Importance and Advanced biology on Edible Mushrooms

Srujani Behera, Chinmayee Mohapatra, Anupam Kumari

Mushrooms are macroscopic fruiting bodies produced by ascomycete and basidiomycete fungi during their sexual reproduction cycles. Mushroom composition includes 85–95% moisture, 35–70% carbohydrates, 15–34.7% protein, 10–20% fat, 6–10.9% minerals, and 3–8% nucleic acids. It also has an abundance of vitamins, including 92–144 mg of ascorbic acid, 6.7–9.0 mg of riboflavin, biotin, and 1.4–2.2 mg of thiamine per 100 grams of dry weight, among others. The use of mushrooms as a source of physiologically active compounds with possible medical benefits, including antimicrobial, immune-modulating, antioxidant, antiviral, and hypocholesterolemic properties, has grown in popularity recently. The significance of mushrooms lies in their capacity to generate a wide range of extracellular enzymes that transform different types of agricultural waste into valuable myco-medicinals and high-value foods. Therefore, mushrooms, with their abundant diversity constitute a cost-effective means, both of supplementing the nutrition of humankind and in alleviating the sufferings. This chapter discusses about some common edible and large scale cultivated mushrooms include Paddy straw mushroom - *Volvariella* spp, Oyster mushroom - *Pleurotus* spp., Button mushroom - *Agaricus* spp, Milky mushroom - *Calocybe* spp., Shiitake mushroom *Lentinulla* spp. and Jew's ear mushroom - *Auricularia* sp. The present communication deals with importance of mushrooms, taxonomy of mushroom and their morphology with different developmental stage.

Keywords: *Edible mushrooms, Biology, Morphology, Importance of mushrooms*

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Introduction

Mushroom is a macro fungus lacking chlorophyll. They rely on outside sources for their nutritional needs because they are unable to make food themselves. In general, the majority of mushrooms grow saprophytically on dead, decaying organisms, whereas others grow parasitically with other living things or associate symbiotically with live things like plant roots as mycorrhizas. A large variety of enzymes are produced by it, and these enzymes break down the complex material (on which they develop) so that they can absorb the soluble elements for their own sustenance. According to Chang (2004), a mushroom is a macrofungus with a characteristic fruiting body that is large enough to be seen with the naked eye and picked up by hand. The fruiting body can be either epigeous or hypogeous. Agaricaceae is the family to which mushrooms belong. Different varieties of mushrooms have different colors, shapes, surfaces, and activities. In a moist and cold environment, they are generated on soil or on their food sources, such as decomposing wood (Ogidi et al., 2020). Worldwide, there are seasonal variations in the occurrence of mushrooms, but some typical edible mushrooms are perennial. Mushrooms are a diverse group with a wide range of sizes, colors, and shapes. They also have different in character and aesthetics. Out of this vast collection of almost 2000 edible species, 300 species from 70 genera have been identified as coming from India. A total of 80 edible mushroom species have been grown experimentally, 20 have been commercially grown, and 4 or 5 species are produced on an industrial basis globally (Chang, 1990b). According to Rahi and Malik (2016), Mushrooms include moisture (85–95%), carbohydrates (35–70%), protein (15–34.7%), fat (10%), minerals (6–10.9%), and nucleic acids (3–8%). Additionally, it includes a lot of vitamins, including folic acid, ascorbic acid, 92-144 mg of ascorbic acid, riboflavin, 6.7–9.0 mg of riboflavin, biotin, and 1.4–2.2 mg of thiamine per 100 grams of dry weight (Hossain et al., 2007). Calcium, iron, manganese, magnesium, zinc, and selenium are the minerals that can be found in mushrooms (Alam et al., 2007). Mushrooms are regarded as a wholesome food with nutritional benefits because they are abundant in potassium, iron, copper, zinc, and manganese, as well as carbohydrates, fiber, protein, vital amino acids, unsaturated fatty acids, vitamins, and low calories (Sánchez, 2004). All the mushrooms under cultivation for the production of fruiting body (sporocarps) without exception fall into either of the 2 major groups a) Ascomycotina b) Basidiomycotina. But most of the cultivated edible mushrooms belong to the order Agaricales of the class Basidiomycetes characterized by the gill formation under their umbrella shaped caps.

Importance of mushrooms

- Rich protein source having essential amino acids and high digestibility.
- Good for Infants, children, pregnant and lactating women
- High biological value.
- Rich in Theronine and Valine.
- More than 126 health benefits, including anti-microbial, immune-modulating, antioxidant, antiviral, and hypocholesterolemic effects, have been attributed to the various bioactive components that mushrooms produce, such as phenolics, terpenoids, polysaccharides, glucans, and lectins (Kumar et al., 2021).
- High fibre, low sodium and high potassium diet hence decrease blood pressure.
- Regulates Digestive System a) Fermentable Fibre & Oligosaccharides Prebiotics role in intestine b) Dietary Fibre Assists the Digestion Process c) Help functioning of Bowel System.
- Low fat with ergosterol and poly unsaturated fatty acids good for heart.
- Absence of cholesterol. It contains Anticholesterol compound i.e Eritadenine (*A. blazei,* Reishi, shiitake mushrooms) and Lovastatin (Oyster mushroom).

- The edible fruit body of mushrooms is rich in vitamins, including B1, B2, C, E, and D2. The most often seen B vitamins include thiamine, riboflavin, pyridoxine, pantothenic acid, nicotinic acid, nicotinamide, folic acid, and cobalamin. The species *Pleurotus ostreatus* has the highest concentrations of folacin, vitamin B1, and vitamin B3 (Tagkouli et al., 2020).
- Vitamin D and health- Wild mushrooms high in vitamin D but dark grown mushrooms has no vitamin D content and UV light converts ergosterol to vitamin D after post harvest.
- Recent research proves mushrooms as a meat alternative can help manage weight.
- Due to their containment of polysaccharides, edible mushrooms are high in antioxidants (Seo and Choi, 2021). Studies have shown that mushrooms with phenolic extract have excellent antioxidant properties. Due to the presence of phenolic acid and other phenolic compounds in its methanol extract, the fruiting body of mushrooms has the highest concentration of antioxidant activity. Additionally, ergosterol, which is a precursor for the production of vitamin D and is well-known for its potent antioxidant capabilities, is found in mushrooms (Zeb and Lee, 2021).
- Anti-aging property- It contains Ascorbic acid, Tocopherols, Phenolic compounds, Carotenoids and flavones, etc. eg-Reishi, *Agaricus blazei*, oyster mushrooms, *Agaricus bisporus*, shiitake, Maitake.
- Rich in minerals like copper (cardio-protective) and selenium (anticancer). Eg-*Lentinula edodes*
- Mushrooms as Medicine- It acts as anti-HIV, anti-viral, anti-histaminic, hypo cholesterelemic, hepato and nephro protective and stamina enhancer etc.
- Oyster Mushroom is a source of Lovastatin. Lovastatin is a member of the drug class of statins. Used for lowering cholesterol and so preventing cardiovascular disease. Lovastatin is a naturally occurring drug found in food such as oyster mushrooms and red yeast rice.
- Shiitake is a source of *Lentinan*. It has Anti-tumor activity, Anti-cancer activity, Anti thromboses activity, Anti-asthma, Antivirus activity, Anti-cholesterol activity, Stimulator macrophage, Stimulator lymphocyte activity, Stimulator during cancer treatment (activation of immune system).
- *Cordyceps* (Kira-ghas) contains Cordycepin (which boosts Energy & Endurance), 16% beta glucan ,7% Cordycepic acid and 3% Adenosine.
- Reduces the side effects of chemotherapy and radiotherapy while preventing cancer. According to in-vivo and in vitro research, button mushrooms (*Agaricus bisporus* L.) have a significant potential to reduce breast cancer because of their ability to reduce aromatase activity and oestrogen production (Kumar et al., 2021).

List of commercially cultivated mushrooms

- Button mushroom-*Agaricus bisporus.*
- King oyster mushroom-*Pleurotus eryngii.*
- Paddy straw mushroom-*Volvariella volvacea.*
- King bolete-*Boletus Edulis.*
- Maitake (Japanese name)- *Grifola frondose.*
- Pine mushroom/ Matsutake-*Tricholoma matsutake.*
- Shiitake-*Lentinula edodes.*
- Golden needle mushroom-*Flammulina velutipes.*
- Beech Mushroom-*Hypsizygus tessellates.*
- Reishi-*Ganoderma lucidum.*
- Jelly ear Jew's ear-*Auricularia auricula-judae.*
- Morels-*Morchella*

Taxonomic position of edible mushrooms

Kingdom	Division	Class	Order	Family	Genus
Fungi	Basidiomycota	Agaricomycetes	Agaricales	Agaricaceae	*Agaricus*
				Pleurotaceae	*Pleurotus*
				Omphalotaceae	*Lentinula*
				Pluteaceae	*Volvariella*
				Physalacriaceae	*Flammulina*
				Tricholomataceae	*Tricholoma*
				Lyophyllaceae	*Calocybe*
			Armillaria	Boletaceae	*Boletus*
				Amanitaceae	*Amanita*
				Coprinaceae	*Coprinus*
			Auriculariales	Auriculariaceae	*Auricularia*
Fungi	Ascomycota	Discomycetes	Pezizales	Morchellaceae	*Morchella*
				Pezizaceae	*Peziza*

Mushroom morphology

Mushroom is a general term applied to the fruiting bodies of fleshy fungus. A mushroom consists of many parts (Figure 1).

Cap/ pileus: The extended portion of the carpophores is called the cap or pileus, and it can vary widely in size, colour, form, and texture (convex, bell-shaped, conical, knobbed, flat, and sunken). The pileus surface might be velvety, rising scale, flat scale, patches, hairy or fibrous, or smooth.

Gills/ lamellae: They extend outward toward the margin from below the cap that protrudes from the apex of the stipe or stalk. The surface of the gills is covered in spores, and the colour of the gills changes to reflect the presence of spores. Identification of the mushroom is made easier by the gills' attachment to the stipe or stem.

- The gills are referred to as free when they do not contact the stipe.
- When they create a nearly straight angle with the stem and are directly linked and is known as adnate.
- They are referred to as adnexed if the attachment only extends a portion of the breadth of the gills.
- Gills are referred to as decurrent when they extend down the stipe in some way.
- When they are near the stalk in a deep notch, they are called sinuate.

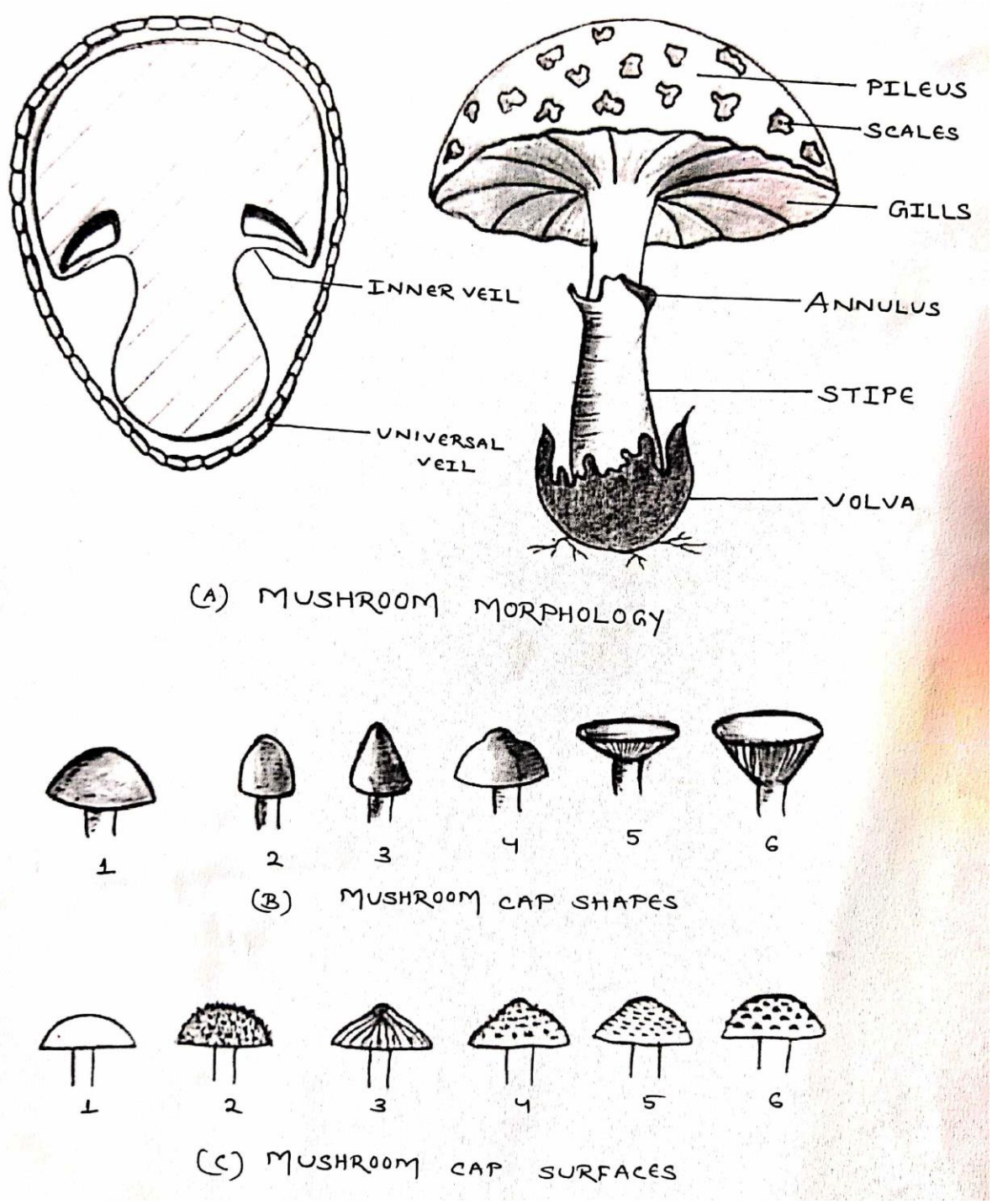
The trama, or mycellial threads, that make up the gills are parallel, interlaced, or divergent in nature. As a result, the cells can be either short or lengthy. Cells branched into short cells as they moved away from the trama, generating a thin layer known as the sub hymenium. It develops into long, club-shaped cells (basidia) that are parallel to one another and angled toward the gill surface. Basidiospores develop on the 2-4 sterigmata that the basidium carries. The basidiospore can have a rough or smooth border and can be any colour or form. Spores are extremely small, lighter in weight, and invisible to the naked eye. Numerous spores are formed from a single carpophore. These spores are disseminated by wind and either fall on to the host or ground and germinate under favourable conditions (Bahl, 2006).

Veil: The veil is a tissue that covers the gill in young fruiting bodies and extends from the margin of the cap to the stalk. This tissue breaks as the cap spreads, with some pieces remaining attached to the cap's margin while the remaining pieces form an annulus, which is a very fragile ring that can be easily rubbed up on the stalk (Figure 1).

Stipe/stalk: The stipe is the stalk that holds up the pileus. Its presence, absence, or method of attachment to the cap are important characteristics for classifying different mushroom taxa. Mostly it is attached centrally but in some other cases it is lateral known as eccentric. The stem may be hollow with a pithy substance filling the central cavity, or it may be solid or fleshy throughout. Stipes can have a variety of shapes, including cylinder, spindle, club, bulbous, base with cup (volva), base with roots, etc.

Volva /universal veil: Before differentiation, initially the entire fruit body is covered by a universal veil. As the carpophore extends, this break and remain as a cup surrounding the base of the stipe. According to the presence or absence of annulus and volva, mushroom can be put under 4 categories (Bahl, 2006).

- Both annulus and volva present- eg. *Amanita*
- Only annulus present and volva absent-eg. *Agaricus*
- Only volva present and annulus absent- eg. *Volvariella*
- Both annulus and volva absent-eg. *Marasmius*


PILEUS
SCALES
GILLS
INNER VEIL
ANNULUS
STIPE
UNIVERSAL VEIL
VOLVA
(A) MUSHROOM MORPHOLOGY
1
2
3
4
5
6
(B) MUSHROOM CAP SHAPES
1
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5
6
(C) MUSHROOM CAP SURFACES

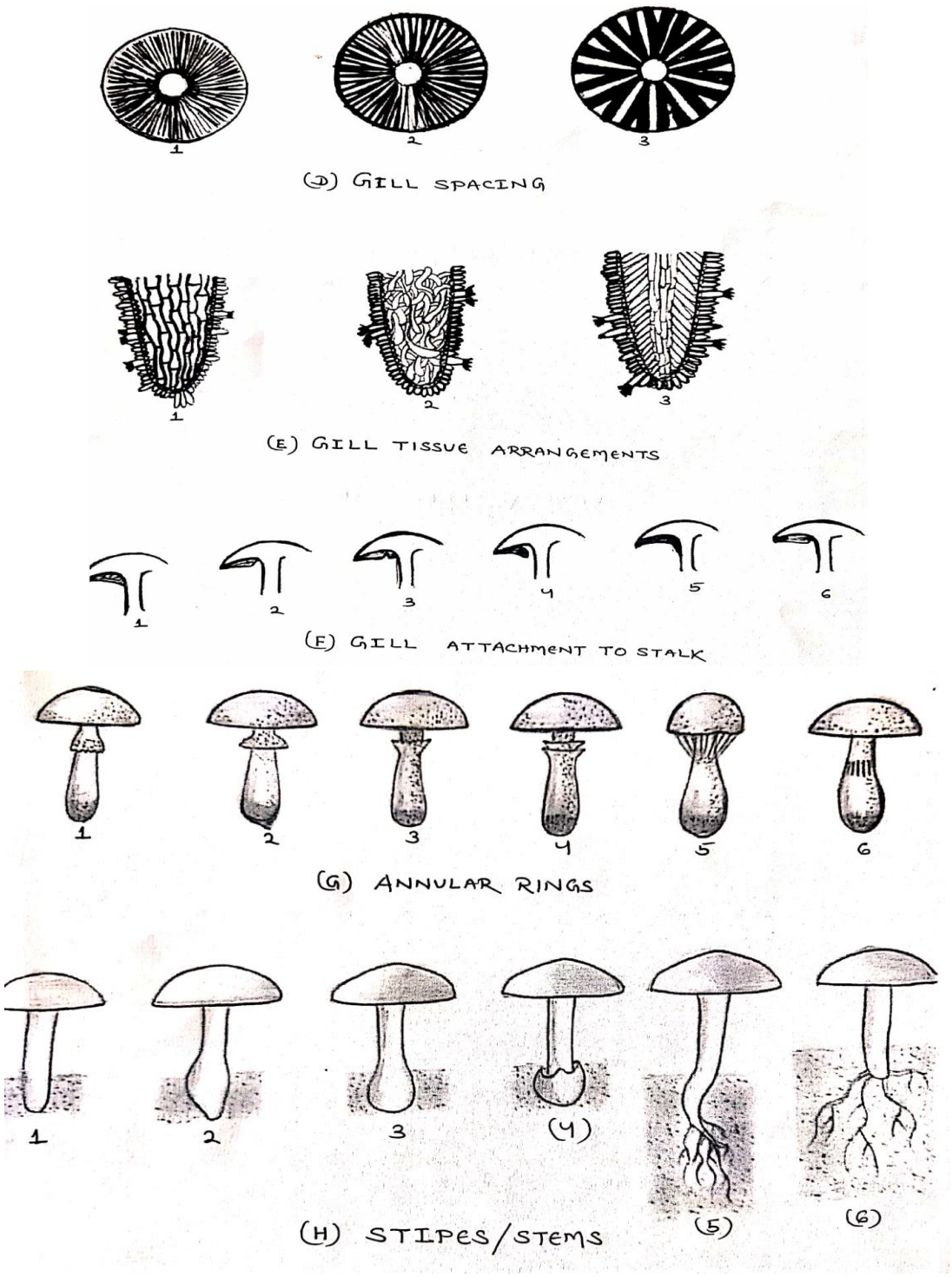

Figure 1. A. Mushroom Morphology B. Mushroom cap shapes 1. Convex 2. Bell shaped 3. Conical 4. Knobbed 5. Flat 6. C. Sunken Mushroom cap surfaces 1. Smooth 2. Velvety 3. Hairy 4. Raised scales 5. Flat 6. Patches D. Gill spacing 1. Crowded 2. Close 3. Distant E. Gill tissue arrangement 1. Parallel 2. Inter woven 3. Divergent F. Gill attachment to stalk 1. Adnate 2. Adnexed 3. Notched. 4. Seceding 5. Descending 6. Free G. Annular rings 1. Pendant 2. Flaring 3. Sheathing 4. Double 5. Cobwebby 6. Ring zone H. Stipes/stems 1. Equal 2. Club shaped 3. Bulbous 4. With cup (Volva) 5. Rooting 6. With rhizoids.

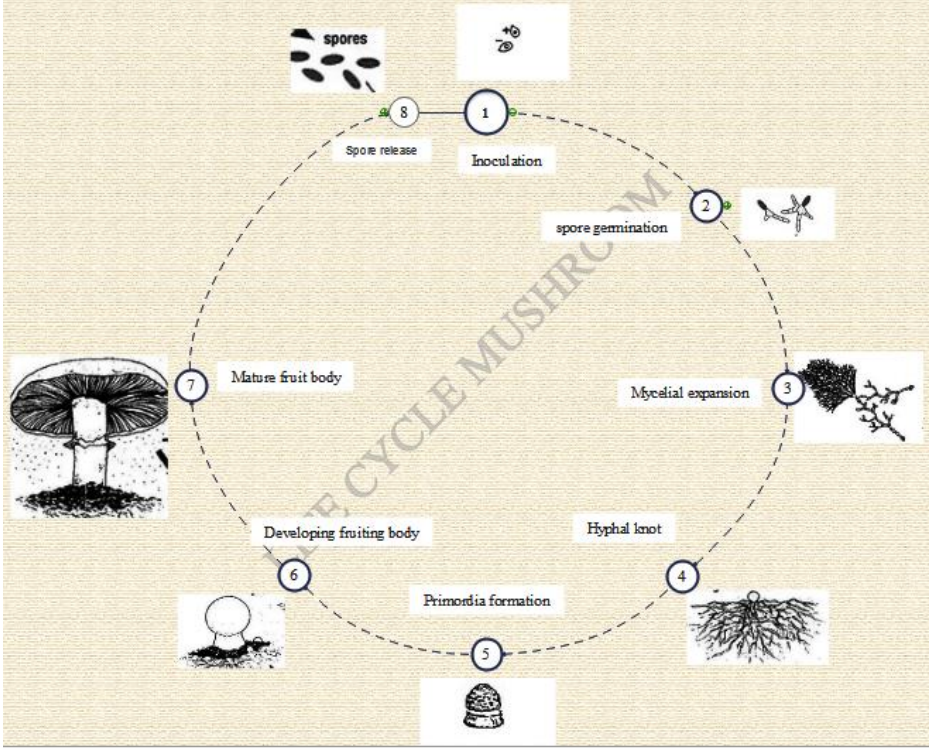

Figure 2. Life cycle of Mushroom

Classification of mushrooms

Out of all edible mushrooms found, only six mushrooms are widely preferred for large-scale cultivation (Figure 3). They are:

- Paddy straw mushroom - *Volvariella spp.*
- Oyster mushroom - *Pleurotus spp.*
- Button mushroom - *Agaricus spp.*
- Milky mushroom - *Calocybe spp.*
- Shiitake mushroom _ *Lentinulla spp.*
- Jew's ear mushroom - *Auricularia spp.*

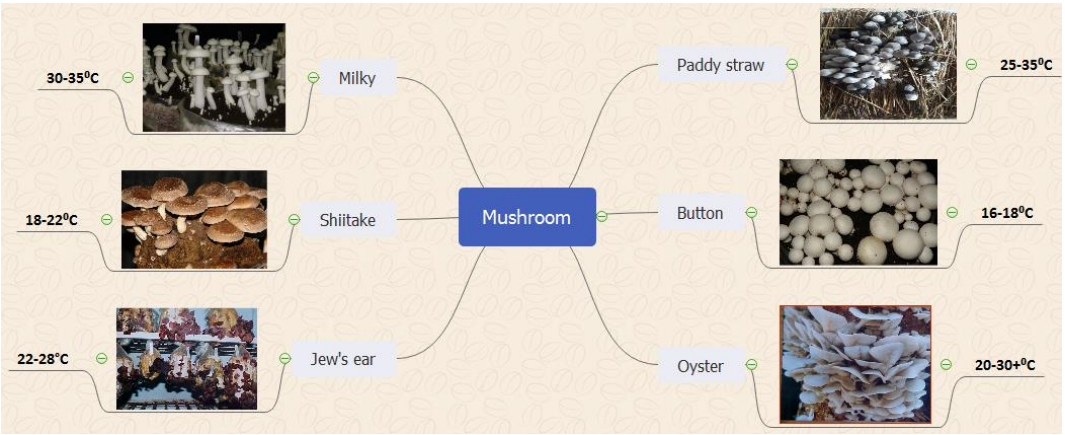

Figure 3. Classification of mushrooms

***Volvariella* sp.:**

These tropical mushrooms, sometimes known as "Chinese Mushrooms," are equally popular in India as Paddy Straw Mushrooms/ Straw Mushrooms. Typically, an edible in subtropical and tropical regions. It was initially grown in China before being gradually brought to South-East Asian nations. The paddy straw mushroom was initially grown in India in 1940, but attempts at systematic cultivation didn't begin until 1943. At the moment, coastal states like Orissa, Andhra Pradesh, Tamil Nadu, Kerala, and West Bengal are where this mushroom is most popular. This mushroom can grow at temperatures between 30 and 35°C. The term "Warm mushroom" is another name for it. Its cultivation method is simple and inexpensive. It grows quickly and only needs 10 days from spawning to harvesting. But this mushroom is highly perishable and cannot be refrigerated for more than 1 to 2 days.

Morphology: The fruiting body of mushroom is divided into 6 different developmental stages such as: Pin head stage, tiny button stage, Button stage, Egg stage, Elongation stage and Mature stage (Ahlawat. O.P and Tewari. R.P., 2007) (Figure 4).

Pin head stage: It is of the size of pinhead in which the veil is white. Pileus and stipe are not visible in longitudinal section. The whole structure is a knot of hyphal cells.

Tiny button stage: These stages are formed from interwoven hyphae. In a young tiny button, only top of veil is brown while rest is white. It is a round in shape and lamellae are seen as a narrow band on lower surface of pileus when vertical cut is made.

Button stage: This stage is perfect stage for marketable condition at a premium price. In this, the whole structure is covered by a membrane called universal veil. The stipe is not visible but in longitudinal section it is visible.

Egg stage: At this stage pileus is formed out of the veil and veil remains as volva. Stipe is not visible. Lamella does not bear basidiospore.

Elongation stage: Pileus remains closed and size is smaller than matured stage. Stipe attains its maximum length.

Mature stage: The pileus, stipe, and volva of the paddy straw mushroom are all fully developed at this point. Pileus is 6-12 cm in diameter and joined at the center by a stipe. A completely developed pileus has a smooth, circular surface and complete edge. The colour is light grey along the margin and dark grey in the center. Pileus' lower surface is covered in 280–380 lamellae per pileus. Each lamella is made up of three layers: hymenium, basidia in the form of clubs, and basidiospores. It might be pale yellow, pink, or dark brown in colour. Stipe measures 0.5 to 1.5 cm in diameter and 3 to 8 cm in length. They have an uneven shape, are white, fleshy, and cup-shaped. Rhizomorphs near the base of the volva bear seeds that take up nutrients from the substrate.

Spore print- brownish pink and salmon in colour.

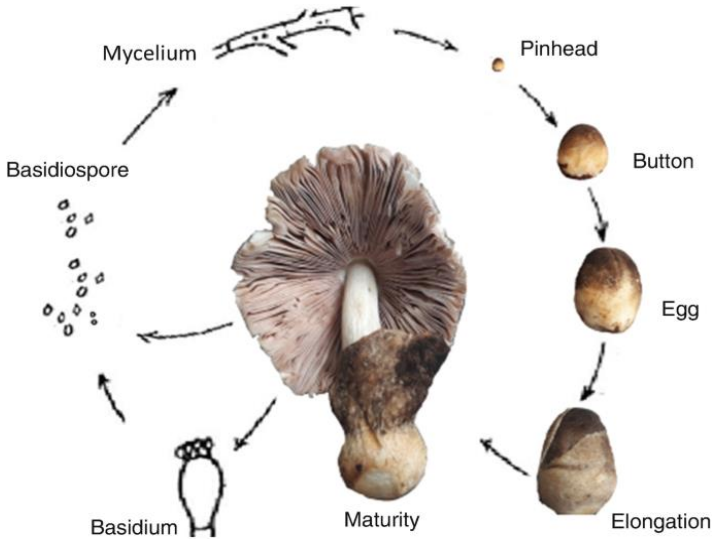

Figure 4. Developmental stages of paddy straw mushroom

2. *Pleurotus* sp.: commonly referred to as Dhingri or the oyster mushroom (wood fungus) in India. It is the third-largest mushroom grown in cultivation. Nearly 85% of the global production of oysters, which is led by China, which produces around a million tonnes annually. The Philippines, Taiwan, Thailand, Korea, Japan, Italy, and Japan are among the other nations that cultivate oyster mushrooms. Due to poor domestic demand, India now produces just about 1500 tonnes of this crop. In 1917, Flack began growing an oyster mushroom species (*Pleurotus ostreatus*) on wood logs and tree stumps as an experiment in Germany. Block, Tsao, and Hau perfected growing technique in the United States. It is a Basidiomycetes fungus. The sporophore or fruiting body of this mushroom is distinctly shell, fan or spatula shaped with different colours of white, light brown, grey, yellow, pink and blue depending upon the species. Oyster mushroom can grow at moderate temperature ranging from 20 to 30^0 C and humidity 55-70% for a period of 6 to 8 months in a year. It can also be cultivated in summer months by providing the extra humidity required for its growth. The best growing season is during March/April to September/October and in the lower regions from September/October to March/April. The oyster mushrooms have 3 distinct parts- 1. a fleshy shell or spatula shaped cap (*pileus*), 2. a short or long lateral or central stalk called *stipe* 3. long ridges and furrows underneath the pileus called gills or *lamellae*. Flesh is thin and white, margin is in rolled when young, and is smooth and often somewhat lobed or wavy, gills are white, decurrent, broadly spaced, stem attached in an off - centred fashion and is short at first and absent in age. The spores are whitish, smooth and cylindrical and germinate very easily (Figure 5). The mycelium of *Pleurotus* is pure white in colour and basidium is tetrapolar producing 4 haploid basidiospores, heterothallic, clamp connections present.

Spore print: White to grey or slightly lilac grey.

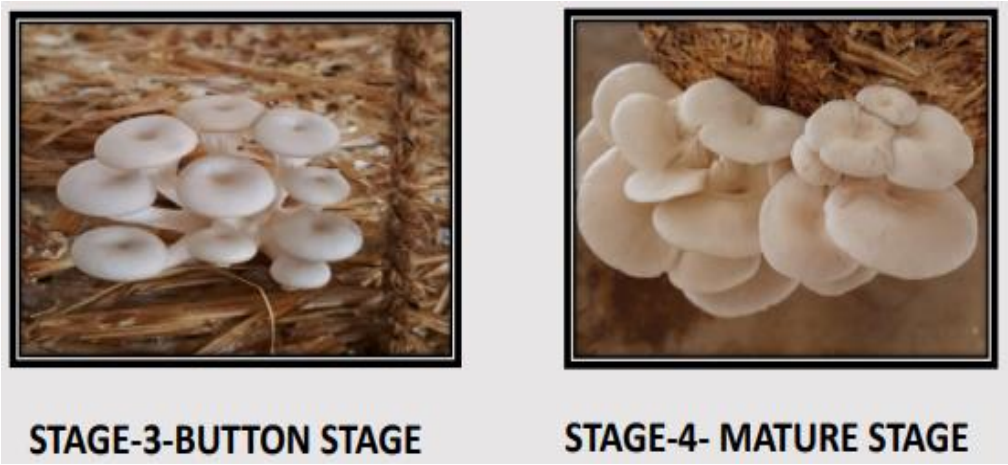

Figure 5. Developmental stages of oyster mushroom

Among all the cultivated mushrooms *Pleurotus* has maximum number of commercially cultivated species suitable for round the year cultivation (Figure 6). Some popular species are:

- Pearl oyster- *Pleurotus ostreatus* – Ashy white coloured.
- Blue oyster- *Pleurotus ostreatus var. Columbines*- Blue coloured.
- Golden oyster- *Pleurotus citrinopileatus*- Yellow coloured.
- Pink oyster- *Pleurotus djamor*- Pink coloured.
- Phoenix oyster- *Pleurotus pulmonarius*-Light brown coloured.
- King oyster- *Pleurotus eryngii*- Brown coloured.
- White oyster- *Pleurotus florida*- White coloured.
- *Pleurotus sajorcaju* – Ash coloured.

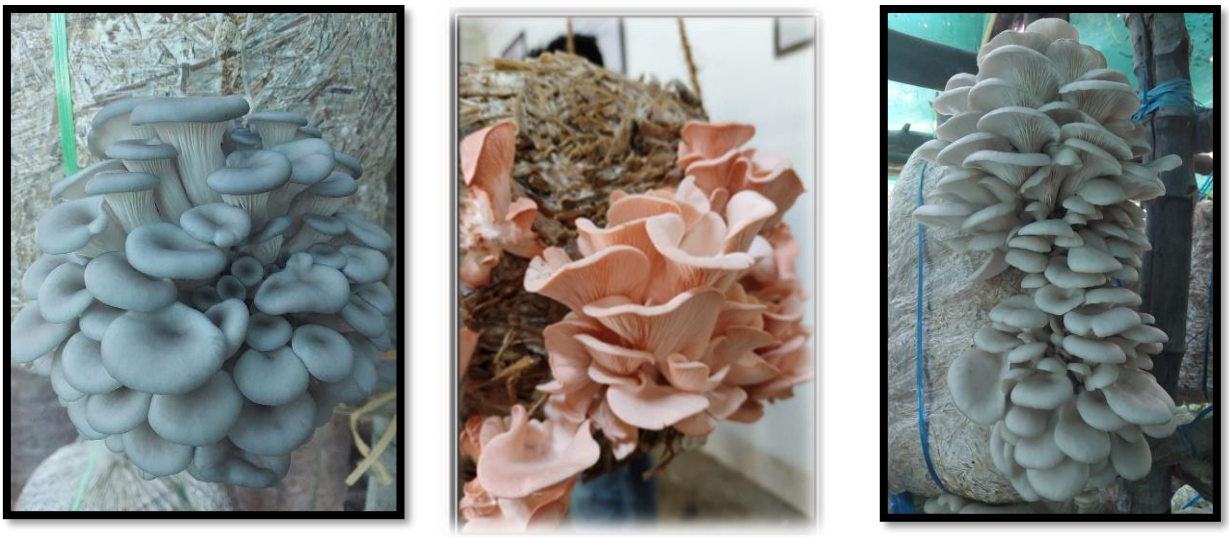

Figure 6. 1. Blue oyster mushroom, 2. Pink oyster mushroom, 3. White oyster mushroom

***Agaricus* spp**.

Also known as white button mushroom. It is one of the worlds' most economically important vegetable crops (Horgen, 1992). Modern commercial varieties of the common *Agaricus* mushroom originally were light brown in colour. The white mushroom was discovered in 1925 growing among a bed of brown mushrooms at the Keystone Mushroom Farm in Coatesville, Pennsylvania (Roy, 1969). Some brown forms of *A. bisporus* are currently being cultivated; brown buttons are sold as crimini (or baby bellas).

- Cap/Pileus is 3-16 cm, convex or nearly flat in age; dry; smooth which is not brightly coloured.
- The spore bearing gills are free from the stem, initially pinkish, becoming brown to dark brown to chocolate brown.
- Stem is 2-8 cm long, 1-3 cm. Thick; it has a ring that sometimes disappears in maturity. Flesh is white and firm.
- The cup like volva at the base of the stipe is absent.
- It has pleasant odour and taste. Spore print brown, the spores are oval to round and Basidia is 2-spored.

Structure of *Agaricus*:
It can be studied in two parts:

- Vegetative mycelium (living inside the soil)
- Fruiting body or basidiocarp (present above the soil and edible in young stage)

Vegetative mycelium is of three types: The primary mycelium is septate, haploid, short lived, and monokaryotic. The secondary mycelium is dikaryotic and long-lived. The hyphae of the secondary mycelium are long, branched and produce mushroom's body or basidiocarp.

Button stage: The fruiting bodies arise as small, white, globular, apical swelling on the branches called tiny knots or "Button-Stage" of the fungus. The dome shaped upper portion is known as pileus/cap. The lower portion called the stalk or stripe. The margins of the pileus are connected with the stipe with the help of a membrane called inner veil. It is a developmental stage of the fruiting body of *Agaricus*.

Mature fruiting body: The basal mycelial portion is known as rhizomorph, from which basidiocarp develops. The basidiocarp is divided into a long structure like stipe and an upper cap like pileus. The stalk is made up of pseudoparenchymatous mass and fleshy. Pileus is umbrella shaped and gills are arranged in the underside of it. A membranous ring or annulus ring is present on stipe and in early stages it remains in contact with pileus. Four basidiospore (purple coloured, oval and uni nucleate) develops from each basidium (Figure 7).
Spore print- dark brown in colour.

Figure 7. Mature fruiting body of button mushroom

***Calocybe* sp**.

Figure 8. Milky mushroom

Commonly known as Milky mushroom. The first report on wild occurrence of *Calocybe indica*, commonly called "Dhuth chatta" (means "Milky white mushroom" originated from India) Figure 8. For several decades, people from West Bengal have collected the mushrooms and sold in local markets. Its milky white color and robust nature are attracting to consumers (Vikineswary & Chang, 2013). Since this mushroom is phenotypically similar to button mushroom, it is popular in southern Indian states and slowly getting demand in other countries (China, Malaysia and Singapore) also. Small scale mushroom growers prefer to grow this tropical mushroom due to the following reasons: 1. ideally suited to warm humid climate (30 to 38°C; 80 to 85% humidity), 2. Its longer shelf life (5-7 days) 3. Retains fresh look and does not turn brown or dark black like that of button mushrooms, 4. Has a short crop cycle (7 to 8 week) (Krishnamoorthy & Venkatesh, 2015). Milky Mushrooms are often found in grassy areas, woodlands, or on decaying organic matter. They can be both saprotrophic and mycorrhizal.

Morphology

Milky Mushrooms (*Calocybe spp*.) can vary between species, here is a more in-depth look at the general characteristics (Subbiah & Balan 2015): (Figure 9)

Cap (pileus)

Convex when young, flattening with age. Mature caps can become slightly depressed in the center. Caps can range from small to large, with diameters typically between 5 to 15 centimeters. Smooth, moist, and often slimy when young, giving it a glossy or milky appearance. Cap color varies with species but is commonly white, cream, or light tan. Some species may exhibit color changes with age or environmental conditions.

Gills (lamellae)

Gills are closely spaced and attached to the stem. They may be slightly decurrent that means they extend down the stem. Typically white, although variations may occur. Gills can be densely packed.

Stem (stipe)

Cylindrical or slightly swollen at the base. The stem may taper upwards. The length of the stem varies, and the diameter is generally consistent. Smooth or slightly fibrous, with a texture matching the cap. White or pale, similar to the color of the gills.

Ring (annulus)

Some species may have a partial or ephemeral ring that is often delicate and may disappear with age.

Spore print

White spore print.

Veil

In the button stage, some species have a membrane (universal veil) that covers and protects the gills. This veil may rupture as the mushroom matures. Some species form a partial veil that connects the edge of the cap to the stem. This may leave remnants on the stem or form a partial ring.

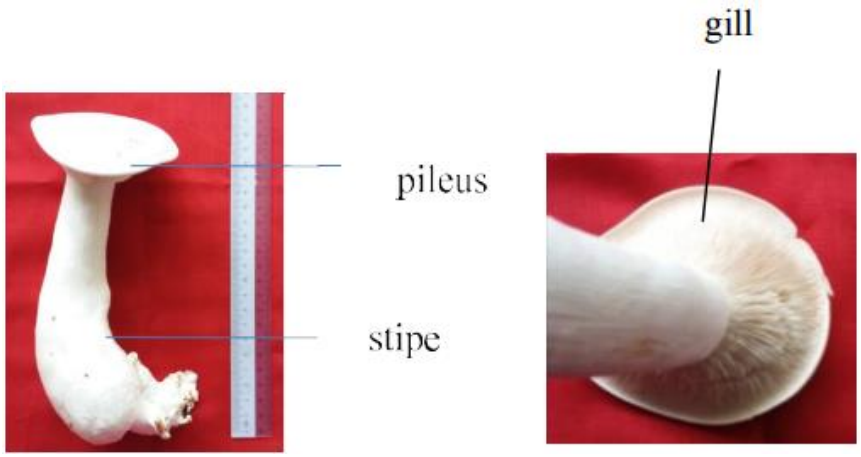

Figure 9. Structure of *Calocybe sp.*

Milky Mushrooms (*Calocybe* spp.) go through multiple stages in their life cycle, from the germination of spores to the maturation of fruiting bodies (Aruna Jyothi Kora, 2020). Although the finer points may differ across the various species in the *Calocybe* genus, many fungi share a similar life cycle for mushrooms. Here's an overview:

Spore germination: Spores germinate to start the life cycle. Usually discharged from fully grown fruiting bodies (mushrooms), these spores scatter across the surrounding area.

Mycelium formation: A hypha, or thread-like structure, appears when a spore germinates in an appropriate environment. A network of interconnected hyphae is referred to as mycelium.

Mycorrhizal associations: A type of association that certain species of milky mushrooms have with plant roots; these associations are voluntary. In these connections, the mycelium interacts with some plants' roots to promote nutrition exchange.

Primordium formation: The mycelium differentiates into structures called primordia when the right environmental conditions are met. Primordia are young, immature mushroom structures that will grow into fully formed fruiting bodies in due course.

Development of fruiting body: The cap, gills, and stem are examples of the mature fruiting bodies that the primordia continue to grow into. At this point, the species' distinguishing characteristics—like cap color, size, and shape become visible.

Production of spores: The mushroom produces spores on the gill surfaces as it ages. When adult mushrooms reach the end of their life cycle, the spores are discharged into the surrounding environment.
Spore dispersal: The discharged spores may travel to other areas due to the action of external factors like wind, water, or animals. This dispersal mechanism helps ensure the propagation of the species.

Decay and recycling: The mature fruiting bodies eventually undergo decay after the spores are dispersed. Ecosystems rely on this mechanism to recycle nutrients because the decomposing material replenishes the environment with organic stuff.

Repetition of the cycle: Mycelium, primordia, and ultimately full fruiting bodies are formed by new spores in a cyclical life cycle. As long as the atmosphere stays conducive, this cycle will continue.
It's important to note that different mushroom species may have different life cycle details, and that different Milky Mushroom species may have different life history methods. In addition, the timing and success of each life cycle stage can be influenced by variables like substrate availability, interactions with other species, and environmental circumstances.

Lentinula edodes

East Asia, especially China, Korea, and Japan, is where shiitake mushrooms (*Lentinula edodes*) are naturally found (Xiang et al, 2021). Shiitake has been popular throughout the world and is currently grown in many nations in Asia, Europe, North America, and other locations throughout the course of centuries. Due to its economic importance and growing demand in the culinary industry, shiitake mushrooms are become more and more popular in India. They are often grown indoors utilizing a variety of techniques, including as log, bag, and bag farming. It's common to find shiitake mushrooms growing on rotting hardwood trees, especially oak, beech, and shii trees. The fungus is mostly a saprophyte that breaks down decaying wood, but it also creates mycorrhizal associations with these trees.

Morphology

The morphology of Shiitake mushrooms (*Lentinula edodes*) involves various structures, including the cap (pileus), gills (lamellae), stem (stipe), and other features (Petruzzello, 2023). Here is a detailed description of the morphology of Shiitake mushroom.

Cap (pileus)

Convex in immature stage, flattening with age. Mature caps may develop a little depression in the center. Although they vary in size, caps typically have a diameter of 5 to 25 cm. smooth surface that, when its new, may feel a bit tacky or sticky at times. Older caps may develop little cracks. The color of the cap varies according to maturity and strain. It could be brown, dark brown, or even pale tan.

Gills or lamellae

The gills, or lamellae, are closely spaced and attached to the stem. From the stem, they radiate outward. Initially white or cream when young. As the mushroom ages, its gills become a deep purplish-brown color. There is a narrow spacing between gills, especially around the stem.

Stem: stipe

Stout and round in form. The base somewhat tapers down. The stem's length varies, but it typically matches the cap's size. Often, the stem is smooth, firm, and white. It could have a fibrous texture.

Veil

In some strains, the edge of the button stage may be joined to the stem by a membrane called a partial veil. As the mushroom ages, this veil may shatter, leaving fragments on the stem or creating a ring.

Spore print

Shiitake mushrooms have spore prints that range in color from white to light cream.

***Auricularia* spp.**

(The Jew's Ear Mushroom/Jelly ear fungus)- is a widely distributed mushroom that grows in many different parts of the world. It is known to exist in tropical and temperate regions. There have been reports of the mushroom in Asia, Europe, North America, Africa, and other continents. The common location for Jew's Ear Mushroom growth is on decaying wood, particularly on dead or dying deciduous trees. It can occur on different hardwoods but is more commonly found on older trees. Jew's Ear Mushroom, scientifically known as *Auricularia* spp., is a fascinating and edible fungus that belongs to the family Auriculariaceae. This mushroom is well-known for its distinctive ear-like or cup-shaped fruiting bodies (Kirk et al, 2008).

Morphology: The primary feature is the ear-like or cup-shaped fruiting body. It often resembles a folded, elastic, or pliable ear. The mushroom has a smooth, gelatinous texture. When young, it is softer and more flexible, while mature specimens may become tougher. Caps can range from a few cm to around 10 cm in diameter, and they may be solitary or clustered. The caps of Jew's Ear Mushroom are typically dark brown to reddish-brown. The color can vary depending on the specific species and the age of the specimen. The fungus directly attaches to wood, often found growing on dead or decaying deciduous trees. It is commonly associated with elder trees (*Sambucus* species). The undersurface of the cap is smooth and may appear lighter in color than the upper surface. Spore Print: Jew's Ear Mushroom produces a white to light-colored spore print. Microscopically, the fungus exhibits a network of hyphae, which are the thread-like structures that make up the mycelium. The morphology of Jew's Ear Mushroom can show some variability, and different species within the Auricularia genus may have subtle differences in appearance. Jew's Ear Mushroom typically grows in a shelf-like or semi-circular pattern on the surface of wood.

Processing and preservation of oyster mushroom: Mushrooms are a great source of high-quality proteins that contain vitamins, minerals, and the majority of amino acids in proportion. The popularity of mushrooms has grown, and their consumption has nearly doubled globally because of their high-quality nutrients. Due to

their distinctively meaty, sharp flavor and texture, mushrooms are valued. Because mushrooms are so perishable, they begin to deteriorate after harvest, making the produce unfit for sale. Freezing, canning, and drying are widely used techniques for preserving mushrooms.

Processing: Mushrooms can be preserved economically by pickling and sun-drying. However, they are of exceptional quality after freezing and freeze-drying. There are descriptions of many technologies that could be used to prepare mushrooms.

- **Drying/ Dehydration:** Drying reduces the water activity in the product to a level (a_w<0.7) that allows for the measurement of microbiological and metabolic activity. Although the product produced by freeze drying is of superior quality, the expense of removing the water is ten times greater than that of traditional air drying. Due to its low capital costs and free energy source, sun drying is a suitable technique for our country. Before drying, two important procedures are blanching and sulphuring.
- **Low temperature:** The use of individual rapid freezing technology results in a product with a longer shelf life and superior quality. The basic principle behind freezing is to quickly remove the heat from fresh mushrooms. Freezing inhibits microbiological activity. Freezing temperatures are the only ones that slow down enzyme activity. Blanching of mushrooms is necessary for freezing in order to regulate their activity. 35^0–40^0C is the ideal storage temperature to sustain for optimal performance. Avoid repeatedly freezing and thawing as it can be harmful.
- **High temperature:** Its primary goal is to eliminate the microbe and use hermatic sealing to stop recontamination. Citric acid, ethylene diamine tetra acetic acid (EDTA), and ascorbic acid are suggested as helpful additives for enhancing the color of mushrooms when they are canned. Before canning, buttons can be steeped in a 0.5% methyl cellulose or carboxy methyl cellulose solution, which increases yield by 5–9% without compromising quality. Agar and pectin are food additives that enhance the flavor of canned goods.
- **Microwave drying:** The drying process involves exposing the food items to microwave-range electromagnetic radiation, which transfers the heat of vaporization directly to the water molecules, causing them to evaporate off the food items. As a result, the produce's moisture content and water activity are decreased quickly. The end result is of higher quality because of the short exposure period and low temperature maintenance.
- **Osmotic dehydration:** The process of osmotic dehydration has two steps. Food must first be submerged in an osmotic agent or concentrated solution. The concentrated meal may be vacuum-dried or air-dried in the second step to create a stable dehydrated product. Dehydrated product at lower temperatures, which lowers the severity of heat treatment, is the main principle of osmotic dehydration. This makes it possible to produce dehydrated goods that, in terms of color, flavor, and texture, are extremely similar to natural items.
- **Chemicals:** Small amounts of a number of chemical additives, which are not nutritional, are added to food to enhance its flavor, texture, appearance, and storage qualities. These chemicals play a significant role in preservation. The primary ingredients are salt, sugar, vinegar, acetic acid, and spice essential oils. Chemical preservatives, on the other hand, improve their keeping quality and preserve their nutritional value. When preparing mushrooms, potassium metabisulphite is a frequently used preservative. For three months, mushrooms are well-preserved. The mushrooms are blanched for three minutes after the solution is drained out when they are ready for processing.

- **Pickling and lactic acid fermentation:** Anaerobic or partial anaerobic oxidation of carbohydrates is the process known as fermentation. A significant amount of lactic acid is produced during fermentation

to stop the product from further spoiling while being stored. Products like pickles, chutneys, and ketchup can be stored at room temperature for at least six months.

- **Irradiation:** Applying gamma radiation helps prolong their shelf life by slowing down the deteriorating processes. The marketability of button mushrooms is increased by doses of 1-2 kg, which also prolongs their storage life for 9–10 days at 15^0C by delaying cap opening and stem elongation.

Conclusion

The fruiting bodies of fungi, mushrooms are crucial to human life, biology, and taxonomy. As decomposers, they are essential to ecosystems and are involved in the cycling of nutrients. In addition, a lot of mushrooms are edible and have therapeutic qualities, which improve human health and nutrition. Some types of mushrooms can be utilized in bioremediation procedures to remove environmental contaminants. The mushroom industry is expanding and offers both a sustainable food source and economic benefits. Mushrooms are categorized under the Ascomycota and Basidiomycota classes, reflecting the diversity of the fungal kingdom. In summary, mushrooms are a complex and intriguing collection of organisms with a rich taxonomic history that transcends their use as a culinary item. They are also essential to the ecological balance and human health.

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