MUSHROOM CULTIVATION

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UNIT 1

INTRODUCTION

The term mushroom means in general a fungus but commonly it is the fruiting body of some fungi which produce and disseminate spores. Like all other fungi, they lack Chlorophyll and thus cannot produce their own food. They grow saprophytically or sometimes symbiotically upon other dead and living plants respectively to obtain organic matter as food.

Mushrooms are variable in size and shape. Many have cap and stalk but some varieties are devoid of stalk. Some varieties even produce fruit bodies below the ground. There are large number of species growing wild in nature, while many are edible, some are highly poisonous. The collection of colourful and variety of shapes of mushrooms is in practice since time immemorial. Auricularia, Lentinus edodus, Agaricus bisporus and volvariella volvacea were collected in China and France and elsewhere in the world. In India they have started to cultivate mushrooms from 1943

Importance:

- Mushrooms are being used as food since time immemorial. These have been considered as the delicacy. From the nutrition point of view mushrooms are placed between meat and vegetables.
- These are rich in protein, carbohydrate and vitamins. Mushrooms are low in caloric value and hence are recommended for heart and diabetic patients. They are rich in proteins as compared to cereals, fruits and vegetables. In addition to proteins (3.7 %), they also contain carbohydrate (2.4 %), fat (0.4%), minerals (0.6 %) and water (91%) on fresh weight basis. Mushrooms contain all the essential nine amino acids required for human growth. Mushrooms are excellent source of thiamine (vitamin-B1), riboflavin (B2), niacin, pantothenic acid, biotin, folic acid, vitamin C, D, A and K which are retained even after cooking. Since mushrooms possess low caloric value, high protein, high fibre content and high K: Na ratio, they are ideally suited for diabetic and hypertension patients. They are also reported to possess anticancer activities.
- India is primarily agriculture based country blessed with a varied agro-climate, abundance of agricultural waste and manpower, making it most suitable for cultivation of all types of temperate, subtropical and tropical mushrooms. It can profitably be started by landless farmers, unemployed youths and other entrepreneurs. It requires less land as compared to other agricultural crops and is basically an indoor activity. These are the ideal tools for recycling the agricultural wastes which otherwise may pose problem of disposal and atmospheric pollution.
- Therefore, mushroom cultivation is not only of economic importance but also has important role to play in integrated rural development programme by increasing income and self employment opportunities for village youths, woman folk and housewives to make them financially independent.

History:

A. Button mushroom

- **1630:** Cultivation of white button mushroom started first in France in the open on ridges made out of horse dung manure.
- **1707:** Tournefort at Royal Academy of Science, France, mentioned about compost preparation and mushroom cultivation.
- **1731:** French method of cultivation was introduced into England by Miller.
- **1779:** Abercrombie described a method of composting stable horse manure in stacks.
- **1831:** Callow grew mushroom in cropping houses warmed by fire heat and got fairly good yield (1.5 lbs/sq.ft)
- **1893:** Costanitin pointed out that the incidence of diseases made constant changing of growing area necessary.
- **1902:** Ferguson published details of spore germination and growing of mycelium.
- **1905:** Duggar succeeded in making mycelium cultures from the tissue of mushroom caps.
- **1929:** Lambert discovered that spawn could also be prepared from single spore cultures.
- **1937:** Sinden found that about one third of monospore cultures of *A.bisporus* he prepared were incapable of producing fruit bodies.
- **1950:** Sinden and Hauser introduced "Short Method " of composting.
- **1973:** The first strain of *A.bitorquis* introduced commercially by a French firm Somycel as strain No. 2017 and later by Le Lion

B. Oyster mushroom:

- **1917:** Falck described the first successful cultivation of *Pleurotus ostreatus.*
- **1951:** Lowhag was the first to grow *Pleurotus* on sawdust mixtures.
- **1962:** Bano and Srivastava reported mass production on straw-based substrates and their work paved the way for large scale commercial exploitation.

History of Mushroom Cultivation in India

Cultivation of edible mushrooms in India is of recent origin, though methods of cultivation for some were known for many years. The important historical developments in the cultivation of edible mushrooms are as below:

- **1886:** Some of specimens of mushrooms were grown by N.W. Newton and exhibited at the annual show of Agriculture, Horticulture Society of India.
- **1896-97:** Dr. B.C. Roy of the Calcutta Medical College carried out chemical analysis of the local mushrooms prevalent in caves or mines.
- **1908:** A thorough search of edible mushroom was initiated by Sir David Pain.
- **1921:** Bose was successful in culturing two agarics on a sterilized dung medium, details of which were published in the Indian Science Congress held at Nagpur during 1926.
- **1939-45:** Attempts on experimental cultivation of paddy straw mushroom (*Volvariella)* was first undertaken by the Department of Agriculture, Madras.
- **1941:** Padwick reported successful cultivation of *Agaricus bisporus* from various countries but without much success in India.

- **1943:** Thomas *et al*. gave the details of cultivation of paddy straw mushroom (*V. diplasia)* in Madras.
- **1947:** Asthana reported better yields of paddy straw mushroom by adding red powdered dal to the beds. He suggested April-June as the most suitable period for cultivating this mushroom in central Provinces and also carried out the chemical analysis of this mushroom.
- **1961:** A scheme entitled "Development of mushroom cultivation in Himachal Pradesh" was started at Solan by the H.P. State Govt. in collaboration with I.C.A.R. This was the first serious attempt on cultivation of *Agaricus bisporus* in the country.
- **1962:** Bano *et al.* obtained increased yield of *Pleurotus* on paddy straw.
- **1964:** Cultivation of *Agaricus bisporus* on experimental basis was started by CSIR and State Govt. at Srinagar in J&K.
- **1965:** Dr. E.F.K. Mantel, F.A.O., Mushroom Expert, guided and assisted Department of Agriculture for construction of modern spawn laboratory and a fully air conditioned mushroom house. Research on evaluation of different strains and use of various agricultural wastes, organic manures and fertilizers for preparing synthetic compost were undertaken. Dr. Mantel's consultancy concluded after a period of 7 years.
- **1974:** Dr.W.A. Hayes, F.A.O., Mushroom Expert, guided further in improving the method of compost preparation, pasteurization and management of important parameters in the mushroom house. New compost formulations, casing materials and important parameters like nitrogen content in the compost, moisture in the casing mixture, air movements and maintenance of proper environmental factors were also standardized which raised the mushroom yields from 7 to 14 kg/m².
- **1977:** A 1.27 crore, Mushroom Development Project was launched under U.N.D.P by the Department of Horticulture (H.P) wherein the services of Mr. James Tunney were made available. He got a bulk pasteurization chamber constructed and made available readymade compost and casing to the growers of H.P. The U.N.D.P. Project was concluded during 1982 and since then the Department of Horticulture (H.P) is running the project.
- **1982:** The Indian Council of Agricultural Research (ICAR) sanctioned the creation of National Centre for Mushroom Research and Training (NCMRT) during VIth plan on October 23, 1982 with the objectives of conducting research on mushroom production, preservation and utilization and to impart training to scientists, teachers, extension workers and interested growers.
- **1983:** All India Coordinated Project on Mushroom (AICRPM) was initiated during VIth Five-Year Plan on 01.04.1983 with its headquarter at National Research Centre for Mushroom Presently known as Directorate of Mushrooms.
- Presently there are ten co-ordinating and one co-operating centres working under AICRPM located in 11 states. Of these,nine centres are based at State Agricultural Universities, while two at the ICAR institutes.

EDIBLE MUSHROOMS WITH MEDICINAL PROPERTIES

MOREL MUSHROOM

'Super Food' Morels, used in Eastern India, as traditional medicine, considering their therapeutic benefits hold healthy nutritive content. They help scavenge and destroy disease-causing bacteria, preventing occurrences of serious ailments. Besides promoting immune health, Morels are effective against cancers of the prostate and the breast. They promote metabolic function vision health, produce energy and combat tumors.

Shiitake Mushroom

One of the most popular varieties, commonly available in supermarkets, Shiitake is a classic vegan substitute for meat, boasting of several medicinal compounds. Abundant in vitamin D, these mushrooms with antiviral compounds help combat infections, keeping diseases at arm's length. Known in the Japanese language, as the 'Oak Fungus' these shiitake mushrooms with loads of lentinan are highly beneficial for preventing the formation of cancerous tumors in the body.

Enoki Mushrooms

Enoki Mushrooms growing in willowy white clusters have heads resembling a cap. Cultivated in small glass containers, these mushrooms offer health-enhancing properties, boosting immunity and providing anti-cancerous benefits.

Oyster Mushroom

Oyster Mushrooms derive their name from oysters, owing to the similarity in appearance. Potent antioxidant compounds in oyster mushrooms have sent scientists researching their potential benefits for treating HIV diseases. Apart from this, these mushrooms are contenders for protecting against cancers and facilitating healthy cholesterol levels in the body.

Maitake Mushroom

Popularly known as "Hen of the Woods" these delectable Japanese delights comprising of potent anticancer elements, prevent hormone-related cancers of the bladder, ovary and the breast. Maitake mushrooms are known to treat cancer and are also used to relieve some of the side effects of chemotherapy. Owing to the existing antiviral properties, they boost immune health, besides lowering blood pressure and blood sugar levels.

Reishi Mushroom

Owing to the presence of Gandodermic acid, an active compound, the Reishi types offer healthy cardiac benefits. These keep the arteries from clogging, preventing sticking of blood clots to the arterial walls. Because of this, they help maintain healthy levels of blood pressure and cholesterol in the body.

Button Mushroom

Button Mushrooms, possessing specific kind of carbohydrates boost metabolism, thereby keeping blood sugar levels under check. In addition to its high metabolic activity, the white button mushrooms, loaded with selenium, help burn fat, affecting weight loss and preventing the incidence of prostate cancer.

POISONOUS MUSHROOMS WITH DEADLY TOXINS

Although, certain varieties of edible mushrooms offer innumerable health benefits, a few others are lethal to the extent of causing death and allergic reactions.

Destroying Angel Mushroom

The most common poisonous variety of mushrooms, the oval-shaped Destroying Angel, possesses amatoxins, one of the major contributors towards mushroom poisoning called mycetism. Within a few hours of consumption, the amatoxin substances destroy the tissues in the kidney and liver ultimately causing mortality.

Death Cap Mushroom

Death caps are common to Asia and Europe. A highly poisonous variety, these are the primary cause for mushroom poisoning across the globe.

False Morel Mushroom

False morels called sponge mushrooms resemble the brain's exterior. Frequently misidentified as the true morel, the false morels with Mono Methyl Hydrazine (MMH), commonly alleged as carcinogenic, trigger diarrhea, giddiness and vomiting, and even lead to death.

Deadly Galerina Mushroom

The Deadly Gallerina mushroom consisting of *amaniti,* a critical toxin destroys the central nervous system, the kidneys and the liver.

Nevertheless, with such wide variety of mushrooms, it is advisable to exercise caution in identifying the nature of a mushroom variety before utilizing it for consumption.

Mushrooms, white, raw

The nutritional values of "Mushrooms, white, raw" per 100 grams are:

Nutrition Summary	
Total Calories	**22**
Protein	3.1 g
Fat	0.4 g
Carbohydrate	3.3 g

Nutrients	Amount	%Daily Value
Calcium, Ca	3 mg	0.3 %
Copper, Cu	0.32 mg	15.9 %
Iron, Fe	0.5 mg	2.78 %
Magnesium, Mg	9 mg	2.25 %
Manganese, Mn	0.05 mg	2.35 %

Phosphorus, P	86 mg	8.6 %
Potassium, K	318 mg	9.09 %

Mushrooms are fungi, which is a separate kingdom of life from plants and animals. Technically, they are not a vegetable, but they are often used and served as a vegetable in recipes.

Mushrooms are a low-calorie, high-fiber food choice that can be used diversely in cooking.[1] They add a savory flavor to recipes but are very low in sodium, making them a healthy choice.

Mushroom Nutrition Facts

One cup of mushrooms (70g) provides 15 calories, 2.2g of protein, 2.3g of carbohydrates, and 0.2g of fat. Mushrooms are a good source of copper, B vitamins, potassium, and iron. The following nutrition information is for 1 cup of raw mushrooms and is provided by the USDA.[2]

Mushroom Nutrition Facts

Nutrient	Amount per serving
Calories	15
Fat	0.2g
Sodium	3.5mg
Carbohydrates	2.3g
Fiber	0.7g
Sugars	1.4g
Protein	2.2g

A serving of mushrooms is 1 cup. Figures from the U.S. Department of Agriculture.

Carbs

One cup of raw mushrooms contains 2.3 grams of carbohydrates. Mushrooms are also a good source of fiber, particularly the soluble fiber beta-glucan.[3]

Mushrooms have a naturally low glycemic index, which means that they are presumed to have little negative effect on blood glucose or insulin response due to their low carbohydrate

content. There is not sufficient, conclusive evidence on the use of mushrooms for diabetes, however.[4]

Fats

Mushrooms have only a minuscule amount of fat, most of which is polyunsaturated fat. As a result, mushrooms are considered a heart-healthy food choice.

Protein

Mushrooms provide a small amount of protein at 2.2 grams per cup, which represents just a portion of your daily needs. So be sure to eat protein-rich foods such as legumes, nuts, dairy, meat, or fish as part of a balanced diet.

Vitamins and Minerals

Mushrooms are full of micronutrients. They are a good source of copper, potassium, phosphorus, and iron. Copper assists in energy production and iron utilization.[5] Potassium is important for maintaining fluid and electrolyte balance, is required for proper nerve and muscle conduction, and may help to lower blood pressure.[6]

Iron is a mineral needed for the synthesis of hemoglobin, DNA, amino acids, neurotransmitters, and certain hormones.[7] Mushrooms also contain niacin (vitamin B3) and pantothenic acid (vitamin B5). B vitamins assist in the release of energy from carbohydrates, protein, and fat.

Calories

One cup of raw mushrooms contains just 15 calories. That makes this a low-calorie food, especially since most people don't eat a full cup at one time and will take in even fewer calories than this.

Health Benefits

A total of 126 health-related functions are thought to be produced by medicinal mushrooms and fungi.[8] Research is ongoing about the potential for using mushrooms to improve health and to prevent or manage health conditions.[9]

In addition to the many vitamins and minerals mushrooms contain, they have also been found to have high levels of some antioxidant compounds. These compounds can be beneficial to health.[10]

Fights Cell Damage

Antioxidants have been shown to fight oxidative stress and inflammation, which contribute to signs of aging and to the development of chronic diseases. Several varieties of mushrooms, such as porcini and white button mushrooms, are high in the antioxidants glutathione and ergothioneine, which are not found in many other plant foods.[11]

Improves Brain Function

Consuming mushrooms may help slow the cognitive decline that comes with aging, according to both the antioxidant research above and a separate study of over 600 people aged 60 and over.[12]

Supports Bone Health

Some mushrooms sold in stores have been treated with UV light to increase their vitamin D stores. These treated mushrooms are one of the best sources of vitamin D.[13] Vitamin D is important for healthy bones. Eating these mushrooms has the same benefit as getting vitamin D from supplements or from sun exposure.[14]

Normally, mushrooms are not a good source of vitamin D. The exception is wild mushrooms, but eating them can be risky if you are unable to determine which are edible and which are toxic.

Lowers Diabetes Risk

Mushrooms are a good source of fiber. Consuming dietary fiber has many health benefits, including a lower risk of type 2 diabetes.[15] A 2020 study adds that the polysaccharides in mushrooms also help protect against diabetes by reducing oxidative stress.[16]

Reduces Depression

After reviewing results of the U.S. National Health and Nutrition Examination Survey (NHANES), researchers noted that people who consumed mushrooms had a reduced risk of having depression.[17] This effect appears to be present regardless of the amount of mushrooms consumed.

Allergies

Food allergies to mushrooms are rare but have been reported. You may have a cross-reaction if you are allergic to molds.[18]

Adverse Effects

Some species of mushrooms can interact with alcohol in unpleasant ways. The inky cap mushroom contains coprine, which acts like the drug Antabuse, causing a racing heart, flushing, tingling, and other symptoms when you ingest alcohol as long as five days after eating the mushroom.[19] Some other mushrooms cause digestive distress in susceptible people who consume alcohol alongside the mushroom dish.

The biggest concerns with adverse effects, however, are with wild mushrooms and the wide variety of poisonous substances they can contain. Effects of ingesting a toxic wild mushroom variety may include gastrointestinal irritation with nausea, cramps, vomiting, and diarrhea. These may either pass on their own or be severe enough to require hospitalization.[19]

Other mushroom toxins can affect the involuntary nervous system, kidneys, and liver, or are carcinogenic. Some of these toxins have no antidote and can be fatal within

hours.[19] Hallucinogenic mushrooms contain psilocybin and related compounds that produce psychological and perceptual effects.[20]

Varieties

There are many types of culinary mushrooms, including white button, crimini, shiitake, portabella, enoki, cloud ear, and more. The largest cultivated mushroom is the portabella, which can grow up to 6 inches in diameter.[21]

Micro- and macro-nutrient levels can vary among different types of mushrooms. For example, white mushrooms have slightly more calcium[22] while shiitake mushrooms have more fiber.[23] But in general, most edible varieties contain important vitamins and minerals like vitamin C, vitamin B-6, magnesium, phosphorous, potassium, copper, folate, and zinc.[2]

Dried mushrooms tend to have more calories and other nutrients than raw varieties because they are more concentrated. When they are rehydrated before cooking or eating, their nutrition is comparable to raw versions. Canned mushrooms are often a little higher in calories, and significantly higher in sodium than raw mushrooms due to additives.[24]

Storage and Food Safety

Many wild mushrooms are deadly and can look like safe varieties, so it is risky to gather wild mushrooms on your own for eating.[19] Wild mushrooms that are sold by reputable purveyors should be safe to eat.

Many people use chop mushrooms and put them in salads raw. Some experts suggest that you're better off cooking mushrooms because cooking helps to release their vitamins and minerals.

Certain varieties of raw mushrooms contain small amounts of toxins, including a compound that is considered carcinogenic, which is destroyed through cooking. However, cooking will not render highly toxic mushrooms safe to eat.[19]

North American Mycological Association. Mushroom poisoning syndromes.

When shopping for mushrooms, look for fresh mushrooms that are clean and free of blemishes, such as soft, moist spots and discoloration. Fresh mushrooms can be stored in the refrigerator in an open container for about five days.[1] Do not wash them until just before use.

How to Prepare

Mushrooms can be cooked in a variety of ways, including grilling, baking, broiling, sautéing, and roasting. They are a hearty, vegetarian ingredient that can add texture, flavor, and substance to meals. Use mushrooms when making sauces, stews, and soups, or simply chop, sauté, and add to grain, potato, or egg dishes.

Mushroom caps serve as a good vehicle for stuffing. Raw mushrooms can hold spreads and dips, or they can be baked with other kinds of stuffing, such as seafood or cheeses mixed with herbs, spices, and vegetables.

Start your day off with a protein and fiber-rich egg and mushroom dish or pair your main course with a side of simple grilled mushrooms. Top healthy pizzas with mushrooms or add them to your sides. Use them as a substitute for meat if you are looking to follow a vegetarian or vegan meal plan.

ADVANTAGES OF MUSHROOM

7 benefits of mushrooms,

Prescott dives into the exciting world of mushroom research. While research hasn't been extensive and more is certainly needed, some studies have shown that mushrooms may:

1. Boost your immune system

Chronic inflammation (long-term swelling) is associated with heart disease, cancer and other medical conditions. Mushrooms contain certain antioxidants that help protect your body from stress and prevent or slow cell damage.

Mushrooms also activate substances in your immune system that can enhance its ability to protect you against infection and disease, including the growth of tumor cells. Some research has found a potential link between higher mushroom consumption and lower cancer risk, especially breast cancer.

2. Lower blood pressure

Potassium is a mineral and electrolyte that helps your body control blood pressure. Most Americans don't get enough potassium. Because mushrooms are rich in this mineral, they may help lower high blood pressure (hypertension). They may also reduce your risk of developing cardiovascular disease.

3. Support weight loss

Research suggests that a mushroom-rich diet can help you safely lose weight when combined with exercise and healthy lifestyle habits. In one study, people who substituted 20% of their meat consumption with mushrooms showed improved weight loss results.

The flavor of mushrooms may reduce your need for added salt, too, which helps control your blood pressure. Researchers found that substituting mushrooms for half the meat in a ground beef recipe kept the taste but reduced sodium intake by 25%.

4. Supply vitamin D

Vitamin D2, a type of vitamin D, keeps your bones strong and muscles working properly. Most of our vitamin D comes from animal-based sources, dietary supplements and good old sunshine. And here's a fun fact: Some mushrooms may have a label that reads "UV-treated" or "rich in vitamin D." That's because mushrooms contain ergosterol, which turns into vitamin D when exposed to ultraviolet light.

"These UV-treated mushrooms are enriched for your health," explains Prescott. "When mushrooms are exposed to ultraviolet radiation or even sunlight, the ergosterol transforms into vitamin D. So, you get a high concentration of vitamin D when you eat them, potentially enough to meet 100% of your vitamin D needs for the day."

You can buy UV-treated or vitamin D-enriched mushrooms at the store. Or try it at home:

1. Slice one portabella or , Production of Bio and Herbal Pesticides at household/ Farm Levelthree smaller, white button or cremini mushrooms.

2. Leave them in direct sunlight for as little as 15 minutes.

Sun and done!

5. Protect brain health

The nutritional value of mushrooms may help protect your brain from mild cognitive impairment (MCI). In one study, participants 60 and older who ate more than two cups of mushrooms per week had a much lower risk of developing MCI. Other research suggests mushrooms rich in polyphenols and certain antioxidants may help protect against neurodegenerative diseases such as Alzheimer's and Parkinson's.

"This mushroom research is interesting because it could help with serious brain conditions that affect so many people," says Prescott. "We need to know much more, but early studies are promising."

6. Maintain heart health

Mushrooms are a boon for healthy heart lovers. Their nutrients and plant-based compounds can help prevent plaque buildup in your blood vessels. Substitute flavorful, low-sodium mushrooms for meat while keeping calories, fat and cholesterol levels low.

"Some mushrooms have taste and texture just like meat," says Prescott. "And the benefits of substituting them for beef, lamb or other red meat can't be beat. You get the nutrients and the low calories, sodium and cholesterol without sacrificing flavor."

7. Improve gut health

Mushrooms contain substances you need to balance your microbiome (fungi, bacteria and viruses) in your gut and fuel the growth of good bacteria. By supporting your digestive system and immune system, mushrooms can help make sure that the nutritious food you eat keeps you healthy and strong.

Are mushrooms safe?

The answer is: It depends. Mushrooms you buy in a store are generally safe unless you have an allergy to mushrooms or mold (remember, mushrooms are fungi). Wild mushrooms you find in nature are much, much riskier to eat.

It takes experience and expertise to identify mushrooms in nature you can safely eat. And even then, few wild mushrooms are safe to eat raw.

Dozens of mushrooms (often called toadstools) contain a deadly poison. Symptoms of mushroom poisoning typically appear within a few hours of eating mushrooms. They include:

- Confusion.

- Diarrhea.
- Difficulty breathing or slowed breathing.
- Dilated pupils or watering eyes.
- Excess saliva.
- Excitability.
- Nausea or vomiting.
- Sweating.

Enjoy the healthy benefits of mushrooms

Mushrooms are a common and nutritious food, recognized around the world for their potential health benefits. With a range of safe, edible types to choose from, you can eat them in a sandwich, mix them into soups and salads or even substitute them for meat. They contain important substances known to ward off disease, while their interesting flavors and textures add flair to any dish. Impress guests — and yourself — with a healthy serving or two.

STRUCTURE AND LIFE CYCLE OF AGARICUS

There are 4,000 species and 197 genera in the order Agaricales. Most species thrive on dead, decaying wood, leaves, and soil rich in organic matter.

Agaricus members are distinguished by their fleshy pileus or cap, from the bottom of which several radiating gills or plates grow and produce the naked spores. Their chocolate-brown spores set them apart from other Agaricaceae family members.

Short-lived primary mycelium originates from homokaryotic basidiospores. The primary component of the *Agaricus* life cycle is the dikaryotic secondary mycelium.

Table of Contents

Classification of Agaricus

The *Agaricus* genus comprises the regular (“button”) mushroom (*Agaricus bisporus*) and the ground mushroom (*A. campestris*), the prevalent cultured mushrooms of the West.

Kingdom	**Fungi**

Division	**Basidiomycota**
Class	**Agaricomycetes**
Order	**Agaricales**
Family	**Agaricaceae**
Genus	***Agaricus***

Life Cycle of Agaricus

The life cycle of *Agaricus bisporus* is similar to most other mushrooms. This fungal life cycle is cyclical, with adults generating spores that grow and develop into adults which produce their own spores.

Inoculation

It is the first phase of the life cycle of *Agaricus bisporus*. Eventually, floating mushroom spores will settle on a suitable substrate or surface. The spores advance to the following stage, germination, if the condition in this place is favourable for the mushroom to survive.

Germination of Spores

During this spore germination phase, individual spores produce tiny filaments called hyphae. Closely placed female and male hyphae combine to form fertile mycelium. The mycelium resembles the roots of real plants in appearance.

Expansion of Mycelium

This life cycle phase constitutes the mycelium growth phase, or the phase when the mycelium extends and develops. This expansion happens exponentially. The mycelium strives to decompose organic waste and take in the nutrients released to support its steady growth. Additionally, the mycelium has protective mechanisms to fight competitors and ward off predators.

Hyphal Knot

The mycelium starts to grow and compress into a knot-like formation. During this stage, the mycelium generates many hyphal knots and primordia. This structure produces the ultimate mushroom “body”, called a hyphal knot.

Formation of Primordia

The hyphal knot finally condenses and becomes a primordia. Primordia are essentially smaller versions of adult mushrooms. One mycelium can produce up to a thousand tiny primordia on its surface. Not all primordia develop into the mushroom's adult "fruiting body."

Fruiting Body Selection

Only the primordia with the highest growth and productivity rates will mature into fruiting bodies. What we see as a "mushroom" is each individual fruiting body. However, these fruiting bodies are not different organisms, but one organism joined by its mycelium. These fruiting bodies keep expanding and transforming into the mushroom's adult form.

Mature Fruiting Body

When a mushroom achieves maturity, it concentrates its growth on the fruiting body, which it will later use for reproduction. The mushroom keeps expanding and transforming until it fully matures and begins to spore. The fruiting body portion of the *Agaricus bisporus* mushroom is what we consume.

Spore Release

During this last stage of the life cycle, the adult fruiting body releases a significant amount of tiny spores into the environment. The gill structure on the bottom of the mushroom's cap releases the spores. In the inoculation stage, these spores ultimately settle on a suitable surface and restart the life cycle.**VEGETATIVE STRUCTURE OF AGARICUS (WITH DIAGRAM) | FUNGI**

Vegetative mycelium grows within the soil.

2. The primary mycelium is septate, haploid, short lived, and each cell contains oil globules, vacuoles and one nucleus.

The secondary mycelium is dikaryotic and long-lived.

4. The hyphae of the secondary mycelium are long, branched and remain twisted to form a thick hyphal cord, called the mushroom's body or basidiocarp.

Button Stage and Its Longitudinal Section:

1. The fruiting-bodies arise as small, white, globular, apical swellings (Fig. 102) on the branches of the subterranean mycelial strands.

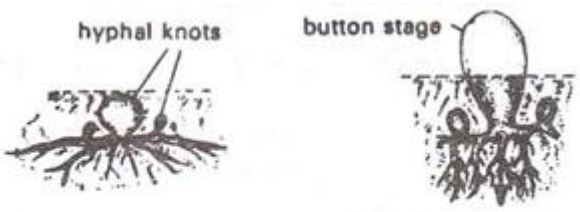


Fig. 102. Agaricus. Some stages of the formation of young fruiting bodies..

2. These small tiny knots represent the common "Button-Stage" of the fungus.

3. The dome-shaped upper portion is known as pileus (Fig. 103).

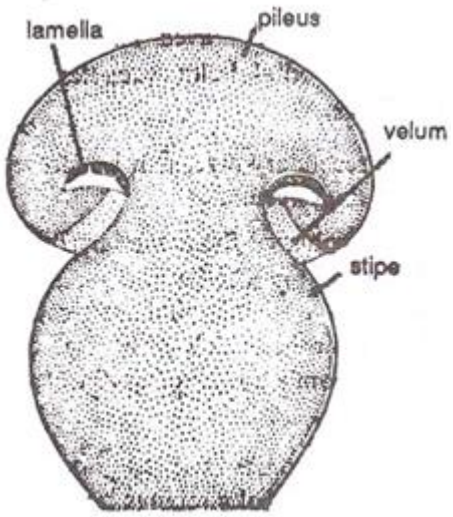


Fig. 103. Agaricus. L.S. button stage.

4. The lower hyphae constitute the stalk or stripe.

5. The margins of the pileus are connected with the stipe with the help of a membrane called inner veil or velum.

6. There is present a constriction between stipe and pileus.

7. Two gill-chamber cavities are present, one on either side of the pileus.

8. From the roof of these cavities arise many gills or lamellae.

9. Button stage is a developmental stage of the fruiting body of Agaricus.

Mature Fruiting Body:

1. The basal underground mycelial portion is known as rhizomorph, from which develops the basidiocarp or fruiting body.

2. The basidiocarp is differentiated into a long stalk-like stipe and an upper cap-like pileus (Fig. 104).

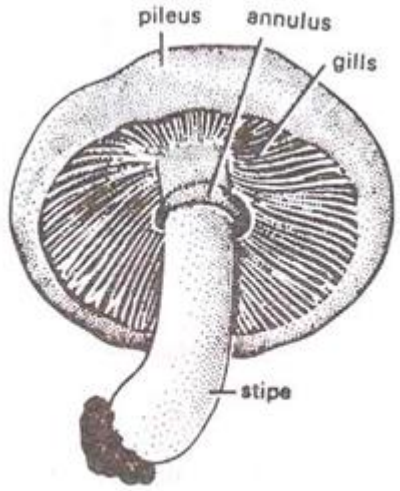


Fig. 104. Agaricus. A mature fruiting body.

3. The stipe is fleshy, and made up of pseudoparen-chymatous mass of hyphae. It gives support to the pileus.

Pileus is an umbrella-shaped structure, the underside of which is lined by many gills.

5. On the stipe is present a membranous ring of velum or annulus, which, in the early stages, remains in contact with the pileus.

T.S. Through Gills:

Three types of gills are present, which vary only in their size. These are known as long gills, half- length gills and quarter-length gills (Fig. 105B).

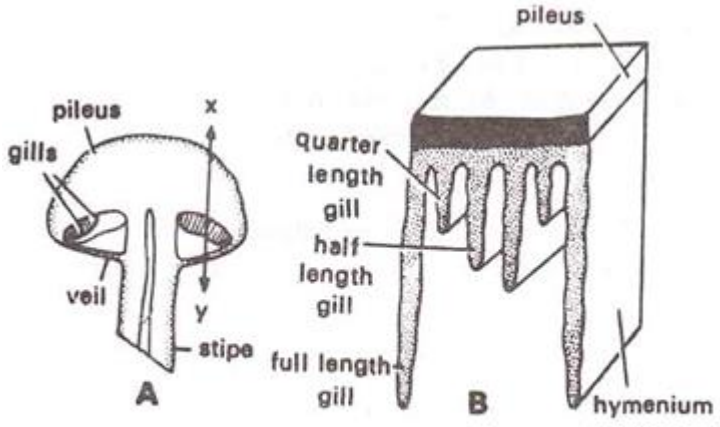


Fig. 105. Agaricus. A, V.S. of basidiocarp; B, V.S. of pileus along the axis `x'-`y' in `A'.

2. In each gill, three different layers are present, i.e., trama, sub-hymenium and hymenium (Fig. 106).

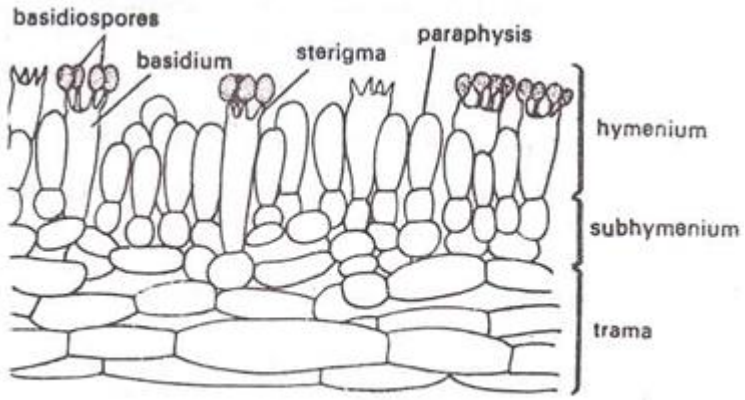


Fig. 106. Agaricus. T.S. gill (a part).

3. The trama consists of many anastomosing, interwoven sterile hyphae. It is central in position.

The hyphae of trama region develop into a compact hypodermal layer on its either side. This is known as sub-hymenium.

5. The hyphae of the sub-hymenial layer terminate into the superficial layer of the gills called hymenium.

6. The hymenium (Figs. 106, 107) consists of many club-shaped cells of two types, of which some are fertile cells and called basidia, and others are sterile cells and called paraphyses.

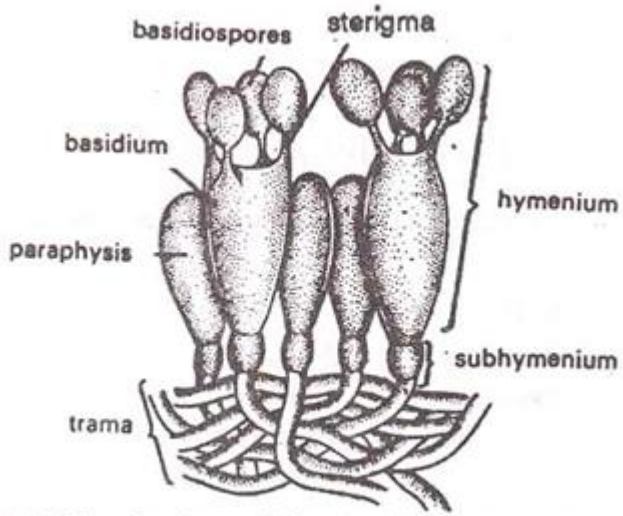


Fig. 107. Agaricus. A few basidia and paraphyses.

7. From each basidium develops four basidiospores.

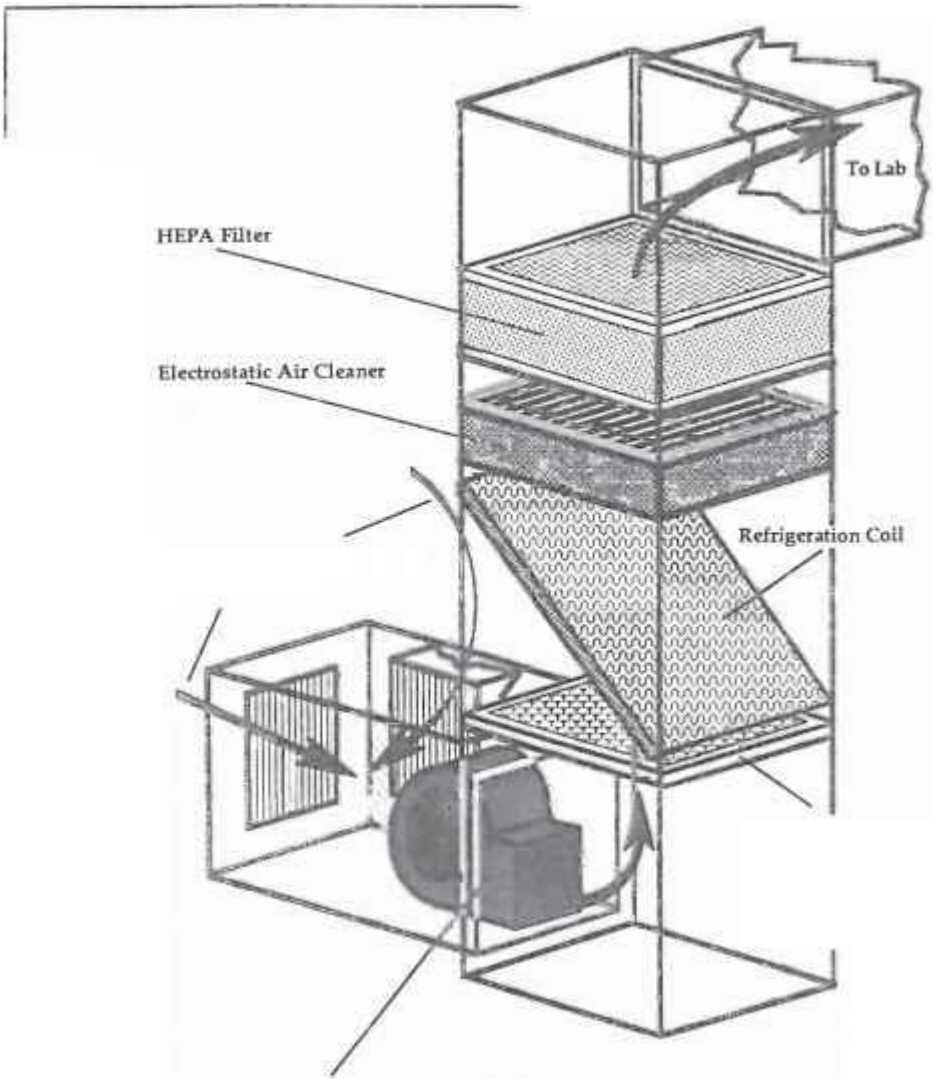
Basidiospores remain attached with the basidium with the help of sterigmata (sing, sterigma).

9. Each basidiospore is a purple coloured, oval and uninucleate structure.

UNIT 2

STRUCTURE AND CONSTRUCTION OF MUSHROOM HOUSE-LAYOUT OF TRADITIONAL AND GREEN HOUSE METHOD

Fungi are everywhere. In the air, in the water, in our bodies, in the trees, in the ceilings of our bathrooms, underground. They can be mushrooms (edible, medicinal, hallucinogenic, or very poisonous), or take other simpler forms, such as molds. They can trigger illnesses, but they can also produce antibiotic remedies, such as penicillin, or help ferment amazing cheeses and breads. Could they also be the future of packaging and building materials.



Fungi are nature's primary recyclers. They produce enzymes that aid in the degradation of organic matter, transforming it into minerals. Typically, these life forms grow best in shaded and humid environments. Like an iceberg, the visible portion of a fungus only represents a small fraction of it. Below the surface, for example, mushrooms develop long thread-like roots called mycelium. These are extremely thin white filaments that develop in all directions, forming a quickly-growing complex web. When the fungus is implanted in a suitable place, the mycelium behaves like glue, cementing the substrate and transforming it into a solid block. This substrate can be composed of sawdust, ground wood, straw, various agricultural residues, or other similar materials, which might otherwise go to waste.

Depending on the mycelium strain and the substrate used, the final product can be molded to produce insulating panels, furniture, accessories, fabrics, packaging materials, and even bricks, with good thermal and acoustic characteristics and strong fire behavior. Scientific research [1] has shown that, in terms of physical and mechanical characteristics, mycelium-

based materials resemble expanded polystyrene (often called Styrofoam), but with an improved level of biodegradability. “In addition to the lignocellulosic substrate, the characteristics of a mycelium-based biocomposite are strongly affected by the selected fungus species and their continuous growth. Thus, the consistency of the mycelium itself is, in turn, affected by the composition and structure of the substrate.”

Ecovative Design is a pioneer of mycelium-based design today, using this unconventional material to create objects such as packaging. To produce these objects, the substrate and fungi are combined in a solution and inserted into molds. After about 5 days of growth in favorable conditions – adequate temperature, humidity, and light – the material is solidified into the desired shape. The object then goes into an oven to completely deactivate the microorganisms present, allowing it be used as common packaging. Companies as large as IKEA and DELL have already begun using these packages, which are completely biodegradable.

The Living studio in New York worked in cooperation with Ecovative Design on the Hy-Fi Project, a pavilion that was built in the yard of MoMA PS1 after winning the MoMA's Young Architects Program in 2014. With ARUP's structural advice, mycelium bricks were developed, which grew in less than a week in prismatic molds from the residue of chopped corn stalks. When constructed, the bricks formed a tower about 12 meters high. At the end of the two-month exhibition, the tower was dismantled and the bricks were taken to composters, taking advantage of their natural biodegradability.

arlo Ratti Associati, working in collaboration with the energy company Eni, developed an architectural structure made of mushrooms that was revealed at Milan Design Week. The “Circular Garden” is a series of arches composed of one kilometer of mycelium, wherein the spores were injected into an organic material to start the growth process. As many pavilions for temporary exhibitions generate a significant amount of waste, Jardim Circular follows a more sustainable course, with its constitutive mushrooms, ropes, and shredded wood chips returned to the ground after the end of the exhibition. The Shell Mycelium Pavillion, a collaboration between BEETLES 3.3 and Yassin Areddia Designs, similarly demonstrates alternative eco-conscious design through temporary structures. A wooden structure was covered with coconut marrow that contained the fungus. After a few days of care, the mycelium grew and formed a snow cover over the structure. The upper layer of growth died and hardened due to sunlight, forming a shell and protecting the lower layers.

In addition to architectural structures, mycelium also has potential for use in thermal and acoustic insulation. According to another initiative by Ecovative, live mushrooms packaged between wooden panels can form an effective insulating wall. In three days, the mycelium grows and solidifies loose particles to create airtight insulation, simultaneously adhering to the wooden boards and forming what is essentially an extremely strong sandwich. The result is similar to a structural insulating panel, but without thermal bridges. According to Ecovative, after about a month the mushroom insulation naturally dries out and becomes inactive.

But European researchers in the fields of computing, biology, and architecture [2] go a step further. They propose to develop a structural substrate using live fungal mycelium, together with nanoparticles and polymers, to make mycelium-based electronics through the implementation of sensory fusion and fungal decision making. “Mycelium networks will be computationally active, giving rise to entirely new biologically-based features for architectural artifacts and materials, such as self-regulation, adaptation, decision-making, growth, and autonomous repair - adding new advantages and value to architectural artifacts and the environment, and providing a radically alternative paradigm to state of the art 'smart buildings' that rely heavily on technical infrastructure. ”

Although we can gather some examples of initiatives in one article, the use of mycelium has still barely scratched the surface of its potential. Scientific articles on the subject almost always conclude with the statement: it is necessary to research heavily and experiment carefully with the material for it to have the efficiency, competitiveness, and industrial quality needed for mass use. But researchers also agree that there is enormous potential for the material in many diverse areas. Mycelium represents a paradigm shift in the way we approach the procurement, use, and disposal of construction materials. Being 100% biodegradable, found in abundance on the planet, “grown” from waste, and achieving excellent functional characteristics, mycelium-based materials have enormous, yet untapped potential. But, above all, mycelium also proves that great innovations do not necessarily require new technologies or complex materials. They may be closer than we think.

Sanitation and hygiene regulations (mushroom farm)
The members of the team that does spawning and compost filling have to:

Spawning and filling the growing rooms with compost.

1. Ensure the cleanness of machinery and all equipment for spawning and compost filling. (If any malfunctions are found, the technical personnel should be told in advance);

2. Ensure the cleanness of growing rooms (floor, walls, shelves, cloths, racks and other equipment and tools must be thoroughly cleaned and treated with disinfectants);

3. Check the cleanness of machinery and equipment at the end of the working day;

4. When the work is done, the machinery, equipment and rooms must be cleaned and washed;

5. Carry out spawning and compost filling according to technology. When filling is done, the shelves with compost must be covered with paper, and growing room doors must be closed and thoroughly sealed.

The team members must: have clean, disinfected clothes and gloves, before entering the working place, footwear must be disinfected (before starting work, after lunch, and after going to the toilet etc.)

Chemical protection team has to:

1. Disinfect the machinery, equipment and the corridor following the route of transportation, the nets, cloths and other inventory with 2% formalin solution before starting work;

2. Maintain the time needed for the contact action of the disinfectant and the processed surface (not less than 20 minutes), then thoroughly ventilate the growing rooms;

3. After filling the growing room with compost, the paper, floor, walls and doors of the growing room must be treated with 2% formalin solution.

During compost filling and spawning, the personnel doing this work isn't allowed to enter a clean corridor or the warehouse, or contact personnel engaged in harvesting mushrooms.

All workers on the farm, except those, who are engaged in compost filling, are not allowed in the working corridor or the growing room where the work is being done.

The preparation and application of casing soil.

1. The components for the preparation of the casing soil (peat, lime) must be stored special places, not allowing them to be mixed;

2. Keep clean the room where the casing soil is stored along with the area adjacent to it;

3. Regularly (once a week) conduct chemical treatment and disinfection inside and around the room in order to destroy pests and diseases, which are dangerous for the mushroom culture;

4. Thoroughly clean, wash and disinfect all machinery and equipment before starting work;

5. Check the working condition of the machinery and equipment and do repair work in advance. If any malfunctions occur during the process, they have to be eliminated as soon as possible. Do not allow the contact of footwear and the used equipment while preparing and applying the casing mixture;

6. Transport the casing mixture and its components to the growing rooms only in thoroughly washed and cleaned transportation;

7. Apply the casing layer according to technology;

8. When the job is done, close and seal the doors in the growing rooms;

9. After the application of casing layer, immediately remove the remains of the casing mixture from the working corridor and the growing room, then, clean the floor, machinery and equipment;

10. During the process, there mustn't be any work that doesn't have to do with the application of casing layer going on in the working corridor, the passageway must be closed.

Personnel that are busy doing their work must have clean and disinfected clothes and footwear, disinfect their footwear before entering their working place (before starting work, after lunch and after going to the toilet etc.)

During compost filling and spawning, the personnel doing this work isn't allowed to enter a clean corridor or the warehouse, or contact personnel engaged in harvesting mushrooms.

All other workers on the farm are not allowed to be in the working corridor and the growing room where the work is being done.

The jobs carried out before and after the formation of fruit bodies.

The personnel that busy working in the growing rooms and a clean corridor (technologists, operators, irrigation workers, sanitarians, and pickers) should follow the following rules:

1. Everyday, begin work in clean, disinfected clothes. Before entering the growing room, disinfect the footwear;

2. Carry out jobs starting from new (clean) growing rooms (irrigation, harvesting, sanitary measures etc.);

3. Use clean equipment and tools for work. Never carry racks, platforms, containers etc. from old (dirty) or diseased growing rooms to new (clean) ones;

4. Never stand on the edge of a shelf, don't put crates, buckets and other inventory on the beds. Use racks and platforms to work with top shelves;

5. Do not leave the growing room doors open even for a little time. Pickers are allowed to leave the growing rooms only during breaks with the permission of the foreman or technologist. The working inventory (racks, crates, buckets, containers etc. must be prepared and carried inside the growing room in advance);

6. Never touch the diseased mushrooms and molds while visiting the growing rooms and harvesting. If the diseases are discovered, inform the technologist. At harvesting, the pickers must mark the affected areas with special sticks. If mushrooms are cultivated in bags, the bags affected with diseases can be isolated;

7. Irrigation and harvesting must be carried out after the growing has been checked by a team of sanitarians and the diseased mushrooms have been removed with the affected areas disinfected;

8. While moving from room to room, all workers must wash their hands and change gloves;

9. After the work is done, the racks, platforms and other inventory must be thoroughly cleaned and washed. Waste bins, containers and other implement must also be cleaned;

10. Nothing must be laid on the bed surface;

11. Smoking during working hours is forbidden. During breaks, smoking in toilets is forbidden.

UNIT 3

ISOLATION AND CULTURE OF SPORES-CULTURE MEDIA PREPARATION

Mushroom Spawn Production Technology [Pure culture: Medium, sterilization, preparation of spawn, multiplication]

Mushroom is an interesting modification of fungal form of life. They are non-green fungal plants occurring seasonally in many parts of the world in various habitats ranging from sandy plains to tropic forests and green meadows to roadsides. There are more than 2000 edible species of which only a few have been brought under cultivation on commercial scale. Of these 80 have been grown experimentally, 20 cultivated commercially and 5 are produced on industrial scale throughout the world. The species grown more commonly and having good export potential are, Agaricus bisporus (white button mushroom), Volvariella spp. (paddy straw mushroom), and Pleurotus spp. (Oyster mushroom). The word spawn in the mushroom

industry means the planting material, which consists of the vegetative body (mycelium) and its substrate. In other words, spawn could be regarded as analogues to the seeds of the higher plants .

Methods of spawn preparation

There are three steps involved in spawn production

1. Raising of pure culture, 2. Preparation of master culture / mother spawn and 3. Multiplication of spawn.

1. Raising of pure culture Isolation techniques for getting pure cultures and their maintenance: There are two methods to have a mushroom culture –
the Spore Culture and Tissue Culture technique.

Spore Culture

a) Spore Print:

To get a spore print or collection of spores, the cap from a healthy, disease free mushroom is removed, surface cleaned with a swab of cotton dipped in alcohol and placed on a clean sterilized white paper or on clean glass plate or on surface of the clean glass slides. The surface nearby should be thoroughly sterilized. To prevent air flow, place a glass jar or clean glass or cup over the cap surface. Spores will fall on the white paper or slide surface within 24-48 hours exactly like radial symmetry of the gills. The spore print on the paper can be preserved for a longer time by cutting and folding it into two halves. Fig. Spore print collected after 24 -72 hours. b)

B) Spore transfer and germination:

To get a pure culture, the scalpel is sterilized by keeping it on a burning flame for 8-10 seconds till it becomes hot red, cool it by dipping in a sterilized medium, scrap some spores from the spore print taken on a paper or glass slide and transfer them by gently streaking on the agar medium aseptically. Minimum, three agar dishes should be inoculated for each spore print and the culture developed after its incubation at appropriate temperature is known as multispore culture.

2.Tissue Culture

A small bit from the pileal region is cut with the help of a sterilized blade or scalpel, washed several times in sterilized distilled water and dried in a clean tissue paper before inoculating aseptically on a Petri plate or tube containing suitable culture medium. The inoculated Petri plates are incubated at 25 ± °IC for 6-12 days and observed at different intervals for the mycelial growth. All Petri plates / glass tubes showing contaminations should be discarded and only the ones with pure growth should be retained for further use after ascertaining the purity and true to type nature of the culture.

Sub-culturing:

The pure culture of edible mushroom, once established either through spore culture or tissue culture technique, is maintained properly in cool atmosphere or a refrigerator.

Sub-culturing is done from time to time by aseptically transferring a small piece of growing pure culture along with the culture medium on the test tube slants containing same or other

suitable medium. The pure culture of a mushroom can be used for preparing master cultures for large scale spawn production on commercial scale..

Preparation of master culture / mother spawn Preparation of master culture or mother spawn is carried out under completely sterile conditions. Pure culture raised either from tissue or spores is inoculated in a suitable substratum (wheat, sorghum, or rye) which provides food to the mycelium. Ten Kg of wheat grains are boiled in 15 litres of water for 20 minutes. Water is then drained off and the grains are put over the sieve or on a wire mesh tray for 8-10 hours to dry or remove excess of water.

Grains are now mixed with gypsum (calcium sulphate) and chalk powder (calcium carbonate) at the rate of 2% and 0.5%, respectively on dry weight basis. 10 Kg of dry wheat grains will require about 200g gypsum and 50g chalk powder. This will help to check the pH of the medium and prevent sticking of grains with one another. The grains are filled into half or one litre glucose bottles or PP bags which are plugged with non- absorbent cotton and sterilized at 22 lb p.s.i pressure for 1.5-2 hours. Sterilized bottles are allowed to cool down overnight. Next day bottles are inoculated with the bits of agar medium colonized with the mycelium of pure culture. Inoculated bottles are incubated at 25 +/-1°C. After 7 days of inoculation, bottles are shaken vigorously so that mycelial threads are broken and become well mixed with the grains. Two weeks after inoculation, the bottles are ready as stock culture for further multiplication of spawn. One bottle of stock culture or master culture or mother spawn is sufficient to multiply 30-40 grain bottles or pp bags.

3.Multiplication of Spawn from Stock / Master Culture

Master spawn or master culture bottles / bags are further used for inoculation of large number of other grain bags / bottles prepared by the same technique and resultant is the commercial spawn. Generally, few mycelial coated grains from one master culture bottle / bag will be inoculated into 30 – 40 grain bags aseptically in front of the HEPA (High Efficiency Particulate Air) filters of a Laminar flow and then incubated in a room at for 25 +/- 1° C 12-15 days. The commercial spawn thus prepared is used for inoculating the compost beds as seed.

Cares to be taken

• Always keep the inoculation chamber and its surroundings very clean. • Switch on UV tube in the inoculation chamber for 30 minutes before inoculation by keeping sterilized substrate, forceps, and cultures inside the chamber. • Inoculation is always done near the spirit the spirit

lamp flame to avoid contamination. • The working person should swab his hands and inoculation chamber using alcohol. • Spawn should grow fast in the bottles, should be silky white in color and should never show fluffy growth. • All grains should be covered by the mycelial growth and fresh spawn should have mushroom odour. • Mother spawn should not be used beyond 3-4 generations as it starts degeneration. Fresh spawn gives higher yield; therefore, spawn should never be stored for more than a month. • All the bottles must be labeled indicating firms name, species, date of inoculation to know the age and type of spawn.

PREPARATION OF MOTHER SPAWN

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. Disease- free sorghum grains are used as substrate for growing the spawn materials. The various steps involving in preparation of mother spawn are listed.

- Soak the sorghum grains in clean water to remove chaffy and damaged grains.
- Cook the grains in a vessel for 30 minutes just to soften them.
- Take out the cooked grains and spread evenly on the platform to remove excess water.
- At 50% moisture level mix calcium carbonate ($CaCO_3$) thoroughly with the cooked, dried grains @ 20 g / Kg .
- Fill the grains in saline bottles up to 3/4th height (approximately 300-330 g / bottle), insert a PVC ring , bold the edges of the bag down and plug the mouth tightly with non-absorbent cotton wool.
- Cover the cotton plug with a piece of waste paper and tie tightly around the neck with a jute thread.
- Arrange the bags inside an autoclave and sterilize under 20-lbs. pressure for 2 hours.
- Take out the bags after cooling and keep them inside the culture room and put on the UV light.
- After 20 minutes put off the UV light and start working in the culture room. Cut the fungal culture into two equal halves using a inoculation needle and transfer one half portion to the bottle. Similarly, transfer another half portion of the culture to another bottle.
- Incubate the inoculated bottle, in a clean room under room temperature for 10 days. This can be used for bed spawn preparation.

MULTIPLICATION OF SPAWN

What is Spawn?

- In dictionary term “ spawn " actually refers to the fingerlings of fish, but here spawn means the vegetative mycelial network of a mushroom developed after the germination of one or more than one fungal spore (s) grown on a convenient medium. It comprises of the mycelial network along with a

supporting medium which provides nutrition to the fungus for its growth and development.

SPAWN PRODUCTION OF MUSHROOMS

Raising or procurement of Pure culture of mushroom.

- As already discussed in the earlier lesson,the pure culture of a fungus can be raised either by the spore print technique or the tissue culture technique. Once pure culture of a particular mushroom is established or procured from some reliable source, the process of production of mushroom spawn involves the following steps :

1. PREPARATION OF MASTER / STOCK CULTURE:

- Preparation of master culture or mother spawn is carried out under completely sterile conditions. Pure culture raised either from tissue or spores is inoculated in a suitable substratum (wheat, sorghum or rye) which provides food to the mycelium. Ten kg. of wheat grains are boiled in 15 litres of water for 20 minutes. Water is then drained off and the grains are put over the sieve or on a wire mesh tray for 8-10 hours to dry or remove excess of water. Grains are now mixed with gypsum (calcium sulphate) and chalk powder (calcium carbonate) at the rate of 2% and 0.5%, respectively on dry weight basis. 10 Kg of dry wheat grains will require about 200g gypsum and 50g chalk powder. This will help to check the pH of the medium and also prevent sticking of grains with one another. The grains are filled into half or one litre glucose bottles or PP bags which are plugged with non- absorbent cotton and sterilized at 22 lb p.s.i pressure for 1.5-2 hours. Sterilized bottles are allowed to cool down overnight. Next day bottles are inoculated with the bits of agar medium colonized with the mycelium of pure culture. Inoculated bottles are incubated at 25± 1ºC. After 7 days of inoculation, bottles are shaken vigorously so that mycelial threads are broken and become well mixed with the grains. Two week after inoculation, the bottles are ready as stock culture for further multiplication of spawn. One bottle of stock culture or master culture or mother spawn is sufficient to multiply 30-40 grain bottles or pp bags .

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UNIT 4

HARVESTING OF MUSHROOM

When harvesting mushrooms, the key is to balance letting your mushrooms grow in size so that you can get the biggest possible yield without them becoming too mature.

The most important thing to keep in mind is that bigger doesn’t always mean better!

As every mushroom species is different, the ideal point of the harvest will be different as well.

Signs that the mushrooms are mature are generally when the caps flatten or become convex with gills enlarging and starting to drop spores. However, sometimes you will have to learn through growing and experimenting, usually by harvesting too late a few times.

Harvesting Mushrooms: Extraction

When mushroom harvesting there are 2 techniques, cutting and pulling. Growers often debate this point, some claim that cutting is better while others prefer pulling. Let's break down each of these techniques so that you can decide which one will suit your style the best.

Note: Read more about fruiting mushrooms here.

Pulling Mushrooms from the Substrate
For the majority of the mushrooms growing from the ground, the best practice would be to pull them. After they are removed from the ground just trim off and discard the butt end that is covered with dirt, and your mushrooms are ready to go.


Mushroom Harvesting – Pulling

Studies have shown that there is very little difference between plucking and cutting mushrooms. However, it is believed that when the mushroom is pulled out from the substrate it will signal the organism sooner that the fruit body is gone so that it can divert energy into fruiting other mushrooms.

The advantage of using the pulling technique is that it will most likely prevent infections. When cutting, an exposed piece of the stem is left behind that can be a potential infection site for bacteria or other fungi.

Twisting and pulling mushrooms by hand is the easiest way to harvest some varieties such as button, oyster, cremini, chestnut, lion's mane, and pioppino mushrooms.

Note: We have a full guide on growing mushrooms here.

Cutting Mushrooms

The best practice for harvesting mushrooms that grow on trees like shiitake and reishi is to cut them with a sharp knife or scissors. Pulling them off could damage the tree, which may shorten the span of that mushroom's life either killing the tree earlier or making the defense system weak, which will leave an open sport for various infections that can ultimately out-compete the mushrooms for resources. Thus if you want your tree to continue producing mushrooms, use this harvesting technique.


Cutting Mushrooms for Harvesting

Mycologists recommend cutting the stem as close to the base as possible when harvesting mushrooms with a knife or scissors. Although, this depends on the type of mushroom you are harvesting. For example, if you are harvesting mushrooms that grow in small clumps with stems joined at the base, like chanterelles or oysters you can cut them off individually.

However, when harvesting some species like chestnut, pioppino, or oyster mushrooms where the individual mushrooms are tightly packed in the cluster it is best to cut the entire cluster off at the base. It is often impossible to harvest individual mushrooms from tight clusters without bruising or breaking other mushrooms.

How To Properly Store after Harvesting Mushrooms

Storing your mushrooms correctly will significantly extend their shelf life. When properly stored in the fridge they'll stay good for up to a week.

It's pretty simple just place a whole, unwashed mushroom in a paper bag and fold the top, enclosing the bag. Place the mushroom bag in the main compartment of your refrigerator, don't store them in the crisper drawer. The environment of a crisper drawer is moist and it will make your mushrooms go bad quicker.


Storing Mushrooms

There are also some other things to consider when putting your mushrooms in the fridge. Avoid placing them near foods that have strong odors or flavors because the mushrooms will absorb everything like a sponge. Don't stack other foods on top of them. In addition to looking unappetizing, bruised mushrooms won't keep for very long. Some mushroom varieties hold up better in the refrigerator than others, if you need to store them for more than a week consider dying or freezing them.

Freezing Mushrooms
When harvesting mushrooms, you can opt for freezing them.

Mushrooms freeze well and can last up to 12 months in the freezer, although it's best to get them in the freezer as soon as possible. Don't wait for your mushrooms to deteriorate in the fridge before deciding to freeze them. You can freeze raw mushrooms. However, it's not recommended as they won't keep their texture and often end up soggy when thawed.

The best practice is to cook or saute the mushrooms first, let them cool, and then pack them into airtight containers or ziplock bags and freeze them.

Dehydrate Mushrooms
In addition to freezing mushrooms, you can also dehydrate them. You can rehydrate dried mushrooms whenever you need them, and they take up little space in the pantry. In order to dry your mushrooms correctly, use a food dehydrator or a low-temp oven. Once dried keep them in an airtight container until it's their time to be consumed.

How To Dry Your Mushrooms for Harvest

The versatility of dehydrated mushrooms when harvesting mushrooms cannot be overstated! Let's learn how you can easily dehydrate your own mushrooms so that you always have some on hand!

Harvesting Mushrooms – Preparation
To prevent contamination, make sure you sanitize your hands, counters, and equipment before you start preparing your mushrooms. The next step is to clean the mushrooms using a damp kitchen towel to remove any dirt or grit from your mushrooms. Avoid washing them, as

it can cause your mushrooms to darken during the dehydrating process. Next, remove any stems that seems tough, and slice the mushrooms using a sharp knife into 1/4 slices, or dice them into small pieces.

Let's Dehydrate


Drying Mushrooms

This is a fairly simple and straightforward process. Arrange the mushrooms on the dehydrator trays. Remember to leave some space between the pieces to allow the air to circulate. Dehydrate at 125F° for approximately 4-8 hours or until the mushrooms are brittle.

If you are using an oven, place the mushroom slices on top of a baking sheet and set up the oven at its lowest temperature. If possible keep the oven door slightly opened to allow steam to escape. Flip the pieces every hour and remove them as soon as they are dry.

Crushing Mushrooms into Powder – Harvesting Mushrooms

Some people like to crush their dried mushrooms into a powder and use it as a supplement. This practice is most common with medicinal mushrooms such as lion's mane, chaga, reishi, cordyceps, and turkey tail.

Mushroom powders can be put into capsules and swallowed, or mixed with hot drinks such as your morning coffee. Some people sprinkle this healthy powder on top of their salads or use them as a seasoning while cooking.

The Bottom Line

After you adequately harvested your mushrooms it's important to store them properly. Fresh mushrooms don't last very long and are best enjoyed right away.

Unwashed, whole mushrooms can be stored in the fridge for up to 10 days. If you want to store them any longer than this, you will have to use other preservation methods.

Mushrooms could be frozen or dried in order to increase their shelf life. This way they could be stored for up to 12 months!

Mushrooms can be used in so many ways that having a surplus should never be a problem.

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 –4 oC), 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 4-5 o 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 forcedchill 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 0-2 oC 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 nonperforated 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.

CANNING Canning is the most common process for preserving mushrooms. For this, cleaned mushrooms are placed in cans containing 2.5 % sodium chloride and 0.25–0.5 % citric acid. The cans are then sealed and sterilized in autoclave for one hour at 100-120ºC. It is one of the best long term storage. Agaricus mushrooms. Canning is divided into six basic operations: cleaning, blanching, canning, sterilization, cooling, labelling and packing. Trimming the steps immediately after harvest can reduce Browning and blemishingof Agaricus. If the mushrooms are not canned immediately before processing then, refrigeration at 1-5 o C along with high RH will help in retaining colour and texture. Soaking for30 minutes prior to canning may increase canning yield. At this stage, an appropriate level of sodium meta-bisulphite or ascorbate is incorporated for colour retention. The mushrooms are then rinsed and blanched for 2 minutes. Blanching is used to reduce the activity of enzymes. After blanching, the mushrooms are placed in cans containing 2.5 per cent sodium chlorideand 0.25–0.5 per cent citric acid. The cans are then sealed and sterilized. Sterilization methods vary according to the type of equipment used. The most commonly used method is the batch process in which the cans are placed in an autoclave and sterilized for an hour at100-120 o C

DRY FREEZING

If you're a mushroom lover, you'll thank yourself if you stock up on your favorite varieties of mushrooms when they're in season. Then freeze them until you're ready to use them in all your favorite dishes and to ensure you don't waste a single one if you have some on hand.

Choose mushrooms that look and smell fresh. Mushrooms that are dry, shriveled, darkened, moldy, have bad spots, or give off an unpleasant odor should be avoided. Only freeze mushrooms that are in good condition.

Clean and Prep

Wash your mushrooms in cold water and trim off the ends of the stems. Mushrooms more than one-inch across should be sliced or quartered.

Freezing will change the color and texture of mushrooms, making them both darker and softer.

Steamed mushrooms have a longer freezer life than sauteed mushrooms.

Cooking for Freezing

Mushrooms should be cooked before freezing. There are two ways to accomplish this:

Sauteeing: Heat the mushrooms in a frying pan with a small amount of butter or oil over high heat. Cook them for about five minutes, or until the mushrooms are fully cooked, and most of the liquid has evaporated.

Steaming: To minimize the darkening effect of steaming, soak the mushrooms in a solution of one teaspoon lemon juice or 1 1/2 teaspoons of citric acid to one pint of water for five minutes. Then steam following these recommended times:

- Whole mushrooms: 5 minutes
- Button mushrooms: 3 1/2 minutes
- Quartered mushrooms: 3 1/2 minutes
- Sliced mushrooms: 3 minutes

Flash Freeze for Best Taste

Allow the mushrooms to cool completely. Then spread them out on a cookie sheet and flash-freeze them. Once they're completely frozen, use a spatula to lift the mushrooms from the cookie sheet. Then pack the mushrooms in freezer-safe containers or bags, leaving a half-inch of headspace for expansion, and return them to the freezer.

Squeeze out as much air as possible before you seal the containers. It will help to prevent freezer burn. Frozen mushrooms should be used within a year, though sooner is better.

Use a FoodSaver from Amazon to vacuum-pack your mushrooms. Since they have a high water content, mushrooms are more prone to freezer burn than other foods.

Note that sometimes washing mushrooms can make them soggy and lead to freezer burn. Some people prefer to simply brush or wipe them off prior to sticking them in the freezer.

How to Use Them

Drop the frozen mushroom pieces directly into recipes that will be heated or thaw the mushrooms in the refrigerator before you use them. Since you froze your mushrooms individually, you'll be able to scoop out just what you need for your recipe.

More Ways to Preserve Mushrooms

If your fresh mushrooms don't last as long in the fridge as you'd like them to, it could be the way you're storing them. Avoid stacking things on top of them to avoid bruising, and keep them away from strong-smelling items as mushrooms are like sponges and will absorb the scent.

If your freezer space is limited, try purchasing dried mushrooms—or dry them yourself—instead of freezing fresh ones. They're easy to rehydrate when you need them and take up very little space.

Freezing Steamed Mushrooms

Wash the mushrooms thoroughly in cold water and pat them dry. Hold the mushrooms under cool running water and wash a few at a time, massaging away bits of dirt with your fingers. You can also place the mushrooms in a colander and rinse them all at once. Pat them dry with a paper towel.[1]

- Button and cremini mushrooms are more sturdy, but be extra careful when working with lion's mane, enoki, and oyster mushrooms—wash these varieties while they're still attached to the larger base and then pull them off and wash them again, if necessary.

Place the mushrooms into a lemon juice solution for 5 minutes. Combine 1 teaspoon (4.9 mL) of lemon juice with 16 fluid ounces (470 mL) of water and stir it together. Then, place each mushroom into the solution and let them sit for 5 minutes. Pat them dry with a paper towel after you take them out. If you don't mind the mushrooms darkening, skip this step.[3]

- Treating the mushrooms with this solution will help them retain their color instead of darkening as they cook.

Trim off the ends of the stems and slice the mushrooms, if necessary. If the mushrooms are larger than 1 inch (2.5 cm) across, use a sharp knife to slice them into quarters. Feel free to cut them into halves or small slivers, just try to keep all the pieces the same size and thickness.[2]

- Avoid slicing them with a serrated knife because it will be hard to make them even.

Bring 2 inches (5.1 cm) of water to a boil in a steamer pot with a basket. Fill the bottom of the steamer pot with 2 inches (5.1 cm) of water and bring it to a boil. Choose a steamer pot that has a lid for even and efficient steaming.[4]

- Make sure the holes in the steamer basket aren't so large that your mushroom pieces can fall through.

Put the mushrooms in the basket, lid the pot, and steam for 3 to 5 minutes. Around the 3 to 5-minute mark, poke the mushrooms with a fork to test for doneness. It should go all the way through but you should feel a little resistance from the meaty insides. The steaming time will depend on the size of the mushrooms.[5]

- Slices and quarters will take about 3 minutes while whole mushrooms can take up to 5 minutes to steam all the way through.

Transfer the mushrooms into a container. Choose a large plastic or freezer-safe glass container with a fitted lid. Leave about ½ inch (1.3 cm) of headspace in the container.[6]

- You can also use a plastic freezer bag to store the mushrooms.

Allow the mushrooms to cool for 30 minutes to 1 hour. Let them cool off on the kitchen counter while you clean up the kitchen or do something else for a while. The mushrooms are ready for freezing when they're cool to the touch.[7]

- Cooling them is important before putting them in the freezer because the heat may cause other items in the freezer to partially thaw and refreeze.

- **Store the container of mushrooms in your freezer for up to 1 year.** Place the container toward the back of the freezer because that area experiences fewer temperature changes when the door is opened. They'll keep for up to 1 year.[8]

UNIT 5

BACTERIAL DISEASES OF MUSHROOMS

1. Bacterial blotch and bacterial pit diseases of white button mushroom:

Symptoms:

- Circular but irregular, yellowish spots appear superficially on or near margin of the cap of a wet mushroom which enlarge rapidly under high humidity conditions and coalesce to form bigger rich chocolate brown spots that are slightly depressed and slimy.

Causal organism:

- The pathogen *Pseudomonas tolaasii* can devastate the crop of button mushroom and *Psilocybe sp*. The bacterium has cylinderical (Bacilli) and spherical forms (Cocci) with its cells measuring 0.4-0.5x1.0-1.7 µ in size, with either one or more flagella (motile hairs) attached at one or both the ends for locomotion. The bacterium is gram negative in character
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Fruit bodies showing blotch symptoms

Epidemiology:

- The casing ingredients and air borne dust particles are the primary sources of infection .Under high humidity and damp conditions, bacterial population increases on cap surfaces and cause the disease. The bacterium remains suppressed in the compost, casing , tools and debris under dry conditions, but it becomes active under high humidity conditions and further spreads through worker's hands, tools, mushroom spores, debris, water splash, flies, mites etc.

Control methods:

- Avoid heavy water sprays during rainy season, introduce fresh air immediately for about one hour after water spray and ensure that water droplets do not remain on the cap surface, remove all the diseased fruit bodies and spray bleaching powder (0.015 %) on the cropping beds at 7 days interval.

II. Bacterial disease of Oyster mushroom:

Yellow Blotch:

- The yellow blotch disease of *Pleurotus spp.* is caused by *Pseudomonas agarici.*

Symptoms:

- Disease appears as blotches of various sizes in pilei, yellow hazel brown or organic in colour. The infected fruit bodies turn yellow and remain stunted, turn slimy and start giving foul smell.
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Fig. 13.43 shows: Symptoms of yellow blotch disease of *Pleurotus sp.*Caused by Pseudomonas agarici

Control methods:

- Same as suggested for controlling bacterial blotch disease of button mushroom.

3) VIRAL DISEASES OF MUSHROOMS:

- Diseases due to mushroom viruses are also known as La France, Die back disease and Mummy disease .

Symptoms:

- The viral diseases are not detectable during spawn – run stage; the initiation of pinheads is inhibited and vigour of mycelium severely reduced; yield is drastically reduced, mushrooms appear with distorted shape, delay occurs in appearance of first flush, sporophores with elongated stem and small caps giving drum stick like appearance and tilted towards one side appear, mushrooms appear in patches, prematrure opening of veils, watery stipe and streaking in the stipe. In case of oyster mushroom, dwarfing or elongation of stem has been observed whereas, no detectable symptoms appear in infected *Volvariella sp.*

Sources of Infection:

- Infected mycelium and spores released from infected mushrooms are the primary sources of infection. These viruses further disseminate through worker's hands, equipments, infected spawn / mycelium present in the trays / bags and spent compost etc.

Control methods:

- Complete hygiene, use of disease free spawn, frequent disinfection with formaldehyde, aeration strictly through high efficiency filters, cook out of exhausted compost at the end of the crop with live steam at 70-71 º C for 10-12 hours, regular disinfection of equipments, wearing clean and changed clothes everytime while entering a mushroom house, harvesting of mushrooms before opening when the veil is intact, visitors to be discouraged, wooden trays and shelves to be washed regularly with 4 % sodium pentachlorophenate solution, growing of resistant strains like *A. arvensis* and *A . bitorquis* have been recommended.

Major Insect, Pest, Weeds and Diseases of Mushroom Insect pests:

Many insect pests attack the mushrooms that belong to the Order Diptera. These included the Phorid fly and the Sciarid fly; Mites are also a common problem. Rats are also a problem as they eat the mushroom bags along with the spawn layers (Kashanguraet al., 2005).

a) Flies:

i)Phorid fly: Megaselia halterata and Megaselia tamilnodolensis

ii) Sciarid fly: Lycoriellamalli

Damage: The larvae feed on the mycelium and show rotting patches in the beds. Young buds are also eaten by the larvae. They also tunnel into the grown-up mushroom and cause rotting of the mushrooms. The flies spread the disease from one bed to another.

Favourable conditions: The temperature of 16-24 is highly favourable and moisture contents of 70 % and above show more incidences. It's more severe in button mushroom cultivation when compared to oyster and milky mushrooms.

b) Beetles: Black beetle: Sacphiso manigrofaceatum Brown beetle: Sacphiso mapictummotschulsky - Golden lines seen on the body of the insect. Both feed on young buds and grown-up mushrooms by scrapping the tissues. They mainly transmit the bacterial blotch disease from one bed to other.

c) Spring tails / Columbolas:

Tiny insects with stout antennae feed on the mycelium and buds. Lepidocyrtuscyaneus and Isotoma simplex.

d) Nematodes: Nematode infestation is more severe in button mushrooms. The following two nematodes are very commonly noticed: Ditylenchus mycelophagus and Aphelenchoides composition.

e) Mites: In addition to insect pests, two mites very severely feed on the mushroom spawn as well as on mushroom buttons. They are

i) Tarsonemid mite- Tarsonem usmyceliophagu sand T. floriculusfeed on mycelium and transmit the diseases.

ii) Tryoglyphid mite- Tyrophagus lintneri, andTyrophagus longior.

Integrated Pest Management: • Bed moisture content should be around 60-65%.

- Fix insect-proof nets in the windows.

- In button mushroom, the newspaper should be treated with 0.1 % formalin

. - Fix white insect traps to attract the flies.

- Spray malathion @ 1 ml./ lit. or dichlorvos 0.5 ml/lit. in the floor and sides to kill the flies and beetles, never spray on the mushroom beds and buttons.

Weeds, moulds and Diseases Viruses, molds and bacteria may also compete with the mushroom mycelium thereby decreasing production (Chiu et al., 1998).

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

It produces dark blue to violet coloured buds with a long white thin stalk, with opens in a few days and disintegrates as a black mass of tissues, covering the entire bed, thus arresting the growth of spawn, development of young buds. The entire bed becomes black in colour show the rotting of the spawn.

Management:

- Remove and destroy the infected beds immediately.

- Avoid chemical methods of sterilization as this process leads to more weed growth.

b) **Green moulds**: Mainly Trichoderma viride is severe both in beds and on mushroom buds. In addition, Penicillium and Aspergillus spp. may also cause mouldy growth on the beds. The infection leads to the development of green colour patches in the beds, which spreads quickly and the entire bed is covered fully with green growth, which completely arrests the spawn from running. This is due to improper sterilization of straw and bed preparation with more moisture.

Management:

- Avoid using damaged and old straw for bed preparation.

- Remove and destroy the infected beds immediately.

- Avoid preparing beds with more than 70 per cent moisture.

c) Fungal diseases:

In addition to the above fungal diseases, some other diseases in the mushroom beds are

i) Dry bubble- Verticillium malthouseiand V. psalliotae

ii) Truffle- Pseudobalsamiamicrospora

iii)Mildew/ Cobweb- Dactyliumdendroides

Management:

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

(c) Bacterial blotch/ bacterial pit / brown blotch: This disease is caused by a bacterium, Pseudomonas tolassi. It produces pale-yellow spots on the surface of the pileus, which later turn brown. Pits are often found just below the surface. This disease also causes considerable damage in storage and transit. The incide nce is more when the mushrooms are watered heavily in the early bud stage. Because of very high humidity film of water is always present on the surface of buttons leading to browning and rotting, emitting a foul smell. Possibly the Tyroglyphus mites carry the pathogen from one bed to other. In addition, the water splash from the infected bed also carries the bacterial inoculums.

Management:

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

e) Viral diseases:

Complex viruses cause a disease variously called the Brown disease/ watering stipe/ X-disease or dieback disease. It is difficult to diagnose the disease based on symptomsdrumsticks like mushrooms and premature opening of veils- because similar symptoms can also be caused by certain environmental and cultural conditions. Even the virus infection may be symptomless. Reduction in the yield of mushrooms is perhaps the most reliable symptom. The other symptom commonly associated with the infected crop is the slow and depressed growth of the mycelium isolated from the infected mushroom. Transmission of the virus is through mushroom spores and spawn. In addition, phorid larvae and tarsenomid mites also act as vectors for this complex disease.

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