# Review Article on Production Technology of Mushrooms

**Abstract**

Mushroom cultivation is being commercialized in India past few decades. Its cultivation is mainly on the hills as it requires low temperature for its growth; however with the emerging of modern cultivation technology it is now possible to cultivate this mushroom seasonally under controlled conditions and throughout the year by employing environmentally controlled conditions. Mushrooms are a nutrient-dense food item that are suitable for all age groups. In addition to higher protein, lysine, and tryptophan, they also have more carbohydrates and micronutrients. The outcomes of this review are then synthesized a production technologies of Oyster and Milky Mushrooms, required resources and overall success. Challenges and opportunities associated with mushroom cultivation in the developing world are also identified. For example, prominent challenges in the developing world are spore production, diseases and pest management, post-harvest technology, storage and marketing. Future practitioners, researchers, and entrepreneurs will be able to use this innovative ways in which the technological advancements of mushroom cultivation in high-resource settings can be applied to resource constrained environments.

**Introduction**

Mushrooms are a fleshy, macroscopic, achlorophyllous, spore-bearing fruiting structure of a fungus belonging to class basidiomycetes of Agaricales order. They are grouped into three categories such as edible, non-edible and medicinal mushroom. Most of the edible and non-edible mushrooms grow in the forest 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. Intake of wild mushrooms have led to loss of death of which is evident in the reports of the newspaper time and on. This calls for promoting mushroom cultivation on mass scale to ensure nutritional security, livelihood improvement and empowering the unemployed and farm women. Mushroom cultivation has not gained the actual momentum in the region. However, there is every possibility of the region to be the mushroom hub of the country with the ideal climate and available resources for its cultivation. The varied climate with average temperature range of 5-35ºC and high humidity, abundant raw materials, ready local markets and access to market in the abroad give the region the advantage to develop as a mushroom hub. On the other hand, lack of knowledge about production technology in the far remote place, non-availability of quality and adaptable germplasms, erratic supply of quality spawn, lack of skill in cultivation, processing, etc. have been the restriction for mushroom industry to grow in this region. Many people are taking up mushroom cultivation as a small scale agriculture alternative in almost all the states of the region. Large scale production and an organized market has to grow up to utilize the potential benefits of this non-traditional cash crop.

# Mushroom production countries in word wide

1. Worldwide 11,898,399 tonnes of mushroom and truffle is generated per year.
2. China is the largest mushroom and truffle producer in the world with 8,948,099 tonnes production per year.
3. China produces alone more than 75 % of world's mushroom and truffle.
4. Japan comes second with 470,000 tonnes yearly production.
5. With 383,960 tonnes of production per year, United States of America is the third largest producer of mushroom

# Mushrooms Varieties and their Values

# There are more than 30,000 identified types of mushrooms worldwide. 99% of these are safely edible and roughly 1% is poisonous.

1. Yet there are still many identified mushroom species and the effects of some mushrooms on human health remain unknown.
2. A wide variety of mushrooms is eaten around the world.
3. Champignon and Field Mushrooms are popular in Europe. Shitake Mushrooms are consumed mostly in China and Japan, while Thai people prefer Yanagi Mushrooms or Straw Mushrooms.
4. Some mushrooms have medicinal qualities and their popularity is rising too. Nowadays, almost every country devotes more attention to research, experimentation, selection and development of mushrooms.

**Safe and Poisonous Mushrooms**

The word ‘Mushroom’ used for the edible members of macro fungi. The name ‘mycology’ was coined to denote the ‘study of mushrooms’ (Mykes = mushroom). Whereas the term ‘Toadstool’ generally used to chosen the poisonous ones of the ‘gill’ macro fungi. However, it is not always that the word “mushroom” means an edible or safe variety and the word “toadstool” means a poisonous or non-edible mushroom. The word toadstool in fact, is distortion of the German word ‘Toadestuhl’, which means ‘death chair’. Many mushrooms can be non-edible and poisonous while some are edible or safe. Mushrooms occupy a prevalent place of importance in the biological world in terms of diversity, economic value and environmental impact. Wild edible mushrooms are not well stated, poorly studied and insufficiently though they are rich source of non-wood forest product. In the hilly regions of North East India, these non-wood forest resources, the wild edible mushrooms are used by the ethnic mycophilic society as food and medicine. The wild edible mushrooms are sold in the local markets and thus provide an earning to the local villagers as well as forest dwellers mostly during the rainy season. Though the region is rich in mushroom diversity due to the lack of adequate knowledge on edible and poisonous nature, extensive exploitation of the wild mushrooms is limited. There is no fool proof method to separate the edible ones from the poisonous mushrooms. Good experience and practical knowledge is required to identify and differentiate the poisonous and non- poisonous wild mushrooms. Time and on the published report of food poisoning and death resulting from intake of poisonous mushrooms is a proof to it. From layman’s points of view, there are no non-scientific tests or rules that can accurately find the safety or toxicity of a mushroom. Identification of mushrooms is an art that is very difficult and time-consuming and requires skill cultured over time. The scientific methods that are available cannot be carried out quickly and are confined to the laboratory only. Some prominent distinctions between poisonous and non- poisonous mushrooms are stated as follows. Although the reliability of these distinctions is less, but these may be referred for identification to avoid accidental deaths associated with consumption of poisonous mushrooms.

# Mushrooms as Food and Health Benefits Mushrooms

Mushrooms have a long association with humankind and provide profound biological and economic impact. Once considered as food for the royals in Rome and wonder compositions of folk medicine in East Asian countries (Manikandan, 2011). Mushrooms are by now an accepted ideal food item, suitable for all age groups and occupy a place between meat and vegetables, from nutrition point of view. Mushrooms not only taste delicious, but they are also a nutritional source, packed with a long list of nutrients. (Khan *et al*., 2006). Rich in protein, mushrooms supplement the carbohydrate rich, protein deficit primarily cereal based Indian diet. All types of edible mushrooms contain different degree of protein, minerals, vitamins, antioxidants and fibre. These can have various health benefits. Factors like species of the mushroom, its developmental stage and environmental conditions affect its nutritive values. Moisture content in the fruit bodies is usually 80- 90% with sufficient carbohydrates (26-82%) and low fat content. Cholesterols is absent in mushrooms, instead contains ergo sterol and that acts as a precursor for vitamin D synthesis. Apart from high crude protein content (12-35%), they are also rich in dietary fiber (8- 10%) and an excellent source of vitamins and minerals. In free amino acids content, threonine and valine are extensively present but deficient in methionine and cystein. Mushrooms if exposed to UV light before or after harvest, they are excellent source of vitamin D and are rich in vitamin B complex, vitamin C, and vitamin B12 (Ahmed *et al.,* 2009). The B vitamins assist in obtaining energy from food by the body and form red blood cells. Besides many of these B vitamins are essential for a healthy brain. Vitamin C consumption may avoid the cardiovascular aliments. The minerals like potassium, sodium and phosphorous are abundantly found in the fruit bodies along with traces of copper, zinc and magnesium but lack iron and calcium (Islam *et al*., 2013). Mushrooms are also known to provide some amount of folic acid or folate which is dietary supplement during pregnancy to boost fetal health. Absence of cholesterol with higher proportion of unsaturated fatty acids in the edible mushrooms, make them the recommended food for heart patients. For instance, *Agaricus bisporus* and *Lentinula edodes* can lower down the cholesterol level by 34 and 35 % respectively. Salt balance and blood circulation in the human body are maintained as mushrooms contain minimal of sodium and more of potassium. Nutritive values of different mushrooms are given Table 1.

**Table 1: Nutritive value of different mushrooms (dry weight basis g/100g)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Mushroom species** | **Carbohydra te** | **Fibre** | **Protei n** | **Fat** | **Ash** | **Energy kcal** |
| *Pleurotus sajor- caju* | 63.40 | 48.60 | 19.23 | 2.70 | 6.32 | 412 |
| *Pleurotus ostreatus* | 57.60 | 8.70 | 30.40 | 2.20 | 9.80 | 265 |
| *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 |
| *Calocybe indica* | 64.26 | 3.40 | 17.69 | 4.10 | 7.43 | 391 |
| *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 |
| *Volvariella volvacea* | 54.80 | 5.50 | 37.50 | 2.60 | 1.10 | 305 |

Mushrooms have over the years proved itself as a perfect food for the young and old by supplying nutrition and health benefits. Beyond diet, they had been and are an important or major component of the common therapies as well as modern day medicines. Medicinal values of some important mushroom are given in Table 2.

**Table 2. Medicinal values of some important mushrooms**

|  |  |  |
| --- | --- | --- |
| **Mushroom species** | **Compounds** | **Medicinal properties** |
| *Ganoderma lucidum* | Ganoderic acid Beta- glucan | Augments immune system Liver protection Antibiotic propertiesInhibits cholesterol synthesis |
| *Lentinula edodes* | Eritadenine Lentinan | Lower cholesterol Anticancer agent |
| *A. bisporus* | Lectins | Enhance insulin secretion |
| *P*. *sajor*-*caju* | Lovastatin | Lowers cholesterol |
| *G*. *frondosa* | Polysaccharide Lectins | Increase insulin secretion, Decrease blood glucose |
| *Auricularia auricula* | Acidic polysaccharides | Decrease blood glucose |
| *Flammulina velutipes* | Ergothioneine Proflamin | AntioxidantAnti-cancer activity |
| *Trametes versicolor* | Polysaccharide-K (Kresin) | Decrease immune system de-pression |
| *Cordyceps sinensis* | Cordycepin | Cures lung infections Hypoglycaemic activity Cellular health properties Anti-depressant activity |

**Agro-climatic Condition for Mushroom Farming**

Before starting mushroom cultivation, the choice of a suitable place is the very important task. Mushrooms are very delicate in nature, so does not need too much sunlight. A temperature ranging between 18 'C to 35 °C is considered as the ideal one & favourable is for mushroom farming profitability. Also, a good moisture level is more beneficial in enhancing the good development of mushrooms. For this, humidity of 85 to 90 % of air should be maintained.

**Considerations for site selection of growing mushroom**

Distance to market, Availability of raw material for production, transportation of both product and substrate materials, Climatic conditions have to suit the cultivated mushroom and Availability of clean water.

# Production Technology of Mushrooms

Dietary supplements, functional foods and other such products production as a commercial activity is gaining outstanding growth in recent times. Mushroom growing is an eco-friendly activity as it utilizes the wastes from agriculture, poultry, brewery, etc. and in turn produces fruit bodies with excellent nutritional and medicinal attributes. There is large scope for mushroom industry to thrive successfully and can become a profitable business for the unemployed rural youth, housewives and an additional income source for the farmer (Borah *et al.,* 2006). Thus mushroom cultivation activities can play important role in supporting the local economy by contributing to livelihood food security, nutrition and medicine, generating additional employment and income through local, regional and national trade, and offering opportunities for processing enterprises. It is reported that there are about 50,000 known species of fungi and about 10,000 are regarded 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 developed 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.*

**Oyster mushroom**

The simple cultivation technology, low production cost and features attributes make this mushroom most widely cultivated throughout the country. Bioconversion ability is highest *i.e.* more than 60%. Moderate range of temperature 20-30oC 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.

# Growing season

# The most suitable months of the year for growing this crop is November to April when the optimum temperature range 18oC to 25oC is usually experienced in different parts of the region. However, at times production is reduced with sudden fluctuation in temperature. During summer months, if proper care is not taken, the yield of summer varieties of oyster mushroom is lowered due to infestations of insects and pests.

**Substrate**

In India mass production of oyster mushroom on straw based substrates was reported in early 60s. Cellulosic agriculture by products available of rice, maize, banana mustard/toria etc. or even sawdust is suitable for growing this mushroom. However, paddy straw is the best substrate and easily available (Zhang., 2014). The straw should be of good quality and not exposed to rain. Maize and banana are also extensively cultivated crops. Maize stalks, leaves or hulled cobs and the pseudo stem of banana can be used but the method requires extra labour and production is comparatively less.

# Cultivation method.

Cultivation of oyster mushroom can be done by following methods, *viz;* I) Polybag culture/ polythene bag method and II) Cube culture method. Most suitable is polythene bag method where the polythene bag can be reused.

# Polybag culture / Polythene bag method Materials required:

(i)Paddy straw (ii) Trays (iii) Spawn (Mushroom seed) (iv) Water boiling drum (v) Chaff cutter

(vi) Sprayer/ hand spray (vii) Transparent poly bags (Size: 40- 45 cm X 20 cm) (viii) Single hole punch machine (ix) Garlic extract and (x) Jute thread.

# Methodology:

**Substrate preparation**

* 1. Collect good quality paddy straw (golden yellow in colour without blemishes or spots) and chop 2 kg dry straw with a hand chopper/ chaff cutter (about 5 cm long) for one polythene bag.
	2. Soak the straw overnight (6-8 hours) in cold water; the 2 kg dry straw becomes

4.5 kg/ 5 kg in weight.

* 1. Put the soaked straw to hot water treatment (70-80°C) for 30 minutes.
	2. Boiling makes straw free from all contaminants and the cellulose is easily broken down by the mushroom fungus.
	3. Remove the straw from the boiled water and allow to cool by spreading on a clean floor. Squeeze or drain out the excess water.
	4. 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.

During winter months, the disease and pest problems are less occurred. The straw can be minimally processed during winter season by soaking the straw (as instep ii) in lime water solution i.e. prepared by adding 20g of CaCO3 to each litter of water required to soak the straw.

 **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 (as in step V) can be an optional practice during winter months.

**Making the polythene bag ready**

Fold the poly bags (mushroom bags) of 40 cm x 20 cm size 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 15-20no. of holes for proper ventilation. Tie the closed end of the poly bag with a piece of jute thread to give a round flat bottom to the bag. Use of a ventilation pipe is optional in this method. A PVC pipe of 3cm diameter and about 35cm in length with holes on two opposite sides at 5cm interval can be used as a ventilation pipe. Alternately, small diameter bamboo can be used for the purpose by opening up nodes in the inside and peeling stripe of waxy coat lengthwise on opposite sides. It is found that use of a ventilation pipe provide adequate air circulation in the closed bed during mycelial run. Later in the cropping stage, watering the bed is proper and the beds can also be kept hanging through the hole made by using the ventilation pipe.

**Making the spawn ready**

Spawn 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.

# Spawning

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. Keep the ventilation pipe in the polythene bag before putting the straw layer, if the bed is to be kept hanging in the cropping room. If the pipe is kept after putting the first straw layer, watering is done properly through the hole made with the ventilation pipe. Mushroom beds can also be prepared without using the ventilation pipe.

# Spawn running

Place the mushroom bag in a cool and dark place, safe from rodents and other insects, for spawn run. More appropriately, the mushroom bag is to be kept in the spawn running room for spawn run which is completed within 15-18 days at 25oC temperature. Completion of spawn run is indicated with white to cream coloured mycelium mat covering the entire straw (Kumari and Achal., 2008).

# Mushroom bed opening

Remove the polythene bag after completion of spawn run to allow space for fruiting. Open the mouth of the bag; hold the bag upside down with right hand and place the other hand on the open end below, remove the poly bag with slight thrust. The same poly bag can be reused after washing with mild detergent and drying in shade. Alternately the mushroom bed may not be taken out of the poly bag during summer to minimize insect’s infestations. A slit can be made with a clean blade in the area where lumps and then pinheads initiate.

# Mushroom house or cropping room or Growing room

Mushroom cultivation is an indoor activity and should be protected from heavy rains, direct sunlight and heat. Well-constructed mushroom house is essential for commercial production. The choice of material, size and design depends on need of the grower. Low cost thatched house made up of bamboo mats allowing diffused sunlight, proper cross ventilation with a clean surrounding can be suitable.

# Cropping

Place the mushroom bed on racks or hang it like pots in the mushroom house. Keep the bed moist by spraying water. Watering is done as and when necessary with the touch of the hand. Harvesting the fruit bodies should be done sometime (8-10 hours) after watering and then commence watering only after harvest.

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. Pileus margin when starts to curl upward or down ward indicates that the fruit bodies have become over maturity. 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.

# 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. 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.

# Milky mushroom

Milky mushroom (*Calocybe indica*) is known to have the highest biological efficiency, up to 140%. Moreover this mushroom has a good shelf life and a good texture which is retained after cooking. The cultivation method is almost similar to that of oyster mushroom. Method of bed preparation is same as in oyster mushroom. (Maurya *et al.,* 2019) However, the boiled straw should be sun dried for 30 minutes to 1 hour to bring down the moisture content to 40-50%. Moisture content of the processed straw is critical for optimum milky mushroom production. Spawning is done at the rate of 3% and spawn run is completed in 15-20 days. The poly bag is not opened after spawn run is complete and the bed is cut in to two beds of about 20cm height. The exposed surfaces of the two beds are covered with 1-2cm casing. Casing materials are nutritionally poor with high water holding capacity. Some of the commonly used casing materials are:

(FYM + Loam soil (1:1),

Rotten cow dung + soil (3:1),

Spent compost + Sand + lime (4:1:1),

Soil + Moss (1:1) and Soil + Sand (1:1).

Any of the combination can be used. Add lime or chalk powder @ 50g/ kg casing material to adjust the pH at 7-7.5. Prior application the casing material is steam sterilized. For cropping the beds are kept in cropping rooms that allow sufficient or more light.Horticultural poly house with roof of UV stabilized low density polythene film together with Netlon Agro shade of 75% can be used. Pinheads appear 6 to 10 days after casing and the second and third crop comes up at 10 days interval. A mist of water is sprayed everyday on casing soil. Mushrooms should be harvested before the cap is fully open.

**The main differences in the cultivation practices of milky mushroom and oyster mushroom are –**

1. Moisture content of the soaked and boiled straw should be possibly less (40- 50%) in case of milky mushroom and that in case of oyster mushroom can be up to 60-70%.
2. The bed is cut into two halves after mycelia run and casing applied in case of milky mushroom which is not done in oyster mushroom production.

**Diseases and Pest management**

**Disease**

**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. (Borah., *et al* 2013). Green mould causes more problems during the warmer period of the year.

**Management**

Spray garlic extract before spawning. Check the spawn packet for any fungal contamination before spawning. Discard contaminated spawn and remove contaminated beds away from mushroom house. Wash mushroom bags properly before re-use. Scooped out the green moulds patches at the initial stage and spray the area with garlic extract.

**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:**

Use good quality and properly dried straw for bed preparation. Avoid decomposed straw or straw exposed to rain. Remove at young stage all the ink caps whenever seen on beds.

**Browning:**

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

**Management:**

Avoid direct watering on the mushrooms. Shake the beds gently after watering to avoid water droplets deposit on the mushrooms.

**Pest**

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:**

Remove over matured fruit bodies at the earliest, to prevent adults from laying eggs. Bleaching powder repels the beetles; apply it in the mushroom house and its premises. 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. To prevent the entry of flies and beetles, nylon net is to be fixed on the ventilations and windows of the mushroom house. Light traps are made with polythene sheet smeared with a sticky material like mustard oil and placed close to yellow or white colored bulb. Adult insects are attracted to white light at temperature above 150C and to yellow light at lower temperature. Smoke daily or at alternate days to get rid of the insect pests from the mushroom house

**Post-Harvest Technology**

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.**

To 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. Mushrooms of the first flush are considered to be best as the colour and taste remain intact during preservation. Spotted, deformed, insect damaged fruit bodies are to be discarded. Fruit bodies should be sorted out based on the size and age to maintain uniformity.

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

**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.

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

**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.

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

**Long term preservation**

**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 to5-6 months.

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

**Blanching:**Sorted out mushrooms are steeped in warm water of 80-850C 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.

**Other methods:**Freeze drying, canning, pickling etc.

**Value - Added products**

Real value – added product in the Indian market is the mushroom soup powder. Technologies for production of some other products like mushroom based biscuits, nuggets, pickle, noodles, chips, murabba, ketch-up, candies and readymade mushroom curry in retort pouches have been developed but are yet to be popularized (Wakchaure, 2011)

**Mushroom: production and marketing**

Marketing is getting the right product, to the right people, at the right price, at the right time and in the right way. Marketing of fresh mushrooms all over the world is not very organised except the auction system in Netherlands. Producers make direct efforts to bring the produce to the super markets and ‘wholesale distributor’ element is mostly missing. However, trade in the processed (canned and dried) is sizeable and organised.

**Scope for entrepreneur or self-employment in mushroom growing:**

Unemployment is the general problem among the youth of nation due to lack of opportunities or technical knowledge. Mushroom sectors could be providing a vast scope for unemployed youth, house hold women and landless farmer. There are following areas where a person thinks for entrepreneur or self-employment and improve their economic condition and play their role in developing nation.

**Importance of mushroom cultivation in India**

1. Mushroom cultivation is labour intensive activity
2. Mushroom harvesting is not automatic process
3. It helps in maintaining the cycle of nature by decomposing agro residues.
4. Good source of high quality of protein rich in vitamins and minerals. It is good for vegetarian population.
5. It provide excellent opportunity to educate rural youth and provide job.
6. Opportunity to use wastelands.
7. Rural women which are educated or uneducated easily handle.

**Availability of research and training facilities in India**

In India, research and training is provided by time to time by National Research Centre for Mushroom and Training Institute at Solan (Himachal Pradesh) and their sub-station like New Delhi, Ludhiana and Bangalore. State Agricultural Universities in particular states, few Krishi Vigyan Kendra's (KVK) and District Agricultural offices through ATMA are also conducted training on mushroom and also facilitate spawn of particular mushroom.

**Summary**

Mushroom which is also known as vegetarian non veg. It is contains major amount of nutritious material. And its cultivation is easy process. It mainly require waste material as a substrate, and mushroom contains several enzymes which decomposes dead organic matter and transform in to simpler form. So, today mushroom cultivation is growing sector especially for rural people. Who fulfill their demand via mushroom cultivation which is also possible in indoor activity. And today according to population growth the demand of nutrition reach food is essential. Mushrooms are major food for these people who buy at normal prize and live a healthy life. At the last but not least it is a big growing sector for future.

**References.**

1. Borah, T.R., Gogoi and Robin (2006). Unconventional food items of Assam – Mushroom. *Asian Agri History* 10 (3): 235- 243.
2. Borah, Tasvina R., Hoque, H., Kikon, Lireni E., Deka, Bidyut C. and G. Rajesha (2013). Mushroom cultivation for subsidiary income and nutritional security. ICAR Research Complex for NEH Region, Nagaland Center, Jharnapani, Nagaland. Pp. 47.
3. Manikandan K, (2011). Nutritional and medicinal values of mushrooms In: Mushrooms cultivation, marketing and consumption. Eds. Singh M, Vijay B, Kamal S, Wakchaure G C. pp 11-14. Published by Directorate of Mushroom Research, ICAR, Chambaghat, Solan-173213 (HP).
4. Y. Zhang, (2014). "Edible Mushroom Cultivation for Food Security and Rural Development in China: Bio-Innovation, Technological Dissemination and Marketing," MDPI Sustainability, pp. 2961-2973
5. Kumari, D., and Achal, V. 2008. Effect of different substrates on the production and non-enzymatic antioxidant activity of Pleurotus ostreatus. Life. Sci. J., 5: 73-76.
6. Islam MK, Khan MMH and Islam MN (2013). An unrealized manner for poverty alleviation: The mushroom industry. Dhaka University Journal of Marketing. 16 (1):43-56. 22.
7. Khan MA, Khan LA, Hossain MS, Tania M, Uddin MN (2009). Investigation on the nutritional composition of the common edible and medicinal mushrooms cultivated in Bangladesh. Bangladesh Journal of Mushroom. 3(1):21-28.
8. Wakchaure G C (2011). Mushrooms-value added products. In: Singh, M., Vijay, B., Kamal, S. and Wakchaure, G.C. (eds.), Mushrooms Cultivation, Marketing and Consumption. Directorate of Mushroom Research, Chambaghat, Solan (H.P.), pp. 235-238.
9. Ahmed SA, Kadam JA, Mane VP, Patil SS, Baig MMV (2009). Biological efficiency and nutritional contents of Pleurotus Florida (Mont.) Singer cultivated on different agro wastes. Nature and Science. 7(1): 44-48.
10. Maurya, A. K., Murmu, R., John, V. and Simon, S (2019). Impact of different substrates for spawn production and production of milky mushroom (*Calocybe indica*). Int. J. Pharma Bio. Sci; 10(3): 5-10. ISSN 0975-6299, DOI: http://dx.doi.org/10.22376/ijpbs.2019.10.3.b5-10.