Bachelor of Science
(B.Sc. – CBZ)

Mushroom Culture Technology
(DBSZSE101T24)

Self-Learning Material
(SEM 1)

Jaipur National University
Centre for Distance and Online Education

Established by Government of Rajasthan
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COURSE INTRODUCTION

The course is designed to impart fundamental knowledge about mushroom growing; to be able to cultivate mushrooms naturally; and to make sustainable use of resources. In order to encourage self-employment, this course also offers hands-on training in the cultivation of mushrooms, gain knowledge about diverse cropping patterns, the numerous facets of production, including the identification and sustainable management of pests, diseases, and weed mushrooms.

Course Outcomes: After completion of the course, the students will be able to:

1. Able to grow mushrooms in a natural way
2. Learn sustainable use of resources
3. Gain practical experience on cultivation of mushrooms
4. Understanding the various aspects of cultivation
5. Learn different cropping patterns
6. Understand how to identify and sustainably manage pest and diseases and weed Mushrooms.

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UNIT - 1

INTRODUCTION TO MUSHROOM

OBJECTIVES

Upon completion of course student will be able to:

1. Describe mushrooms with number of classes that exist worldwide.
2. Discover if mushrooms are classified as plants or animals and how they manage to thrive in the wild;
3. Comprehend the background of mushroom growing and the advantages it offers to both farmers and the environment;
4. Enumerate the health benefits of eating mushrooms;
5. Summarize the fundamental stages of mushroom farming.

Farmers' incomes from conventional agriculture are declining. A farmer must plant a variety of crops in order to achieve agricultural diversity, which is necessary to guarantee a steady revenue each year.

Mushroom farming is an easy and indoor activity, as opposed to plant agriculture. In natural settings, mushrooms can be grown at a specific season. Under regulated conditions, mushrooms can be grown all year round. Another benefit is that mushroom cultivation requires relatively little land.

You have probably noticed that numerous mushrooms just seem to appear after a rainstorm, especially in grasslands that are close to manure piles, dung, or decaying wood or straw. It is important to remember that not all mushrooms found in the wild can be eaten. There is currently no easy way to distinguish between edible and non-edible mushrooms. Certain mushrooms are useful medicinally. As many mushrooms are toxic in nature, it's critical to cultivate edible mushrooms.

1.1 Mushroom cultivation

Mushroom cultivation is important as it describe what mushrooms are and the number of species that exist worldwide. Discover if mushrooms are classified as plants or animals and how they manage to thrive in the wild; comprehend the background of mushroom growing and the advantages it offers to both farmers and the environment; enumerate the health benefits of eating mushrooms; summarize the fundamental stages of mushroom farming.

1.2 What are Mushrooms?

Many people exclusively associate button mushrooms with the word "mushroom" (Fig. 1.1). This is particularly applicable in the West, & where agaricus or button mushrooms are for almost all of the mushroom business in Europe & UK and other nations to western world. There are various forms of edible and non edible mushrooms. In actuality, nature has thousands of distinct types of mushroom

Fig. 1.1 Button Mushroom

In contrast to higher plants, mushrooms lack chlorophyll, the green substance (chlorophyll) found in leaves that aids in the synthesis of food by the plant using carbon dioxide, water, and solar energy. Because they lack chlorophyll, mushrooms are unable to grow their own nourishment and must rely on larger plants. Straw, dead wood, manure, dung, and other organic materials are sources of nutrients for mushrooms.

Workers in the past thought of mushrooms as plants. We now understand that these are neither animals nor plants. Plants are descended from lower organisms through evolution.

Not long later, the animals and fungi split apart as well (Fig. 1.2).

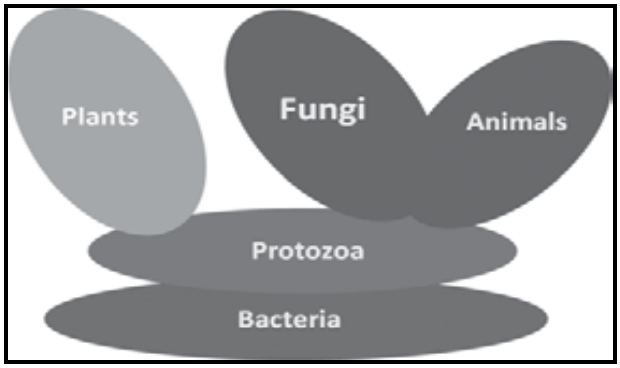


Fig. 1.2: Evolution of five kingdoms of organisms on Earth

Plants produce nourishment on their own. Animals and fungi both rely on other creatures for food. Plant cell walls are not like those of mushrooms. Animals lack cellular walls. Owing to these traits, as well as the ways in which they feed, grow, and reproduce, among other factors, researchers have classified all fungi into a distinct kingdom.

1.1.2 TYPES OF MUSHROOMS

After insects, fungi are the second biggest group of living things. Merely a few of these are known to us. An estimate places the number of fungi in the globe at roughly 15 lakh (Fig. 1.3). Only 1.1 lakh fungi have been researched by scientists, of which 14,000 are stared as

mushrooms. (there could be actually be 10 times of this). Nevertheless, we have not been able to study all.Not every mushroom can be eaten. Some even have toxic properties. Only 3,000 of them have been deemed to be genuinely edible. It is not possible to cultivate every one of these, though. Only about 200 species have been successfully cultivated experimentally by us, out of that 60–70 are grown in a commercial way and roughly 10 are grown on an industrial basis.

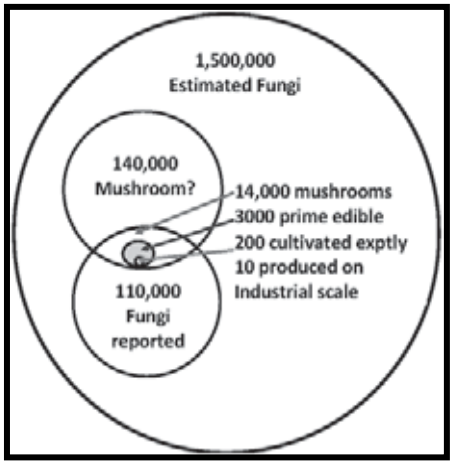


Fig.1.3: Projected and truly fungi and mushrooms

1.3 HOW MUSHROOMS SURVIVE IN NATURE

Mushrooms basically are fruiting body of fungi. Moreover, a significant portion of a mushroom grows in a shape of tiny threads that resemble wood or have cottony appearance (Fig. 1.4a).

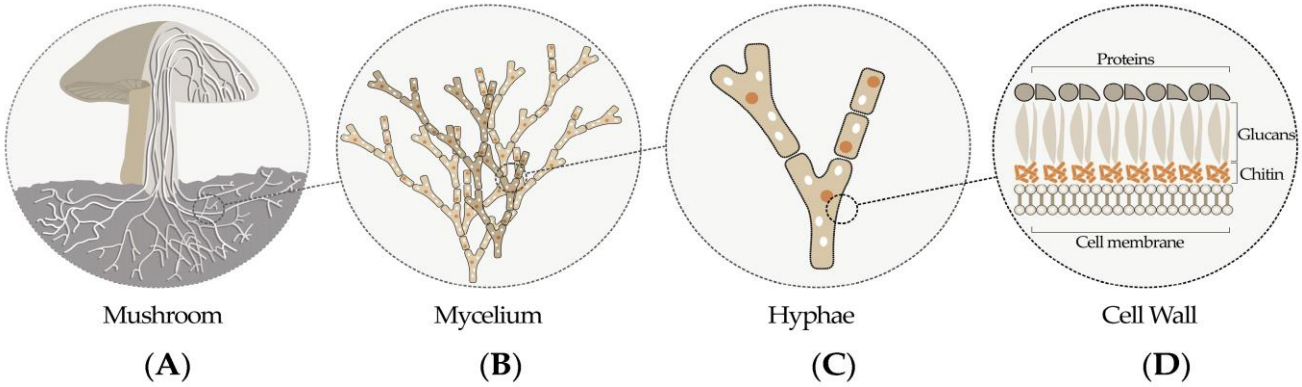


Fig 1.4(a) Schematic Appearance of Mycelium (A) Mushroom (B) Mycelium (C) Hyphae (D) Cell wall of hyphae (adapted from https://www.nature.com/articles/srep41292.pdf).

Various parts of mushroom are shown in Fig. 1.4 b

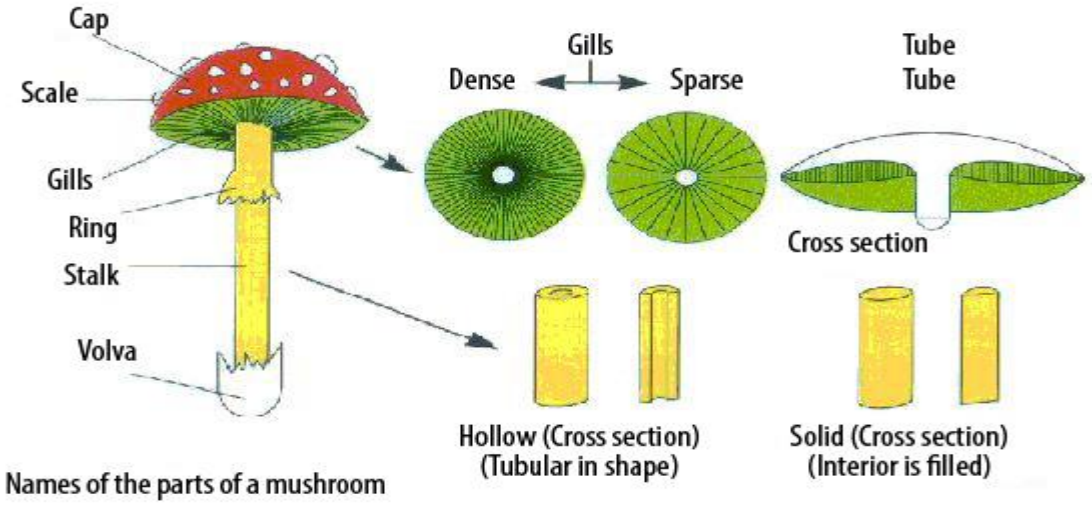


Fig 1.4(b) Detailed structure of the Mushroom

The term "mycelium" refers to these tiny threads. Mycelium in a single cubic centimeter of soil can reach lengths of up to 13 kilometers. These strands come together to create pinhead-sized structures, which enlarge into mushrooms. The spores produced by these fruiting structures aid in the fungus's distribution.

Spores are produced by mushroom they germinate in soil and wood by spreading of mycelium. During optimum conditions the mycelium cracks into fruiting bodies, which is known as mushroom.

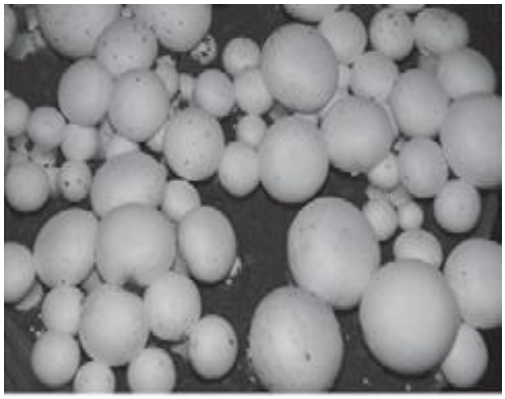
But remember that not all the fungi are called as mushrooms. Many of the fungus aid in the growth of trees in forests, provide medication, and support farmers by turning trash into compost. Numerous fungi can also infect plants and animals, causing illnesses. As previously stated, not all mushrooms are edible. While certain mushrooms are useful medicinally, others are not healthy for eating. We'll talk about various edible and therapeutic mushrooms in this book.

1.4 HISTORY AND PRESENT STATUS

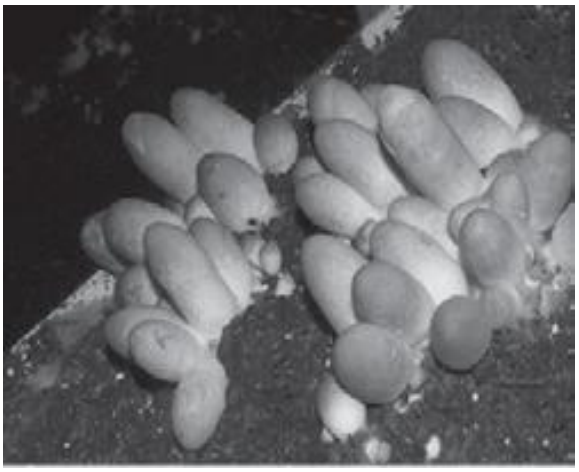
More than a millennium ago, approximately 400 years ago, button mushrooms were grown in France while wood ear, winter, and Shiitake mushrooms were grown in China on wooden logs. However, button mushrooms were the most widely grown fungus in the early years of scientific mushroom farming, which began around the turn of the 20^{th} century. Many more mushrooms were subsequently brought under cultivation. Approximately 80% of the world's mushroom production in 1960 came from the cultivation of white button mushrooms, with Shiitake accounting for 15% and other species contributing barely 5%.

Output of button mushrooms has increased over the years, but other mushrooms have grown far more as a result. As a result, button's proportional involvement in the world creation is currently only 15%, and it is no longer the most widely used mushroom in the world. The most popular grown mushroom right now is Shiitake (Fig. 1.5). Ninety percent of the world's total mushroom crop is produced by six species: shiitake (Lentinula), oyster (Pleurotus), wood ear (Auricularia), button (Agaricus), winter mushroom (Flammulina), and paddy straw mushroom (Volvariella). Approximately 60 different varieties of mushrooms are grown in China now, accounting for about 85% of the 40 million tons of mushrooms produced worldwide. In India, the four primary varieties of mushrooms that are grown are button, oyster, paddy

straw, and milky.



Button Mushroom Milky Mushroom



Oyster Mushroom Paddy straw Mushroom

Fig.1.5: Cultivation of Mushrooms in India

Button accounted for three-quarters of the projected 2.8 lakh tonnes of total mushroom production in India in 2021 (Fig. 1.6). Mushrooms, such as morels and its varieties, are still gathered from the forests since we are unable to successfully cultivate them in our nation.

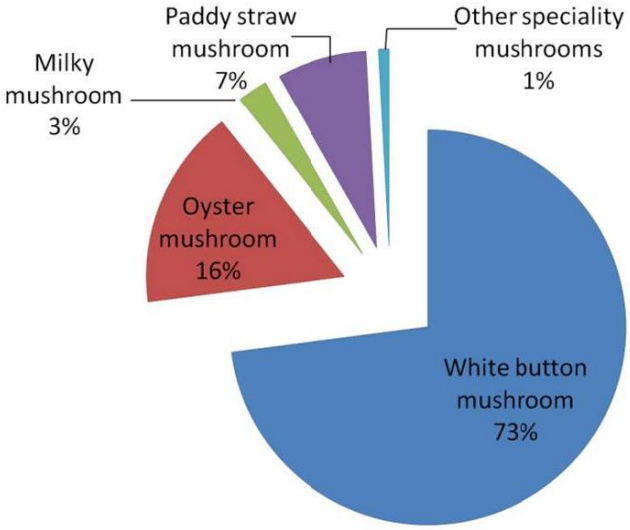


Fig. 1.6: Diversity of species of mushroom in India

Button mushrooms are newly introduced as a cash crop. The low temperature needed for button mushroom cultivation was naturally present in the hilly regions of Himachal Pradesh and J&K, therefore cultivation of these mushrooms began in the middle of the 1960s in India. Later, additional areas began to cultivate it under regulated circumstances. Currently, our nation uses a combination of high-tech industry and seasonal farming for its mushroom production. India produced just 5,000 tons of mushrooms in 1990; by 2010, that number raised to almost 1, 00,000 tonnes, & by 2016, it reached 1, 30,000 tonnes. The mushroom production in 2023 was 201000 tonnes and to grow at the rate of 30 % annually.

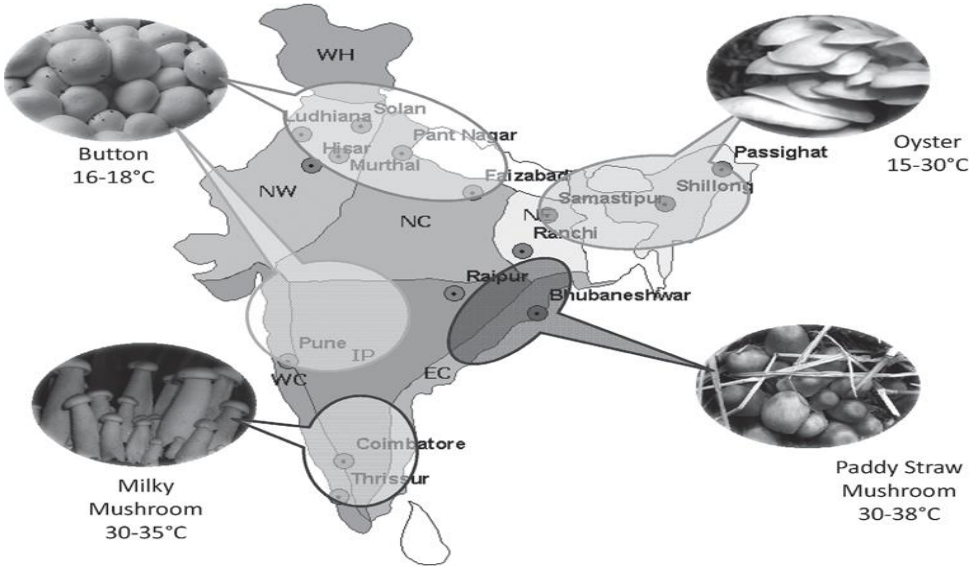


Fig. 1.7: Major areas of cultivation of different mushrooms in India

Button mushrooms are grown all year round by commercial growers and seasonal growers in the winter. Gujarat, Goa, Haryana, Maharashtra, Punjab, Uttrakhand and Himachal Pradesh are states with higher agricultural production (Fig. 1.7). While milky mushrooms are more common in southern India, paddy straw mushrooms are only grown in Odisha. Despite being grown throughout the nation, oysters are more popular in the East. There are numerous oyster varieties and the greatest numbers of these mushrooms are being cultivated worldwide. Fig. 1.8 depicts the areas globally where mushrooms are grown .

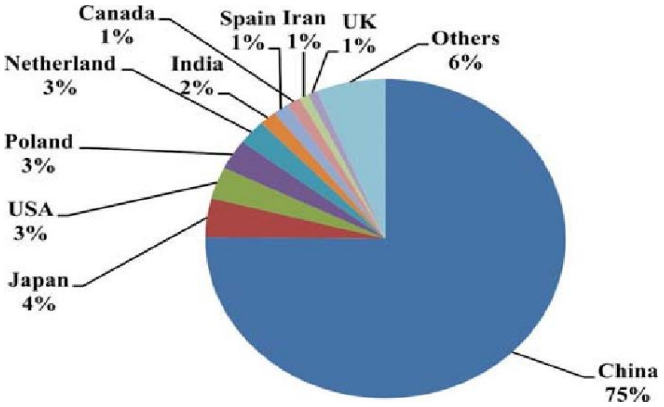


Fig. 1.8: Global status of mushroom-production-2019

1.5 WHY MUSHROOMS

We only created food in the nineteenth century in order to survive. Convenience was a major factor in the last century when we produced enough food in many parts of the world. For instance, items that were ready to eat and cook were widely accessible. The 21st century will be characterized by functional foods—that is, meals that provide us with the calories we need

while also containing substances that are good for our health. We shall see that mushrooms are a great fit for this category when we learn about the benefits of eating mushrooms.

In addition to being a high-quality food, mushrooms can be used to make money out of agricultural waste. Spent mushroom substrate (SMS), the material left over after growing mushrooms, can be turned into manure. Therefore, growing mushrooms is a crucial way to support farming that is based on manure and is sustainable. It has also been claimed that adding leftover mushroom substrate improves the health of the soil. Growing mushrooms is justified simply by the fact that they can be grown on a variety of agricultural wastes, including paddy straw, many of which are simply burned. Growing mushrooms not only results in the production of high-quality food, but it also benefits the environment.More significantly, it promotes women's empowerment and the creation of jobs. Since mushroom farming uses vertical area and doesn't need much land, it is conceivable to develop mushrooms in both urban and peri-urban locations when the land becomes smaller due to population growth. According to some estimates, mushrooms produce the most protein per unit area per unit time.

1.6 Health Benefits of Mushroom

Our forefathers were gathering mushrooms from fields and forests. In several civilizations, they were regarded as royal cuisine and were regarded as a delicacy. Following their production, mushrooms are now widely accessible to everyone. We now know that they are nutritious foods of high quality. In actuality, some of the tastiest vegetarian foods are recipies made of mushrooms. With its excellent digestibility and necessary amino acid content, mushrooms are a significant source of protein. Every of nine essential amino acid needed by humans are found in mushrooms. Undernourishment is an issue in our nation. Mushrooms have the potential to help solve this issue.

Due to their low fat content and some chemicals (such as lovastatin found in oyster mushrooms) that are known to decrease blood cholesterol, mushrooms are heart-healthy. Furthermore, because mushrooms are high in potassium and low in sodium, they are a good meal choice for people with high blood pressure. Being low in fat and high in protein mushroom are good for heart, also are good for people suffering from BP as they are low in sodium.

Due to their low calorie content, lack of starch, and plenty of antioxidants, mushrooms are a favorite food among diabetics. These are beneficial for the intestines and digestive system

because they are high in fiber content. They are also an excellent source of vitamins, particularly the vitamin B complex. The only vegetarian source of D vitamin is mushrooms. Mushrooms that have been harvested and exposed to sunshine or UV light will have a significantly higher vitamin D concentration. Additionally, these contain vitamin B12, which is not found in plants. These are also abundant in minerals, such as anti-cancer selenium and heart-protective copper (Table 1).

Table 1: Health benefits of different constituents of Mushroom

Characteristics	Benefits
Increased protein content	Combats malnutrition
Reduced sodium high potassium	Controlshypertension
No starch and sugar	Delight of diabetics
Cholesterol absent	Healthy heart
Fibre Rich	Improves digestion
High Vit.D	Cures Ricketssia
Presence of Folicacid	Improves health
Ascorbic acid present	Antioxidant
Low calorie food	Reduces obesity
Selenium present	Anticancer property

Consuming mushrooms stimulates the human immune system and several of them are known to have therapeutic and antiviral qualities. Many mushroom compounds have been used in cancer studies, and some of them have even been shown to lessen the negative effects of chemotherapy and radiation treatment. A summary of the advantages is provided in Fig. 1.9. As was previously said, mushrooms are readily absorbed. We now understand that these are healthy foods because they can satisfy our dietary needs.

1.7 ABOUT MEDICINAL PLANTS

Approximately thirty percent of global trade currently involves medicinal mushrooms. However, we have just lately begun to cultivate therapeutic mushrooms in India. Certain

species, such as *Cordyceps sinensis*, also known as keera ghaas, are harvested and sold from the forest. In our nation, some farmers have begun to cultivate *Cordyceps militaris*. The reishi mushroom, or *Ganoderma*, has a standardized cultivation method, but it is not being pushed because it is known to cause diseases in a variety of tree species. In our nation, edible mushrooms continue to be a major priority.

Several medicinal mushrooms, including *Lentinus edodes, Grifola frondosa, Schizophyllum commune, Ganoderma lucidum, Trametes versicolor, Inonotus obliqus, Flammulin avelutipes, Phellinus linteus, and Cordyceps sinensis,* are the subject of ongoing research worldwide, including human trials. *Ganoderma* is arguably the most well-known medicinal mushroom.

1.8 BASIC STEPS IN MUSHROOM CULTIVATION

The technique used in mushroom cultivation varies. Before beginning to cultivate any type of mushroom, one must have a thorough understanding of the life cycle of mushrooms and a solid training program. But for most mushrooms, the basic stages are the same (Fig. 1.10).

Fig.1.10Three steps in mushroom cultivation

i**. First stage**: The first thing to do before beginning cultivation is to obtain or create high-quality spawn.

ii. **Second stage**: The preparation of a high-quality substrate is the second step. The procedure of preparing the substrate varies depending on the species of mushroom to be farmed, as we will see in the next chapters. The process of spawning, which involves combining spawn with compost, and the quantity of spawn needed for each type of mushroom will differ. Sometimes spawn is poured layer-by-layer, while other times it is blended entirely. In certain circumstances, such as those where the substrate has been autoclaved, spawning can only take place in sterile conditions. However, in other circumstances, spawning can occur in the open under hygienic conditions. For every 100 kg of compost, we only need half to one kg of spawn for button mushrooms; however, for oyster mushrooms, we need 2.5 kg, and for milky mushrooms, we can need up to 5 kg of spawn.

iii. Third stage: Cropping is the third stage. We take action to encourage the formation of mushrooms after the spawn run, which is the process of allowing the fungus to spread across the substrate. In certain situations, fruiting can be produced without the need for a layer of casing material, but in other situations, it is. In any situation, some kind of adjustment is necessary to bring about fruition. For instance, in the case of button mushrooms, fresh air is introduced to reduce carbon dioxide levels and lower the temperature from 25 to 17°C. Diffuse light and fresh air are both required for oysters to fruit.

In India, growing mushrooms in rural areas has become a popular pass time for women, landless people, educated individuals, and school dropouts. With the increasing need for high-quality food, growing mushrooms has become a significant hobby. In several regions of our nation, there are also numerous commercial facilities that cultivate mushrooms under controlled circumstances. But before beginning this endeavour, one must have a solid understanding of the field and a scientific aptitude for agriculture.

1.8 BASIC TERMS

- Agaricus bisporus: Mushroom with white buttons.
- Ascomycetes: A significant class of fungi with fruit bodies that resemble sacs called ascus.
- The scientific name for wood ear mushrooms is Auricularia.
- Bagasse is the crushed, juiceless residue left over after sugarcane is milled.
- A significant class of fungi called basidiomycetes has basidia in their gills.
- Bran: The cereal grain's outer coating that split off from the kernel.
- Casing: A layer of material placed on top of a substrate, usually made of soil or peat mass, with the purpose of controlling the compost's humidity and promoting the growth of mushrooms.
- In the context of button mushrooms, compost refers to material made by combining straw, chicken dung, gyspsum, etc. in a certain amount and fermenting it in a particular way under aerobic condition.
- Aerobic: With fresh air and oxygen present.
- Anaerobic: Without oxygen or clean air.
- Culture: The sterile cultivation of mushroom tissue in a media.
- Flush: A term describing the sporadic appearance of mushrooms. A mushroom's life cycle, beginning as soon as its heads emerge from the casing.

- Fruit body: The sexual spore-bearing mushroom structure of fungi.
- Gills: The underside of the mushroom cap contains spores with thin blades.
- Grain spawn is made of sterile grains that have been injected with spores or mushroom culture. The mycelium that emerges from the spores feeds on the grain.
- Shiitake, a common Japanese name for *Lentinula edodes*, is derived from the words "shii" (tree) and "take" (mushroom).
- Hand harvesting: gathering produce by hand.
- A macrofungus that may develop above or below ground and has a visible fruit body is called a mushroom.
- Mycelium: A network of white filaments that resembles plant roots and joins to form pinhead-shaped fungi that eventually turn into mushrooms.
- Pasteurization is the process of heating compost to 60°C for four to six hours in order to destroy all insects, pests, nematodes, dangerous fungi, and their spores.

WHAT HAVE YOU LEARNT

Let us recapitulate the important points we have learnt in the lesson:

- Only a small number of the thousands of edible mushrooms found in nature have been successfully cultivated by humans.
- Mushrooms are neither plant nor animal; instead, they are members of the distinct kingdom known as Fungi.
- Ninety percent of all mushrooms produced worldwide are of six kinds: shiitake, oyster, wood ear, button, winter, and paddy straw mushrooms.
- Various types of mushrooms have diverse popularity in different regions. For example, button mushrooms are more common in the USA and Europe, In contrast, oyster, wood ear, and shiitake
- Mushrooms are more common in the East, especially in China, Japan, and Korea.
- Farmers burn wastes such as cereal straw, which contributes to air pollution. However, by using this trash to produce mushrooms, we are able to both reduce environmental pollution and create profit from it.

UNIT – 2

CULTIVATION OF MUSHROOM

OBJECTIVE

1. Identify edible and poisonous mushrooms.
2. Provide hands-on training for preparing mushroom cultivation beds, harvesting techniques, pest and disease control, and post-harvest management.
3. Educate students about current marketing trends in the mushroom industry.
4. Expose students to expert knowledge and operational mushroom farms..

2.1 Major Phases of Mushroom Cultivation

Mushroom farming is a precise and complex process, involving several key steps:

1. **Selection of an Acceptable Mushroom Species**: Choosing the right species is crucial for successful cultivation.
2. **Secreting a Good Quality Fruiting Culture**: This involves obtaining a culture capable of producing fruiting bodies under suitable conditions.
3. **Development of Robust Spawn**: Creating strong spawn to ensure healthy mushroom growth.
4. **Preparation of Selective Substrate/Compost**: Preparing a nutrient-rich and selective substrate for the mushrooms to grow.
5. **Care of Mycelial (Spawn) Running**: Ensuring the mycelium spreads and grows well in the substrate.
6. **Management of Fruiting/Mushroom Development**: Maintaining the right conditions for mushroom fruiting.
7. **Harvesting Mushrooms Carefully**: Properly harvesting to maximize yield and market value.

Fruit Culture Definition A "fruiting culture" is a culture genetically capable of forming fruiting bodies under appropriate growth conditions. The chosen stock culture should meet criteria for yield, flavor, texture, and fruiting time.

2.2 Tissue Culture Method

- Select a large, healthy mushroom at the button or egg stage.
- Clean with 75% alcohol and split longitudinally.
- Place tissue from the upper stipe on a sterilized medium with a needle.
- Close and date the test tube, incubate at 25-34°C.
- Within days, white mycelia should form, covering the medium in about ten days, ready for spawn transfer.

Spore Culture Method

- Transfer collected spores to a test tube or Petri dish to develop into mycelium.
- For homothallic mushrooms like Volvariella volvacea or Agaricus bisporus, single-spore isolates can be used as fruiting culture.
- For heterothallic mushrooms like Lentinula edodes, spores must mate with a compatible isolate to form a dikaryon/fruiting culture.

Pure Culture from Laboratories

- Obtain tested, pure cultures from reputable research labs.

Cultures from Another Source

- Transfer spawn from another source to agar slants, although the risk of unknown transfer history exists.

2.3 Culture Media

Different mushrooms grow on various natural and synthetic media. However, synthetic media are less commonly used due to cost and preparation time.

Potato Dextrose Agar (PDA)

- Commonly used and simple to prepare.
- Commercially available as ready-mixed powder or can be prepared with potato, dextrose, agar, and water.

Malt Extract Agar (MEA)

- Also available commercially, can be enhanced with peptone or yeast for faster growth.

2.4 Development of Robust Spawn

Spawn is the medium through which mycelium grows, serving as the seed for mushroom cultivation. The type of spawn substrate affects growth and yield.

Definitions

- "Spawn" refers to the substrate with developed mushroom mycelium used for propagation.
- "Spawning" means inoculating the substrate with mushroom spawn.

2.5 Spawn Substrates- A spawn substrate is a nutrient-rich material essential for the initial stage of the cultivation cycle. Typically, these substrates are inoculated and allowed to fully colonize within a sterile environment, as their high nutrient content makes them particularly prone to contamination.

- Commonly used agricultural wastes include rice straw, sawdust, and cereal grains.

2.6 Preparation of Mother Spawn

Mother spawn refers to mushroom fungus cultivated on a grain-based medium. Among various substrates tested by TNAU, Coimbatore, sorghum grains have proven to be the most effective for optimal fungal growth. Disease-free sorghum grains are used as the substrate for growing the spawn materials. The following steps outline the preparation of mother spawn:

- Soak the sorghum grains in clean water to remove chaffy and damaged grains.
- Cook the grains in a vessel for 30 minutes to soften them.
- Spread the cooked grains evenly on a platform to remove excess water.
- At a 50% moisture level, thoroughly mix calcium carbonate (CaCO3) with the cooked, dried grains at a ratio of 20 g per kg.
- Fill saline bottles with the grains up to 3/4th full (approximately 300-330 g per bottle), insert a PVC ring, fold 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 it tightly around the neck with a jute thread.
- Arrange the bags inside an autoclave and sterilize them under 20 lbs. pressure for 2 hours.
- After cooling, remove the bags and place them inside the culture room, turning on the UV light.

- After 20 minutes, turn off the UV light and begin working in the culture room.
- Cut the fungal culture into two equal halves using an inoculation needle, transferring one half to one bottle and the other half to another bottle.
- Incubate the inoculated bottles in a clean room at room temperature for 10 days. The resulting mother spawn can then be used for bed spawn preparation.

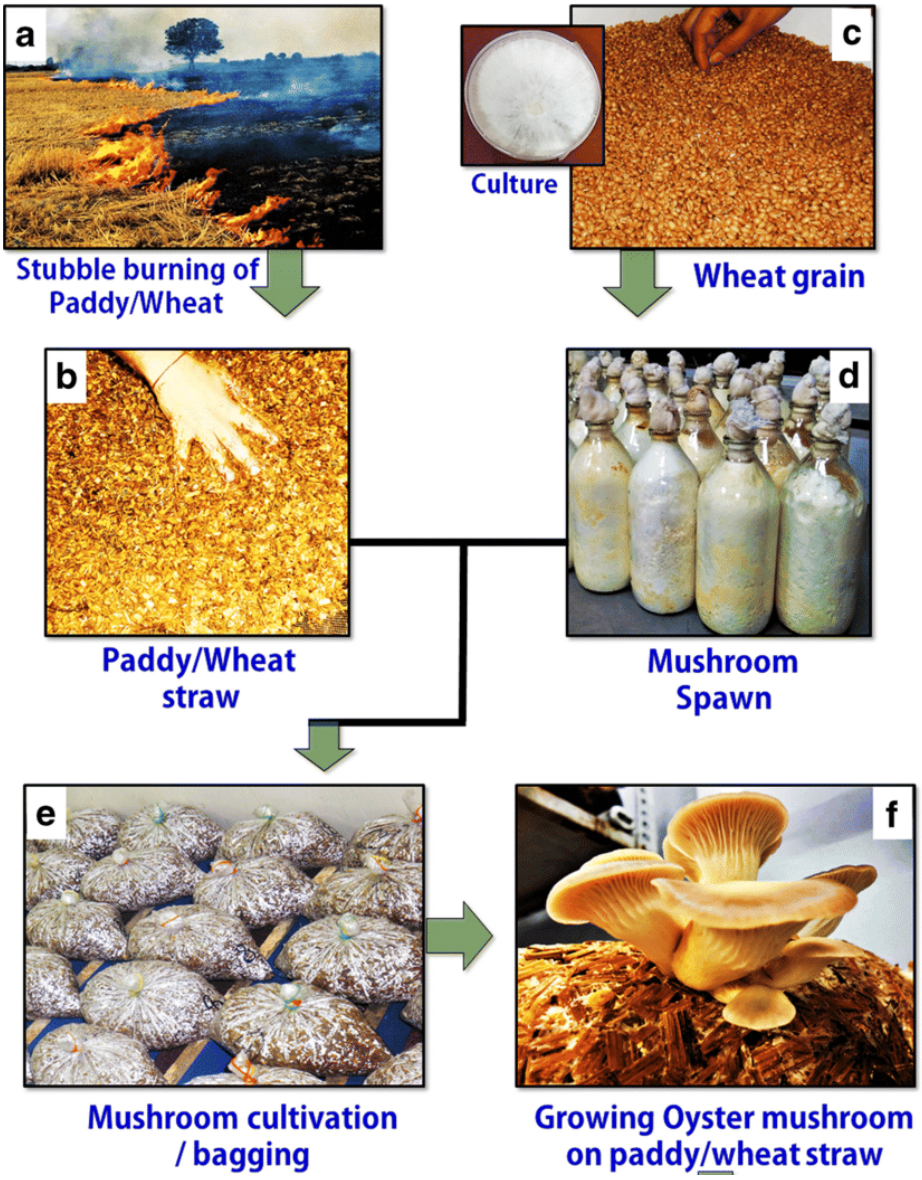


Fig 2.1 Steps in cultivation of mushroom

2.7 Preparation of Planting Spawn

- Use rice straw or water hyacinth leaves, mixed with sucrose, chalk, and bran, sterilized, and inoculated with mother spawn.

Spawn Handling

- Maintain spawn quality by refrigeration and ensure vigorous growth to outcompete other organisms.
- Use the appropriate quantity to ensure rapid colonization and yield.

2.8 Preparation of Selective Substrate/Compost

Straw is the commonest substrate for Oyster Mushroom cultivation. Other agricultural wastes (e.g. corn stalks) can be used. Invasive plant species such as water hyacinth and kudzu are also possible substrates**.**

Methods of preparation include:

- Heat pasteurization
- Lime bath treatment
- Peroxide treatment
- Cold Fermentation

- A sterile substrate is ideal but impractical; pre-treatments are used to promote mushroom mycelium growth while excluding other microorganisms.
- The substrate must have essential nutrients, proper moisture, pH, and gaseous exchange.
- **Spawn Run:** The spawn run is the phase where the mycelium from the inoculated spawn begins colonizing the new substrate. This process occurs in a controlled environment with specific temperature, humidity, and lighting conditions tailored to the growth needs of the particular mushroom species. During this phase, the mycelium spreads throughout the substrate, breaking down complex organic compounds into simpler substances.
- **Colonization:** During the spawn run, the mycelium grows and forms a network within the substrate, creating a white, web-like structure. This colonization process can take several weeks, depending on the type of mushroom and the environmental conditions.
- **Consolidation:** Once the mycelium has fully colonized the substrate, it enters a consolidation phase. During this time, the mycelium network becomes denser and more intertwined, which is a crucial step before fruiting can occur.

- **Fruiting Conditions:** After thorough colonization and consolidation, the substrate is exposed to specific conditions to induce fruiting. These conditions typically include a drop in temperature, increased humidity, higher oxygen levels, and changes in lighting. These environmental cues signal the mycelium that it is time to produce mushroom fruiting bodies.
- **Fruiting:** In response to the altered conditions, the mycelium begins producing mushroom pins, which eventually grow into mature mushroom fruiting bodies. This stage marks the transition from the spawn run to the fruiting stage.

2.9 Management of Fruiting/Mushroom Development

- Adjust environmental conditions for primordia formation and fruiting body production.
- Harvest at different maturation stages based on species and market preferences.

2.10 Mushroom Diseases

Mushrooms can be affected by various fungal and bacterial diseases, notably:

1. **Dry Bubble (*Verticillium fungicola*)**: Brown spots on caps, controlled by reducing humidity and temperature.
2. **Wet Bubble (*Mycogone permiciosa*)**: Malformed, necrotic tissues with a foul smell, controlled by disinfecting casing material and maintaining hygiene.
3. **Mildew (*Cladobotryum sp*.)**: Cotton wool-like growth leading to wet rot, controlled through hygiene and environmental management.

Short Question Answer

1. Explain types of material used for spawn culture
2. Give schematic diagram of mushroom culture
3. What is seed culture
4. Explain harvest and yield of mushroom

CHAPTER-3

VALUE ADDED PRODUCT OF MUSHROOM

OBJECTIVE

1. Help the students to study a resource of self-employment and income generation
2. Enable self-employment.
3. Know the nutrient worth of mushroom.
4. Study the morphology and types of mushrooms.

Mushroom has been part of diet in many parts of world since the history of agriculture. In addition to its many nutritional and physiological advantages, mushrooms can help with malnutrition and undernutrition in a number of ways. Despite this, the use of mushrooms and their production are not keeping up quickly due to their high perishability. Therefore, it is crucial to turn mushrooms into value-added products that will address the issue of their short shelf life and postharvest losses while also meeting the general public's need for protein and micronutrients. Here are a few technologies that can be used to turn mushrooms into goods with more value and longer shelf lives. Because they don't know how to prepare mushrooms, many people avoid buying them. We shall thus read about a few recipes.

3.1 Drying of Mushrooms

As you're probably conscious, one of the most crucial techniques for reducing the produce's amount of water is dehydration. There are numerous additional value items that can be made using the dried produce. Sun-drying button mushrooms is a difficult task. Nonetheless, sun-drying mushrooms such as oyster, shiitake, wood ear mushroom, etc. is a simple process (Fig. 3.1). In addition to sun drying, mushrooms can be dehydrated at 55 to 60 degrees Celsius in cabinet dryers. This method produces a dehydrated final product with a reduced amount of moisture, an extended shelf life, and superior taste. A solar-powered heater is an option. However, it's crucial to keep an eye on the degree of drying. Over 60°C is not a good temperature because it chars the sugars, loses their flavor, and decreases their rehydrability, which causes the dry product to rehydrate and increase weight.

The dried mushrooms can be ground into a powder and used to create a variety of goods. Flour used for biscuits, bread, cakes, or any other bakery product can have up to 10% powder added to it.

3.1 Dried mushroom as a value added product

3.2. Canning of Mushrooms

The majority of the global mushroom trade is conducted in canned form, which allows mushrooms to be kept for up to a year in storage.Depending on demand, mushrooms can be canned whole, chopped, and in stems and bits. Cleaning, blanching at 95–100°C for 4-6 minutes, and adding brine solution (2% salt with 0.1% citric acid or 100 ppm ascorbic acid) to the can heating to 118^0C for sterilization, cooling, labeling, and packing are all steps in the canning process (Fig. 3.2).

Figure 3.2: Canned Button Mushrooms

3.3. Steeping Mushroom Preservation

By brewing the mushrooms in an acidic or salt solution, you can preserve them for a amount short time using this easy and affordable method. Blanched mushrooms are steeped for 8–10 days at 21–28^0C in solution with 0.15% KMS, 2% sodium bicarbonate, 2% citric acid, and 2% sodium chloride

Figure 3.3: Mushroom Murrabba

To make mushroom preserve, grade, wash, pierce, and blanch fresh button mushrooms in a 0.05% KMS solution for ten minutes. Then, after blanching, the mushrooms are submerged in a 50X Brix sugar solution and let to rest overnight. The following day, the mushrooms are strained out of the sugar solution, and 0.1% citric acid, enough sugar, and heat are added to the mixture to achieve a 60X Brix strength. The mushrooms are immersed in it once more and left overnight. To produce the preserve, repeat this process until the syrup concentration reaches 70 X Brix. Then, dip the mushrooms into the syrup and let them sit for a week. After draining the preserve from the sugar syrup, freshly made 68 X Brix sugar syrup is added to a container. The containers are sealed airtight.

Candy of Mushrooms

The method used to make candies is essentially the same as that used to make mushroom preserves, but in order to achieve the chewable consistency, the produce is partially dried under shade and impregnated with a higher concentration of sugar (75X Brix). The mushroom candies keep well for up to eight months in storage (Fig 3.4).

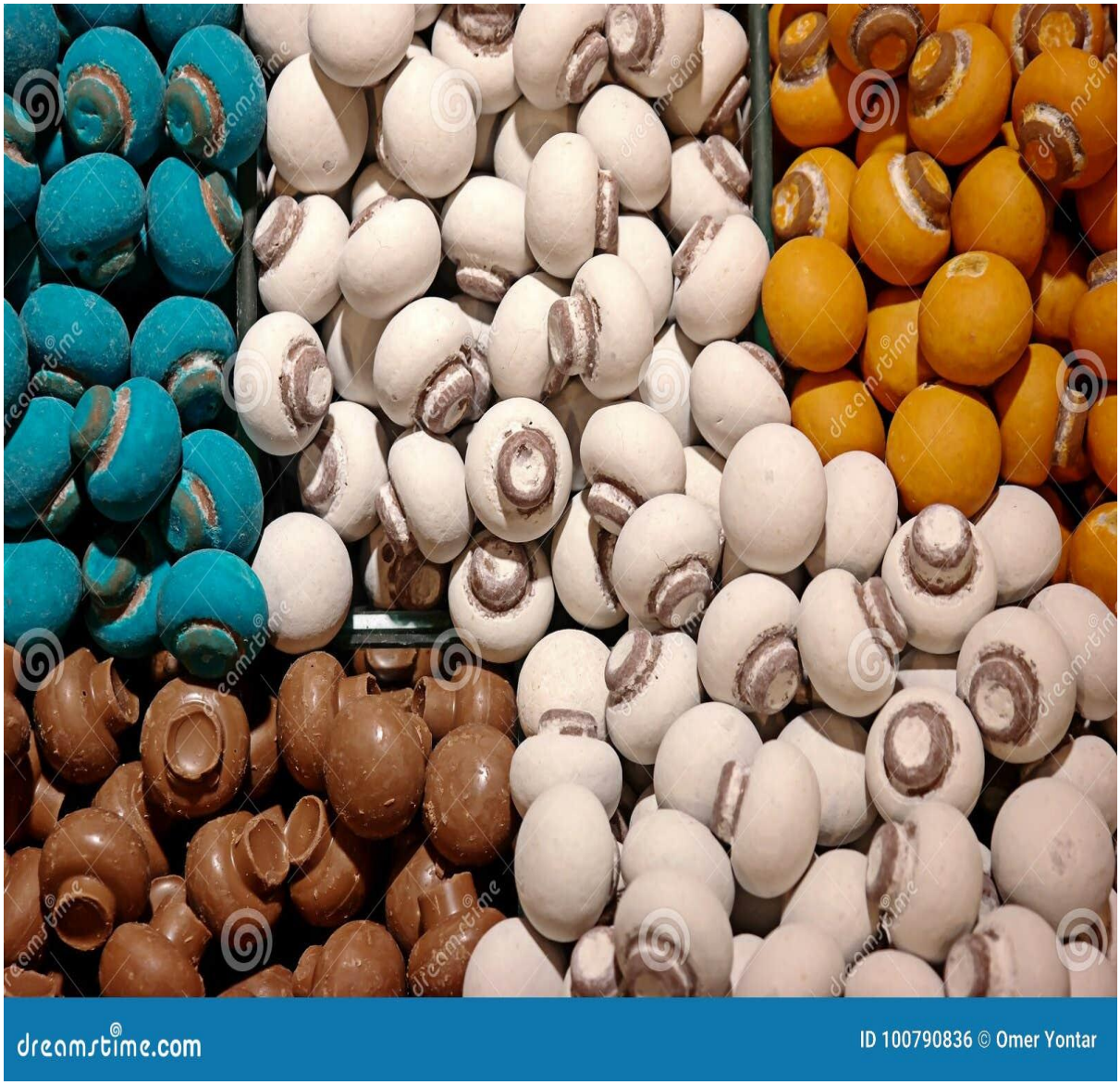


Figure 3.4: Mushroom Candies

3.4 Mushroom Chips

Freshly picked button truffles are cleaned, sliced into 2 mm pieces, and blanched in a 2% brine solution to make mushroom chips. The mushrooms are immersed in a solution containing 0.1% citric acid, 1.5% NaCl, and 0.3% red chili powder for an entire night. Following the solution's removal, the mushrooms are dried for eight hours at 60^0C in a cabinet dryer. After that, it is cooked in refined oil to produce delicious chips (Fig 3.5).

Figure 3.5: Mushroom chips

3.5 Biscuit

Pleasant and nourishing mushroom biscuits can be made with button or oyster mushrooms and the following ingredients:

Ghee (bakery fats) - 30%

Sugar – 45%

Baking powder 0.6%

Milk powder - 1.5%

Ammonium bicarbonate - 0.3%

Vanilla essence - 0.02%

Rice flour or maida : mushroom powder - 80:20 or 90:10 ratio

All of the dry ingredients are sieved and finely ground before being used to make biscuits.Next, using a dough kneeder, thoroughly combine the fat and sugar for five to seven minutes. Then, for dry mixing, these components are put in to the bread kneeder along with additional dry ingredients. Water is then added to the dough to make it cohesive and

homogenous, and mixing is done until the dough is completely combined. The dough is then covered with a damp cloth and left for ten minutes. Using several steel dies, thin (1.25 cm thick) sheets of dough are formed and cut into various biscuit forms. After being baked for 20 minutes at 180^0C in a hot oven, these raw cut biscuits are then ready to be packaged(Figure 3.6).

Figure 3.6: Mushroom biscuits

3.6 Mushroom Soup

Button mushrooms or dried oysters are carefully pulverized in a pulverizer to pass through a 0.5 mm sieve in order to make mushroom soup powder. Next, 20g of mushroom powder is combined with 25g of milk powder, 40g of corn flour, 8g of salt, 3g of sugar, 2g of black pepper, and 2g of oregano. To make a high-quality mushroom soup with a distinct flavor and aroma, this soup mix must be combined with six times as much water.

3.7 Nuggets of Mushroom

In order to make mushroom nuggets, black gram (Urad) dal powder and mushroom powder (dried, roughly ground mushrooms) are combined (1:8 ratio), and the necessary amount of water is then added to create a paste. Round balls with a measurement of 2-4 cm are formed by adding red chili powder (1%) and salt (2%) to the prepared paste. The balls are placed on a steel plate and let it dry in the sun. These mushroom nuggets can be used to make veggie curry or they can be deep-fried and eaten as snacks right immediately.

3.8 Papad with mushrooms

A thin, crispy disc-shaped delicacy from India, papad is typically made with a spiced batter consisting of rice, tapioca, potatoes, lentils, chickpeas, and peeled black gram flour (urd flour), and is either fried or cooked over dry heat. Mushrooms can be added to papads as a protein supplement as a paste or dried powder added to the batter composed of the previously stated sources. Because of this, papad can become a healthy, high-protein meal.

Corn extrudates fortified with mushrooms: For both single and twin screw extruders, supplementation in extrudates up to 20% paste and 10% powder can produce extrudates of passable quality.

Cakes fortified with mushrooms: Cakes fortified with mushrooms are created by fortifying wheat flour or refined flour to a quantity of 10–20% dry mushroom powder. There is no change in the method for making cake.

3.9 Vegetable Sausages Made From Fresh Mushrooms

To make vegetarian sausages, add 5% saturated fat and binding agents such as xanthan gum, carrageenan, soybean protein concentrate, or the casein protein.

3.10 Instant noodles with mushroom fortification

By adding 4% of mushroom powder (Pleurotus ostreatus) to the noodle dough, ready-to-cook instant noodles with a high nutritional value can be produced.

Short Question

1. What occur when a very high temperature is used to dry the mushrooms?
2. Which mushroom naturally contains the chemical lovastatin, which lowers cholesterol?
3. How much powdered mushroom may be added to cakes, biscuits, etc.?
4. What occurs if the mushrooms are overdone?
5. Why don't some people buy things made from mushrooms? How would you persuade them to consume mushrooms?

CHAPTER – 4

ENTREPRENEURSHIP WITH MUSHROOM CULTIVATION

OBJECTIVE

1. Understand the spawn manufacturing process
2. Aware the documentation of edible and poisonous mushrooms.
3. Learn the predictions and choice of mushroom cultivation in small scale industry.
4. Understand the illnesses. Techniques used after mushrooms are harvested

The creation of capital, the writing of a project report, financial management, knowledge of production costs, and marketing are all necessary for anyendeavor to succeed. Any endeavor must begin with good training, and these days there are many of online resources available. Using these before or after receiving the appropriate training can broaden our understanding and assist in the development of more durable and reliable systems. These are some of the topics we will cover in the pages that follow

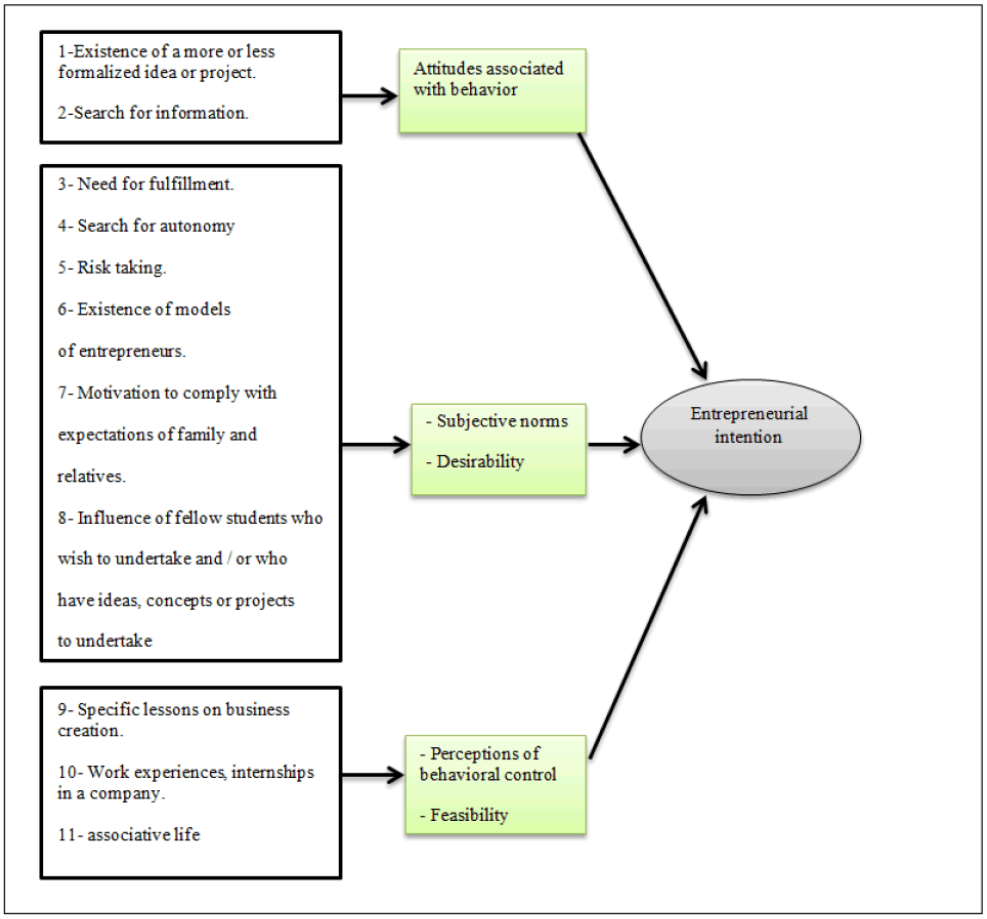


FIGURE 1
THEORETICAL MODELING OF ENTREPRENEURIAL INTENTION

4.1 GENERATION OF FUNDING

Funding is the first and most important prerequisite for the creation of any unit. Numerous organizations in our nation offer loans and, in some situations, subsidies. Understanding the several government programs and the processes involved in obtaining loans and subsidies is crucial. It will be crucial to have a solid understanding of both the phrases used frequently in financial interactions and banking processes. These days, the websites of many agencies provide information about plans as well as the forms needed to access the advantages of the schemes. You can get in touch with the district's KVK, the state agricultural university's extension division, the state department of horticulture and agriculture, and other similar organizations.

States also differ in their plans.

1. Cash Book
2. Debtor Book
3. Inventory Record
4. Credit Record
5. Labor Book
6. Cash Book

Every penny that enters and leaves the system is recorded in the cash book. You can use any notebook with a suitable binding, or you can purchase printed money books. Every day, we make entries into the cash book, writing the expenses on the right column and the revenue on the left(Figure 6.1)

JOURNAL

Date	Account	Debit	Credit
May 10	Accounts Receivable	1,736.30	
	Credit Card Expense	53.70	
	Sales Revenue		1,790
	To record credit card sale, 3% fee, 1790 × 3%		
May 10	Cost of Goods Sold	1,100	
	Merchandise Inventory		1,100
	To record cost of sale		
May 19	Accounts Receivable	1,086.40	
	Credit Card Expense	33.60	
	Sales Revenue		1,120
	To record credit card sale, 3% fee, (80 × $14) x 3%		
May 19	Cost of Goods Sold	584	
	Merchandise Inventory		584
	To record cost of sale; 80 × $7.30		
May 28	Cash	345	
	Sales Revenue		345
	To record cash sale		
May 28	Cost of Goods Sold	122	
	Merchandise Inventory		122
	To record cost of sale		

Figure 4.1: Sample bill book can be used for mushroom business

4.2 Inventory Record Book

You have to maintain a separate book with a record of all the tangible goods your business owns. It will tell you what you had at the start of the calendar year, what you brought into it through producing and buying, and how much was taken out of your business by losses, revenue, utilization, or planned use.

4.3 Book of Credit

In the business world, not every sale we make results in money. We frequently give things credit. All of the money that consumers owe for goods and services they borrowed must be documented. For our convenience, we might write each customer's information on a different page.

Additionally, not every purchase we make is made with cash. All of this should be documented in a different book. We maintain a record of everyone the company owes (those who have provided goods and services to the business on credit) in our debtor book. It will have columns for the time, product definition, debt, payment, and balance.

4.4 Workbook

We will have a large number of employees in our unit. We require accurate information on the quantity of work they have done (hours, days, or amount of labor completed), how much money they were paid, and when that money was paid. Each of these specifics is documented in a different book.

4.5 Project report used terms

You must prepare a thorough project report once you have a thorough understanding of the cultivation and the funding source. Normally, it's necessary to get any kind of loan or assistance. The technical aspects of trimming, composting, spawning and the assets you have available will be covered in the first section of the report. The financial information in the second section of the report will include information on the money that is suggested to be spent, any loans or subsidies that are needed, how and when you plan to repay the money, etc. It's possible that those assessing the project from a financial viability perspective won't always comprehend the technical components.

Depreciation

The process of loan amortization is known as amortization. Calculating amortization involves dividing the total loan amount by the interest rate, term (i.e., number of years borrowed), and total amount paid each period into equal payments for principle and interest.

Equilibrium Report

Comprehensive data regarding assets and liabilities is provided by a balance sheet. Balance sheet is a type of financial report that displays an organization's financial status at a specific point in time. It provides you with a sense of your ability to pay creditors, control your inventory, and handle billing.

Break-Even Point

It basically means figuring out the minimum production required to cover both the fixed costs and the manufacturing costs of the sold goods.

DSCR, or Debt Service Coverage Ratio

You'll see that the project report will include a table named DSCR. It's just the ratio of the annual amount of cash you can create to the total amount of principal, interest, and additional payments that you have to make. Simply put, it shows if you will be able to earn enough money to cover the debt. If your DSCR is less than one, the bank won't finance the project because you won't be able to repay them.

4.6 Statement of Income

An income statement is a document that displays the amount of money a business makes.The rate of return on the capital investment is known as the internal rate of return. For instance, the internal rate of return, or IRR, is 20% annually if you invest Rs. 100 today and receive Rs. 120 one year later.

Net Present Value (NPV) is the future cash flow value expressed in terms of investments as of today.

Repayment Time

All of the money that is received and expended. Assume, for instance, that a Rs 6000 investment will yield Rs 1000 in cash flows annually for a period of ten years. A period of six years is the amount of time needed to recover the investment.

4.7 Cost of Production of Button Mushroom in India

In India, the annual earnings from mushroom growing can reach ₹1,90,000. The nicest part about growing mushrooms is that they don't need a lot of space and can be harvested in three weeks after the compost is casked—a thin layer of sterile soil or materials like chalk powder is applied.

The amount of biological efficiency (BE) determine the production cost. There was significant variance in the price of production per kilogram in commercial units when the number of flushes taken annually and biological efficiency (BE) were compared. One commercial unit cost Rs 65 per kilogram at 18% BE and 6 harvests annually. Another producer had a BE of 14% and was only harvesting four crops. In this instance, the cost of production was well below the economic threshold at Rs 120/kg. Thus, while figuring up the production cost per kilogram of mushrooms.The BE and the quantity of flushes gathered must be mentioned. According to the majority of producers, the average cost of producing mushrooms in the state was Rs 65 per kg.

Low productivity is one of the factors contributing to higher manufacturing costs, which are nearly on level with those in industrialized nations. The BE of commercial units in the state is 16–18%, while it is approximately 32–35% in the USA, Australia, and Europe. Therefore, folks in the West are getting twice as much with the same inputs but greater utilization of technology.

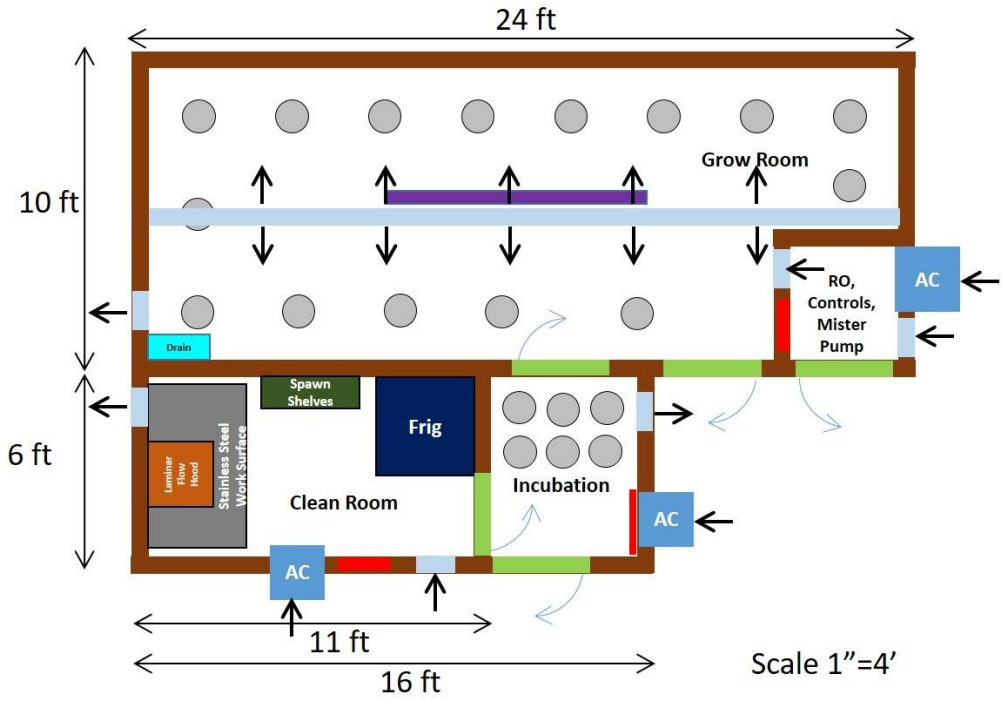


Figure 4.2: Set-up of Button mushroom cultivation and Packed Mushrooms.

Short Answer Questions

1. Which organizations offer financial assistance for establishing a mushroom unit?
2. What do the terms cash flow, depreciation, IRR, and DSCR mean?
3. Why are button mushroom costs so low throughout the winter?
4. Why do different industrial units' button mushroom manufacturing expenses vary from one another?
5. Can you explain what amortization and depreciation mean?

CHAPTER-5
INSECT-MANAGEMENT SYSTEM FOR CULTIVATED MUSHROOM

OBJECTIVE

1. Start small scale industry of mushroom cultivation.
2. Training the morphology and types of mushrooms.
3. Documentation of edible and poisonous mushrooms.
4. Produce spawn on their individual.
5. Learn the forecasts and the extent of small-scale mushroom farming.
6. Examine the mushroom-cultivation system.

Pests of farmed mushrooms include nematodes, cecids, phorid flies, sciarid flies, and springtails worldwide. From the time the crop is spawned until it is harvested, these pests harm it. In addition to causing direct crop harm, mushroom flies aid in the spread of several mushroom diseases. As a result, we need to take action to stop nematodes, mites, and insect pests from entering the cropping rooms.

5.1 Mushroom fly

The three primary types of flies that harm button mushroom crops are phorid, cecid, and sciarid flies. Other mushrooms are equally problematic for flies, especially if they are cultivated in unsanitary conditions. Fly damage begins as soon as the plants spawn, and crop production may become challenging if appropriate precautions are not followed.

5.2 Sciarid Fly

The tiny fungus gnats, or sciarid flies, are mosquito-type insects that range in size from 1.5 - 5 mm (Fig. 7.1). Flies range in color from brown to black. Its larvae use mycelium, compost, and mushrooms as food. After entering the mushrooms, larvae begin to feed and tunnel inside the stipe. They eventually arrive at the pileus and begin to feed heavily. Pinhead development entirely stops and eventually dies when larval attack happens at the pinhead stage.

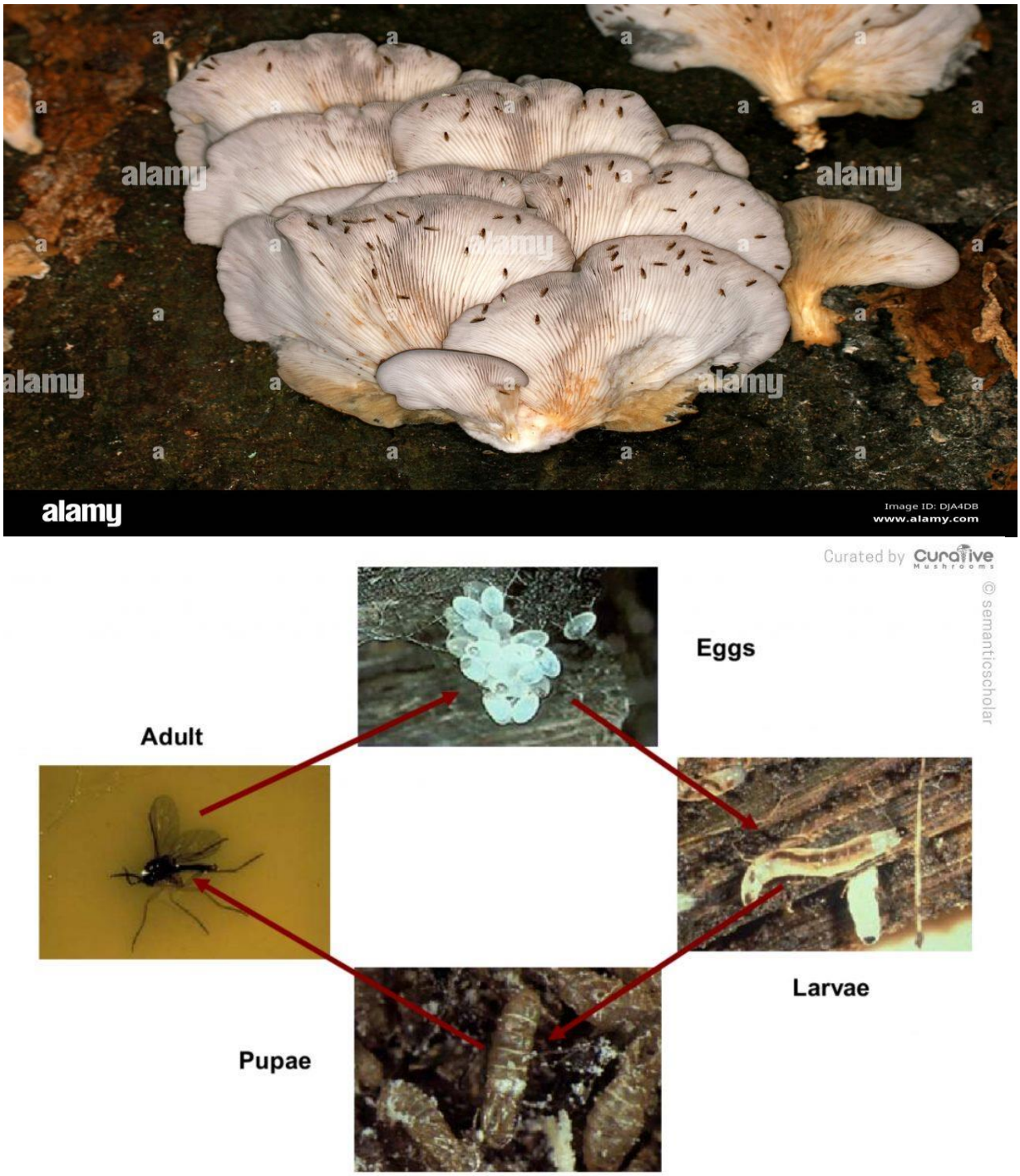


Figure 5.1: Scrid fly for Mushroom

5.3 Phorids

Phorid flies are tiny, 1.9–3 mm, hump-backed, black or light–dark brown flies (Fig. 5.2). These insects resemble house flies in size. Their movements are choppy and fast. Adult phorids are drawn to light and are most prevalent in the early summer. Although phorid flies are less dangerous than sciarid flies, these also consume truffles.

Gall midges, or Cecid flies

Cecid flies are dark brown in color, less noticeable than even sciarid flies, and smaller. Larvae create vertical grooves in the stipe while feeding on mycelium. They feed on the exterior of the stipe at the point where the gills and stipe meet, where bacteria may grow later and stain the area. It is crucial to utilize pasteurized casing soil because it is the primary source of infection. Because larvae are sticky, they can get on workers' uniforms, tools, and other items. The venation on the wings allows us to identify the flies as well (Fig. 5.2). We are also able to recognize the larvae of many flies. Larva of the phorid is around 3–4 mm with pointy tips, while larva of the sciarid is 5-8 mm long with a spherical black head.

5.4 Control and Management Techniques

It is possible to reduce fly damage by practicing good hygiene and sanitation. The fragrance of mushrooms and compost attracts flies. Fly spawning can only occur at that stage, and flies will grow with the spawn if it is not done in a clean, protected environment. In this case, damage will begin with the first flush. Maintaining the cleanliness of the unit is crucial. Screen doors, install ventilators, and create light traps. Install poison bait (such as diluted Baygon diluted with water 1:10) with a small amount of sugar added). These precautions will keep flies out of the cropping rooms. But after the crop is finished, a decent barbecue (70°C for 4-6 hours) and adequate

5.5 MITES

Several mite groups infest button mushrooms and other cultivated mushrooms. The raw materials used to prepare the mushroom beds are the source of the initial mite infection in mushroom houses.On rare occasions, mushroom mites are also carried by phorid flies. In general, their existence signifies subpar compost. Human allergy responses have also been reported as a result of these mites.

5.6 Control of Mites

We must create high-quality compost and maintain hygienic conditions throughout. Among the techniques for integrated mite control.

- Proper pasteurization of compost and casing material.
- Disinfection of mushroom houses by spraying 0.1% dicofol.
- Cooking out at 70°C.
- Applying a 1.0 g a.i/m2 solution of chlorfenvinphos, fenitrothion, fenthion, trithion, or metasystox to beds right after spawning but before casing

5.7 Nematodes

There are particular worms that consume the mycelium of mushrooms. These could cause the crop to fail entirely if they are present. These nematodes are typically discovered in compost produced using the long method or the short method, when phase II is not completed properly and there are pockets or lumps where the necessary temperature is not reached.

These were a regular issue when using wooden trays and also spread from crop to crop.Blank spaces and pale fugal growth (Botrytis) are characteristics of casing soil.

5.8 Control of nematodes

The easiest way to control nematodes in compost is to properly pasteurize the material. Even while substances like furadon have applications, their dosages could not be profitable or environmentally friendly. In our nation, the biological control methods are not very well-liked.

Short Questions

1. List the main types of flies that are present in button mushroom cropping units. How can these be distinguished from one another based on the size, motion, wing venation, and kind of mushroom damage?
2. What physical techniques are used to manage insect pests?
3. What kind of compost has the highest nematode content? Could you explain the physical approach of nematode control in button mushroom compost?
4. The conclusions drawn from the crop's mite infestation. How can the mites be controlled?
5. Which chemicals are frequently used to control different kinds of insects?

GLOSSARY

- ***AGARICUS BISPORUS*:**
- Commonly cultivated mushrooms, available in various strains.
- **AMMONIA:**
- A crucial byproduct created during fermentation and decomposition during Phase I composting. During Phase II composting, it should be transformed into microbial protein and removed since the free ammonia that remains at the end of this stage is harmful to the
- **ANAEROBIC FERMENTATION:**
- A fermentation process that occurs in the absence of oxygen, which is undesirable for mushroom cultivation.
- **BIOLOGICAL EFFICIENCY (BE):**
- A measure of substrate productivity.
- **BLENDED COMPOST:**
- A combination mainly made up of horse dung mixed with wheat straw bedded in it, along with other elements including hay, corncobs, cotton seed hulls, and other materials in different ratios (e.g., 80% horse manure, 20% hay and cobs).
- **BREWERS GRAIN:**
- Residue from breweries, consisting of grain hulls with a nitrogen content of 4.0 to 4.3%.
- **BUTTONS:**
- Marketable but immature mushrooms.
- **CASING:**
- The fourth stage of mushroom farming, which occurs 14–21 days after spawning and involves topdressing spawn-run compost.
- **CASING LAYER:**
- The top-dressing that induces the fruiting of mushroom mycelium. Common materials include peat moss with limestone, spent mushroom substrate, and loam topsoil.
- **CASING INOCULUM (CI):**
- Low-nutrient materials such as vermiculite, peat, or spent mushroom substrate, which are sterilized and colonized with mushroom mycelium.

- **COLONIZE:**
- The process by which mycelium, the thread-like strands of growth, develops in the compost after grain spawn is applied.
- **COMPETITOR MOLDS:**
- Various molds that compete for nutrients in the compost or casing, inhibiting or destroying mushroom mycelium.
- **COMPOSTED SUBSTRATE (COMPOST):**
- A mixture of organic and inorganic substances managed to produce nutrients favorable for growing cultivated mushrooms.
- **FLUSHING:**
- A crucial step to promote mushroom development, where fresh air is introduced to reduce carbon dioxide levels produced by mushroom mycelium.
- **GYPSUM, AGRICULTURAL:**
- A naturally occurring mineral composed of calcium sulfate, used in Phase I composting to
- prevent greasiness.
- **PRODUCTION CYCLE:**
- The total time span of mushroom cultivation, from the initial build to the steam-off and clean-out phase.
- **SPAWNING RATE:**
- The amount of spawn applied per square foot or by weight to the compost immediately after
- Phase II composting.
- **THERMOCOUPLE:**
- A temperature-sensing device made of two dissimilar metals within a stainless steel sheath, used for precise temperature measurement, requiring special electronic equipment.

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