 5-6 minutes at 95-100°C to inhibit polyphenol oxidase enzymes activity, inactivate microorganisms, remove the gases from the mushroom tissue and reduce bacterial counts. Thereafter, blanched mushroom are filled in tin cans in brine solution (2% salt and 0.1% citric acid) at 90°C. The cans are exhausted for 10-15m after lidding loosely, sealed, sterilized at 15psi for 25-30minute, cooled and labeled.

Flow chart for canning

Mushrooms-Grading- Brining-Storage-Slicing- Labeling-Drying-Washing-Blanching-Sterilization

Photograph of Value added products



Value added product Mushroom soup powder



Mushroom pickle

Competitor moulds and diseases of mushrooms

a) Competitor moulds:

i) Ink Cap:

Coprinus comatus is a common weed on mushroom beds. It is favoured by high moisture content of the beds, more compaction of beds and poor ventilation with more of ammonia inside the cropping room.

It produces dark blue to violet coloured buds with a long white thin stalk, with opens in a few



Coprinus infected bags

days and disintegrate as black mass of tissues, covering the entire bed, thus arresting the growth of spawn, development of young buds. The entire bed becomes black in color show rotting of the spawn.

Management:

- Avoid using damaged and old straw for bed preparation.
- Remove and destroy the infected beds immediately
- Avoid preparing beds with more than 70 per cent moisture
- Avoid chemical method of sterilization as this process lead to more weed growth.

b) Green moulds:

Mainly *Trichoderma viride* is severe both in beds and on mushroom buds. In addition, *Penicillium* and *Aspergillus* spp. may also cause mouldy growth on the beds. The infection lead to development of green color patches in the beds,



which spreads quickly and entire bed is covered fully with green growth, which completely arrests the spawn running. This is due to improper sterilization of straw and bed preparation with more moisture.

Management:

- Avoid using damaged and old straw for bed preparation.
- Remove and destroy the infected beds immediately
- Avoid preparing beds with more than 70 per cent moisture

c) Fungal diseases

In addition to the above fungal diseases, some

other diseases in the mushroom beds are

- Dry bubble- *Verticillium malthousei* and *V. psalliotae*
- Truffle- *Pseudobalsamia microspora*
- Mildew/ Cobweb- *Dactylium dendroides*

d) Bacterial blotch/ bacterial pit / brown blotch:

This disease is caused by a bacterium, *Pseudomonas tolassi*. It produces pale-yellow spots on the surface of the pileus, which later turn brown. Pits are often found just below surface. This disease also cause considerable damage in storage and transit. The incidence is more when the mushrooms are watered heavily in the early bud stage. Because of very high humidity film of water always present on the surface of buttons leading to browning and rotting, emitting a fowl smell. Possibly the tryoglyphid mite mites carry the pathogen from one bed to other. In addition, the water splash from the infected bed also carries the bacterial inoculum.

Management:

- Keep the population of tryoglyphid mite under control
- Avoid pouring excess water to the beds.
- Remove the infected beds periodically to avoid further spread.
- Spray water mixed with bleaching powder @ 2 g / 10 litres of water.

e) Viral diseases:

Complex viruses cause a disease variously called the Brown disease/ watering stipe/ X-disease/ die back disease. It is difficult to diagnose the disease on the basis of symptoms- drumstick like mushroom and premature opening of veils- because similar symptoms can also be caused by certain environmental and cultural conditions. Even the virus infection may be symptomless. Reduction in yields of mushroom id perhaps the most reliable symptom. The other symptom commonly associated with the infected crop is the slow and depressed growth of the mycelium isolated from infected mushroom. Transmission of virus is

through mushroom spores and spawn. In addition, phorid larvae and tarsonemid mites are also act as vectors for this complex disease.

ABIOTIC DISORDERS

Unfavourable environmental conditions create both quantitative and qualitative losses. Inadequate or high level of substrate moisture, pH of the growing medium, bed substrate and RH in the spawn running and cropping room, CO₂ accumulation in cropping rooms bring abiotic disorders in mushroom. Some of the commonly occurring abiotic disorders of oyster and milky mushroom is given.

1. Stroma

Appearance of discrete dull white or slight yellowish patches of mycelia as a dense fluffy layer of tissue on the surface of the substrate or casing layer is called stroma formation. Stroma prevents free air exchange in the beds leading to oxygen demand to the growing pin heads and hence putrefying smell occurs in the beds which ultimately invites pests mainly flies.

2. Hard cap and open veil

Caps open prematurely and the gills become rudimentary or poorly developed. Toxic fumes, hot fumes may result in hard cap, sometimes become malformed where the cap size is smaller than the stem diameter. Open veil formation means premature opening with abnormal gill development which occurs due to water stress.

3. Hollow stem and brown pith

Water stress in the beds and less humidity in the growing room result in the formation of central hollow in the stipe.

4. Rose comb

Large swellings or humps appear on the mushroom cap. Gills appear over the cap and stipe. These misshapen gills make the swellings to look like spongy. Such mushrooms become twisted, split and brown.

5. Scales or crocodile skin formation

Scale like out growths occur on the pileus and stipe. Mushrooms become small with less weight. Low levels of RH and increased temperature with dry air in the cropping room increases scaling.

6. Long stemmed mushrooms

Long thick stipe with small cap resembling appear due to excess CO₂ accumulation and poor light in the cropping room.

7. Browning and drying

Browning and drying of the pin heads occur due to high temperature and less humidity.

Practical

2.00 PM to 5.00 PM (3 hours)

1- Demonstration on mushroom dehydration and pickling

2- Acquaintance with competitor mould and diseases of mushroom certificates

DAY-5 (Theory)

Time-10 AM to 1 PM (3 hours)

**Establishment of commercial, mushroom
production unit**

Valedictory function

**Interaction with trainees and distribution of
certificates**



ICAR- Agricultural Technology Application Research Institute, ZONE-VII

Indian Council of Agricultural Research

JNKVV, Jabalpur – 482004 (M.P.)