

# **MUSHROOM**

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# Mushroom

- Mushrooms are the fruiting bodies of macro fungi. They include both edible/medicinal and poisonous species.
- However, originally, the word “mushroom” was used for the edible members of macro fungi and “toadstools” for poisonous ones of the “gill” macro fungi.
- Mushrooms have been recognized as food rich in protein, folic acid as well as vitamin B12.
- Its characteristic meaty biting, texture, and flavour also contribute to mushroom demand.
- Mushroom is gradually becoming popular, as they are rich in minerals and vitamins with low fat and sugar.
- The top three mushrooms consists of *Lentinula* (shiitake and relatives), *Pleurotus* (oyster mushrooms), and *Auricularia* (wood ear mushrooms).
- The button mushroom (*Agaricus bisporus* and relatives), the most popular edible mushroom in the Western world, is only at the fourth position of most cultivated mushrooms.
- Many mushroom-forming fungi belonging to the class of primary decomposers can be cultivated on a range of lignocellulosic material, including various types of straw, cotton seed hulls, corn cobs, peanut shells, cotton from textile industry, coffee pulp, paper, and leaves.

# ...Mushroom

- The oldest form of mushroom cultivation is probably the outdoor log culture, which has been used in China to cultivate shiitake at least for a millennium.
- Nowadays, this technique has largely been replaced with the more effective indoor cultivation on “artificial logs,” plastic bags filled with nutrient complemented sawdust-based substrates.
- Once the bag is colonized, it is unpacked to allow fruiting. The sawdust is being held together by mycelium, like glue, and will not fall apart.
- Very similar to the artificial logs are the column cultures that consist of long plastic bags that are hung from the ceiling.
- Once the mycelium has colonized these bags, holes are punched into the plastic to allow mushroom fruiting.
- The substrate composition however will play a large role in colonization and fruiting efficiency.
- For instance, *Pleurotus florida* colonization results in a dry weight reduction of pea and rice straw of 20 and 12%, respectively.

# Mushroom cultivation

- There are three major stages involved in mushroom cultivation:
  - (1) inoculum (spawn) production,
  - (2) substrate preparation, and
  - (3) mushroom growing i.e. inoculation of the substrate with propagules of the fungus, growth of the fungal mycelium to colonise the substrate, followed by fruiting, harvesting and processing of the fruiting bodies.
- **Inoculum (spawn) production:** In order to achieve reliable and vigorous fungal growth and fruiting bodies production of good quality, inoculum fungal cultures are necessary.
- Inoculum is produced by inoculation of sterilized cereal grains (usually wheat, rye or millet) from high quality stock mycelial cultures.
- Spawn-making is a rather complex task, not feasible for the common mushroom grower, and is produced by specialist companies (spawn-makers) using large scale bulk autoclaving, clean air and other microbiological sterile techniques for vegetative mycelia cultures onto cereal grains, wood chips and plugs or other materials.
- The colonized cereal grain/mycelium mixture is called spawn.

# ... Mushroom cultivation

- **Substrate preparation:** The substrates used for mushroom production, varying according to cultivated species, are prepared from waste agricultural or forest product materials using ingredients such as manures, cereal straws or other crop residues, sawdusts etc.
- In certain cases the substrate is be directly inoculated and require very little pre-treatment, e.g. *L. edodes* production using logs.
- In other cases, the substrate is microbiologically or physically pretreated.
- Microbiological pre-treatment normally comprises some form of controlled bulk composting process.
- Physical pre-treatment could include steam treatment or sterilization by autoclaving.
- Substrates for fungal growth can be prepared as sterile materials, to produce an axenic growth medium, e.g. bottle cultures of *Flammulina velutipes*, or be non-sterile, e.g. compost substrates to produce *A. bisporus*.

# Key mushroom species and their corresponding cultivation medium

Growing Medium	Mushroom Species
Rice straw	Straw ( <i>Volvariella</i> ), Oyster ( <i>Pleurotus</i> ), Common ( <i>Agaricus</i> )
Wheat straw	Oyster ( <i>Pleurotus</i> ), Common ( <i>Agaricus</i> ), Straw ( <i>Volvariella</i> ), Roundhead ( <i>Stropharia</i> )
Coffee pulp	Oyster ( <i>Pleurotus</i> ), Shiitake ( <i>Lentinus</i> )
Sawdust	Shiitake ( <i>Lentinus</i> ), Oyster ( <i>Pleurotus</i> ), Lion's Head or Pom Pom ( <i>Hericium</i> ), Ear ( <i>Auricularis</i> ), Ganoderma ( <i>Reishi</i> ), Maitake ( <i>Grifola frondosa</i> ), Winter ( <i>Flammulina</i> )
Sawdust-straw	Oyster ( <i>Pleurotus</i> ), Roundhead ( <i>Stropharia</i> )
Cotton waste from textile industry	Oyster ( <i>Pleurotus</i> ), Straw ( <i>Volvariella</i> )
Cotton seed hulls	Oyster ( <i>Pleurotus</i> ), Shiitake ( <i>Lentinus</i> )
Logs	Nameko ( <i>Pholiota</i> ), Shiitake ( <i>Lentinus</i> ), White jelly ( <i>Tremella</i> )

# ... Mushroom cultivation

- **Mushroom growing:** This stage deals with the two phases of mushrooms life cycle i.e. the mycelium (vegetative phase) and the fruiting body formation (reproductive phase).
- Following inoculation, the mycelium, grows through the substrate, biodegrades its ingredients and supports the formation of fruiting bodies.
- Mycelial growth and fruiting during this stage are regulated by temperature, gaseous environment, nutrient status, water activity and in certain cases by light e.g. *Pleurotus* spp. has an obligate requirement for light for fruiting induction, *Agaricus* spp. have no light requirement.
- Mushroom production on the culture medium surface occurs as a series of cycles (flushes).
- After harvesting, mushrooms are normally cooled down to retard fruiting body metabolism, packed and sent to the fresh market, or processed further through freezing, canning, drying etc., depending on marketing strategies.

# *Agaricus bisporus*

- The substrate used for *A. bisporus* cultivation is a complex culture medium made from straw- and manure-based compost.
- Its preparation is a two-stage process in which the first stage includes composting of the raw material consisting of straw, horse or poultry manure and gypsum.
- I stage takes 3–6 days during which temperature increases to 80 °C due to activity of thermophilic microflora.
- During composting that lasts about 3 weeks, the lignocellulose waste is modified by various bacteria and fungi to a better-digested form suitable for *A. bisporus*.
- In the second week stage, the compost is pasteurized before inoculation with *A. bisporus* spawn.
- Temperature of the compost during phase II is initially 50 °C, followed by a 2-day period at 60 °C and a 3-day period at 45 °C
- Natural drop in temperature and lack of free ammonia are signs that the composting process has been completed.
- Cultivation begins with inoculation (spawning) and growth of the mushroom mycelia into the compost under high humidity and temperature 25°C.
- At complete colonization, after 2–3 weeks, a casing layer containing peat moss and limestone is spread on the top of the compost.



# ... *Agaricus bisporus*

- A casing layer is able to provide a consistently humid environment at the interface of the substrate and the environment (where pins form), which can often make up for less than ideal environment conditions.
- After allowing 7 to 9 days for the *Agaricus* mycelium to grow into the casing layer, a machine with rotating tines is run across the mushroom bed to mix the casing layer thoroughly.
- The above process is called 'ruffling', serves in breaking up the mycelial strands, and encourages the mushroom mycelia to grow and colonize the surface of the casing layer.
- The mushroom mycelium grows into the casing layer in similar conditions to those of compost colonization, and when it reaches the upper surface of the casing layer the fruiting process starts comprising environmental manipulation.
- The growing room is ventilated to decrease the concentration of carbon dioxide (usually to < 0.1%) and to help reduce the temperature to 16–18°C.
- The temperature, humidity and CO<sub>2</sub> level are then adjusted to trigger fructification and to favor the development of mushrooms.
- The first pin initials begin to appear about 2 weeks after casing. One layer of compost produces 2–4 crops called flushes.
- In general, the production of *A. bisporus* is time-consuming due to the long composting stage.

# *Agaricus bisporus* cultivation



# *Pleurotus* spp.

- *Pleurotus* species (like *P. ostreatus*, *P. sajor-caju*, *P. pulmonarius*, *P. eryngii*, *P. cornucopiae*, *P. tuber-regium*, *P. citrinopileatus* and *P. flabellatu*) are commercially very important edible mushrooms, found all over the world.
- Both pasteurized and sterilized substrate of a wide range of residues can be used and **no casing is required**.
- The primary ingredients used for *Pleurotus* spp. production is chopped wheat straw (*Triticum aestivum* L.) or cottonseed hulls (*Gossypium hirsutum* L.) or mixtures of them.
- For production on wheat straw, the material is chopped from 2 to 6 cm, water is added and pH of the material is adjusted with limestone to about 7.5 or higher to provide selectivity against *Trichoderma* green mold.
- The substrate is then pasteurized, then cooled followed by addition of grain spawn (inoculum) at about 3–5% of the fresh weight and the substrate, packed into 15–20 kg plastic bags or blocks, is placed in a dark room at 25–30°C with 80 per cent humidity.
- Depending on the strain, complete colonization of the substrate is achieved in 2–3 weeks.
- Fructification of *P. ostreatus* is triggered by lowering the air temperature to 12–15°C (cold-shock treatment) although no such treatment is required for other *Pleurotus* spp.
- The fruiting is light-dependent, requiring a 8–12 hour light cycle (solar or fluorescent lamp light) and adequate ventilation is given to keep CO<sub>2</sub> levels lower than 500 ppm.
- Three to four weeks after spawning depending on strain, amount of supplement used and temperature of spawn run, mushrooms begin to form around the edges of bag perforations and they are harvested from the substrate.

# *Pleurotus* spp. cultivation



# *Lentinula edodes*

- This fungus can grow on synthetic logs as well as natural logs. The most traditional but laborious cultivation is carried out in wood logs, mainly oak.
- The wood logs are holed and the mycelia plugs are inserted in these holes.
- After inoculation the logs are stored several months for mycelium colonization and finally for the formation of fruit bodies.
- This method is still used because of its high quality mushroom product.
- The last decades, new methods for *L. edodes* cultivation on residue-based substrates have been developed using milled wood residues (e.g. oak, hornbeam, sweetgum, poplar, alder, ironwood, beech, willow, pine, maple and birch sawdust) supplemented with nitrogen sources (e.g. rice bran).
- The main advantages of using synthetic medium over natural logs are time and efficiency.
- Substrate's ingredients are mixed, watered to gain a moisture content around 60% and filled into polypropylene bags 1–3 kg/ bag.

# ***...Lentinula edodes***

- The filled bags are stacked on racks, loaded into an industrial-sized autoclave, sterilized for 2 hours at 121°C, cooled and inoculated with spawn.
- After a 20 to 25 days spawn run, the bags are removed and the substrate blocks are exposed to an environment conducive for browning of the exterior log surfaces.
- As the browning process reaches completion (4 weeks), primordia begin to form about 2 mm under the surface of the bag-log indicating that it is ready to produce mushrooms .
- Primordia maturation is stimulated by soaking the substrate in water (12°C) for 3 to 4 hours (or 3 to 4 min if vacuum soaking is used to reduce temperature for fruiting body induction).
- Soaking allows water rapidly to displace carbon dioxide contained in air spaces, providing enough moisture for one flush of mushrooms.
- Approximately 9 to 11 days after soaking, mushrooms are ready to harvest.

# *Lentinula edodes* cultivation

## OLD METHOD



Laying yards



Raising yards



Mushroom growth

## NEW METHOD



# Questions

- Write an essay on mushroom production using waste material.
- Write short notes on:
  - Importance of mushroom
  - Explain stages involved in mushroom cultivation
  - *Agaricus bisporus*
  - *Pleurotus* spp.