University of Kentucky
College of Agriculture,
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Center for Crop Diversification Crop Profile
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Shiitake and Oyster Mushrooms

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Introduction

Shiitake (*Lentinula edodes*) and oyster (*Pleurotus* spp.) mushrooms are specialty mushrooms that are well-suited for small-scale production in Kentucky. Unlike *Agaricus* types (common button mushroom, portabellas, and criminis), which require large, highly mechanized facilities with environmental controls, shiitake and oyster mushrooms can be log-cultivated outdoors. While growers with access to a woodlot will have a clear advantage in terms of production site and log supply, these mushrooms can also be cultivated in other heavily shaded locations as well as indoors.

Shiitake mushroom (left) grown on stacked logs (above).

Marketing

The market for log-grown specialty mushrooms continues to develop in Kentucky. Growers have successfully marketed mushrooms at farmers markets and to specialty grocers and fine restaurants (particularly those specializing in Continental, French or Asian cuisine). Other direct markets, including on-farm stands and CSAs, are also feasible.

Additional options for marketing Kentucky log-grown fresh shitake and oyster mushrooms include locally owned supermarkets (in contrast to national chains) and pizza parlors. Dried mushrooms can be sold at local outlets, as well as by mail order or on the internet. Value-added products, such as soups or dip mixes, are an additional possibility. Shiitake is known for its medicinal as well as its culinary value, so there may be possible markets in the pharmaceutical or nutraceutical industries for large-scale producers. Growers will need to provide a consistent year-round supply of quality mushrooms to compete in these larger markets.

Growers producing sawdust-grown mushrooms under controlled environmental conditions can provide a year-round supply, giving them a marketing advantage. However, log-grown mushrooms are considered superior in flavor and have a longer shelf life when compared to those grown on artificial media. Log-grown mushrooms may also appeal to consumers interested in local foods and sustainable food systems. Additionally, log-grown mushrooms may contain higher percentages of the medicinally active ingredient(s) present in these species. Whether the quality factors are sufficient to outweigh the efficiency factors in larger-volume markets is uncertain.

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Market Outlook

Specialty mushrooms, still relatively

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new to the U.S., first gained popularity as a gourmet food item. Their increasing presence (especially shiitake mushrooms) in national food supply chains indicates they are becoming mainstream. Sales of shiitake mushrooms have increased steadily over the past 15 years. Sales of specialty mushrooms, including shiitake and oyster, increased from $65 million in the 2012-2013 season to $106 million for 2017-2018. These values only count growers with 200 or more logs. For those larger growers, average prices reported in 2017-2018 were $4.44 per pound for shiitake and $3.13 per pound for oyster mushrooms.[1] The Letcher County (Kentucky) farmers market reported mushrooms selling for $5 per quart container in fall 2018, and the Lexington Farmers Market had mushrooms selling for $8 a quart at the same time.[2]

Oyster mushroom

Production Considerations

Production methods

Shiitake mushrooms are cultivated on small-diameter (3 to 8 inches) hardwood logs that have been cut from decay-free, live trees with intact bark. Log inoculation can happen at any time, although higher yields can be achieved if it occurs in late winter/early spring (February/March) as soon as possible after felling, or at the time of leaf drop in the autumn when the food-rich sap is returning to the roots for the winter (October/November). However, the rising sap in the late winter/early spring has higher sugar content and will encourage a more rapid growth of the fungus. The selection and preparation process of logs according to species, season and size should be developed prior to the ordering of inoculum and can be a valuable part of a larger timber stand management plan.

Shiitake is introduced into holes drilled in the logs by inserting commercially produced spawn (either as loose sawdust, dowels or plugs). The inoculation sites are then sealed with hot wax to reduce contamination and to reduce moisture loss in the logs at those sites. Logs are stacked and incubated for six to 18 months in a moist, shady location. The moisture level of the logs must be closely monitored and irrigation may be necessary if drought conditions develop. Once white mycelial growth from the spawn is visible at the ends of the logs, growers will know that the logs can then be forced to fruit on a schedule (if using a strain that can be forced) by immersing them in water overnight or for 24 hours, although it is recommended that producers wait a year from the time of inoculation before placing the logs on a production schedule. After soaking, the logs are loosely stacked for production under a clear plastic cover. A building or greenhouse with humidity and temperature controls is necessary for winter production. The normal season for shiitake production in Kentucky is from March to October or November, although it depends on the strains used.

Shiitake can also be grown on artificial (compressed sawdust) logs or blocks under controlled environmental conditions. Artificial logs are composed largely of sawdust with supplements (such as millet, rice bran or wheat bran) added to this substrate. Artificial logs have the advantages of controlled productivity and efficiency over natural logs. However, in comparison with natural logs, production of shiitake on artificial logs is highly capital- and labor-intensive. As such, artificial log production may not be appropriate for producers just starting out in a shiitake venture. It is recommended that new producers start small and get a sense of what is involved in shiitake production on natural logs (as well as a sense of what their proposed market will bear) before moving on to artificial log shiitake production.

Oyster mushrooms can similarly be grown on hardwood logs using spawn introduced into holes drilled in logs. Alternately, the grower can cut an inch-thick layer from the end of a log, cover the cut end with spawn, and then nail the slice back onto the log. Inoculated logs are then placed in black polyethylene bags of vermiculite or sand drenched in water. The bags are

stored in a cool place for four to five weeks before mushrooms appear.

In addition to log culture, oyster mushrooms can be grown on a variety of other substrates, such as composted straw, chopped wheat straw with cottonseed hulls, and sawdust. After the substrate is pasteurized or sterilized, it is cooled and spawn is added. The mixture is placed in perforated plastic bags, bottles, trays or beds in a controlled environment. Timing to production can be similar to that of logs, depending on the volume of substrate inoculated.

Pest management

Potential contaminant threats include *Trichoderma*, *Biscogniauxia* and *Trametes versicolor*. These fungi can invade the logs, resulting in wood decay, although *Trametes versicolor* isn't much of a competitor unless the logs dry out or are exposed to direct sunlight. Logs exhibiting *Trichoderma*, the most serious competitor for shiitake, must be removed from the log area and destroyed. Termites, bark beetles and springtails may also cause damage to the logs, but can be controlled fairly simply by good log management. Direct damage to the mushroom caps can occur as a result of feeding by slugs, snails, birds, squirrels and deer, if the logs are left unprotected. University of Kentucky recommended management practices to deter slugs and snails include placing log stacks on gravel pads, or sprinkling lime and wood ash around the stacks, while the use of netting, fencing or repellents may be used for problems with mammals. See UK publication FOR-84, Pest Control, part of the Kentucky Shiitake Production Workbook, for more information.

Harvest and storage

Harvest mushrooms by either cutting or twisting them off at the base of the stem. They should be refrigerated immediately in corrugated cardboard containers or paper bags to retain quality and freshness. Packing boxes for fresh mushrooms should be vented to allow for air circulation. Shiitake have a longer shelf life under refrigeration (12 to 14 days) than the more fragile oyster mushroom (five to seven days). Both species can be dried (air-dried or in a dehumidifier) and stored in sealed containers. Drying increases their shelf life by at least six months.

Labor requirements

Log-production of shiitake mushrooms requires labor for cutting trees, hauling logs to the inoculation/incubation site, drilling and inoculating logs (five minutes per log or approximately eight hours per 100 logs), moving logs into and out of soak tanks, harvesting (30 to 60 minutes per 100 logs per harvest), packing and transporting to markets. Pre-harvest labor for a 500-log operation is estimated at 42 hours, with harvest labor at approximately 18 hours.

YELLOW OYSTER MUSHROOMS

Economic Considerations

The major start-up costs for specialty mushroom production include a refrigeration unit, high-speed drill, hardwood logs, spawn and wax. Costs can vary considerably depending on raw materials, equipment used, equipment already available, ability of the producer to build equipment, efficiency and costs of labor, and the production methods used. For example, growers who own their own woodlot can utilize the low quality logs that are cut during timber stand improvement, a cost advantage over producers who must purchase their logs.

University of Kentucky shiitake costs and returns estimates (Potential Profits from a Small-Scale Shiitake Enterprise, FOR-88), first published in 2003, are based on the small-scale production of shiitake using approximately 500 logs inoculated over a four-year period. After six to 18 months of incubation, the logs are forced to fruit three times a year. It is not until the third year that a positive annual return to land, labor and management is realized. Variable establishment costs during the first four years (not including the value of operator labor) is about $1,700. Labor costs during the first four years, at a wage rate of $12.50 per hour, are about $2,500. Fixed costs during the first four years ($772 total) bring the total economic cost over $5,000 for the first four years. This results in a $2,000 loss to

land and management, assuming all labor is valued at $12.50 per hour and mushroom sales total $2,911 over the first four years.

In Year 5, excluding labor, pre-harvest variable costs are $320 and harvest variable costs are $783. Total variable costs in Year 5 are approximately $1,100, with total fixed costs of $315 for a total cost of $1,415, excluding labor. Revenues total $4,103, based on 746 pounds sold at an average of $5.50 per pound. The value of labor (60 hours at $12.50 per hour) adds an additional $750 in costs. The estimated return to land and management in Year 5 is $1,935. Using these assumptions, this means a 100-log enterprise would approximately break even (not accounting for the time value of money) during the first five years of production, when accounting for all labor costs.

A budget template for a 1,000-log shiitake operation, prepared by Virginia State University and the University of Maryland, indicated a net zero return to land and management over four years when labor is valued at $12.50 per hour and mushrooms were sold at $3.50 per pound. Higher sale prices are the main factor for obtaining profitability from specialty mushroom production.

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[1]Mushrooms (National Agricultural Statistics Service, 2018) https://downloads.usda.library.cornell.edu/usda-esmis/files/r781wg03d/pc289m64k/47429c713/Mush-08-21-2018.pdf

[2]Kentucky Farmers Market Price Reports (Center for Crop Diversification, University of Kentucky, 2018) http://www.uky.edu/ccd/pricereports/KYFM

Selected Resources

Online

- Forest Farming, FOR-115 (University of Kentucky, 2009) http://www2.ca.uky.edu/agcomm/pubs/for/for115/for115.pdf
- Kentucky Shiitake Production Workbook (University of Kentucky)
  - Shiitake Production on Logs: Step-by-Step in Pictures, FOR-77 (2010) http://www2.ca.uky.edu/agcomm/pubs/for/for77/for77.pdf
  - Introduction to Shiitake: The "Forest" Mushroom, FOR-78 (2010) http://www2.ca.uky.edu/agc/pubs/for/for78/for78.pdf
  - Log Selection and Preparation, FOR-79 (2013) http://www2.ca.uky.edu/agcomm/pubs/FOR/FOR79/FOR79.pdf

Shiitake mushrooms

  - Spawn Selection, FOR-80 (2011) http://forestry.ca.uky.edu/sites/forestry.ca.uky.edu/files/for80.pdf
  - Inoculation, FOR-81 (2011) http://forestry.ca.uky.edu/sites/forestry.ca.uky.edu/files/for81.pdf
  - Monitoring Moisture Content of Logs, FOR-82 (2011) http://forestry.ca.uky.edu/sites/forestry.ca.uky.edu/files/for82.pdf
  - Incubation and Stacking, FOR-83 (2013) http://www2.ca.uky.edu/agcomm/pubs/FOR/FOR83/FOR83.pdf
  - Pest Control, FOR-84 (2013) http://www2.ca.uky.edu/agcomm/pubs/FOR/FOR84/FOR84.pdf
  - Harvesting, FOR-85 (2011) http://forestry.ca.uky.edu/sites/forestry.ca.uky.edu/files/for85.pdf
  - Processing and Storage, FOR-86 (2013) http://www2.ca.uky.edu/agcomm/pubs/FOR/FOR86/FOR86.pdf
  - Marketing, FOR-87 (2013) http://www2.ca.uky.edu/agcomm/pubs/FOR/FOR87/FOR87.pdf
  - Potential Profits from a Small-Scale Shiitake Enterprise, FOR-88 (2004) http://forestry.ca.uky.edu/sites/forestry.ca.uky.edu/files/for88_0.pdf
  - Resources for Shiitake Growers, FOR-89 (2007) http://forestry.ca.uky.edu/sites/forestry.ca.uky.edu/files/for89_0.pdf
  - Production Options, FOR-90 (2013) http://www2.ca.uky.edu/agcomm/pubs/FOR/FOR90/FOR90.pdf
- Best Management Practices for Log-Based Shiitake Cultivation in the Northeast (Northeast SARE), https://www.nesare.org/Dig-Deeper/Educational-Resources/Northeast-guides-and-books/Shiitake-Mushrooms
- Specialty Mushrooms (Cornell University)

https://smallfarms.cornell.edu/projects/mushrooms/

- Growing Shiitake Mushrooms in an Agroforestry Practice (University of Missouri, 2008) http://extension.missouri.edu/explorepdf/agguides/agroforestry/af1010.pdf
- Mushroom Cultivation and Marketing (ATTRA, 2004) https://attra.ncat.org/attra-pub/summaries/summary.php?pub=77
- The Basics of Hardwood-Log Shiitake Mushroom Production and Marketing (Virginia Cooperative Extension, 2014) https://hortintl.cals.ncsu.edu/sites/default/files/documents/2018jul30thebasicsofhardwood-logshiitakemushroomproductionandmarketing.pdf
- Shiitake Mushroom Production on Logs (Alabama Cooperative Extension, 2007) https://www.mushroomcompany.com/resources/shiitake/ala-logs.pdf
- Shiitake Mushrooms Enterprise (University of Maryland, 2003) http://extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/woodland-steward/RES_11Shiitake.pdf
- Cultivation of Oyster Mushrooms (Penn State University, 2016) https://extension.psu.edu/cultivation-of-oyster-mushrooms

Books in print

- Growing Gourmet and Medicinal Mushrooms. Paul Stamets. 3rd ed. 2000. Ten Speed Press: Berkley. 574 pp.
- Growing Shiitake Mushrooms in a Continental Climate. M.E. Kozak and J. Krawczyk. 2nd ed. 1993. Field and Forest Products: Peshtigo, WI. 112 pp.

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