MUSHROOM CULTIVATION

Introduction

Agriculture will continue to be the main strength of Indian economy. With the variety of agricultural crops grown today, we have achieved food security by producing about 240 million tons of food grains. However, our struggle to achieve nutritional security is still on. In future, the ever-increasing population, depleting agricultural land, changes in environment, water shortage and need for quality food products at competitive rates are going to be the vital issues and secondary agricultural vocations are going to occupy a prominent place to fill the void quality food requirements. The demand for quality food and novel products is increasing with the changes in life style and income. To meet these challenges and to provide food and nutritional security to our people, it is important to diversify the agricultural activities in areas like horticulture. Diversification in any farming systems imparts sustainability. Mushrooms are one such component that not only impart diversification but also help in addressing the problems of quality food, health and environmental sustainability. The present century is going to be a century of functional foods from synthetic chemicals and mushroom cultivation fits very well into this category and is going to be an important vocation. Mushrooms represent microbial technology that recycles agricultural residues into food and manure. It is solid state fermentation system in which crop residues are converted into valuable food rich in microbial protein.

These are important source of quality protein, minerals and various novel compounds of medicinal value, do not compare for land and have very high productivity per unit area and time. These are considered to be the highest protein per unit area and time due to utilization of vertical space and short crop cycle. Due to their cultivation under controlled conditions the water requirements are less than any other crop grown in the field and has all the potentials of being a major crop in coming years.

History Of Mushroom Cultivation

Mushroom cultivation has a long and fascinating history, dating back to ancient times. The earliest recorded evidence of mushroom cultivation comes from China, where farmers began growing shiitake mushrooms over 1,000 years ago. However, the practice of cultivating mushrooms for food is thought to have started much earlier, as early as 600 AD.

Early Mushroom Cultivation

During the 17th century, mushroom cultivation became popular in France and other parts of Europe. In fact, French gardeners were among the first to develop the process of growing mushrooms in caves, which provided the perfect environment for mushroom cultivation. This method was later adopted in other parts of Europe, and became the standard way of growing mushrooms until the mid-19th century.

In the United States, mushroom farming did not become popular until the early 20th century. The first commercial mushroom farm in the U.S. was established in 1896 by W. Robinson in Pennsylvania. However, it was not until the 1920s that mushroom farming really took off in the U.S., as immigrants from Europe brought their knowledge and expertise in mushroom cultivation with them.

Mushroom Spawn Changes Everything

One of the biggest challenges facing mushroom farmers in the early days was finding a reliable source of spawn, which is the material used to start the growth of mushrooms. At the time, spawn was imported from Europe, but it was often unreliable and expensive. This led to the development of the American spawn industry in the early 20th century, which greatly improved the quality and availability of spawn for mushroom farmers.

In the mid-20th century, new technologies and techniques were developed that revolutionized the mushroom farming industry. The development of synthetic compost and climate-controlled growing environments allowed for year-round cultivation of mushrooms, which greatly increased production and lowered costs. This led to the widespread availability of mushrooms in supermarkets and restaurants, making them a staple food in many parts of the world.

Mushroom Cultivation Today

Today, mushroom farming is a major industry, with millions of tons of mushrooms produced each year around the world. While most mushrooms are still grown using compost and climate-controlled environments, new techniques are being developed that could revolutionize the industry once again. For example, researchers are exploring the use of robotics and artificial intelligence to optimize mushroom production, while others are looking at new ways to use waste materials and other sustainable practices in mushroom cultivation.

Despite its long and storied history, mushroom farming remains a dynamic and evolving industry. From its humble beginnings in ancient China to the high-tech farms of today, mushroom farming has come a long way, and will likely continue to play an important role in our food system for many years to come.

Scope of Mushroom cultivation

Mushroom farming today is being practiced in more than 100 countries and its production is increasing at an annual rate of 6-7%. In some developed countries of Europe and America, mushroom farming has attained the status of a high-tech industry with very high levels of mechanization and automation. China leads in mushroom production and China alone is reported to grow more than 20 different types of mushrooms at commercial scale and mushroom cultivation has become China's sixth largest industry. The USA is the second largest producer of mushroom sharing 16% of the world output. Presently, three geographical regions- Europe, America and East Asia contribute to about 96% of world mushroom production. With the rise in the income level, the demand for mushrooms at very low costs with the help of seasonal growing, state subsidies and capturing the potential markets in the world with processed mushrooms at costs not remunerative to the growers in other mushroom producing countries. Crop Production Guide 420 Commercial production of edible mushrooms represents unique exploitation of the microbial technology for the bio conversion of the agricultural, industrial, forestry and household waste into nutritious and proteinaceous food.

Our country can emerge as a major play in mushroom production in wake of availability of plenty of agricultural residues and labour.Integrating mushroom cultivation in wake of availability of plenty of agricultural residues and labour. Integrating mushroom cultivation in the existing farming systems will not only supplement the income of the farmers but also will promote proper recycling of agro-residues thereby improving soil health and promoting organic agriculture.

In India, mushroom research started in1960s and the cultivation picked up in 1970s and new varieties

were evolved in button and oyster mushroom during 1980s and 1990s. Since the year 2000, our country is progressing keeping in pace with global growth by developing technologies for cultivation of medicinal mushrooms. India has varied agro-climate, abundance of agricultural residues and plenty of manpower making it suitable for cultivating different mushrooms.

Our country produces about 600 million tons of agricultural waste per annum and a major part of it is let out to decompose naturally or burnt in situ. This can effectively be utilized to produce highly nutritive food such as mushrooms and spent mushroom substrate can be converted into organic manure and vermi-compost.

Mushrooms are grown seasonally as well as in state-of-art environment controlled cropping rooms all the year round in the commercial units. Mushroom growing is a highly labour oriented venture and labour availability is no constraint in the country and two factors, that is, availabilities of raw materials and labour make mushroom growing economically profitable in India.

Moreover, scope for intense diversification by cultivation of other edible mushrooms like oyster, shii-take, milky and other medicinal mushrooms are additional opportunities for Indian growers. At present, four mushrooms viz., Button mushroom (*Agaricusbisporus*), Oyster Mushroom (*Pleurotusspp*), Paddy straw mushroom (*Volvariella spp*.) and Milky mushroom (*Calocybe indica*) have been recommended for round the year cultivation in India. India produces about 600 million tons of agricultural by products, which can profitably be utilized for the cultivation of mushrooms. Currently, we are using 0.04% of these residues for producing around 1.29 lakh tons of mushrooms of which 85% is button mushroom. India contributes about 3% of the total world button mushroom production. Even if we use 1% of the residues for mushroom production, we can produce 3.0 million tons of mushrooms, which will be almost equal to current global button mushroom production (current world production 3.4 million tons). To remain competitive, it will be important to harness science and modern technologies for solving the problems of production and bio–risk management. Mushroom being an indoor crop, utilizing vertical space offers a solution to shrinking land and better water utility. Mushrooms have been reported to be capable of transforming agro wastes like paddy straw into protein rich food and have been confirmed to be sources of single cell Mushroom Cultivation 421 protein.

Importance of mushroom cultivation

Mushrooms contain rich source of carbohydrates, proteins, amino acids and dietary fiber. Vitamins such as riboflavin, niacin and pantothenic acid, and the essential minerals selenium, copper and potassium are abundant in mushrooms. The foremost importance is that mushrooms do not have cholesterol, instead contain ergosterol that act as a precursor for vitamin D synthesis in human body. Mushrooms are believed to help fight against cancer, relieves hypertension, imparts protection from heart diseases. Mushroom crop is in fact a boon that can solve several problems like the protein malnutrition, unemployment issues and environmental pollution. Mushrooms are cultivated indoors and do not require arable land and mushroom is a short duration crop with high yield per unit time. For small farmers and landless workers mushroom cultivation is highly suitable for the economic and social security of this group. This hi-tech horticulture venture relieves the pressure on arable land, because its cultivation is indoors, and is also more suited to the women folk. Mushrooms supplement and complement the nutritional deficiencies and are regarded as the highest producers of protein per unit area and almost 100 times more than the conventional agriculture and animal husbandry.

At present, in Tamil Nadu the annual production of mushroom is around 11,000 tons, button mushroom

accounts for 7,500 tons, Oyster mushroom accounts for 2700 tons and milky mushroom contributes for 800 tons. During the past two decades, the Mushroom Research and Training Centre of the Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore has made tremendous efforts on transfer of mushroom cultivation technology by imparting trainings. By this way it has contributed for the establishment of about 50 spawn producers and 600 oyster mushroom growers accounting for 7- 8 tons / day, 50 button mushroom growers producing 18-20 tons / day and 35 milky mushroom growers contributing 1-2 tons / day in Tamil Nadu. This account for around 8 per cent of total mushroom capable of transforming agro wastes like paddy straw into protein rich food and have been confirmed to be sources of single cell Mushroom Cultivation 421 protein.

Mushroomvarieties/strainsreleasedforcommercialcultivation

ScientificName	Variety/strain name	Placeofrelease
Oystermushroom		
Pleurotussajorcaju	M2	Dept.ofPlantPathology,TNAU,Coimbatore
P.citrinopileatus	CO1	Dept.ofPlantPathology,TNAU,Coimbatore
P.djamor	MDU1	Dept.ofPlantPathology,AC&RI,Madurai
P.eous	APK1	RegionalResearchStation,Aruppukottai
P.ostreatus	Ooty1	Horticultural Research Station, Uthagamandalam
P.florida	Pf	Dept.ofPlantPathology,TNAU,Coimbatore
P.platypus	Pp	Dept.ofPlantPathology,TNAU,Coimbatore
P.flabellatus	MDU2	Dept.ofPlantPathology,AC&RIMadurai
Hypsizygusulmarius	CO2	Dept.ofPlantPathology,TNAU,Coimbatore
Milkymushroom		
Calocybeindica	APK2	RegionalResearchStation,Aruppukottai
Tricholomagiganteum	CO3	Dept.ofPlantPathology,TANU,Coimbatore
Buttonmushroom		
Agaricusbisporus	Ooty1 Ooty2	Horticultural Research Station,ijaynagaram HorticulturalResearchStation, Vijaya-nagaram

Mushroom: Culture preparation and spawn production

Spawn (mushroomseed) is the vegetative mycelium from a selected mushroom cultured on a convenient medium/substrate like wheat, pearl millet, sorghum grains, rye etc. It is a medium that is impregnated with mycelium made from a pure culture of the chosen mushroom strain. Spawn production is a fermentation process in which the mushroom mycelium will be increased by growing through a solid organic matrix under controlled environmental conditions. The purpose of the grain spawn is to boost the mycelium to a state of vigor such that it will rapidly colonies the selected bulk growing substrate. Each individual grain becomes coated with the mycelium and in fact becomes a mycelia capsule. An extensive technology has been developed throughout the world to ensure the production of high-quality mushroom spawn. The availability of good quality spawn is the limiting factor for mushroomcultivation in many developing countries. The complete procedure of spawn production involves spawn laboratory and basic requirements; preparation of the media, culturing and maintenance of mushroom fungi, substrate preparation and it's spawning etc.

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Spawn laboratory and general requirements:

In general, the layout plan of a spawn laboratory should have a total built up area of 19x8x3.6m (LxBxH). This area will be divided into different work areas like cooking/ autoclaving room, inoculation room, and incubation room, washing area, store, office and one cold storage. Cold storage roomof3x3x3.6m (LxBxH) is enough to store thespawnat4-5°C.The walls, roof floor as well as door is provided with heavy insulation (7.5-10cmthickness) and two air conditioners (each of 1.5 tons capacity) are required to maintain the temperature inside the room. Incubation room 2 (3x6.0x3.6 m, LxBxH) with entire surface area (wall, floor, ceiling, doors) insulated with 5-7.5cm thick insulation is required. Two (each 1.5tonnes capacity) are required for maintenance of temperature (25°C) in the incubation room. Besides these, some ancillary structures like office, small lab space delivery area etc. may also be required.

The equipment and other miscellaneous items required in a spawn laboratoryare:

1)autoclave (horizontal type) is required for the sterilization of grain bottle sand substrates filled in polypropylene bags for producing spawn and also the non- composted substrates for production of specialty mushrooms

2) small autoclave (standing type) for the sterilization of culture media in tubes / flasks and the substrates, including grains for production of Master culture and spawn in glass bottles/ PP bags on a small scale

3) pressure cooker required for sterilization of media for routine laboratory work

4) baby boiler run by wood fuel, electricity or diesel and required for production of pressure steam for boiling, sterilization of grains and pasteurization of casing mixture

5) laminar Flow required for isolation of fungi and inoculation of grain bags/ bottles with master cultures under aseptic conditions

6) weighing machine required for the exact measurement of raw materials for producing spawn and compost

7) steel or cemented racks required in the incubation and storage rooms on which the inoculated bags are to be kept at a particular temperature for mycelia run and their storage at different temperatures

8) steel trolleys required for easy movement and carriage of grain bags, spawn bottles, compost bags and

other materials from one room to another room

9) BOD incubators required to incubate culture s inoculated or transferred in tubes, Petri dishes, flasks and Master culture bottles for their speedy growth at a fixed temperature

10) oven is required for the sterilization of glass wares, including Petri plates, pipettes, beakers, glass tubes etc.

11) refrigerator for maintain purity of the fungal cultures for a considerable period, these are to be kept in the refrigerators in a cool environment

12) wire mesh Tray required for removing excess water from boiled cereal grains or the boiled substrates like straw or sawdust used for mushroom production

13)boiling pans/boiling kettle/ gas/ kerosene stove or electric stove required for boiling the grains/ preparation of media

14) pH meter to Check the pH of the medium,

15) microscope for diagnosis of microbial contaminations and infections,

16)hotplate/ heater to heat the media and boil the contents of culture media,

17) glassware viz., Petri dishes, test tube, culture tube, beakers, funnels, measuring cylinders' glucose bottles, Glasslides,coverslipandconicalflasks,

18)chemicals for medium preparation, calcium carbonate, calcium sulphate and disinfectant (formaldehyde) etc.,

19) furniture like steel racks in incubation room and cold storage for keeping bags/bottles, exhaust fans, filters, office table, working tables etc. and other miscellaneous items like Bunsen burner, inoculating needle/ loop, non-absorbent and absorbent cotton, polypropylene bags(or bottles),rubber band, sieves, inoculating needles, scalpels, culture tube rack, tripod with asbestos mat, butter paper sheets, muslin cloth, Petridis can, wire basket, plastic mist sprayer, razor blades, cork-borer, forceps, scissors, troughs etc. are also required in a spawn laboratory.

Media for mushroom fungi:

The pure cultures are raised on a convenient culture medium which is generally in solidified state due to the addition of Agar-agar. In laboratory, the edible mushroom strains may be cultured on different media.
The composition of media and the methods of preparation are as given under:

Potato-dextrose Agar medium (PDA):

- Peeledandslicedpotato:250g
- Dextrose: 20g
- Agar–agarpowder:20g
- Water:1000 ml.

About 250g potatoes are peeled, cut into small pieces, boiled in water for 25-30 minutes and filtered through a muslin cloth. The volume of the extract is raised to 1000 ml with water and boiled along with dextrose and agar- agar powder so as to get a thoroughly mixed solution. Before pouring in the test tubes or flasks, the pH is adjusted to7.0andthenafterpluggingwithnon-absorbentcotton and sterilization at 15 p.s.i. for 15 – 20 minutes in an autoclave.

Potato -dextrose Yeast Agar Medium (PDYA):

Just like preparation of PDA, PDYA can be prepared by adding 2g Yeast extract in the solution for selected fungi.

Malt Extract Agar medium (MEA):

– Malt extract ---- 25g

– Agar-agar powder ---- 20g

– Distilled water ---- 1000ml

Malt extract and agar are mixed in 1 litre water and boiled by continuously stirring with a glass rod so as to avoid formation of clumps followed by sterilization at 15
p.s.i. for 15–20 minutes in an autoclave

Compost Extract Agar medium (CEA):

– Pasteurized compost ---- 150g

– Agar–agar powder------ 20g

– Water------1000ml

Compost is boiled in 1.5 to 2.0 litre water for few minutes till volume of the water is reduced to half and after filtering through muslin cloth, the volume is again ma-deto1litreandautoclavedaftermixingagarpowder in it and filling in the test tubes.

Malt Peptone Grain Agar Medium (MPGA):

– Malt extract----- 20g

– Rye or Wheat grains --- 5g

– Yeast (Optional) ---- 2g

– Agar-agar powder ----20g

– Peptone ----- 5g(pH-7.0)

Wheat or rye grains are boiled in waterfor1-1.5hours; the filtrate is mixed with other ingredients and continu-ously stirred while heating before filling and autoclaving.

Oat meal agar:

– Oatmealflakes30g

– Agar-agar:20g

– Distilledwater:1000ml

Cook oatmeal in water for 15 – 30 minutes. Filter through three or four layers of cheese cloth and bring filtrate back to volume with water. Add agar and autoclave it at 15 p.s.i. or 121°C for 15 minutes.

Wheat extract agar:

– Wheatgrain:32g

– Agar-agar powder: 20g

– Distilledwater:1000ml

Boil 32gwheat grains with 1 litre of distilled water for about 2hrs and filter after24hrs.Bringfiltrate back to volume with water.Add agar and autoclave it at15p.s.i. or 121°C for 15 minutes.

Rice bran decoction medium:

– Rice bran: 200g

– Agar-agar: 20 g

– Distilledwater:1000ml

Boil 200 g rice bran with 1 litre of distilled water for about 2hrs and filter it. Bring filtrateback tovol-

ume with water. Add agar and autoclave it at 15 p.s.i. or 121°C for 20 minutes.

The pH of the medium adjusted by adding N/10 NaOH or N/10 HCl drop by drop to raise it to 7or brought down to be adjusted to 7.0, respectively before sterilization. Wheat grain and compost extract are most suitable culture media for *A.bisporus*and *A.bitorquis*cultures. Cultures of *Volvariella spp.* and *Pleurotus spp.* can be maintained on PDA or Malt extract agar medium. It is desirable that cultures are not maintained on the same type of culture medium in each sub-culturing.

Culturing of Mushroom fungi:

Culture isolation: Fresh and healthy mushroom fruit body (basidiocarp) showing all the desirable attributes of that species/ strain or their spores are used to raise mycelial cultures by following methods:

Vegetative mycelium culture (tissue culture**):**

Step 1: Cleaning of young basidiocarp with sterilized distilled water and dipping in 2.5% sodium hypochlorite solution for 1 min under aseptic conditions using laminar flow.

Step2: In case of button mushrooms, the basidiocarp is air dried and split open longitudinally from centre and vegetative mycelial bits are cut from the collar region (junction of pileus and stipe). Whereas, in black ear mushrooms, the ear is cut along the edge with a sterilized scissor and inner tissues are scraped and small bits of tissues are removed.

Step3: These bits are then washed insterilized water to remove sodium hypochlorite and placed in oven sterilize Petri plates having culture media.

Step4: Incubation of inoculated plates at 25°C±2° C in a BOD incubator.

Step5: New mycelium growth over the tissue is observed within 4-5 days.

Step6: Purification of cultures by carefully transferring young mycelium from growing edge of the colony from Petri plate to test tubes.

Step7: Incubation of inoculated tubes at 25°C± 2°Cfor 10-14 days (35°C for *Volvariellavolvacea*).

Multispore culture:

Step1: Under aseptic conditions, spore massisscraped froma fresh spore print or basidiocarp and suspended in 100ml of sterilized distilled water in flasks and shake to obtain uniform spore suspension.

Step : A few drops of this suspension is added to luke warm culture medium and poured into oven sterilize Petriplates. Petriplates are rotated to homogenize the spore suspension into culture medium. The culture medium is allowed to solidify and then Petri plates are inoculated at 25°C± 2°C for 3-4 days (35°Cfor *Volvariellavolvacea*).

Step 3: The spore germination is observed under microscope and germinating spores along with a pieceof agar are transferred carefully to culture tubes.

St ep4:Incubation of culture tubes of *Agaricusbisporus and A. bitorquis*at 25°C for 10-14 days and *Volvariellavolvácea* at 32°C for 7 to 10 days.

Single spore culture:

*Agaricusbitorquis*and *Pleurotus spp.*are heterothallic with tetra spored basidia, therefore single spore is self-sterile but this technique can be successfully used forbreeding new-strains.*Agaricusbisporus*beingsecondary homothallic with bispored basidia and majority of its sporesbeing self-fertile, can be used to raise fertile cultures.Single spore cultures are procured in the sameway as in multisporecultures except serial dilution of spore suspension for single spore culture isolation. Its methodology

is given below.

Step 1: Single spore culture isolation: serial dilution of spore suspension-to obtain10-12spores/petriplate so that individual germinating spore is marked and could be lifted underaseptic conditions.

*Step 2 :*Transfer of above individual germinating spore into culture tubes and its incubation at 25°C for 10-14 days in BOD incubator.

Step 3: Procurement ofpure mycelial cultures followed by their preservation for a particular need.

Maintenance and storage of mushroom culture:

There are following methods used for preservation of mushroom cultures.

Regular sub-culturing: For storage purposes cultures are prepared on agar slants in culture bottlesortest tubes. These cultures can be stored at rooms temperatures for one to few weeks.The periods between sub-culturing can be extended up to 46 months by storage at cooler temperatures, *i.e.,*at4-7°C in a refrigerator or cold room. However, all mushroom species cannot be stored at low temperature. For example, *Ganoderma* and *Volvariella*sp. should be kept at temperature less than 15°C or so. *Volvariellavolvacea*is incubated at 32°C for 7 to 10 days.The other mushroom strains are incubated at 25°C for 2-3 weeks until the slants are fully covered with mycelium.*V. volvacea*should be sub-cultured every 2 months.Species of *Lentinula, Pleurotus*and *Agaricus*.

Water storage: The cultures are grown on a suitable culture medium and after full growth,4-5bits of 0.5mm diameter are transferred aseptically to pre cooled and sterilized McCartney bottles containing de mineralized water and the lid stightly screwed down and are stored at room temperature. All mushroom cultures except *V. volvacea* can be stored by this method. Revival of culture is by removal of a block and placing the mycelium on a suitable growth medium.Survivals of fungal cultures stored this way are reported for 2to5 years'period satisfactorily.

Lyophilization (freeze-drying): It is a method for long- term preservation of spore-bearing fungi. Mycelial mushroom cultures are not well preserved in this way. However, spore collected from a young and healthy mushroom aseptically can be stored for several years by this method. In freeze- drying, spore is frozen and water is removed by sublimation. The drying of the spores is accomplished by freezing under reduced pressure in vacuum. Primary drying is achieved at- 40°C for 4 hours. Vacuum is released and glass ampoules are stored at - 20°C(or-70°C). Secondary drying is done in freeze-dryer under vacuum at 20°C for 2 hours. The ampoules are then stored at 4°C to 6°C for longer shelf-life inside a refrigerator.

Preservation at -70°C: Glycerol (10%) in aqueous solution is sterilized by autoclaving at121°C for 15minutes. Alternatively, Dimethyl sulfoxide (DMSO)is sterilized by filtration using 0.22 micron Teflon filter. Usually, 10% glycerol suspensions of cultures are made (0.5ml to1ml) and the aliquots are distributed in small vials or tubes. The vials/tubes are placed at -70°C.

Mushroom Cultivation techniques for Oyster and Milk mushroom Base culture/ Nucleus culture

Tissue culture technique is used to bring the edible mushroom to pure culture so that the mushroom fungus can further be used to prepare spawn which is an essential material for mushroom cultivation.

- ThisnucleusculturеisgrownonPotatoDextroseAgarmediumintesttubes.
- A small tissue from a well-grown mushroom is aseptically transferred to agar medium in a test tube in a culture room.
- The test tubes are incubated under room temperature for 10 days for full white growth of fungal culture. This is called baseculture/nucleus culture and further used for preparation of Mother Spawn.

Motherspawn

Mother spawn is nothing but the mushroom fungus grown on a grain based medium. Among the several substrate materials tested by TNAU, Coimbatore, sorghum grains are the best substrate for excellent growth of the fungus. Well-filled, disease-free sorghumgrainsareusedassubstratefor growingthespawnmaterials.Thevarious steps involving in preparation of mother spawn are listed below here under.

- Thesorghumgrainsarewashedinwaterthoroughlytoremovechaffyand damaged grains.
- Thegrainsarehalfcookedinanautoclave/vesselfor30minutestosoftenthem.
- Thehalf- c o o k e d grainsarespreadevenlyoverhessianclothonaplatformto remove the excess water.
- Calciumcarbonateismixedthoroughlywiththecooked,driedgrains@20g/Kg.
- The grains are filled in polypropylene bags up to 3/4thheight (approximately 300- 330 g/bag).
- AoneinchdiameterPVPringisinsertedonopenendofthebagandplugged with non-absorbent cotton wood.
- Thebagsarearrangedinsideanautoclaveandsterilizedunder20-lbs, pressure for 2 hours.
- The bags after cooling are keptinside thecultureroomunder theUVlight for20 min.
- After20minutestheUVlightisputoffandthefungalcultureistransferredinto the sterilized cholam bags.
- Theinoculatedbagsarekeptinacleanroomunderroomtemperaturefor10 days for further preparation of bed spawn.

BedSpawn

Themethodofpreparationofbedspawnwassameasthatofmotherspawn. The cooking, filling and sterilization were similar to that of mother spawn. After sterilization, the bags are taken and the fully grown mother spawn is used for inoculation to prepare bed spawn. Thirty bed spawn can be prepared from a single motherspawn.Thebagsareincubatedatroomtemperature(27±2˚C)for10days and used as bed spawn.

CultivationofOystermushroom

The oyster mushrooms can be grown indoors in cropping house where a temperature of 25-30 °Cand relative humidity of 80-85 per cent can be maintained.

- Paddy strawisusedastherawsubstratewhichhas tobesoakedinwaterfor 4 hours and boiled or steamed in autoclave for 45 minutes and shade drieduntil 65-70% moisture.
- Cylindricalbedsarepreparedusing60x30cmpolythenebagswitha thickness of 80 gauge.
- Paddystrawandspawnarefilledasalternatelayersinpolythenebagsand 10-12 holes are made in the beds.
- The bags are placed in the cropping house/shedin racks or in hanging rope system. After 15-16 days when the paddy straws in the bags are covered with white mycelia growth, pinheads start emerging where water spray is essentialto prevent drying of buds.
- Firstharvest beginsfrom3-4 daysafter in heademergenceand likewiseat 5- 7 days internal three harvests can be done.
- Totalcroppingcycleisaround40-45days.
- Theaveragebioefficiencyranges(100-150percent)dependingonthe variety.

CultivationofMilkymushroom

The milkymushroomrequires atemperature of 30-35˚Candrelativehumidity of 85-90 per cent. For cultivation of this mushroom two shed are needed.

- Thatchedshed/croppinghouse(28±2˚C)forSpawnrunning
- Asunkenbluepolyhouse(ForCropping)
- Three feet deep pit is dug out and sides are lined with hollow blocks and semicircular structure is built with GI pipe of Langley and covered with Blue silpaulin sheet.
- Paddy straw is processed as in oyster mushroom cultivation and cylindrical beds are prepared with 90x30 cm polythene bags and stored at 30℃ in thatched sheds (spawn running room).
- After 18-20 days when the paddy straws in the bags are covered with white mycelial growth, the beds are cut in to two halves and casing soil (autoclaved garden soil) is layered on to the cut halves for 2 cm height and sprayed with water.
- The cased beds are placed in poly houses and the required temperature is maintained.
- Thepinheadsemergefromthecuthalvesoverthecasingsoilon25-26thday.
- Firstharvestbeginson28thdayandlikewisethree-fiveharvestscanbe done. The total cropping cycle is around 45-50 days. The average bioefficiency ranges from 150-160 per cent.

EconomicsofSpawnProduction(100spawnbagsperday)

Sl. No.	Item	Quantity	Rate(Rs.)	Total

				(Rs.)
A.	**Capitalinvestment**			
1.	Autoclave	1	70,000	70,000
2.	Boiler(GLdrum100lit.Capacity)	2	2,500	5,000
3.	Cultureroomwithworktable(lowcost)	1	20,000	20,000
4.	UVlampwithfittings	1	2,500	2,500
5.	Tubelightfittings	1	1000	1000
6.	AdvanceforLPGgas	2	3,000	6,000
7.	Spawnstorageroom	1	30,000	30,000
8.	Bunsenburner	1	300	300
9.	Heatefficientchulah	1	1000	1000
10.	Glassware&chemicals			5000
	Total			**1,40,800**
B.	**Fixedcost**			
1.	Interestoncapitalinvestment@15%			21,120
2.	Depreciation(Item3&7@ 5%)			2,500
3.	Depreciation(Item12,4,5,8&9,10-10%)			9,080
	Total			**32,700**
C.	**Recurringcost(100spawnx300days)**			
1.	Polypropylenebags	150Kg	140	21,000
2.	Cholamgrains	8000Kg	26	2,08,000
3.	Calciumcarbonate(commercialgrade)	160Kg	25	4000
4.	Non-absorbentcotton(400grolls)	600	110/roll	66,000
5.	Electricity&Fuel	--	--	60,000
6.	Labour@2menperdayfor300days	300	360/day	2,16,000
7.	Miscellaneous	--	--	10,000
	Total			**5,85,000**

TotalcostofSpawnproduction/Year(Rs)—

Workingexpenditure	:	5,85,000
Totalfixedcost	:	32,700
TotalCost	:	**6,17,700**
Income(Rs.)		
Bysaleof30,000spawnbags@Rs.40perbag	:	12,00,000
Totalcost	:	**6,17,700**
Netincomeperyear	:	**5,82,300**

Economics of Oyster mushroom production (10 Kg/day/300 days) Low cost Investment

Sl. no.	**Item**	**Quantity**	**Rate(Rs.)**	**Total(Rs.)**
A.	**CapitalInvestment**			
1.	ThatchedHouse(15'x25')	1	30,000	30,000
2.	Chaffcutter(Levertype)	1	2000	2,000
3.	Boiler	1	2,000	2,000
4.	Drum	1	1,000	1,000
5.	Sprayingsystems	1	1,000	1,000
6.	Biomassstove		1,000	1,000
	Total			**37,000**
B.	**Fixedcost**			
1.	InterestonA@15%			5,550
2.	Depreciation(Item1@30%)			9,000
3.	Depreciation(Item2,3,4,5&6@10%)			700
	Total			**15,250**

C.	**RecurringCost**			
1.	Paddystrawcost+transport	3.5t	7000	24,500
2.	Spawn@Rs.40/No	2000	40	80,000
3.	Polythenebagsforbed&packing	25Kg	135	3,375
4.	Labour@1Perday	300	360/day	1,08,000
5.	Others	--		5,000
	Total			**2,20,875**

Totalcostofmushroomproduction/Year(Rs.)

Workingexpenditure

Totalfixedcost: 15,250

TotalCost: **2,36,125**

Income(Rs.)

Bysaleof10Kg/day@Rs.135for300days: 4,05,000

Totalcost: 2,36,125

NetIncomeperyear: **1,68,875**

Economics of Milky mushroom production (10 Kg/day/300 days)
Low cost Investment

Sl.No.	**Item**	**Quantity**	**Rate(Rs.)**	**To-tal(Rs.)**
A.	**CapitalInvestment**			
1.	ThatchedHouse(15'x20') BluePolyhouse-20'x50'area(1000 sq.ft)	1 1	20,000 60,000	80,000
2.	Chaffcutter(Levertype)	1	2000	2,000
3.	Boiler	1	2,000	2,000

4.	Drum	1	1,000	1,000
5.	Sprayingsystems	1	1,000	1,000
6.	Biomassstore		1,000	1,000
	Total			**87,000**
B.	**Fixedcost**			
1.	InterestonA@15%			13,050
2.	Depreciation(Item1@10%)			8,000
3.	Depreciation(Item2,3,4,5,&6@ 10%)			70 0
	Total			**21,750**
C.	**RecurringCost**			
1.	Paddystrawcost+transport	3.5t	7000	24,500
2.	Spawn@40/day	1600	40	64,000
3.	Polythenebagsforbed&packing	25Kg	135	3,375
4.	Labour@1perday	300	360/day	1,08,000
5.	Others	--		5,000
	Total			**2,04,875**

Totalcostofmushroomproduction/Year(Rs.)

Workingexpenditure : 2,04,875

Totalfixedcost : 21,750

TotalCost : 2,26,625

Income(Rs.)

Bysaleof10Kg/day @Rs.145for300days : 4,35,000

Totalcost : 2,26,625

NetIncomeperyear : 2,08,375

Mushroom processing and preservation

Post-harvest technology involves all treatments or processes that occur from time of harvesting until the food-stuff 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 postharvest 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, especially during peak season, suitable postharvest 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)

- Long term preservation
- Short term preservation (cooling)
- Straw mushroom can be stored for 2days at 10 - 150C in polythene bags (100 gauge) with 5% vent area. Other mushrooms like button, oyster and milky mushrooms are preserved at 50C 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 • Brine preservation: Mushrooms are sorted, washed, trimmed and blanched for 3 minutes in 2% salt solution and 0.1%acitic acid and stored in 5% slat solution containing 0.2% acetic acid and 0.1% potassium meta bisulphate in glass bottles.

- Drying: Mushroom contains about 90% moisture at the time of harvesting and are dried to maintain 10-12%. Drying at 55-60℃, the insects and microbes are killed. The dehydrated product at low moisture percentage increases the shelf life of mushroom. Oyster, shitake, paddy straw and black ear are being dried in sun or in cabinet drier which increases the shelf life upto 6months.

• 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 mushrooms are filled in tin cans in brine solution (2% salt and 0.1% citric acid) at 900C. The cans are exhausted for 10-15m after lidding loosely, sealed, sterilized at 15psi for 25-30minute, cooled and labeled.

Poisonous Wild Mushrooms

Some mushrooms are poisonous and symptoms range from mild gastrointestinal discomfort to death. For example, a wild species of mushroom, *Amanita phalloides*, famously known as the 'death cap,contains amatoxins that cause severe gastroenteritis and hepaticnecrosis. The toxin of *Psilocybesemilanceata* (liberty cap) is a potent hallucinogen; anxiety and peripheral sympathomimetic symptoms may follow ingestion. Another species, *Amanita pantherina* (panther cap) may cause severe anxiety and agitation, hallucinations, and peripheral anticholinergic symptoms. The toxin in *Cortinarius speciosissimus* has an almost exclusively nephrotoxic action.

The most common reason for poisoning is misidentification or the close resemblance of edible mushroom species to toxic mushrooms. Thus, an expert should inspect mushrooms before consumption. Most importantly, there are no antidotes for mushroom poisoning and symptoms can only be treated in the hospital, and may still be fatal. It is worth noting that:

•Symptoms can appear after 12 h or longer following consumption.

•Toxins will remain in the system and continue to cause harm, meaning raw samples should be retained for (correct) identification.

•While casual handling of poisonous mushrooms is not problematic, these should not be mixed with edible mushrooms if harmful contamination of foods is to be avoided

•Some people are allergic to edible mushrooms.