

# **Kentucky Shiitake Production Workbook**

## Introduction to Shiitake: The "Forest" Mushroom

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The history of forest management in the eastern United States tells us that the native hardwood forests were mined or "high-graded." This meant that the very best trees in size, shape, and commercial value were cut out from the forest, leaving behind the poorer trees. Farmers know that selling all the prime livestock or the best-producing seed of grains, beans, or vegetables makes the farm progressively less profitable over time. Similarly, this earlier poor forest management has resulted in our current forests being second- or third-growth forests of second- or third-rate commercial quality. Balanced forest management to reverse this increasingly poorer trend recommends "weeding" these forests, just as you would weed a healthy garden. This often means the removal of small diameter hardwood trees to allow larger, healthier trees more room to grow. In many parts of this area, there are few, if any, markets for small-diameter timber.

Shiitake mushrooms (~~Figures 1 and 2 removed to simplify printing~~) may prove to be a new commodity that will provide some economic return on small diameter wood from private woodlands that otherwise would be used only for firewood. Hardwood logs (beech, hickory, maple, oak, etc.) from small tree trunks or large branches (3 to 8 inches in diameter) are perfect for the production of shiitake (shee-TAH-kay) mushrooms as a value-added non-timber forest product.

People are increasingly curious about producing this gourmet mushroom, native to Japan, known as shiitake or the forest mushroom (*Letinula edodes*). They have been grown and eaten in Japan and other Asian countries for centuries and are developing a steadily growing market in the United States. Although the majority of the U.S. market for these mushrooms is still supplied by Japan, interest has increased rapidly in growing them locally. In addition, the vast majority (over 90%) of the market is supplied by people who grow shiitake mushrooms on artificial substrate, not on natural logs.

Shiitake mushrooms, normally larger than the white button mushrooms (*Agaricus* spp.) found in your local supermarket, are honey to dark chocolate brown in cap color (Figures 1 and 2). They also are usually speckled with white spots around the rim of the cap or split along the top, showing the white inner part through the brown top, looking something like campfire-burned marshmallows. The underside of the cap, or gills, is white, as is the stem or stipe (Figure 3). They have meaty flesh and a distinctive, somewhat nutty or garlicky flavor, and they are high in B vitamins and essential amino acids. If exposed to sunlight, they can also increase their vitamin D content. The Japanese have studied the medicinal effects of these mushrooms and have found that eating them seems to reduce blood cholesterol levels. Shiitake may also fight viruses and boost the immune system.

If forest landowners consider growing these mushrooms, they have several options:

1. cutting the trees into logs and selling them to shiitake growers (2002 prices ~ \$1.00/log),
2. cutting and inoculating logs with shiitake spawn and then selling them to people who want to grow the mushrooms,
3. selling short-length, inoculated logs for the gourmet "kitchen" market, or
4. controlling the whole operation from cutting the logs to growing, harvesting, and selling the mushrooms themselves.

It is possible to grow shiitake on sawdust or other constructed substrates, but this type of production demands much higher production costs and requires more intensive labor than growing them on logs.

Also, shiitake mushrooms grown on artificial substrate have poorer shelf life, poorer texture, and a reduced level of medicinal value than shiitake grown on natural logs. At present, over 95% of the shiitake mushrooms available in supermarkets are produced artificially and not from logs.

As with many crops, you need to plan shiitake production and marketing ahead of time. Most writers have identified about six steps in the mushroom production process. These include:

1. log selection and preparation.
2. inoculation.
3. incubation.
4. fruiting (actual mushroom production).
5. harvesting and handling.
6. marketing.

People all over the U.S. have been experimenting with this new crop. Local climatic conditions and size and species of logs affect how quickly and how abundantly the mushrooms grow naturally in a given growing season. Some production generalizations can be made, however, with each state or region requiring specialized fine-tuning of the details.

In the log selection and preparation stage, small living trees or large branches of big trees (3 to 8 inches in diameter) are cut and moved to the location where you plan to inoculate and incubate the mushroom logs. These trees should be in fairly long lengths (whole tree lengths, if possible) to start with\*.

\*At the time of inoculation, the long lengths are then bucked into lengths that are most manageable by the producer (usually 3 1/2 to 4 feet long).

The types of trees generally found to be most desirable are in the family that includes the American chestnut, beech, and oaks. Other hardwoods, such as hickories and maples, may also be used. Some rot-sensitive species, such as birches or sweetgum and the true poplars, produce mushrooms quickly but for a shorter period of time than the denser varieties of hardwoods. Logs are most commonly inoculated in late winter (February to March in Kentucky) but can also be done in the fall (October/November) after about a third of the leaves have fallen off the trees. Fall inoculation gives the advantage of allowing the fungus to begin to colonize the logs on warm days during the winter.

Trees should be cut in February for spring inoculation or in October for fall inoculation when the wood has the maximum amount of stored sugars in it, which is what the shiitake fungus eats. Cut logs should be inoculated, if possible, within two weeks after cutting. If you are planning to coordinate with a logger to obtain small diameter trees and/or large branches that they do not want as part of their commercial cut, be sure that they can provide the logs when you will have the time to inoculate. What is most important is that the log length is a size that is easy to move around.

Inoculating the logs is like planting seeds—you have to get the actively growing material that will produce the mushrooms into the logs. It also means that you must wait for the "seed" to "sprout"—a longer time (6 to 18 months) than you may be used to with other food crops. The inoculum is called spawn and comes in two major forms: dowel spawn (in which the material is pre-injected into small wooden dowels that are then hammered into drilled holes in the log)

(Figure 4), or sawdust spawn (which usually is produced in blocks that are then crumbled into small pieces and packed by hand or by a special tool into the drill holes) (Figure 5).

Different strains are available for hot weather, cool weather, and wide-range temperatures (see suppliers' lists in FOR-77 and FOR-89). Using several different strains allows a grower to continue production virtually year-round, especially if the logs are protected from very hot weather (usually by tree shade around the log yard) and from very cold weather (in a heated greenhouse, for example). If the logs are inoculated in the fall, they should be protected from cold and wind over the winter by locating the logs on a south-facing slope or south side of a building and covered with a clear plastic "tarp," leaving space at the bottom edge for some air circulation. It is important to keep the logs damp over winter, so if the stacks are covered with plastic or another solid tarp, water them every couple of weeks. If you use shade cloth as a cover, rainfall can usually penetrate it. Check your log weights to be sure they are not losing moisture.

Holes are drilled by hand using a high-speed (4,000 to 8,000 RPM), heavy-duty electric drill. Spacing of holes on logs depends on each log's diameter, but one general rule is approximately 6 inches apart in the rows, and rows spaced every 1½ to 2 inches around the outside of the log. Holes in even-numbered rows should be staggered with the spaces in the first and other odd-numbered rows to form an overall diamond or web pattern (see FOR-77). Another general rule is that the number of rows of holes on a log is the same as the diameter in inches of the small end of the log. Logs of 3 to 8 inches in diameter will probably end up with 30 to 40 inoculation holes. Once the spawn has been placed in the inoculation holes, most growers seal the holes with hot (400°F) cheese wax to sterilize the surface, to retain moisture, and to protect against contamination by other fungi and bacteria.

Once the logs are inoculated and sealed, they need to incubate to allow the mycelia (root-like structures) to penetrate through the log. Only when this has happened (remember that this will take 6 to 18 months) will the mushrooms, or fruiting bodies of the fungus, appear. Like most mushrooms, shiitake thrives in cool, damp conditions. During incubation the wood in the logs must maintain at least 30% to 35% moisture (see FOR-82). They also need enough air circulation around the logs to keep the bark dry enough to discourage competing fungi and bacteria.

Logs can be stacked several different ways (Figures 6-8) for the incubation period (see FOR-83, Incubation and Stacking). One of the best stacking methods is lean-to (Figure 8), where the logs are laid close to the ground, but on a clean surface such as gravel, not directly in contact with the soil. Other stacking methods include teepee stacking (Figure 6) and log-cabin stacking (Figure 7), where the logs are stacked higher off the ground. Placing the logs on a gravel bed (which could be laid down over fabric) and up on two or more base logs, or a recycled pallet will make it easier to keep water (and therefore good conditions for contamination) off the bottom logs. Logs should be moved around within the stacks several times during the incubation period. If mold appears on the logs, the logs need to be re-stacked more openly to improve air circulation so that further mold growth will be discouraged.

Figure 6. Teepee method of stacking logs.

Figure 7. Log cabin crib method of stacking logs. [removed]

Figure 8. Lean-to method of stacking logs.

Ideally, the logs need to have 85% to 90% shade—evergreen shade is usually a little cooler and is present year-round. Our hardwood trees lose their leaves in the winter, and warm days in the winter can dry out unprotected logs. Many spawn strains will produce mushrooms within the first year, some in six months, some longer, depending in part on the

time of inoculation (fall/spring). It is wise to test different strains of spawn and different species of wood to see what works best in your particular circumstances. If the weather is particularly dry, the logs should be wetted by soaking them in a container (animal water trough, large buckets) or by short-term, heavy overnight sprinkling every few days in a dry period.

After several months when you see the white mycelia of the fungus on the ends of the logs, indicating that the spawn run is complete (the fungus has occupied the entire log)(Figure 9), you may want to soak them overnight to encourage fruiting (Figure 10). Doing this repeatedly and allowing a minimum of eight weeks between fruitings is known as forced fruiting and has the advantage of controlling when you will have mushrooms. After soaking, the log stacks can be covered with plastic while the mushrooms are beginning to emerge (see FOR-85, Harvesting for greater detail). The cover can be removed to harvest the larger mushrooms and then replaced while the smaller ones are growing over the two- to three-day period of fruiting. If you do cover the logs with plastic, be sure to cut an air vent hole in the top, and leave a space at the bottom so that air can continue to circulate through the stack. Also, the cover should be large enough so that it does not rest against the outside surface of the logs. Resting logs are left uncovered between their production cycles.

Figure 9. White mycelia showing on ends of incubated logs.

Figure 10. Immersing logs overnight when ready for production. Keep top logs under water.

When mushrooms actually begin to appear, many growers change how the logs are stacked. From a lean-to position, the logs are stood on end teepee fashion, either around the base of a large tree or against a high (2½ to 3 feet off the ground) cross bar or wire so that you can reach all sides of the logs to harvest the mushrooms (Figure 6). Another option is a relatively short (5 logs high on each side) log-cabin stack, as its open middle makes it possible to reach mushrooms on all sides of the logs (Figure 7). Natural mushroom production on any particular log should continue for about a week during spring and fall "seasons" when the weather is both warm (more than 70°F during the days) and wet. It is possible that production may continue—more or less—for several months during the growing season.

Mushrooms are ready for harvest when the edge of the cap (the veil) (Figure 3) breaks free from the stipe. You want the caps to be rounded with the edges curled in when you pick for market. They will continue opening after harvesting. Mushrooms that have their caps fully expanded or flat are considered of much lower quality and will bring a lower price. It is important to cool the mushrooms within one hour of harvest, so you should locate your harvesting area near your cooler and move mushrooms into the cooler as soon as you fill the basket, bag, or other container you are picking into.

To harvest shiitake, you simply twist the stipe of the mushroom where it enters the log or cut the mushrooms off the logs with a sharp paring knife and box them for market in vented boxes like those used for tomatoes. Check for insects on the mushrooms and make sure that they are free of bark or soil. They may need a little brushing but should not be washed. The mushrooms have a minimum shelf life—fresh refrigerated—of two to three weeks. They can also be dried sliced or whole and marketed that way, although currently large volumes of inexpensive dried shiitake are available from foreign sources. If you have a relatively small operation (e.g., 100 to 1,000 logs) your production would probably be on a weekly basis, which means you would actually harvest on two or three days. For larger operations, you may be on a continuous production cycle and would be harvesting daily.

Many things affect the level of productivity, such as climatic conditions, type of spawn, and log species and sizes used, and you need to keep records of the details in your own situation.

All crops need a market. Fine restaurants, especially of continental, French, or Asian cuisine, would probably be interested in buying these mushrooms fresh, but try selling them to your local pizza parlor, too. Health food/natural food stores and food cooperatives may also be interested in buying locally produced, fresh mushrooms. Shiitake are well enough known that they can be sold at farmers' markets. Large supermarkets are usually only interested in buying produce in large volumes on a regular basis (i.e., weekly), so they may not be a good outlet. Be prepared to sell the idea of this new commodity with recipes and cooking suggestions, along with some nutrition information, included with your label. You may want to do a cooking demonstration for local groups because often the flavor of these mushrooms helps them sell themselves.

Good packaging and quality control on your mushrooms will improve their marketability. Because there are no "automatic" markets for these mushrooms other than large produce markets in major cities, the "footwork" of establishing markets for your mushrooms must be done before you start inoculating logs and continue as your logs incubate and then produce.

The intent of this workbook is to provide interested people with enough information to begin a shiitake production program, whether working with a few logs to provide your household with enough mushrooms for your kitchen or going into commercial production with hundreds or thousands of logs.

This workbook is divided into 14 sections, all of which are relevant to shiitake production. They are available on-line at University of Kentucky Cooperative Extension website. Each section includes a shiitake recipe on the last page. An effort has been made to provide a variety of recipes, from main dishes to soups and dips and spreads.

## Wild Mushroom Frittata

- \* 2 large eggs
- \* 6 egg whites
- \* 2 tablespoons water
- \* 1/4 teaspoon salt
- \* 1/4 teaspoon freshly ground pepper
- \* 1 tablespoon olive oil
- \* 3/4 pound assorted mushrooms (such as crimini, portobello, and shiitake), coarsely chopped
- \* 1 shallot, thinly sliced
- \* 2 teaspoons dried oregano
- \* 1/4 cup shredded light mozzarella cheese
- \* 1 tablespoon chopped fresh basil

1. Beat the eggs, egg whites, water, salt, and pepper together in a bowl until frothy.
2. Heat the oil in a medium nonstick skillet with an ovenproof handle. Add the mushrooms, shallot, and oregano and saute until the mushrooms are golden, about 5 minutes. Add the egg mixture to the mushrooms, stirring gently to combine. Reduce the heat and cook, without stirring, until the eggs are set, 12 to 15 minutes. Sprinkle with the mozzarella. Preheat the broiler.
3. Broil the frittata 5 inches from the heat, until the top is lightly browned, about 2 minutes. Allow to stand for 5 minutes before serving.

Yield: 4 portions.

Per serving: 156 calories

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