## Sawdust as Substrate

Many types of wood are suitable for primary decomposers. Alder and oak are commonly used (probably since alder is an abundant weed tree in the Pacific Northwest and oak is common in the East). 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. 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.

Straw of many small grains is a suitable substrate for Oysters. The straw is chopped into 1 to 4 inch lengths and pasteurized by submerging for 1 to 2 hours in water maintained at 160 F. After the straw is drained well, it should contain about 65% moisture. **Pasteurization** is treatment of a substrate, usually by heat, that eliminates certain microorganisms. We typically soak straw for 4 hours, drain overnight on hardware cloth, and autoclave for 1 hour (the straw is then sterile, and must be handled as such – it may be more susceptible to weed molds if they are introduced since there will exist, by definition, a **biological vacuum**). A bleach method is described in the text (this method is not recommended since chorine may be toxic). Other substrates suitable for specific mushrooms, especially the Oysters, include cellulose from paper, coffee grounds, seed hulls, corncobs and stalks, and many others.

Straw and sawdust are nitrogen poor and **semi-selective** for mushrooms. Usually, these substrates are supplemented with nitrogen to increase mushrooms yields. When nitrogen is added, however, 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. As 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.

### Substrate Recipes

**Standard sawdust recipes** (Shiitake, Enoki, *Hericium*, Reishi, Oysters, *Agrocybe*, etc.) expressed as percentages of the dry weight of the ingredients. The moisture content of each material must first be determined for computations of the final recipe.

**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 | | 1.36 L water |

**Stamets' Sawdust Recipe:**

| By dry wt: | moisture: | For 5 lb block: |
|---|---|---|
| 73.0 % oak sawdust | 14.70 % | 1.50 lbs |
| 24.6 % bran | 6.64 % | 0.46 lbs |
| 2.4 % $CaSO_4$ | 20.4 % | 0.053 lbs |
| | | |
| 65 % moisture | | 1.36 L water |

**Paul Stamets' enriched sawdust Recipe:**

100 pounds of sawdust 50 pounds of one half to four inch wood chips,
40 pounds of bran, 5 to 7 pounds of gypsum,
moistened to 60 to 65% water and then sterilized.

**Calculations for a Sawdust-based Substrate**

To determine how much of each ingredient to add in the following recipe,

| By dry wt: | Moisture: | For 5 lb block: |
|---|---|---|
| 72 % sawdust | 22.25 % | 1.53 lb |
| 20 % cornmeal | 12.0 % | 0.38 lb |
| 7.8 % rice bran | 6.64 % | 0.14 lb |
| 0.2 % $CaCO_3$ | 0.3 % | 0.003 lb |
| 67 % moisture | | 1.34 L water |

Calculate as follows:
67 % X 5 lbs = 3.35 lbs water
5 lbs – 3.35 = 1.65 lbs dry ingredients

| | Dry wt % | dry lbs/100% – moisture content % | wet wt |
|---|---|---|---|
| Sawdust | 1.65 X .72 = | 1.188/.7775 = | 1.53 lb |
| Cornmeal | 1.65 X .20 = | .330/.880 = | 0.38 lb |
| Rice bran | 1.65 X .078= | .129/.934 = | 0.14 lb |
| $CaCO_3$ | 1.65 X .002= | .003/.997 = | 0.003 lb |
| | | | ------ |
| | | | 2.053 lb |

2.053 - 1.65 = 0.403 lbs water in materials
3.35 - .403 = 2.95 lbs water to add (1.34 L)

**Examples of Moisture Levels in Materials**

| | |
|---|---|
| Calcium carbonate (lime) 0.3% | Oak sawdust (from Cal Oak) 14.7% |
| Calcium sulfate (gypsum) 20.4% | Oat hay, chopped 12.0% |
| Cornmeal 12.0% | Rice bran 6.6% |
| Cotton seed hulls 9.5% | Rice hulls 8.1% |
| Cotton seed meal 10.5% | Rice straw 9.6% |
| Millet 10.0% | Rye grain 11.4 |

**Supplies**:

Sawdust, oak and walnut mix (very fine, needs to be mixed with coarser materials): Calico Hardwoods, Inc., Windsor, CA, 707-546-4045. Free sawdust, open 8-4:30.

Sawdust, oak: Cal Oak Lumber Co., 1000 Cal Oak Rd, Oroville, 530-534-1426. $10/cubic yard, 2 yard minimum. North on Hwy 70 to Oroville, turn right on Oroville Dam Blvd, turn right on Feather River Rd (before McDonalds), turn left on Cal Oak Rd.

**Sterilization:**

We sterilize liquid and dry goods at 250 F (121 C) at 15 pounds per square inch (PSI). To sterilize agar, 1 to 2 liter batches are autoclaved for 30 minutes (on slow exhaust for liquids). Quart jars of grain are sterilized for 45 minutes followed by another 45 minutes 24 hours later (to kill heat resistant bacterial endospores - the day interval results in their germination, thereby increasing their susceptibility to heat). We autoclave straw for 1 hour and sawdust filled bags for 90 minutes or more, depending on volume and number of bags.

(Note: When autoclaving glass jars, place the jars in a tub with about an inch of water to minimize temperature swings and breakage. Jars that break along the bottom rim are sharp and dangerous! Sometimes jars simply crack, only to give way later. **Be careful!**)

**Incubation:**

Substrates are subject to self-heating, or thermogenesis, as the substrate is consumed by the mycelium. This is especially true when grain is used to spawn sawdust; therefore, bags must be spaced apart by about one inch. Where bags touch each other, black pin molds are common. Open wire shelves may offer a little more control over thermogenesis compared to a solid shelf. If temperatures in the bag approach 100 F, dormant thermophiles may be activated.

If the sawdust is not fully colonized within a few weeks of incubation, contamination is likely (it's a race between the mushroom and contaminants). A sour, putrid smell indicates bacterial contaminants. When bags are free of contaminants, each mushroom species has a distinctive "odor **signature**" (clean and mushroomy). The incubation room should be maintained at about 75 F with fresh air. While $CO_2$ levels inside the bag will be high (up to 40,000 ppm), low levels in the room will prevent excessive levels in the bag since the breathing strip allows gas exchange. Very high levels of $CO_2$ encourage contaminants.

Depending on the species, the substrate is usually fully captured by mycelium within 2 to 6 weeks. Fruiting of many specialty mushrooms is initiated by dropping the temperature for 2 days to 2 weeks, reducing $CO_2$, and providing light (if you can read by it, there is enough light).