CULTIVATING MUSHROOMS on SMALL FARMS

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Commonly Cultivated Edible Fungi

- Oyster Mushrooms — *Pleurotus spp.*

Commonly Cultivated Edible Fungi

- Button Mushrooms — *Agaricus spp.*
- Oyster Mushrooms — *Pleurotus spp.*
- Shiitake — *Lentinula edodes*
- Reishi or Ling Chi — *Ganoderma lucidum*
- Lion's Mane — *Hericium erinaceus*
- Nameko — *Pholiota nameko*
- Ears — *Auricularia* spp.
- Chicken-of-the-Woods — *Polyporus sulphureus*

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★Lion's Mane *Hericium erinaceus*

Commonly Cultivated Edible Fungi

★Chicken-of-the-Woods *Polyporus sulphureus*

Commonly Cultivated Edible Fungi

★Nameko *Pholiota nameko*

More Cultivated Edible Fungi

★Jelly, Witch's butter *Tremella* spp.
★Shaggy Mane *Coprinus comatus*
★Garden Giant *Stropharia rugoso-annulata*
★Paddy Straw *Volvariella volvacea*
★Velvet-Stemmed or Enokitake *Flammulina velutipes*
★Maitake or Hen-of-the-Woods *Grifola frondosa*

Commonly Cultivated Edible Fungi

★Ears *Auricularia* spp.

More Cultivated Edible Fungi

★White Jelly, Witch's butter *Tremella* spp.

More Cultivated Edible Fungi

★Shaggy Mane *Coprinus comatus*

More Cultivated Edible Fungi

★Velvet-Stemmed or Enokitake
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More Cultivated Edible Fungi

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More Cultivated Edible Fungi

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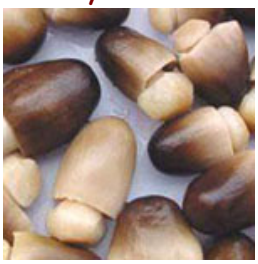

Limited Cultivation Edible Fungi

★Morel	*Morchella esculenta*
★Black Morel	*Morchella angusticeps*
★Summer White Truffle	*Tuber aestivum*
★White Italian Truffle	*Tuber magnatum*
★Black Perigord Truffle	*Tuber melanosporum*
★Chanterelles	*Cantharellus* spp.
★Maize Mushroom	*Ustilago maydis*

Limited Cultivation Edible Fungi

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Limited Cultivation Edible Fungi

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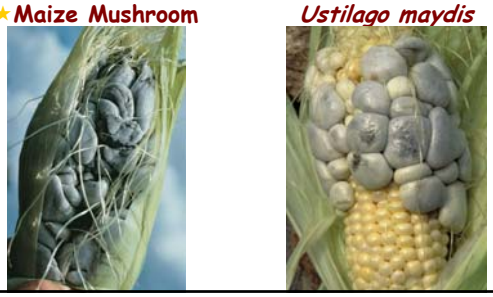
Limited Cultivation Edible Fungi

★Chanterelles *Cantharellus* spp.

Limited Cultivation Edible Fungi

★ Maize Mushroom — *Ustilago maydis*



Commonly Cultivated *Agaricus* Mushrooms

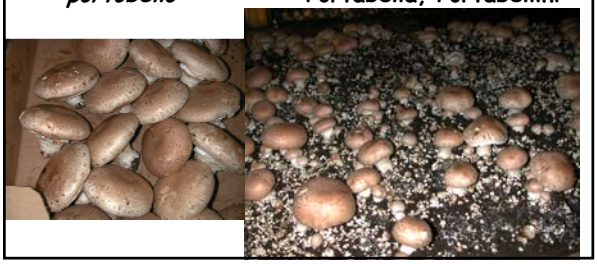
★ *Agaricus bitorquis* — Warm-Weather Button

Commonly Cultivated *Agaricus* Mushrooms

- ★ *Agaricus augustus* — Prince Button Mushroom
- ★ *Agaricus bitorquis* — Warm-Weather Button
- ★ *Agaricus bisporus "portobello"* — Italian *Agaricus*, Portabella, Portabellini
- ★ *Agaricus bisporus* (=*A. brunnescens*) — White Button Mushroom, Cremini

Commonly Cultivated *Agaricus* Mushrooms

★ *Agaricus bisporus "portobello"* — Italian *Agaricus*, Portabella, Portabellini

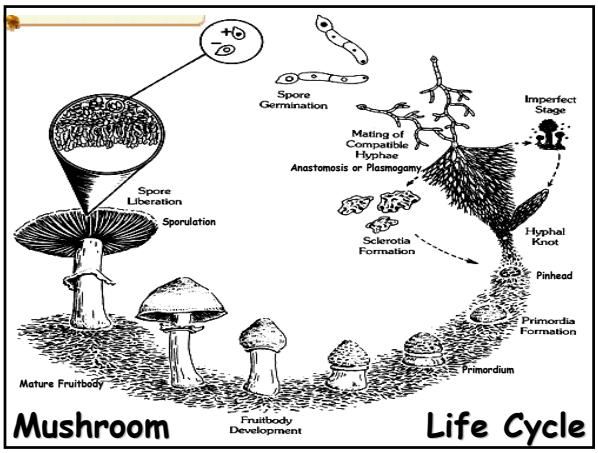


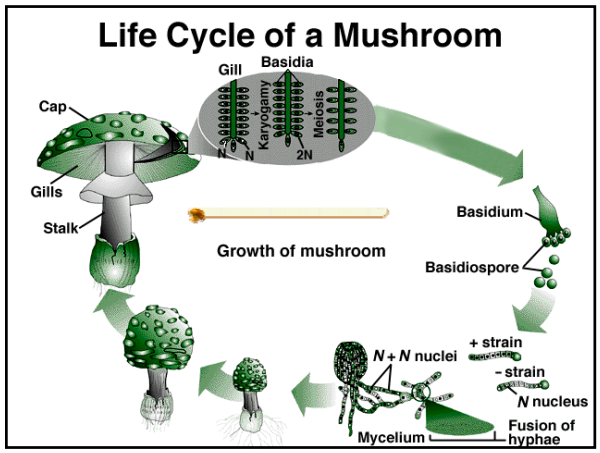
Commonly Cultivated *Agaricus* Mushrooms

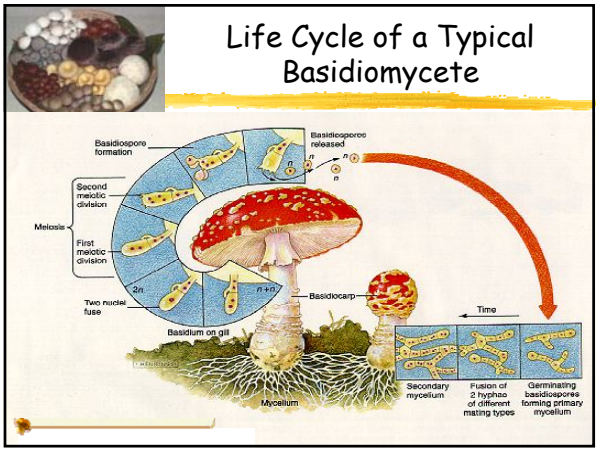
★ *Agaricus augustus* — Prince Button Mushroom

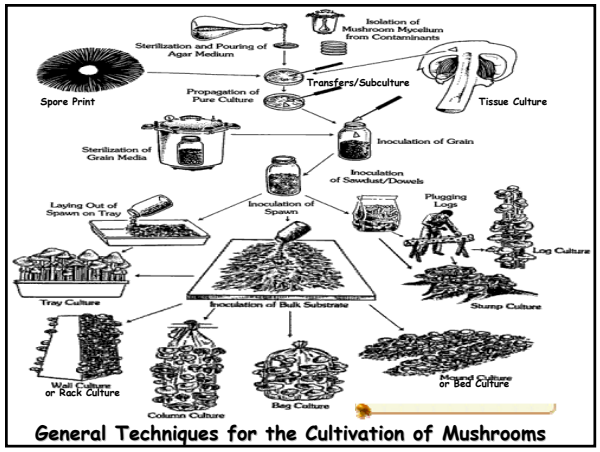
Commonly Cultivated *Agaricus* Mushrooms

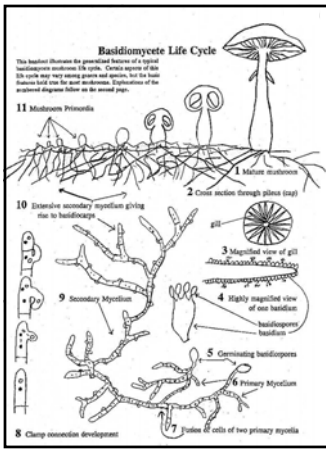
★ *Agaricus bisporus* (=*A. brunnescens*) — White Button Mushroom, Cremini





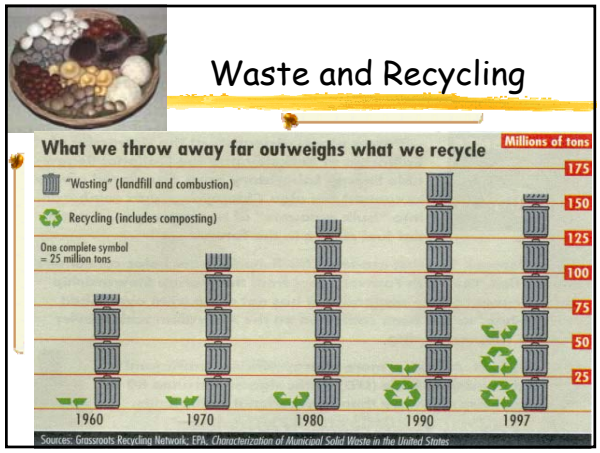


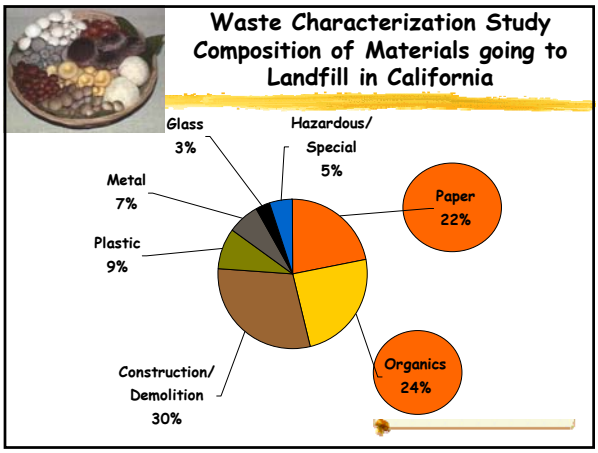


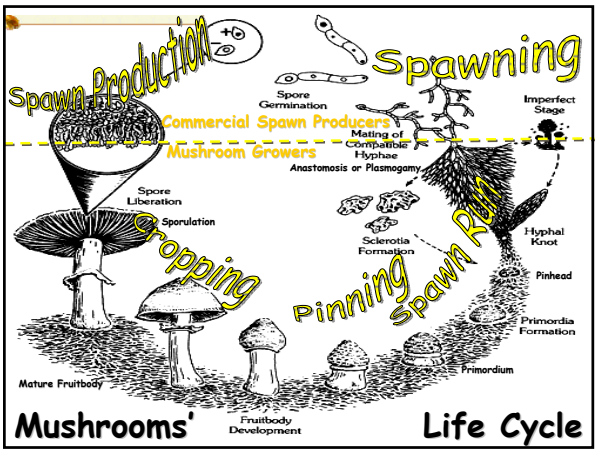


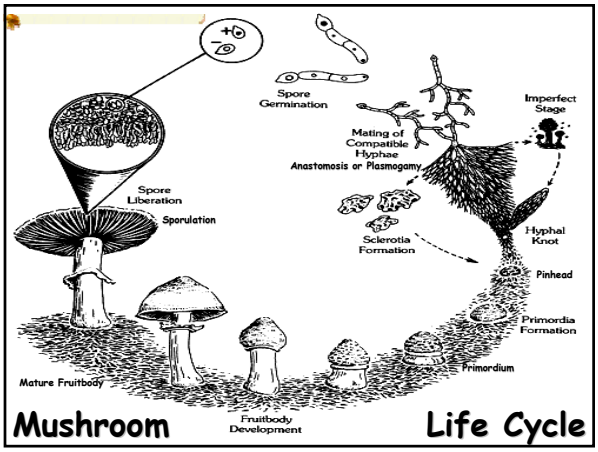
Major Stages
Basidiomycota Life Cycle

1) Mature Sporocarp
2) Gilled Hymenophore
3) Gill
4) Basidium
5) Basidiospore
6) Monokaryon
7) Fusion of Monokaryons
8) Clamp connections
9) Dikaryon
10) Mycelium
11) Young sporocarp









Culture Parameters at Every Production Stage

- **Spawn Run Parameters** or conditions during mycelial colonization of the substrate.
- **Pinhead Initiation Parameters** or conditions for fructification to occur.
- **Cropping Parameters** or conditions needed to sustain the cyclic production of mushrooms or flushing.

Production Stages

- Spawn Production.
- Spawning or Inoculation.
- Spawn Run or Colonization.
- Pinning.
- Cropping.

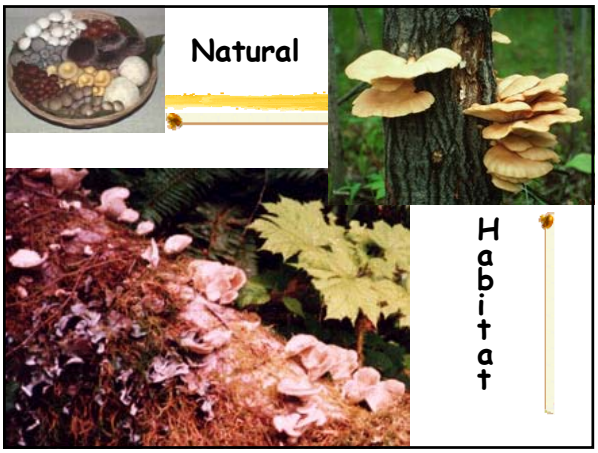
Culture Parameters or Conditions to Monitor

- Relative Humidity:
- Air T:
- CO_2:
- Fresh Air Exchanges:
- Light:
- Watering:
- Duration of Stage:
- Intervals:

Semi-Controlled Conditions

- Temperature of substrate: pocket thermometers (metal 1-inch dial and 5-inch stem).
- Air temperature and relative humidity: battery operated LCD digital thermometer/hygrometer (Thermo-Hygro ®), which also shows temperature maximums and minimums.
- Relative Humidity: time-set semi-automated misting system (Raindial – Irritrol Systems ® Model RD 600 Ext).
- PVC pipes: along the production areas on the ceiling, with Turbo-Flo ® Misters, extremely low flow (1/2 gph) and very small droplet size.

Natural Habitat



Insulation Material

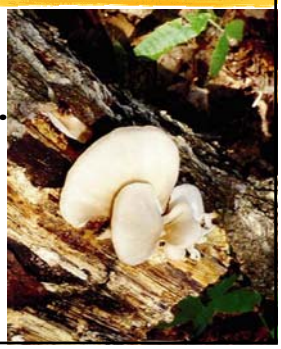
- External walls and ceiling insulated with insulation boards, Tuff-R Blackore ®, an insulating sheathing made by Celofex ®, consistent of semi-rigid carbon black-filled polyisocyanurate-foam with aluminum foil faces on both sides of about ¾ inch thickness. This gives an insulation coefficient of R=7.5.

Biology

Pleurotus spp. efficiently utilizes its substrate. Its ability to fruit on a single component substrate, to permeate the straw rapidly while tolerating high carbon dioxide levels and to produce abundant crops within a short time period, makes it ideal for small scale cultivation.

Oyster Mushroom Production

***Pleurotus* spp.**



Commonly Cultivated Oyster Mushrooms

- ★ *Pleurotus citrinopileatus (=P.cornucopiae)* Golden Oyster Mushroom, Tamogitake.
- ★ *Pleurotus cystidiosus* Abalone Mushroom, Maple Oyster, Miller's Oyster.
- ★ *Pleurotus columbinus* Blue Oyster Mushroom.
- ★ *Pleurotus djamor (=P.salmoneo-stramineus)* Pink Oyster, Salmon Oyster, Strawberry Oyster, Albino Oyster Flamingo Mushroom, Takiiro Hiratake.

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★ *Pleurotus citrinopileatus (=P.cornucopiae)*
Golden Oyster Mushroom, Tamogitake.

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Pink Oyster, Salmon Oyster, Strawberry Oyster, Albino Oyster Flamingo Mushroom, Takiiro Hiratake.

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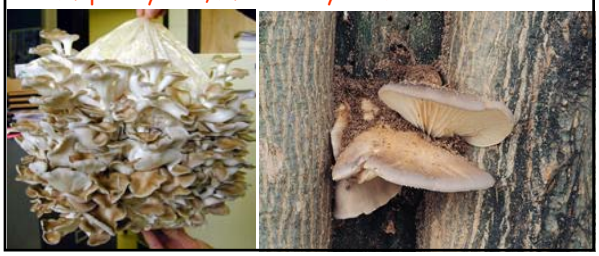

Commonly Cultivated Oyster Mushrooms

★ *Pleurotus eryngii*
King Oyster Mushroom.

★ *Pleurotus euosmus*
Tarragon Oyster Mushroom.

★ *Pleurotus flabellatus*
Strawberry Oyster Mushroom.

★ *Pleurotus ostreatus*
Old World European Blue Oyster, New World American Beige Oyster, Tree Oyster, Oyster Shelf, Espresso Oyster, Pearl Oyster, Hiratake.

Commonly Cultivated Oyster Mushrooms

★ *Pleurotus columbinus* Blue Oyster Mushroom.

Commonly Cultivated Oyster Mushrooms

★ *Pleurotus eryngii* King Oyster Mushroom.

Commonly Cultivated Oyster Mushrooms

★ *Pleurotus euosmus* Tarragon Oyster Mushroom.


Commonly Cultivated Oyster Mushrooms

★ *Pleurotus ostreatus-florida (=P. floridanus)* Tropical Oyster, Florida Oyster.

★ *Pleurotus pulmonarius* Phoenix Oyster, Indian Oyster Mushroom.

★ *Pleurotus sajor-caju* Tropical Phoenix Oyster, Tropical Indian Oyster Mushroom.

★ *Pleurotus tuberregium* King Tuber Oyster Mushroom, Tiger Milk Mushroom, Omon's Oyster.

Commonly Cultivated Oyster Mushrooms

★ *Pleurotus flabellatus* Strawberry Oyster Mushroom.


Commonly Cultivated Oyster Mushrooms

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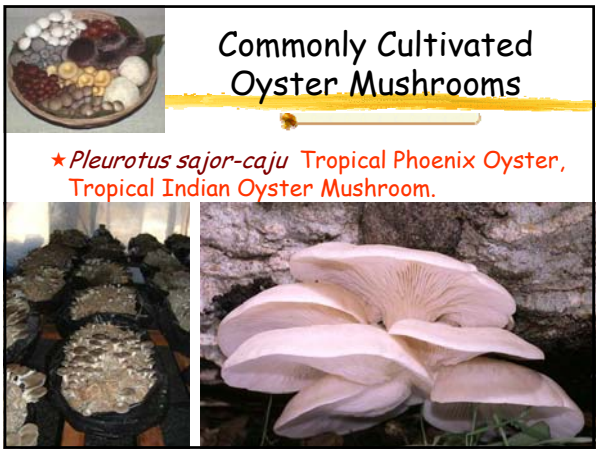
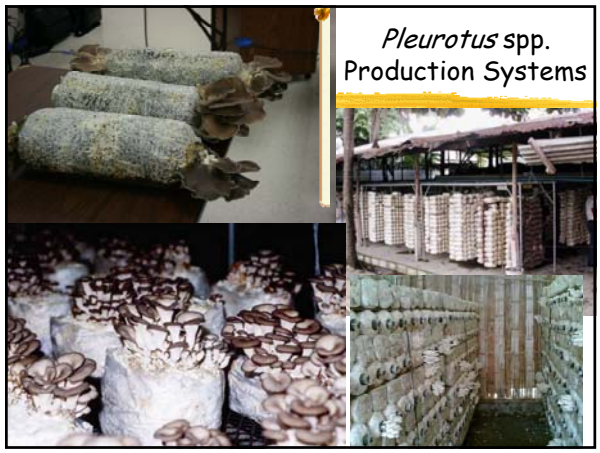
Commonly Cultivated Oyster Mushrooms

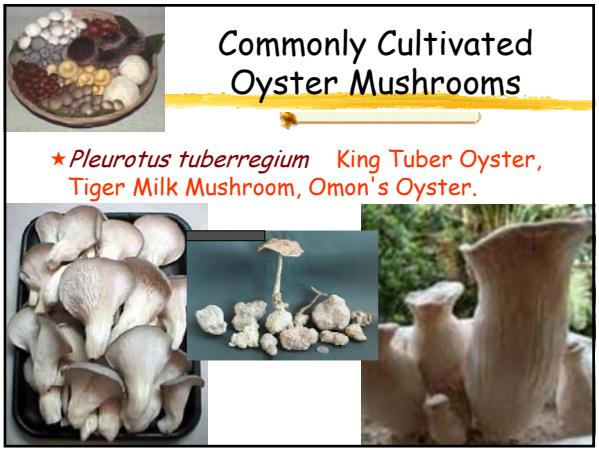
★ *Pleurotus ostreatus* Old World European Blue Oyster, New World American Beige Oyster, Tree Oyster, Oyster Shelf, Espresso Oyster, Pearl Oyster, Hiratake.

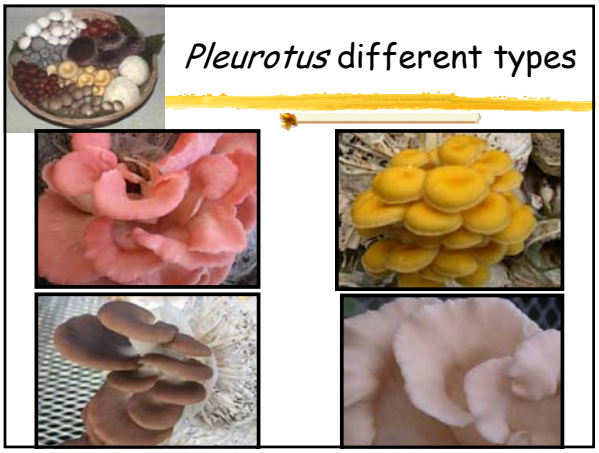

Commonly Cultivated Oyster Mushrooms

★ *Pleurotus pulmonarius* Phoenix Oyster, Indian Oyster Mushroom.



Commonly Cultivated
Oyster Mushrooms
★ *Pleurotus sajor-caju* Tropical Phoenix Oyster,
Tropical Indian Oyster Mushroom.


Pleurotus spp.
Production Systems

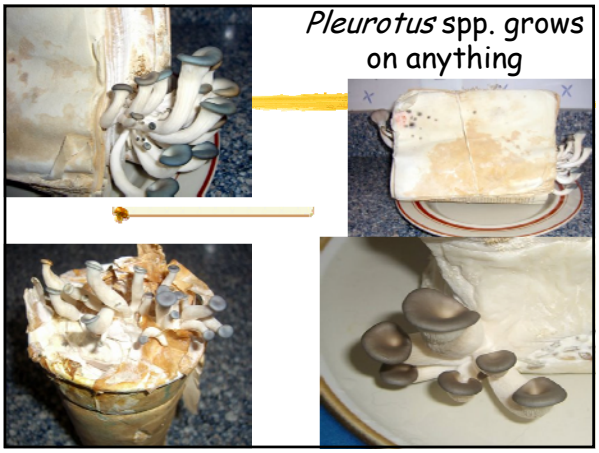

Commonly Cultivated
Oyster Mushrooms
★ *Pleurotus tuberregium* King Tuber Oyster,
Tiger Milk Mushroom, Omon's Oyster.


Pleurotus different types

Pleurotus spp. Spawn Run Parameters

(Substrate Colonization)

- **Relative Humidity**: 90-100%.
- **Substrate T**: Fastest growth 78-84°F. Thermal death occurs above 104°F /48 hr.
- **Duration**: 10-14 days for colonization.
- **CO_2**: 20,000 ppm or 20% by volume. Growth is stimulated up to 28,000 ppm.
- **Fresh Air Exchanges**: None (0/hr).
- **Light**: Incubation in total darkness.



Pleurotus spp. grows on anything

Pleurotus spp. Pinhead Initiation Parameters

- **Relative Humidity**: 95%. **Air T**: 55-60°F.
- **Duration**: 7-14 days. **CO_2**: less than 600 ppm.
- **Fresh Air Exchanges**: 4/hr.
- **Light**: Phototropic, most responsive to an exposure of 2,000 lux/hr for 12 hr/day. Grow-lux type fluorescent lighting recommended. Diffuse natural light is sufficient.
- **Watering**: Regular misting once to twice daily until fruit bodies are 30-40% harvest size.

Primordia or Pinheads

Fruiting Clusters

Pleurotus spp. Cropping Parameters

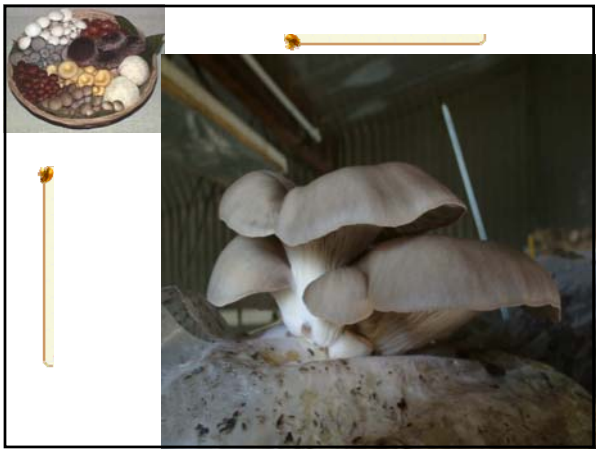
- **Relative Humidity**: 85-92%. **Air T**: 60-64°F.
- **Duration**: 5-7 weeks. **CO_2**: less than 600 ppm.
- **Fresh Air Exchanges**: 4-6/hr.
- **Light**: Same as for pinhead initiation.
- **Harvest Stage**: Directly before incurved margins elevates to plane.
- **Flush Intervals**: ~10 days.
- **Watering**: Regular misting to prevent caps from cracking and to keep resting pinheads viable.

Pleurotus spp. @ Harvest

- **Moisture Content**: 91% water, which means that for every 100 g of fresh weight of mushrooms, we get only 52.36 g of dry matter after dehydration, loosing 47.64 g of water.
- **Nutritional Content**: Crude Protein has been reported at 30.4% of dry weight.
- **Yield Potential**: Average commercial yield are 1 kilogram fresh weight of mushrooms per kilogram of dry weight of substrate.
- **Biological Efficiency**: 100% or more.

How to Calculate Moisture Content

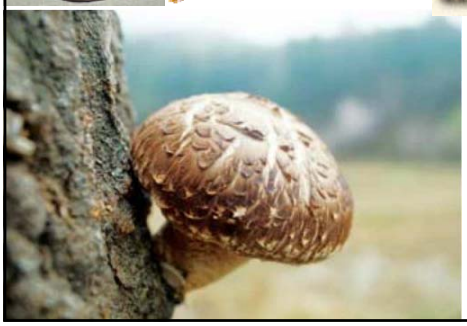
- **100 g of Mushrooms (or any matter) dry in oven (@60°F) until constant weight.**
- **Moisture Content = Weigh of lost water (100 g - dry weight) /dry weigh x 100**



Shiitake Production

Lentinula (Lentinus) edodes

Natural



Habitat

Biology

Lentinula (Lentinus) edodes. A wood decomposer, typically saprophytic growing on dead tissue of deciduous trees mainly Fagaceae (oak, shiia *(Pasania),* chestnut, and beech), and fruiting in the fall, early winter and spring.

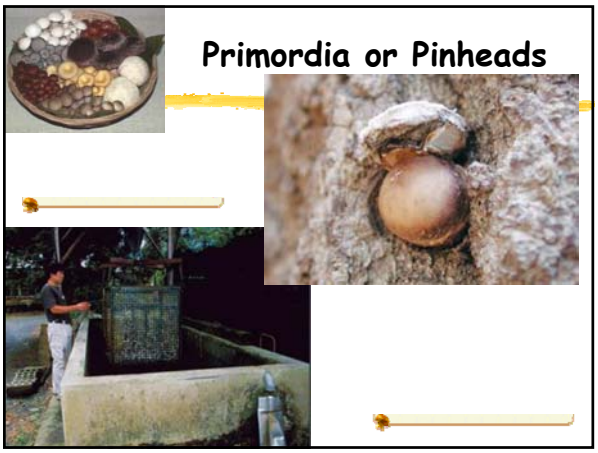
Shiitake Production Systems

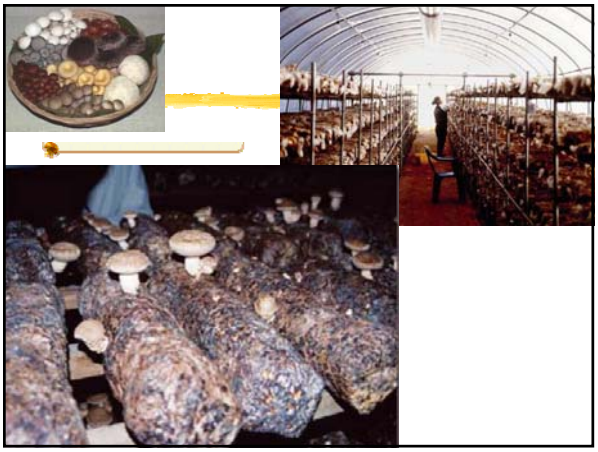
Shiitake Spawn Run Parameters

(Substrate Colonization)

- **Relative Humidity**: 60-75% for logs; 90% for sawdust blocks or artificial logs.
- **Substrate T**: Fastest growth 77°F. Below 41°F and above 95°F mycelial growth halts.
- **Duration**: 6-12 months for logs; 30-60 days for sawdust blocks.
- **CO_2**: None established. **pH:** 5-6
- **Fresh Air Exchanges**: None (0/hr).
- **Light**: None required.

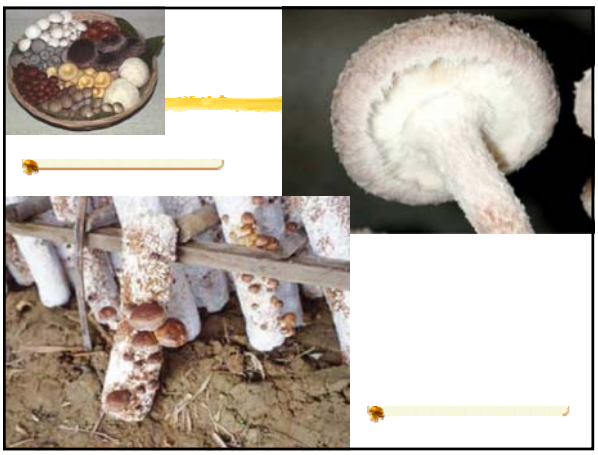
Primordia or Pinheads





Shiitake Pinhead Initiation Parameters

- **Initiation:** Submerge logs and blocks in cold water for 24-72 hr.
- **Relative Humidity**: 95%. **Air T**: 59-68°F.
- **Duration**: 7-14 days after soaking.
- **CO_2**: None.
- **Fresh Air Exchanges**: 2 - 4/hr.
- **Light**: Ambiental natural light or optimally 10 lux in the 370-420 nanometer range.



Shiitake @ Harvest

- **Moisture Content**: 85% water (54.05 g dry matter / 100 g of mushroom).
- **Nutritional Content**: Crude Protein 10-17.5% and 55 mg niacin/100 g of dry weight.
- **Yield Potential**: Average commercial yield are 2-3 lb fresh weight of mushrooms per log.
- **Biological Efficiency**: 50-145%.

Shiitake Cropping Parameters

- **Relative Humidity**: 85-90%. **Air T**: 59-68°F.
- **CO_2**: less than 1000 ppm.
- **Fresh Air Exchanges**: 2-4/hr (cooling).
- **Duration**: 3-5 years on oak logs; 2-3 years on alder.
- **Light**: Same as for pinhead initiation.
- **Harvest Stage**: Directly before incurved margins straightens and the cap expands to plane.
- **Flush Intervals**: Outdoor fall and spring; indoor up to 4 flushes depending on soaking schedule.

Biological Efficiency

- Biological Efficiency is the ability of converting dry matter into fresh weight, expressed as percentage.
- To produce one pound of beef, a cow needs 15 lb of dry matter = 6.7%.
- To produce one pound of chicken, a chicken needs 5 lb of dry matter = 20%.
- To produce 1 lb of mushrooms, substrate needs 1 lb or less of dry matter ≥ 100%.

Examples of Biological Efficiency

- Oyster Mushrooms = 100 - 200%
- White Button Mushrooms = 70 -100%
- Shiitake = 50 - 145%
- Maitake = 5 - 35%

Sawdust as Substrate

- Sawdust is nitrogen poor and semi-selective for mushrooms. Usually it is supplemented with nitrogen to increase mushrooms yields.
- When nitrogen is added, selectivity is somewhat lost (other fungi will grow in the substrate). If high levels of nitrogen are used, temperatures in the substrate increase by respiration as the mycelium of the mushroom or other organisms grow.
- Temperatures rise due to the biological growth (called thermogenesis), other molds loose dormancy as temperatures approach 100°F. Below this, the mushroom consumes these organisms.
- Temperatures of 75-85°F are ideal. Adding nitrogen to a substrate always increases the risk of contamination.

Sawdust as Substrate

- Many types of wood are suitable for primary decomposers. Alder and oak are commonly used (abundant trees in the Pacific Northwest).
- Cedar and redwood are resistant to colonization by most fungi, including the cultivated mushrooms.
- Pines are colonized by only a few of the fungi commonly cultivated due to turpenes and resins in the wood.

Substrate Recipes

Oregon Sawdust Recipe

By dry wt:	Moisture:	For 5 lb block:
76% oak sawdust	14.70 %	1.56 lbs
12% millet	10.00 %	0.23 lbs
12% bran	6.64 %	0.22 lbs
65% moisture water		1.36 L

Sawdust as Substrate

- The coarseness of wood sawdust should be about that from a chain saw with larger chips thrown in.
- Use 2 units of sawdust and 1 unit of wood chips.
- Sawdust should be sterilized for 2 to 4 hours, depending on volume.

Substrate Recipes

Stamets' Sawdust Recipe:

By dry wt:	Moisture:	For 5 lb block:
73 % oak sawdust	14.70 %	1.50 lbs
24.6 % bran	6.64 %	0.46 lbs
2.4 % CaSO4	20.4 %	0.053 lbs
65 % moisture water		1.36 L

University of California
Cooperative Extension

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