



# Gourmet & Medicinal Mushrooms

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## Introduction

Commercial growers who have successfully produced shiitake (*Lentinula edodes*) and/or oyster (*Pleurotus* spp.) mushrooms may want to consider expanding their operation to include other specialty mushrooms. While considered riskier from the perspectives of production and marketing than shiitake and oyster mushrooms, a number of other exotic and native mushroom species could be successfully cultivated in Kentucky. Four of these potential species are discussed here.

## Marketing

The market for Kentucky-farmed specialty mushrooms continues to develop in the Commonwealth. Fine restaurants (particularly those specializing in Continental, French, or Asian cuisine), along with organic or health food stores, are currently the main market outlets.

Additional options include locally owned supermarkets (in contrast to national chains) and pizza parlors. Farmers markets, community supported agriculture (CSA) subscriptions, harvest festivals, and agritourism booths may provide opportunities for retail sales. Dried mushrooms can be sold at local outlets, as well as by mail order or on the internet. Value-added products, such as dried soups, sauces, dip mixes, and teas, are an additional possibility. Mushrooms produced for their medicinal value may require searching out markets in the pharmaceutical or nutraceutical industries. Growers raising mushrooms under controlled environmental conditions are in the best position to provide the consistent year round supply demanded by wholesale markets.

## Market Outlook

Specialty mushrooms, still relatively new to the U.S., are popular as a gourmet food item. The perceived health benefits of mushrooms have added to their



*Hericium erinaceus*, also known as Lion's mane mushroom

attractiveness. Since shiitake and oyster mushrooms have become mainstream, as evidenced by their presence in national food market chains, consumers and restaurant chefs look for other unusual mushrooms to satisfy their palate for the new and different.

Gourmet mushrooms may be more difficult to market than the better-known shiitake and oyster mushrooms. Markets with good potential for gourmet mushroom sales in Kentucky include restaurants, especially those focused on local foods, and farmers markets. On-farm markets, retailers with a more extensive local food product line, and CSAs, or other subscription or membership-based marketing, also have good potential. Because gourmet mushrooms are still new to many consumers, education

and point-of-purchase materials may be needed. Cooking demonstrations can also be a helpful way to introduce these mushrooms to consumers.

Gourmet mushroom production fits



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into the realm of agroforestry practices. Farmers and landowners managing smaller timber and woodlots may be more likely to incorporate non-timber forest products into their woodland management and marketing program. Mushroom production can be a satisfying way to utilize hardwood logs, and even stumps, to contribute to long-term woodlands productivity and management.

## Production considerations

### *Selecting a mushroom species*

Determining which mushroom species to produce will require research into the various mushroom production techniques, as well as a familiarity with fungal life cycles. Available resources, grower experience, and market demand should all be factored into the decision. The following mushroom species show potential for outdoor commercial production in Kentucky. Indoor production under controlled environmental conditions is also feasible for growers who have the appropriate knowledge, along with the economic resources, to develop the necessary facilities.

LION'S MANE (*Hericium erinaceus*) is also known as bearded tooth mushroom, hedgehog mushroom, and pompom. Instead of gills, this white fungus has downward cascading spines or "teeth." It grows wild in Kentucky on hardwood logs or stumps, as well as on dead and dying trees that are still standing. Lion's mane can be marketed for both culinary and medicinal purposes. Cooked lion's mane reportedly has the flavor of lobster.

MAITAKE (*Grifola frondosa*), or hen-of-the-woods, can be found in Kentucky forests where it grows mainly as a saprobe or opportunistic pathogen on various hardwood species. It can be found on stumps, as well as at the base of dead or dying trees. This fleshy polypore fruits in fan-shaped clusters with overlapping sections. It is prized for both its nutritional and medicinal properties.

KING STROPHARIA (*Stropharia rugoso-annulata*), or winecap Stropharia, is most commonly found in the Mid-Atlantic states; however, its native range also includes Kentucky. It grows on the forest floor, as well as on wood chips or bark mulch in urban areas. This large gilled

mushroom has a round, wine-red to reddish-brown cap arising from a single white stalk. King Stropharia is noted for its culinary uses.

REISHI (*Ganoderma lucidum*) is used for medicinal purposes, rather than culinary uses. It is widely distributed in the subtropical regions of the world, but is less frequently found growing wild in temperate zones, including Kentucky. This fungus has a shiny red or reddish-brown upper surface and pores rather than gills. Reishi is an annual mushroom that is primarily found fruiting on stumps or at the base of aging hardwoods growing as a saprobe or pathogen, depending on the host tree. There is possible risk associated with high inoculum levels of potential tree pathogens, such as reishi, that large-scale cultivation might entail. *Ganoderma lucidum* can kill a wide variety of hardwood tree species, and airborne spores produced by the mushrooms may colonize root wounds on area trees and lead to the spread of tree root disease and decline.



## Production Considerations

### *Production Methods*

Fruiting of these more exotic species can be unpredictable and experimentation may be necessary to determine the most reliable production system(s) for your farm. The literature on mushroom cultivation is extensive with many variations in production methods. Often growers develop their own individual techniques based on trial and error.

### NATURAL LOG PRODUCTION

Maitake, reishi, and lion's mane can be cultivated on logs in the same manner as shiitake. Oaks seem to be preferred; however, many other hardwood species, such as beech or maple, can be used. Logs approximately 3 to 8 inches in diameter and 3 to 4 feet long are cut from decay-free, live trees with intact bark. Freshly cut logs are inoculated with commercially produced dowel or sawdust spawn. The spawn can be introduced via drill holes, wedge cuts, or by slicing the log into disks and nailing the slices back together. Inoculation sites are generally sealed with hot cheese wax, which serves as a protective barrier against moisture loss, insect invasion, and contamination. Logs are stacked and incubated in a moist, shady location. The stacking configuration used should allow for air circulation without excessive water



loss. Common stacking techniques include the crisscross method, the X-pattern method, and the lean-to method. Regardless of the stacking system, there should generally be a barrier (such as gravel or fabric) between the bottom logs or ends of the logs and the soil surface. Lion's mane production can be an exception; these logs are often buried vertically in the ground to one-third their lengths.

Alternatively, logs inoculated with maitake or reishi may be buried horizontally, either right after inoculating the top portion of the log or after a successful spawn run. A thin layer of mulch or soil is used to cover the logs. Some commercial producers cover the buried logs with hoop frames supporting shade cloth. These coverings not only provide shade, but they also reduce water loss through evaporation. Coverings may provide some protection from animal predators and insect infestation.

The moisture level of the logs, whether stacked or buried, must be closely monitored. Irrigation may be necessary if drought conditions develop; some specialty types will require frequent watering. Logs are watered either by immersing them completely or by using drip tapes. Well-maintained logs can continue to produce for at least three to five years.

#### STUMP PRODUCTION

Maitake, lion's mane, and reishi mushrooms can also be produced on freshly cut hardwood stumps. The cut surface of the stump is inoculated by filling drilled holes with dowel or sawdust spawn. Natural cracks in the wood can also be used as inoculation sites. The cut-wedge and sliced-disk methods used for log production can be used for stump production as well. Hot cheese wax is used to seal the inoculation sites. A production site that remains cool and moist is best.

#### WOOD CHIP PRODUCTION

King Stropharia is produced in a bed of wood chips or sawdust. Select a wooded site with a north- or east-facing slope since these locations will be cooler and moister than others. An area about 4 feet by 8 feet is cleared, disturbing the underlying soil to a depth of 8 inches. A 2-inch layer of wood chips is added, watered, and then inoculated by broadcasting spawn. An additional 2- to 3-inch layer of wood chips is added and the bed is gently stirred. The bed should be kept heavily watered for the first four days following inoculation. After three to four months of regular watering, the bed is stirred again. Fruiting bodies should develop within a couple of weeks after the second stirring. Additional woodchips

can be incorporated into the bed each year for three to four seasons of production. Spent shiitake or oyster mushroom production logs can be ground up and used as a substrate for Stropharia production. Chips should be sterilized prior to inoculation when using previously colonized logs. Wood chips may be obtainable from some utility companies; however, mulch with little to no leaf litter is preferred.

#### ARTIFICIAL PRODUCTION

Growers with access to high-tech, climate-controlled facilities can produce gourmet mushrooms on artificial substrates, either in bags or bottles. Controlled conditions will produce the most consistent and reliable means of production. It is also more labor intensive and significantly more costly than log production. Maitake, reishi, and lion's mane mushrooms can be produced in this manner. Indoor cultivation of maitake requires more exacting requirements and attention to detail than other artificially produced mushrooms. Stropharia indoor production is not considered economically viable due to the lengthy time from spawn to crop.

Growing media consists largely of sawdust, wood chips, or straw. Supplements, such as bran and/or another carbohydrate source, are also added. The ingredients are mixed together with water, and sterilized or pasteurized in the production container (bags or bottles). After cooling, the substrate is inoculated. Containers are sealed in such a way that gas exchange can still occur. Once the fungal mycelium has colonized the substrate, containers are moved to a temperature-controlled grow room with high humidity. In some cases, a single bag or bottle may yield a second, smaller flush of mushrooms.

#### *Pest Management*

Potential disease threats to outdoor log production include Trichoderma, Hypoxylon and Polyporus versicolor. These fungi are naturally occurring wood decay fungi that can compete with the cultivated mushrooms. Logs exhibiting the blue-green Trichoderma fungus, a very aggressive competitor, are toxic and must be removed from the log area and destroyed.

Termites, bark beetles and springtails can also cause damage to the logs. Direct damage to the mushroom caps occurs as a result of feeding by slugs, snails, birds, squirrels and deer, if the logs are left unprotected. University of Kentucky management practices recommended for shiitake mushroom production can eliminate many of these difficulties in log-produced mushrooms.

### ***Harvest and storage***

Time to fruiting will depend on several factors, including the substrate, the mushroom strain, quality of spawn, and environmental conditions. Specialty mushrooms are harvested by either cutting with a sharp knife or twisting them off at the base of the stem, depending on the species. Harvesting mushrooms in clusters is not only easier, but also reduces the amount of handling and damage that can occur to individual mushrooms. Freshly picked mushrooms should be refrigerated immediately in vented cardboard containers that allow for good air circulation.

Mushrooms may be sold fresh in damage-proof containers covered with clear, breathable plastic wrap or in plastic clamshells. Restaurants generally prefer 5- to 7-pound boxes, while 3-, 5- or 7-ounce containers are more typical for consumer sales. Mushrooms can be sold in bulk at farmers markets.

Many specialty mushrooms can also be dried, a process that extends their shelf-life for six to 12 months. Once dried, mushrooms can be frozen until sold. Low pressure steam sterilization or maintaining mushrooms at 0° F for several days may be required if there is any possibility of insect infestation. Specialty mushrooms, especially those for medicinal purposes, can also be sold in a powdered form for use in value-added soups, spices, teas, capsules, etc.

Lion's mane will fruit in five to six weeks when grown under controlled conditions, whereas log production can require approximately 18 months to obtain harvestable mushrooms. Lion's mane should be harvested when the spines have elongated but before the top of the mushroom softens and becomes noticeably yellow or pink. Lion's mane requires careful handling because it is extremely fragile and bruises very easily. Even slight injuries can become sites for bacterial invasion.

Maitake-inoculated stumps may take one to three years to fruit. They are harvested for fresh market sales before the mushroom caps droop downward and spores are released. Mushroom sections should be fully extended with darkened edges. Harvested mushrooms are very fragile and great care must be taken when harvesting. Maitake can be wrapped in rice paper and stored for up to two weeks. These mushrooms may also be sold as a dried product.

King Stropharia mushroom fruiting is highly variable, typically between two months and one year. They are harvested when the cap is bell-shaped and while the gills

are still white. Once the cap has flattened and the gills have darkened due to spore formation, the flavor and the value of the mushroom declines. King Stropharias can grow to an impressive size at maturity (up to 5 pounds each); however, they will be well past their prime if allowed to become that large. These mushrooms are generally not sold dried.

Reishi natural outdoor production can take six months to two years to obtain harvestable mushrooms. These mushrooms are considered fully mature and ready for harvest when the whitish margin around the edge of the fruiting body turns red. Well-maintained logs can continue to produce for several years.

### ***Labor requirements***

Outdoor log production is seasonal with periods of especially high labor needs, such as during inoculation and harvest. Indoor production is even more labor-intensive, requiring continuous attention year round.

Log production of gourmet 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. These labor figures are based on shiitake mushroom production.

### ***Economic considerations***

The removal of poor quality or less desirable tree species for forest or timber stand improvement tends to be a net cost to the woodlot owner. Other than firewood sales, there are few markets for the small diameter trees removed during this process. Natural log mushroom production offers woodlot owners an opportunity to utilize these low quality logs to produce an economically valuable product, while also upgrading the residual stand. Logs used for forest mushroom production are worth considerably more than those sold as firewood.

The major start-up costs for log/stump production of gourmet mushrooms include a refrigeration unit, high speed drill, spawn and wax. The purchase of hardwood logs can be an additional expense for producers who do not own a woodlot. Indoor production will require a building or other structure with environmental controls, substrate, containers, spawn, and possibly a laboratory facility. Costs can vary considerably depending on raw materials, equipment used, equipment already available,

ability of the producer to build equipment, worker efficiency, costs of labor, and production methods used. For example, growers with their own woodlot have a cost advantage over producers who must purchase their logs. Recycling spent logs from a shiitake or oyster mushroom enterprise for King Stropharia production can also provide a cost savings. Log recycling would essentially generate added income to a small-scale shiitake enterprise.

Budget information for these specific gourmet and medicinal mushrooms is not available. However, budgets for shiitake log production may be helpful in providing ballpark estimates for other log-produced mushrooms. Keep in mind that gourmet mushrooms may not produce as quickly, as these exotic mushrooms are less dependable in their fruiting habits.

The following University of Kentucky costs and returns estimates (2010) are based on a 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. Net revenues in the first two years are negative and it is not until the third year that a positive annual return to land, labor and management is realized. In this scenario, pre-harvest costs are \$320 and harvest costs are \$285. Total variable costs are approximately \$600 with total fixed costs running \$315, for a total cost of more than \$900. Profits with no hired labor (a family run business) for the 500-log enterprise can occur in the \$2,300 range. Hired labor, at a cost of \$540, would reduce these profits to about \$1,700.

## Selected Resources

### *On the web*

- Farming Exotic Mushrooms in the Forest (USDA National Agroforestry Center, 2000) <http://nac.unl.edu/documents/agroforestrynotes/an13ff02.pdf>

- A Guide to Outdoor Mushroom Log Cultivation: Highlighting shiitake, reishi and tree oyster mushrooms (D-Acres of New Hampshire Organic Farm and Educational Homestead, 2004) 1 MB file <http://www.dacres.org/media/articles/forestry/MushroomCultivationGuide.pdf>
- Cornell Small Farms Program Mushroom Cultivation <http://blogs.cornell.edu/mushrooms/>
- Lion's Mane: A New Candidate for Profitable Forest Cultivation (Cornell Small Farms Program, 2015) <http://smallfarms.cornell.edu/2015/04/06/lions-mane/>
- Maitake at a Glance (Alice W Chen, Paul Stamets, Nian-Lai Huang, and Sheng-Hua Han, The Mushroom Growers' Newsletter, September-October 1999) <http://mushroomcompany.com/resources/maitake/ataglance.pdf>
- Method for Cultivating Stropharia Mushrooms (Cornell University, 2013) <http://blogs.cornell.edu/mushrooms/files/2013/06/Stropharia-21lckcx.pdf>
- Mushroom Cultivation and Marketing (ATTRA, 2004) <https://attra.ncat.org/attra-pub/summaries/summary.php?pub=77>
- Specialty Mushrooms (by Daniel J. Royse in Purdue University Specialty Crop Proceedings, 1996) <http://www.hort.purdue.edu/newcrop/proceedings1996/V3-464.html>

### *Books in print:*

- *Growing Gourmet and Medicinal Mushrooms*. Paul Stamets. 3rd ed. 2000. Ten Speed Press: Berkeley. 574 pp.

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*Photos courtesy of Dr. Nick V. Kurzenko, University of California-Berkeley (Lion's mane); Tom Volk, University of Wisconsin-La Crosse, TomVolk.Fungi.net (Maitake); Holger Krisp, Wikimedia Commons (King Stropharia); and Eric Steinert, Wikimedia Commons (Reishi)*

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