18BBO47S –SKILL BASED ELECTIVE-II-MUSHROOM CULTIVATION
Handled by Dr.J.JAYACHITHRA

UNIT-V
Post-harvest technology: Harvesting and marketing, Preservation and storage of mushrooms. Problems in mushroom cultivation-pest and diseases, weed moulds and their control. Delicious recipes of mushrooms (mushroom soups and pickle).

Post Harvest Processing

Introduction
Mushrooms are best consumed as fresh. However, in actual practice this is may not be possible. The storage at high temperature results in browning. Mushrooms have a high rate of respiration and hence proper attention should be given for storage. Some of the commonly adopted methods are described hereunder:

1) Refrigeration/ Instant packing:
Freshly harvested mushrooms are packed in 25 gauge polythene bags without making any holes. Immediately after packing they are stored at 5°C in a refrigerator. This process extends the storage life for 3-5 days. This process helps in reducing the respiratory rate and minimizing the water loss. In addition, it reduces browning of mushroom and off flavour development.

2) Freeze-drying:
The mushrooms are sliced and immersed in 0.05 per cent sodium meta bisulphite and 2 per cent common salt solution for 30 minutes. They then blanched in boiling water for 2 minutes, followed by cooling. This then frozen for one minute at -12°C and store at –20°C. This process extends the storage life for 3-4 months.

3) Dehydration:
This treatment involves three steps viz., Pretreatment, drying and storage.

a) Pre treatment:

- Clean the mushroom and blanch it in boiling water for 2 minutes and immerse it in cold water for 2 minutes.
- Dip the mushroom in water containing 0.2 per cent potassium meta bisulphite and 1 per cent citric acid and use for drying.

b) Drying:

- Sun drying: The pre treated mushroom is dried in open sunlight till it reaches 1/10th weight of the fresh product. After drying, it can be stored for 3 months, however colour may turn to brown and appearance of the final product is not good.
- Drying in flow drier: Dry the pre treated mushroom at 60°C with heated air for 6-8 hr. This process lead to bring the final moisture level to 3-5%.

- Vacuum drying: Dry the pre treated mushroom at 40°C under vacuum condition instantly. This process yield a very good quality mushrooms but cost of processing is heavy.

4) Canning:

Canning is adopted on a very large scale, especially for preservation of button mushrooms. For canning purpose, the mushrooms should be harvested at an early stage. The mushrooms of uniform size are selected and stalks are cut before processing.

Procedure:

- Wash the mushroom in clean water to remove dirt and other foreign materials.
- Dip the mushroom in boiling water for 2 minutes, take it out and dip in cold water for 2 minutes.
- Fill the mushrooms in the specially made cans upto ¾ capacities. (Approximately 220-g mushrooms are filled in 1-lb cans)
- Add salt solution consisting of 2 per cent common salt, 2 per cent sugar and 0.3 per cent citric acid just to fill up to the brim. (Before adding, the salt solution should be boiled and filtered through muslin cloth) (Approximately 125 ml. solution is needed for 1 lb can).
- Place the lid on the can and keep the cans in boiling water or steam till the temperature in the centre of the cans reaches 80-85° C.
- Seal the can on a seamer to get an air tight seam.
- Sterilize the cans in an autoclave at 10 lb. pressure for 20-25 minutes.
- Keep the cans immediately after sterilization in clean cool water for cooling.
- Wipe the cans with a dry cloth and store in a cool dry place. This process extends the storage life up to 12 months.

MUSHROOM STORAGE

Mushrooms continue to respire after harvest and they have a relatively high respiration rate compared to other fresh produce, the respiration rate of oyster mushroom being three times greater than most fruits for example. Respiration rate is a good indicator of storage life and respiration results in changes in mushroom texture.

Spoilage during storage can be caused by bacteria and fungi within the mushrooms. Bacteria and enzymes continue to increase during cold storage. This results in rapid deterioration when the mushrooms are removed from cold storage.

The mushrooms' texture is altered as they lose their firmness and their flesh darkens. The water inside the mushrooms is also favourable for bacterial growth.

Many mushrooms are white to gray in colour while they are growing. Under certain storage circumstances, however the enzymes react with oxygen and form brown pigments. Such discoloration seriously decreases the quality of mushrooms.

Mushrooms have 85-95% water of its dry weight. There are no barriers to water loss from their surface. Water loss in the mushrooms after harvesting is influenced by the status of the mushrooms, the humidity, fresh air and atmospheric pressure. When mushrooms wilt and shrivel, the quality of fresh mushrooms is lowered.

Fresh mushrooms have a short shelf life. Therefore it is necessary that they are either marketed soon after harvesting or preserved with special care such as in cold storage or other controlled environment storage.

STORAGE

Each species needs compatible and distinctive alternative techniques for their active, pure and viable
physiology in terms of colour, texture, and taste. Preservation protocols are applied accordingly.

The shelf life of fresh mushrooms may be extended by refrigeration at 1-4°C. Cooling the mushrooms result in lower rates of all the physiological process within the mushrooms. During the initial cooling there is a high cooling load. Once the mushrooms are pre-cooled, however, the cooling load is much reduced.

Freshly harvested mushroom is highly perishable as it is susceptible to deterioration by the enzyme and microorganisms. It has been realized that merely producing mushroom is of no use unless these are properly preserved, keeping in view the export objectives. Hence, following proper processing and storage methods is of supreme importance. Two types of preservation techniques are available:

Short term preservation

Long term preservation

SHORT-TERM PRESERVATION

Low temperature is effective for short-term preservation. Mushrooms may be packed in wooden cases with three compartments; ice is placed in the central compartment and mushrooms are packed in the two other sections. Mushrooms may also be packed in bamboo baskets and transported by airfreight. An aeration channel is formed at the centre of the basket and dry ice, wrapped in paper, is placed above the mushrooms.

Mushrooms stored in a perforated plastic box at 10-15ºC have excellent keeping quality for up to 4 days and the loss of moisture is less than 5 per cent. Straw mushroom can be stored more effectively at button stage than at any other stage. At temperatures below 10ºC, however, the mushrooms liquefy rapidly, irrespective of type of packaging due to chilling injury.

Cold-preservation of mushrooms is the most important aspect of the storage and can be classified in two categories:

Refrigeration and freezing. Household and commercial refrigerators usually run at 4–70C. Cold or chill storage may use a slightly lower temperature (–1 to –4oC), depending upon the freshness of the mushrooms to be refrigerated. Freezing is done at a temperature of below -18oC. Chill storage will preserve perishables for days or weeks

and frozen storage (deep freezing) will preserve for months or even years. Refrigeration has certain advantages over freezing as it takes less energy to cool mushrooms to just above its freezing point than to freeze it. The temperature of the button mushroom after picking, which varies between 15 and 18oC, rises steadily during the storage due to respiration and atmospheric temperature and the heat causes deterioration in quality; in addition, the respiratory rate increases with the increase in the storage temperature leading to a vicious cycle. It has been estimated that mushrooms at 10oC have 3.5 times higher respiratory activity than those at 0oC, which necessitates immediate shifting of mushrooms to the refrigerated zone.

Hence the heat should be removed immediately after the harvest and the temperature of mushrooms should be brought down to 4-5o C as quickly as possible. Low temperature retards the growth of microorganisms, reduces the rate of postharvest metabolic activities of the mushroom tissues and minimizes the moisture loss. The choice of the cooling system depends upon the quantity to be handled; it may be a refrigerator for a small grower or consumer a cold room with all the facilities for a commercial grower.

Forced-chilled air, ice-bank or vacuum cooling systems are the other systems in vogue at commercial level. The size and shape of the packs play important role in the selection of the cooling room system and design. Packs with more than 10 kg mushrooms or with 15 cm thick layers of mushroom cause problems. Vertical flow of air is more suitable for cooling. The mushrooms should not be stored in the same cooler along with fruits as the gases produced by fruits cause discolouration of mushrooms. As the simple forced-chill air-cooling system is time consuming.

Vacuum cooling is becoming popular. To ensure high quality mushrooms in the market place with enhanced shelf-life, these must be cooled as quickly as possible after picking and kept cool throughout the cold chain (*Rai and Arumuganathan, 2003*).

Storage under low temperature is an excellent method for restricting deterioration of harvested mushrooms for a limited period of time. The maturation and textural changes in button mushrooms were slowed down at 0oC ensuring the maintenance of excellent quality (*Murr and Morris, 1975 a*). *Minamide et al. (1980*) observed that the shelf-life of the button mushroom was about 14-20 days at 1oC, about 10 days at 6oC and 2 to 3 days at 20oC. Also, polyphenol oxidase activity and respiration rate were enhanced at 20oC storage. *Baker et al. (1981*) observed that in button mushrooms, forced air cooling resulted in a weight loss of about 2.5 per cent within 15-30 min.

Minamide et al. (1985) reported that hydro-cooling of button mushroom near their freezing point for 3 h within 6 h of harvest, packing in 100 per cent nitrogen gas (N2) for 2 h and then transferring to room temperature (200C) preserved them for 15 days. *Chopra et al. (1985)* recommended 100 gauge polythene bags with 0.5 per cent venting area for packing button mushroom in case of refrigerated storage.

Nichols (1985) recommended optimum temperature and relative humidity for storage of button mushrooms as 0-2oC and 85-90 per cent respectively. *Saxena and Rai (1988)* however, reported the adverse effects of over-ventilation of polythene packs; mushrooms were best preserved in non-perforated 100 gauge polypropylene bags kept at 5oC. *Varszegi (2003*) conducted an experiment to determine the relationship between the bacterial growth on mushroom cap and the pre-cooling methods (forced wet cooling and vacuum cooling) and

found that vacuum cooling provided the longest period of time needed to reach the maximum value of microbial population and this method was found beneficial for the quality. Blanching for a short period is absolutely essential for producing good quality frozen mushrooms. Steam blanching for 3 min prior to freezing recorded retention of qualities of oyster mushroom also *(Das and Pathanayak, 2003).*

Vacuum-cooling

In vacuum-cooling, the water in cell walls and inter-hydral spaces of mushrooms gets evaporated under low pressure, and the evaporative cooling lowers the temperature from the ambient to 2oC in 15 to 20 min. Vacuum-cooling is a uniform and faster process, where mushrooms are subjected to very low pressure

and water evaporates giving off the latent heat of vaporization. The vacuum cooled mushrooms have superior colour than conventional-cooled mushrooms. The major drawback of the system is the high capital cost and loss of fresh weight of the produce during the process of cooling. Filling and emptying the cooling chamber adds to the marketing cost. However, air spray-moist chillers can also cool the mushrooms rapidly. The temperature can be lowered by 16-18oC in an hour without any moisture loss.

Ice-bank cooling

With a view to reduce the weight loss during the conventional vacuum cooling, ice bank cooling of mushrooms is now in vogue where a stack of mushrooms is passed through forced draft of chilled but humidified air from the ice bank (Water body maintained at sub zero temperature).

Irradiation

Radiation preservation offers a method of "cold sterilization" where the mushrooms may be preserved without marked change in their natural characters. Low dosages of α- radiation could be used to reduce the microbial contamination and extend the shelf-life of mushrooms. However, irradiation should be given immediately after harvest for optimum benefits. Various types of beneficial effects of radiation have been observed in preserving the button mushroom *(Staden, 1967; Campbell et al., 1968; Wahid and Kovacs, 1980; Roy and Bahl, 1984 a; Lescane, 1994)* and oyster mushroom *(Roy et al., 2000).*

Irradiation has been found to delay the maturation *i.e*. development of cap, stalk, gill and spore and also reduce the loss of water, colour, flavour, texture and finally the quality losses. Cobalt-60 (60Co) has been used as a common source of rays. A dose of 400 krad gave whiter buttons than the controls when the atmospheric temperature during growth and *R.D. Rai & T. Arumuganathan* subsequent handling was slightly lower than 200C *(Roy and Bahl, 1984 b*). A dose of 10 kGy (Kilo Gray) is reported to completely destroy microorganisms. Enhancement in shelf-life of *Agaricus bisporus* upto a period of 10 days was achieved by application of gamma rays close to 2 kGy and storage at 100C *(Lescane, 1994)*. Irradiation reduces the incidence of fungal and bacterial infection and also retards the breakdown of mannitol and trehalose.

However, the loss of flavour components has been noticed in irradiated mushrooms. But amino acids in fresh mushrooms were better preserved by irradiation and this showed that irradiation at low levels
proved better than irradiation levels of 1 & 2 kGy *(Roy and Bahl, 1984 a*). *Benoit et al. (2000)* investigated the effect of gamma irradiation on some biochemical parameters of the mushrooms: higher doses significantly reduced the rate of respiration compared to samples irradiated with 0.5 kGy and non-irradiated mushrooms.
Ionizing treatments significantly increased phenylalanine ammonia-lyase (PAL) activity and total phenolic concentration. *Koorapati et al. (2004*) evaluated the effect of electron-beam irradiation on quality of white button mushroom and observed that irradiation levels above 0.5 kGy prevented microbes induced browning. They recommended that irradiation at 1 kGy was the most effective in extending the shelf-life of mushroom slices.
A study was conducted by *Escriche et al. (2001)* to determine the effect of ozone on post harvest quality of mushroom. Ozone treatment (100 mg / h) of mushrooms prior to packaging increased the external browning and reduced the internal browning rates. The ozone treatment exhibited no significant differences in terms of texture, maturity index and weight loss of mushrooms.

LONG-TERM PRESERVATION

Canning, pickling, and drying, preparation of papads and use of chemicals are employed for long-term storage. These processes are not always suitable for all types of mushrooms. The quality of the finished product is rarely comparable with that of fresh mushrooms.

DRYING:

Mushrooms can be dried by sun drying and thermal power drying. For general drying, the picked mushrooms are exposed to the sun for about 2-4 days. Dried mushrooms are highly hygroscopic and readily absorb moisture from the air. The dried mushrooms should therefore, be put into polyethylene bags, sealed, and kept in a dry, cool, and dark place. For prolonged storage, dried mushrooms should be packed in cartons or wooden boxes and kept at 2-5ºC in a low temperature store.

Steps of Drying:
A. Cleaning: The easiest way to clean mushrooms, **except for morels**, is to gently wipe or brush away any dirt and debris.

Mushrooms - Depending on what type of mushroom you are planning on dehydrating you may want to keep the mushroom whole for presentation purposes of the dish. You can dehydrate the mushrooms whole, but it will take longer.

For most mushrooms slices are a fine for dehydration. If you slice the mushrooms you will increase the available surface area to be dried and reduce your dry time. Cut mushrooms should never be washed. The exposed inner flesh will quickly absorb water, leaving them soggy. And washing whole ones usually isn't required. For those of you concerned about the potential of food borne illness that might be present in the growing substrate it may be sterilized in dry heat and pasteurized.

B. Drying: Arrange the mushroom slices in the dehydrator and dry them until they are crisp and break easily instead of bending.(drying times will vary depending on the make and model of your dehydrator). At this point you can stop here if you want.

For use in soups and other moisture rich dishes you can simply add the dehydrated slices in during the cooking process and the mushroom slices will rehydrate while the dish cooks. For fast cooking dishes or less liquid intense dishes, you will need to soak the dehydrated mushroom slices in warm water for around 20-30 minutes so they are plump and juicy instead of hard and splintery.

Turn your hard dried mushroom slices into a fine powder in a grinder and sieve it. Once you have your desired consistency you want to store your mushroom powder in a cool dark place in an air tight container to avoid spoiling or rehydrating before you are ready to use it.

A. Cleaning: The easiest way to clean mushrooms, **except for morels**, is to gently wipe or brush away any dirt and debris.

Mushrooms - Depending on what type of mushroom you are planning on dehydrating you may want to keep the mushroom whole for presentation purposes of the dish. You can dehydrate the mushrooms whole, but it will take longer.

- rea from the healthy.
- Dug around 2m (6-8ft) ahead of the advancing disease and the trench itself to be several inches wide.
- All compost and casing has to be removed from the trench
- Gap thoroughly disinfected.
- If crop is growing in separate containers, the usual advice is to isolate or dispose of them.
- Good hygiene is strongly recommended.

3. Viral Disease **Top**

- Virus (several)

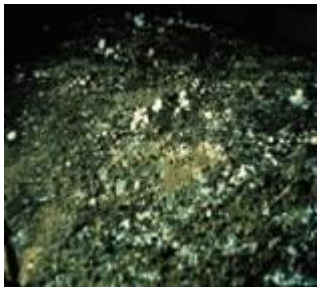
- Double-stranded RNA
- Reduced cropping,
- bare patches on the beds,
- long-bent stalks with small caps,
- Premature opening of mushrooms,
- Stalks tapering towards the base of stalk,
- Dying pinheads
- Infected mycelium grows slowly in the beds and fruiting bodies are not produced.
- Infection of the crop at spawning lead to a higher level of disease

Spread and source of infection of virus

- Infected mushroom spores
- Mycelium from previous crops also survive in the trays
- Mushroom sheds can also release infected spores
- Dust from around the farm may introduce infected spores
- Only 10 infected spores are required for a disease outbreak.
- Farm hygiene
- Maintain 60oC temperature throughout the compost
- Filter air and seal rooms properly to prevent spores from entering during cool down phase of compost.
- Clean equipments
- Ensure workers have clean-spare clothes
- Ensure absolute filters are fitted to spawn-run buildings

- Clean trays to prevent infection from old-infected mycelia

Green moulds



- *Trichoderma koningii*
- *T.viride*
- *T.aggressivum f.sp.aggressivum*
- Dark green mould patches on casing spreading to lesions on stems.

Control of green mould

- Sanitation and hygiene programme, especially targeting post crop
- Cover spots with sodium hypochlorite solution, salt, lime or gypsum and lime mix.
- Good insect and mite control
- Personnel movement patterns further reduce the spread of the disease.

- chlorothalonil at casing or mix into casing material 254 mL formulation per 100 m2 of production
- Chlorothalonil is not effective against an established infection but lowering the infection

Cinnamon Mould

- *Chromelosporium fulva* (*Peziza ostrachoderma*)
- The color of this mold ranges from yellow gold to golden brown to cinnamon brown.
- It grows rapidly in circular patches.
- It is very common in soil, and flourishes on damp wood.
- Areas in compost overheated during spawn run may be colonized.
- Improperly conditioned compost will also support growth,
- It often occurs on sterilized soil.
- Sexual fruiting bodies may appear several weeks after the first appearance of the mold.
- Spores are airborne

Pink Mold

- *Neurospora* spp.
- Commonly to occasionally seen on agar and grain.
- It is ubiquitous in nature, occurring on dung, in soils and on decaying plant matter.
- *Neurospora* spores germinate more readily at elevated temperatures.
- The pink mold seen in mushroom culture is most frequently *Neurospora sitophila*, a pernicious contaminant that is difficult to eliminate.
- All infected cultures should be removed as soon as possible from the laboratory and destroyed.
- A thorough cleaning of the laboratory is absolutely necessary.
- If contamination persists, remove all spawn and start anew

Delicious recipes of mushrooms (mushroom soups and pickle).

Ingredients

- **dried porcini** 10g
- **unsalted butter** 50g
- **vegetable oil** 1 tbsp
- **chestnut mushrooms** 500g, cleaned and sliced
- **onion** 1, finely diced
- **garlic** 3 cloves, sliced
- **thyme** 15 sprigs, leaves picked
- **chicken stock** 600ml
- **double cream** 100ml

PICKLED MUSHROOMS

- **white wine vinegar** 75ml
- **caster sugar** 100g
- **mushroom mix** 200g, (such as Ocado's gold exotic mushroom mix)

Method

- **STEP 1**

  To make the pickled mushrooms, heat the white wine vinegar and caster sugar in a small pan with a pinch of salt until the sugar dissolves. Remove from the heat and add 50ml of water. Cool to room temperature, add the mushroom mix and leave to pickle while you make the soup.
- **STEP 2**

  Put the dried porcini mushrooms in a bowl and cover with boiling water. Heat the butter and oil in a large pan and, once the butter is foaming, add the chestnut mushrooms. Cook on a high heat for 10 minutes or until all the water has evaporated and the mushrooms are a deep golden brown.
- **STEP 3**

  Reduce the heat and add the onion, garlic, thyme leaves and a pinch of salt, and fry for 3-4 minutes until soft. Strain the porcinis (to remove any grit), add to the pan with the strained porcini liquid and chicken stock, and simmer for 15 minutes. Remove from the heat and stir through the double cream. Put the soup in a blender or food processor and blend until smooth. Serve the drained pickled mushrooms on top of the soup.