Growing Gourmet Mushrooms for Food & Profit

Sarah Brackney
Agriculture & Natural Resources Educator
Daviess County

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Presentation Overview

- Fungi Basics
- Terms to Know
- Commonly Cultivated Species
- General Growing Information
  - Substrates, Spawn
- Shiitake on Logs
- Winecap in Compost
- Oyster in Heat Pasteurized Straw
- Oyster in pH Pasteurized Hardwood Pellets
- Indoor Cultivation – Controlling the Environment at Different Scales of Production
- Uses and storage
- Use for Expended Substrate

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Basics of Mushroom Cultivation

Understanding the Fungi Kingdom

1. Eukaryotic Cells
2. Heterotrophic Nutrition
3. Cell Walls
4. Reproduction
5. Diverse Lifestyles
6. Role in Ecosystems
7. Economic Importance

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1. Fungi have cells and internal parts with membranes
2. They absorb nutrition by secreting enzymes to break down their food.
3. Fungus cells are made of structural sugars.
4. Fungus reproduce both sexually and asexually.
5. Fungi can be single-celled, like yeast, or multicellular, like mushrooms.
6. Fungi break down dead material into something usable.
7. Fungi help make food and drink, medicine, and materials for industry.

Importance of Fungi in Soil Health

1. Nutrient Cycling
2. Mycorrhizal Associations
3. Soil Structure
4. Disease Suppression
5. Water Relations
6. Carbon Sequestration

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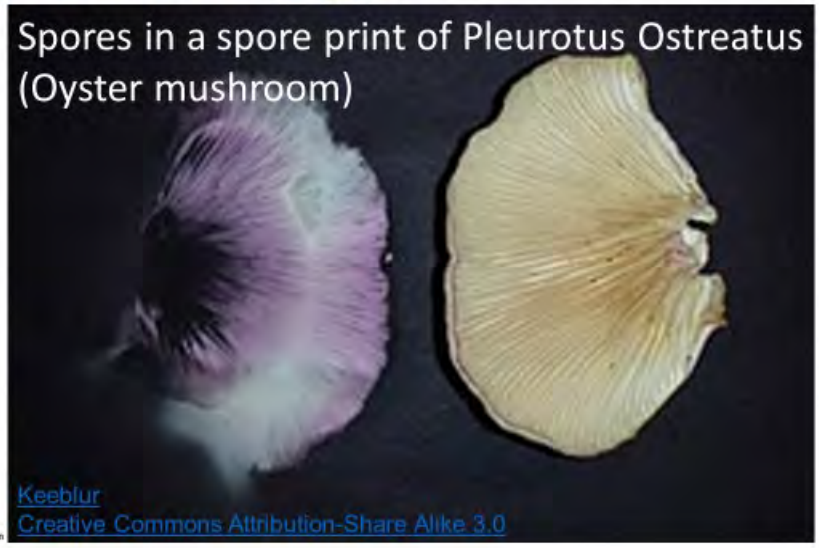
Overview of Mushroom Life Cycle



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EO/EA

1. The mushroom life cycle begins with a mushroom **spore**, which develops into a single-celled structure called a **germling**.

   Each mushroom species has a unique spore. Oyster mushroom spores are a lavender color.

Overview of Mushroom Life Cycle

Hyphae or mycelium are colonizing.

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1. Germlings grow into a network of **hyphae or mycelium** and expand by eating surrounding organic matter. We call this "**colonization"**

Overview of Mushroom Life Cycle

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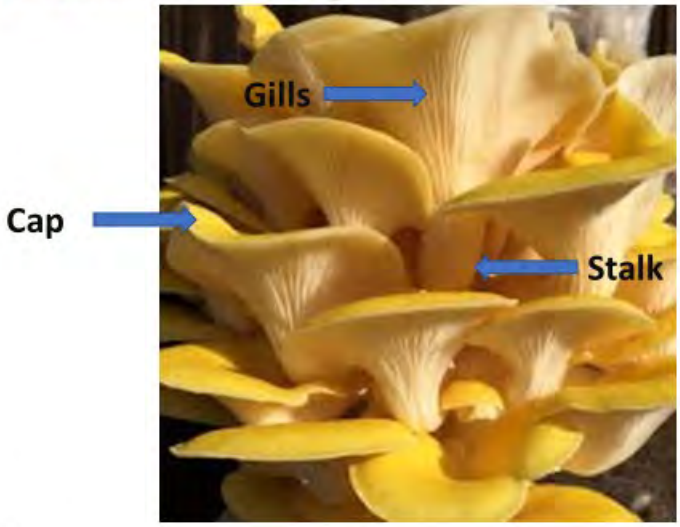
When temperature and humidity are favorable, mycelium develop a **fruiting body**, or mushroom. This is called "**pinning**".

Overview of Mushroom Life Cycle



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1. Fruiting bodies have stalks and caps, and the caps contain reproductive structures called **basidia.**

   Here, spores are created and released, on the underside of the mushroom where the **pores or gills are.**

Overview of Mushroom Life Cycle

Lion's mane mushroom fruiting bodies are tubercules with spine like structures that produce spores.

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Oyster, shiitake, and Reishi mushrooms have caps, but not all mushrooms do.

Lion's Mane, for instance, has a fruiting body made of **tubercules and spines.**

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Overview of Mushroom Life Cycle

Herbert Baker
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Stinkhorn (Phallus ravenelii) sclerotia

Morel mushrooms can reproduce by sclerotia.

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When spores are mature, they are released into the environment, potentially germinating and beginning the process again.

Sometimes mushrooms reproduce by asexual means. An example is morel mushrooms that reproduce by **sclerotia**, which is a ball of mycelial cells. The life cycle length of different mushrooms is variable, and within a species, it is often temperature and humidity-dependent. The conditions for fruiting also vary among species.

Terms to Know

- **Spores** - tiny, reproductive cells that allow fungus to replicate and grow.
- **Spore print** - allow spores of a fungal fruit body (mushroom) to fall onto a surface underneath, like paper. It is an important diagnostic character to identify species. Each mushroom has a specific spore coloration. * Blue Oysters have lavender spores
- **Culture -** the cultivation of cells in an artificial medium containing nutrients
- **Mushroom Spawn** - any substance that has been inoculated (introduced) with mycelium.
- **Mycelium** - , the vegetative growth of a fungus. Mycelium, a thread-like collection of cells, is to a mushroom like an apple tree is to an apple.
- **Substrate** - any material from which mushrooms will grow.
- **Primary Feeder** – break down materials into their nutrient components
- **Secondary Feeder** – continue breakdown of materials already partially broken down by primary feeders.

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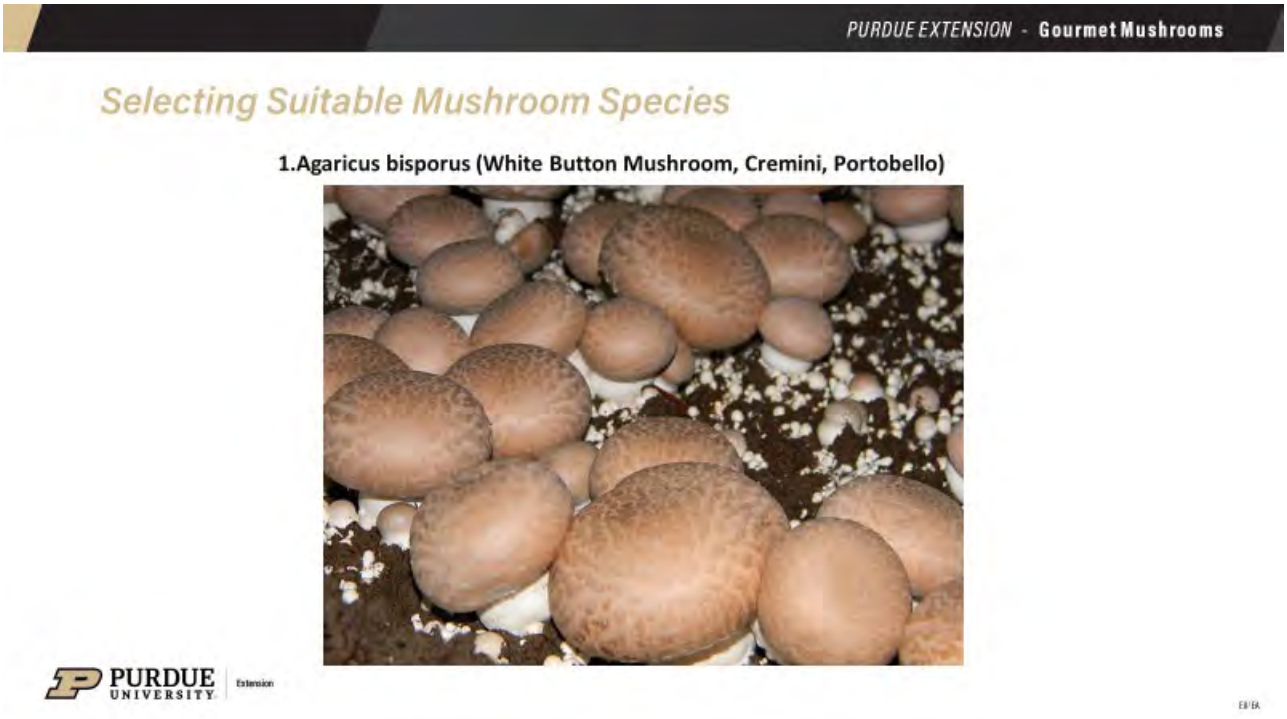

We talked about **secondary feeders** in the previous slide. Button mushrooms are secondary feeders and are often grown on compost, horse manure, etc.

When referring to mushrooms, it is important to know the **scientific names** to avoid miscommunication. Mushrooms and mushroom supplies are bought and sold all over the world, so a common term ensures less confusion. Cremini and portobello mushrooms are different stages of the same species, harvested at various levels of maturity.

Selecting Suitable Mushroom Species

Pleurotus ostreatus (Oyster Mushroom)

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Pleurotus ostreatus (Oyster Mushroom): Oyster mushrooms are popular for their delicate taste and texture.

They come in various colors, including white, pink, yellow, and blue. Oyster mushrooms are known for their ability to grow on a variety of substrates. In my opinion, oysters are, by far, the easiest mushrooms to grow.

Photos by Sarah Brackney

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Selecting Suitable Mushroom Species

Lentinula edodes (Shiitake Mushroom)

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Lentinula edodes (Shiitake Mushroom): Shiitake mushrooms are highly valued in Asian cuisine for their rich, savory flavor.

Usually cultivated on hardwood logs or nutritious substrates, requiring more equipment, precision, and skill to grow with regularity. Outdoor log cultivation would be the easiest method for homesteaders. Photos by Sarah Brackney

Selecting Suitable Mushroom Species

Hericium erinaceus (Lion's Mane Mushroom)

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Hericium erinaceus (Lion's Mane Mushroom): Lion's Mane mushrooms have a unique appearance with long, white, tooth-like spines.

Known for their delicate flavor and potential health benefits. These mushrooms are cultivated on nutritious substrates.

Special considerations for Lion’s Mane cultivation make is less of a “starter” mushroom.

Watering practices can affect the fruiting body of Lion's Mane mushrooms. They need high humidity during certain stages,

but water trapped between spines can lead to distorted mushrooms with odd textures and appearance.

Selecting Suitable Mushroom Species

Ganoderma lucidum (Reishi Mushroom)

Conk Shaped

RevDanielElisAxelrod
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Pores instead of gills

DimitărBoevski
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Nina Filippova
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Antler Shaped

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Ganoderma lucidum (Reishi Mushroom): Reishi mushrooms, also known as Lingzhi, are highly regarded in traditional Chinese medicine for their potential health-promoting properties. Grown on wood-based substrates.

Growth form is oxygen dependent: Ample oxygen and low CO2, they will grow large caps with pores underneath (called conk shape)

In the absence of sufficient oxygen and high CO2, they grow into “antler” shape.

Selecting Suitable Mushroom Species

Morchella spp. (Morel Mushroom)

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Morchella spp. (Morel Mushroom): Morel mushrooms are prized for their distinctive appearance and earthy flavor.

Challenging to cultivate commercially and are often foraged in the wild. One of the most difficult to cultivate reliably and is very strain-dependent.

Selecting Suitable Mushroom Species

Winecap stropharia - Stropharia rugosoannulata

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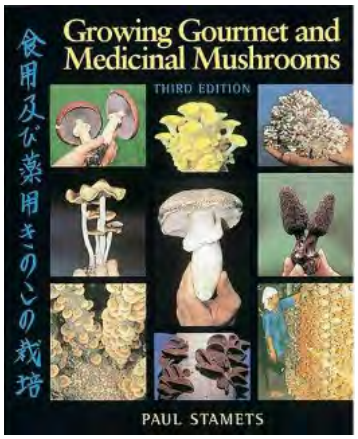
Wine Cap mushrooms (Stropharia rugosoannulata), also known as Garden Giant mushrooms, are relatively easier to cultivate compared to some other mushroom species. They can be grown in wood chips under your garden plants.

Why to Start? How to Start?

Action is the antidote to hesitation. Don't take yourself too seriously, and just get growing.

- Market research
- Test grow
- Network with current growers
- Expansion to commercial production



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What do I need to start growing?

"Seeding Material"

Spore Culture - Created in sterile lab conditions by using spore prints from mushrooms to inoculate a sterile, nutrient – rich medium (called agar)

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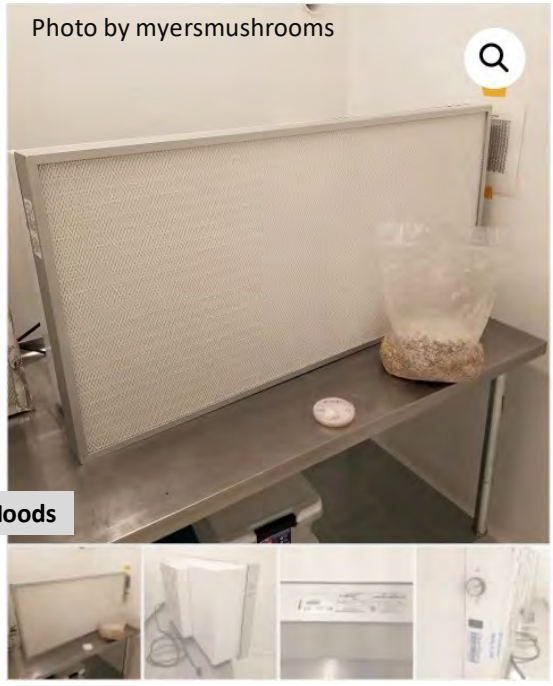
Most home growers do not complete this step themselves and can purchase seeding material that is further along in the process.

Clean area usually consists of a flow hood – a bench that blows clean air across a work surface, in a way that doesn't stir up or make room for contaminants. Agar made with malt, seaweed, dogfood, etc.



Laminar Flow Hoods

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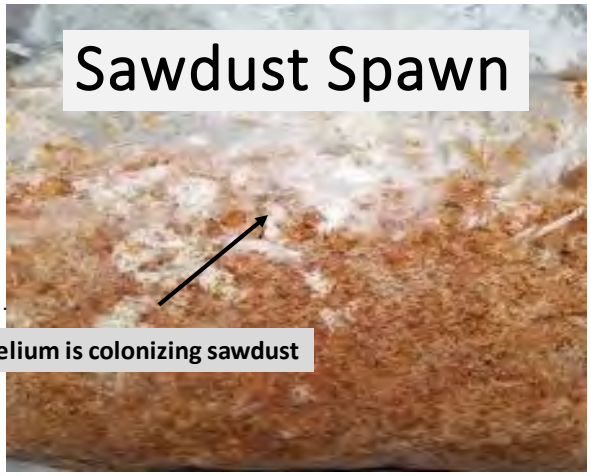
These are laminar flow hoods -- Filter units with a sealed box and inline duct fan – creating a clean air stream to work in.

Mushroom Spawn

- any substance that has been inoculated (introduced) with mycelium.

- Sterilized sawdust that has been inoculated with mycelium
- Made of small hardwood particles
- Uses: logs, outdoor mushroom beds, pasteurized straw, cardboard
- Because particles are so small, there is more surface area for the mycelium to grow into the substrate.
  - Faster colonization with less time for contaminants to take hold.
- Not as nutritious for mushroom growing
- Requires the addition of nitrogen enrichment



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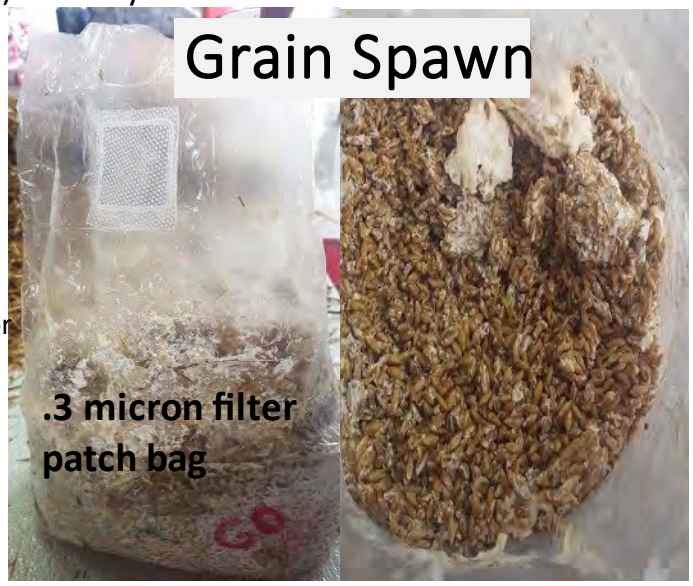
Mushroom Spawn

- any substance that has been inoculated (introduced) with mycelium.

- Soaked, drained, sterilized grain that has been inoculated with spores or a sterile culture of mycelium.
- Rye, millet, corn, **wheat, oat**, barley, popcorn, etc…
- Uses: create sawdust spawn, more grain spawn, or inoculate all sorts of pasteurized substrates such as straw.
- Advantage - nutritious
- Disadvantage- grains attract birds and rodents.



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In my experience, wheat and oats are the quickest and most contaminant-free for growing oyster mushrooms and shiitake mycelium.

You can source grains from a local feed mill. Be sure to purchase untreated grains.

If they are treated with fungicides, you can guess how well a fungus will grow on them. The filter patch bag shown here is a container option that allows air exchange without contaminants entering the growing media. .3 micron size is required for creating grain spawn.

Making grain spawn at home:

Soak grain overnight. Strain until no water runs off. Fill filter patch bags up to the bottom of the patch with grain, roll bag and pressure cook for 45 minutes at 15 psi. Let cool completely. Remove from pressure cooker, add ¼ cup colonized grain spawn to the bag and impulse seal immediately. This process must be as clean as possible to avoid contamination.

Mushroom Spawn

Plug Spawn

- small wooden dowels that have been inoculated with mycelium.
- Very effective for inoculating wood & fiber, like cardboard and paper.

* Liquid spawn also exists. It involves a nutrient– rich liquid being inoculated with spores. Moderate success in outdoor cultivation can be had with morel liquid spawn.

Mushroom Substrate - any material from which mushrooms will grow.

- Endless possibilities
- The substrate needs to be a proper size to allow bands of mycelium to colonize it.
- It also must provide the proper water and nutritional content.
- Examples are:
  - Wood, paper, grains, coconut fiber, corncobs, coffee waste, seed hulls, soy waste, straw

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Mushroom Substrate - any material from which mushrooms will grow.

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Growing Mushrooms

Outdoor Cultivation

- Easiest to grow
- Indoor/outdoor cultivation possible
- Range of temperature options, depending upon strain

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Top left : High Stack; Top Right : Low Stack ; Bottom Left : Angled (with or without the log partially buried; and Bottom Right: Totem Stack

The way you stack is dependent on 1.How much space you have, 2. What sized logs you have available, 3. What your weather conditions are: Low stack is for winter protection and High Stack is for fruiting.

Growing Mushrooms: Outdoor Cultivation

High/Low Stack Shiitake Cultivation on Black Cherry Logs

- **Logs should be cut when they are budding.**
- **Limbs and small trunks are the best (8 - to 10 – inch diameter max)**
- **Type of log depends upon type of mushroom you are trying to grow (even strain matters).**
- **Mushrooms will not cultivate rotting wood that is already colonized by other fungal species.**
- **Once a log is cut, it is best to let it rest 1 to 2 weeks before inoculating logs**

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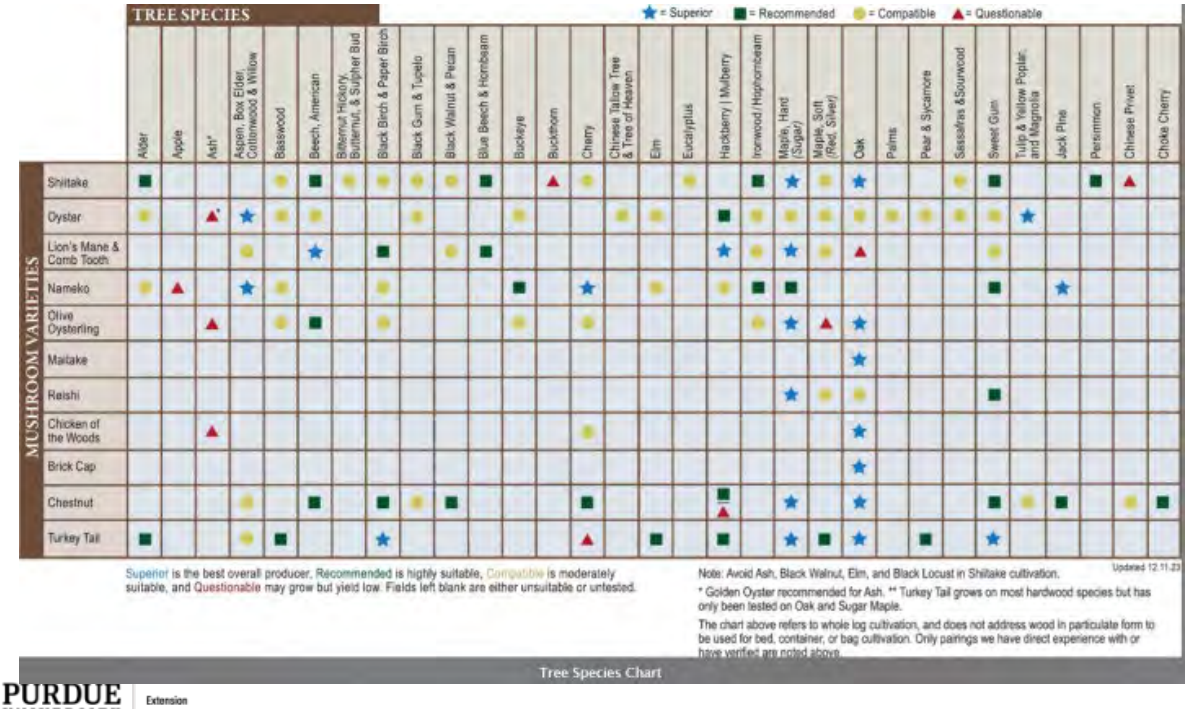
Find a living tree and cut when sugar is rising, (8-10 inch limbs). Charts online for matching mushroom type to wood.

Let the log rest for a few weeks to lose its antifungal properties, but not long enough to be colonized by other fungus.



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https://www.fieldforest.net/product/463/instruction-sheets

EO/EA

Each mushroom cultivation supply company has its own substrate/mushroom chart. This is an example, not a company endorsement.

Growing Oyster Mushrooms – Outdoor Cultivation

Inoculating the Logs

- There are tools that can make the inoculation process easier and quicker, and I suggest using them, even for people who will do it once.
- Inoculating without tools is extremely time-consuming and the tool is well-worth the 40-100$

Log inoculating tool

Other Tools for the Job

- Cotton balls
- Funnel and 1/2 in metal punch, if no inoculating tool
- ½ inch drill bit and power drill
- Wax of some type (I used beeswax)
- Crockpot to melt wax
- Sawdust spawn
- Sawhorses
- A FRIEND OR 10

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EB/EA

Growing Oyster Mushrooms – Outdoor Cultivation

1. Gather tools, logs, and prepare workspace
2. Heat beeswax in crockpot on low until liquid
3. Set log on saw horses. Drill holes 6 inches apart and 1 inch deep in diamond pattern up and down log.
4. Fill funnel or inoculation tool with sawdust spawn and transfer to holes.
5. Using cotton ball, cover holes and ends of log with wax. Allow to dry and stack logs as desired.
6. Douse with water every couple weeks.
7. Depending on the strain, wait 6 to 9 months for first crop.
8. Expect repeating crops for 3-6 years, depending upon wood type used.

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Final Product = Delicious

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Outdoor shiitake will look different than those grown indoors. The caps are usually wider and softer, and the stems shorter, due to lower CO2 concentrations outside. In addition, they produce or “flush” predictably but not as often as indoor cultivated. Usually when it's been dry, rains, and the temp drops, you will check for mushrooms. And your logs and mushrooms will be subject to rodents digging the spawn out of the holes, eating your mushrooms, etc. Be willing to share. If you’re growing anything worth eating, other creatures will be enticed, so take it as a compliment!

Just some pretty pictures of shiitake for inspiration.

Food storage guide:

https://extension.umn.edu/preserving-and-preparing/drying-food#store-your-dried-food-properly-331862

Properly dehydrated mushrooms that are stored correctly in an airtight container can be kept for 4-12 months.

Growing Wine Cap Mushroom in your Yard or Garden

1. **Shaded location**
2. **Prep Bed**
3. **Buy Wine Cap spawn**
4. **Plant in late March/early April.**
5. **Add mulch over area.**
6. **Keep moist; don't waterlog**
7. **Wine cap will fruit between 5575F.**
8. **Harvest when caps are open but gills are not turning upward. (2-5 inches across)**
   - Gently twist or cut at base of stem.
10. **Remove old mushroom remnants and compost them.**
11. **Add substrate and keep moist for future "flushes".**

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Growing Mushrooms Indoors : Oyster

What Do Mushrooms Need to Live?

- **Water (mist)**
- **Nutrients (substrate)**
- **Little to no competition (a method of pasteurization)**
- Fresh Air Exchange (FAE) (a fan)
- **Time**
- Small Amounts of Light

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Growing Mushrooms Indoors: Oyster

- Mushrooms cannot grow on substrate that is already colonized.
- While sawdust must be sterilized to get rid of ALL contaminants, straw MUST ONLY be pasteurized to get rid of MOST contaminants.
- The difference is due to nutrient levels and additives. TEMPERATURE AND PH MATTER!

Pasteurization – *partial* sterilization to reduce contaminants
Sterilization – *Complete removal of live contaminants*

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Pasteurizing Substrate: Oysters

Methods of Pasteurization

Large scale Heat method:

- **55 gallon barrel pasteurizer**
- **Load chopped straw into to pillow cases tied with baling twine and carefully place in pre-heated pasteurizer.**
- **The barrel must maintain a temperature of between 150 and 180 degrees for 50 minutes in order to penetrate all substrate with the heat.**
- **Candy Thermometer**
- **The barrel will hold two pillowcases at once, or about 20 lbs of straw.**

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These instructions can be scaled down to make small batches on the stove, as well.

Substrate Pasteurization

Small Scale #2:

- Using a candy thermometer, heat water in a pot to between 150 and 180 degrees. Heat straw in same way as large-scale (50 minutes).

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This was my little setup. Straw in pillow cases. Insulated barrel with two electric water heater elements and a drain valve, and a table that you can see behind the barrel for drying and cooling the straw, coated plastic or FRP for easy cleaning.

When I was done using the pillow cases, I let them dry inside out, shook, and then laundered as normal.

Draining Substrate

- Straw should be drained, in any case, after pasteurization.
- No water should drip from straw when it is squeezed.
- Small Scale: Use clean towels
- Large scale: Use slanted, clean, non-porous surface

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PURDUE EXTENSION - Gourmet Mushrooms

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When heat-pasteurizing your substrate (like straw), you don't need to use filter patch bags to grow the mushrooms. You can grow in any container that is soap and water clean. Rubbing the interior down with isopropyl alcohol is an extra step you can take to avoid contamination while the mycelium is colonizing (taking hold and eating through the substrate). Commercially, I grew oysters on straw in 6 mil poly tubing, securing the ends with clamps after filling the bag. Holes are then punches in a diamond pattern around the bag, about 6 inches apart.

Growing Mushrooms Indoors: Oyster

Materials Needed

- Hardwood Fuel Pellets
- Hydrated Lime **(Ca(OH)2)**
  - **NOT** ag lime (CaCO3)
  - **NOT** gypsum (CaSO4)
- Soybean Hulls
- Water
- Mixing Tote
- .5 micron Filter Patch Bags (5lb or 10lb)
- Oyster Grain Spawn
- P100 Mask
- Gloves
- Impulse Sealer

Be careful not to have prolonged skin or airway exposure to any of these compounds. They are all tiny dust-like particulates (think flour), and can cause irritation. Read and follow all label instructions.

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A more economical method, both in time and funds is called lime pasteurization, which uses pH change to pasteurize, rather than heat.

HWFP from farm supply stores –think pellet stoves (no flavor or scent). Can be up to 20% softwood

Here, we don't use heat, so we add a chemical that alters pH, making it less optimal for contamination to take hold while the oyster mycelium is colonizing the substrate. When growing with the pH pasteurization method, you can add up to 20% of the weight in a nutrient additive.

Soybean hulls are perfect for this, and they are cheaply available at Grain elevators. After mixing ingredients, transfer to .5 micron filter patch bags and impulse seal. **While working with hydrated lime (and mature mushrooms that are producing spores, for that matter, you should ALWAYS be wearing a P100 mask.

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My Personal Recipe
pH Pasteurization for Oyster Substrate

40 lbs dry material : 60lbs H20
1 gal H20 = 8.34 lbs
You can use up to 20% nutrient additive per batch without increased contamination

Makes 25, 8 lb + blocks

- 64 lb HWFP (hardwood fuel pellets)
- 16 lb soybean hulls
- 133 lb water (around 16 gallons)
- 8 C Hydrated lime
- 16 lb oyster grain spawn

Makes 1, 8 lb (+/-) block

- 4 lb HWFP
- 1 lb soybean hulls
- 1 gallon water (8.34lb)
- ½ C Hydrated lime
- 1 lb oyster grain spawn

Instructions: Wearing P100 mask, mix all ingredients thoroughly and allow to sit until all water has been absorbed. Bag, seal with impulse sealer, and allow to sit in a 70F fish degree space for up to 2 weeks.

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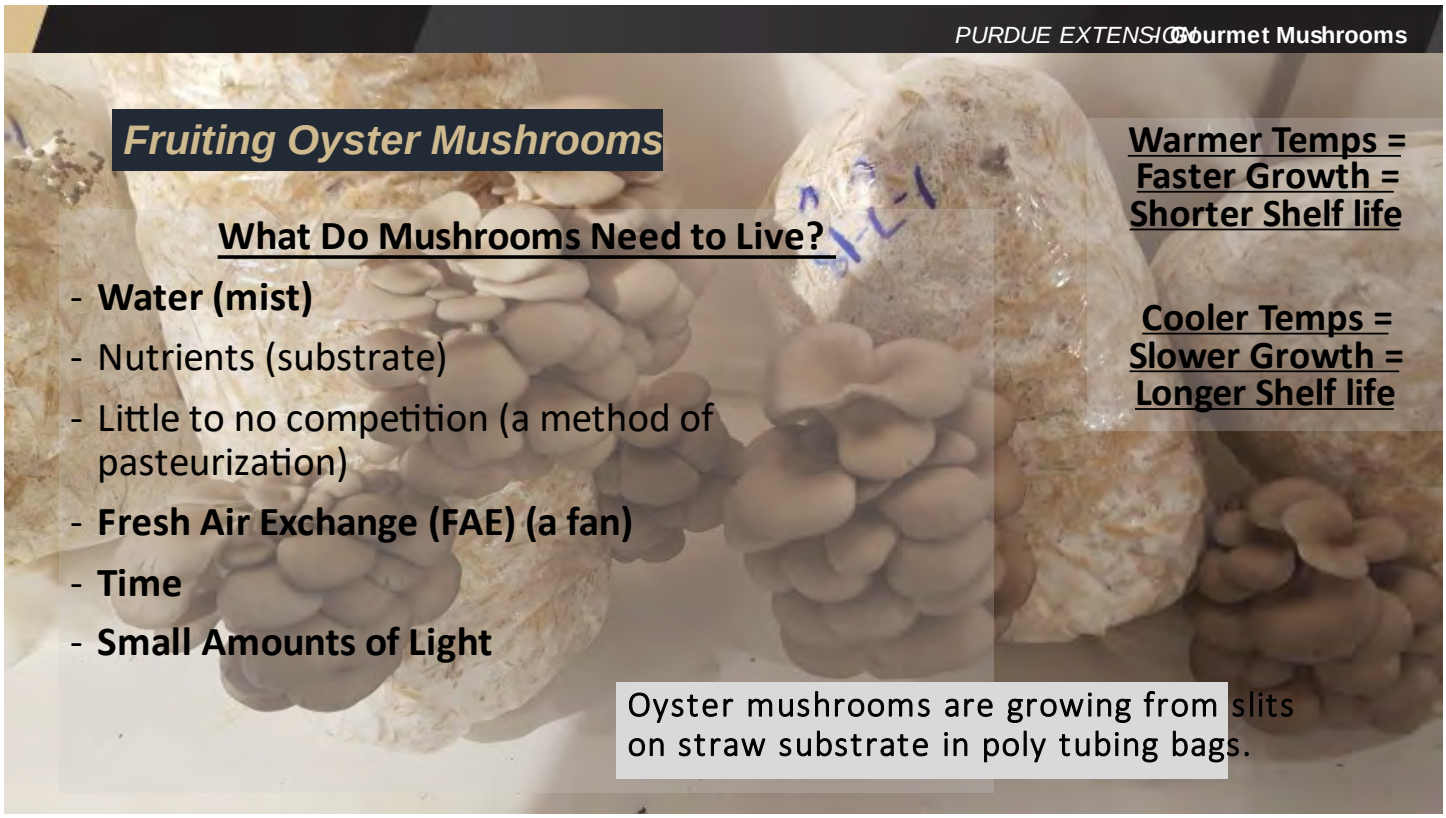
After bags are made, they will sit at temperatures of around 70F. Keep in mind that colonization will release heat, so feel the bags every so often to check temperature. Your growing medium will start to look like white styrofoam. When mostly white, cut existing holes slightly larger. In filter patch bag, cut large "X" in the bag's front to prepare for pinning.



When mushrooms begin to pin and fruit, increase moisture to 90% humidity. You can put your bags on a shelf covered with plastic and run a little humidifier for very small grows. Mushrooms also require oxygen to complete their life processes, just like humans. And they give off CO_2. So fresh air exchanges are a must – For a small home grow, that can look like a fan sucking air out and a hole that allows air to come in and replace it. Depending on the temperature, your mushrooms will be ready to pick anywhere between 3 days and 3 weeks after they begin to pin.

Harvesting Oyster Mushrooms

Biological efficiency (BE) = total weight of fresh mushroom divided by dry weight of substrate × 100

Expected BE varies by oyster variety, but a good grower can expect 150% BE from many oyster mushrooms.

That means, for every 1 lb of substrate you use, you can get 1.5 lbs of food.

Oyster mushrooms are ready to harvest just before their caps begin to flatten.

EO/EA

Mushrooms are ready to harvest just before their caps begin to flatten. Once mushroom caps flatten and start to curl upward, they are producing thousands of spores. Spores are messy and sticky and not something you want in your house for air quality reasons (wear a p100 mask, if you are going to grow with any regularity, as sensitivity to spores develops over time and can cause lung problems long-term). When caps are beginning to flatten, put your hand behind the cluster in a C-shape, grasp, and twist the whole cluster off. After a harvest, the bags can rest and fruit again. Expect smaller and smaller harvests and discard when you see contamination or they've fruited 3 – 4 times.

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Providing moisture to mushrooms

35-gallon food-grade drum

10-disk pond fogger

Cheap inline duct fan

Float and float valve

Inkbird humidistat

Flexible ducting to match fan diameter

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National Center for Home Food Preservation : How Do I Dry?

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Scott Monroe, Food Safety Extension Educator

(812) 888-7401

jsmonroe@purdue.edu

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Compost and Recycle

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As homesteaders, we usually have a goal of being self-sustaining in the ways we can. Used substrate is a fantastic way to add organic materials to your compost pile. Regardless of the substrate, you can put it in your compost when it is no longer as productive as you want it to be. Usually after 3 fruiting cycles. When conditions are right, mushrooms will even grow on the compost pile. They are fine to eat, and I consume them, but I refrain from selling such mushrooms. Unfortunately, poly bags and filter patch bags are not recyclable, although there are some industrial compostable options available now, so you might look into that.

Resources for Mushroom Growing

Book & Education:

- Stamets, Paul, (2000). Third Ed. *Growing Gourmet and Medicinal Mushrooms*. USA: Ten Speed Press.
- http://www.mushroomappreciation.com
- Mushroom Growing- Facebook Group

Spawn and Grow Materials:

- Field & Forest Products
- Fungi Perfecti

Grow Tek– Instructions or materials:

- Fresh Cap Mushrooms
- Myers Mushrooms
- House of Hydro

This is not intended to be an endorsement, but simply a list of resources that I am familiar with and want to share.

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Questions?

Sarah Brackney
Purdue Extension Ag & Natural Resources Educator
Daviess County
812-254-8668
sbrackne@purdue.edu

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Reach out with any questions. Thank you and Happy Growing!