

Growing Mushrooms Commercially — Risks and Opportunities



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People have harvested mushrooms from the wild for thousands of years for food and medicines. Of the estimated 1.5 million species of fungi, about 10,000 produce the fruiting bodies we call mushrooms. While commercial harvesting of wild mushrooms continues today, most of the world's supply comes from commercial mushroom growers. The Chinese first cultivated shiitake (*Lentinula edodes*) mushrooms around 1100 AD, with domestication efforts beginning centuries earlier. White button mushrooms (*Agaricus* spp.), most familiar to Americans and Europeans, were first domesticated in France in 1650. Commercial production began in the United States in the 1880s. *Agaricus* is the leading mushroom crop worldwide and accounted for 99 percent of the 1997 United States' mushroom production. Oyster mushrooms (*Pleurotus* spp.) were more recently domesticated, and now rank second in world production. Shiitake mushrooms, which are very popular in Asian cultures, rank third. Many other edible mushrooms, such as straw and wood ear mushrooms, are gaining in popularity.


Roughly 300 mushroom species are edible, but only 30 have been domesticated and 10 are grown commercially. Button, oyster, and shiitake mushrooms make up about 70 percent of the world's production (table 1). During the past 30 years, mushroom production worldwide increased

twenty-fold, with much of that increase occurring in the 1980s and 1990s. Increased demand for specialty mushrooms (everything besides *Agaricus*) has been particularly strong. Asian countries continue to dominate world production and consumption, however, consumption in the United States has increased sharply in recent years, providing potential opportunities for mushroom growers.

Mushroom production in the United States has traditionally centered in Pennsylvania, which produces nearly half the nation's button mushrooms. California and Florida are the second and third leading producers, with limited production in 27 other states. Large-scale growers with established, year-round markets dominate commercial mushroom production. In 1997, 7 percent of United States mushroom farms supplied 20 million pounds or more each, or 38 percent of total U.S. production. In contrast, 36 percent of mushroom farms produced less than one million pounds per year.

Even established growers are challenged with recent imports of canned *Agaricus* from China, Chile, India, and Indonesia. In the face of this competition, the prospects for new *Agaricus* growers are poor. The number of button mushroom growers in the United States has decreased steadily, from 357 in 1987 to 153 in 1997.

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Table 1. World production of cultivated edible mushrooms in 1986 and 1994.

Species	Fresh weight and percentage of total production				Percent increase
	1986		1994		
	(X 1,000 tons)	(%)	(X 1,000 tons)	(%)	(%)
<i>Agaricus bisporus</i> (button)	1,215	55.8	1,846	37.6	51.9
<i>Lentinula edodes</i> (shiitake)	320	14.7	826	16.8	158.1
<i>Pleurotus species</i> (oyster)	169	7.8	797	16.3	371.6
<i>Auricularia species</i> (wood ear)	119	5.5	420	8.5	301.0
<i>Volvariella volvacea</i> (straw)	178	8.2	299	6.1	68.0
<i>Flammulina velutipes</i> (enokitake)	100	4.6	230	4.7	130.0
<i>Tremella fuciformis</i> (jelly fungus)	40	1.8	156	3.2	290.0
<i>Hypsizygus marmoreus</i> (bunashimeji)	---	---	55	1.1	---
<i>Pholiota nameko</i>	25	1.1	27	0.6	8.0
<i>Grifola frondosa</i> (maitaki)	---	---	14	0.3	---
Others	10	0.5	239	4.8	2,290.0

Table 1 adapted from S.T. Chang, 1996. Mushroom research and development - equality and mutual benefit. *Mush. Biol. Mush. Prod.* Vol. 2:1-10.

Specialty mushroom production is more evenly distributed throughout the United States than is button mushroom production. The number of commercial specialty mushroom growers in the United States decreased slightly (from 188 to 183) between 1995 and 1997. There are a few large-scale specialty mushroom farms. Most growers operate small farms and focus on local markets. For 1997, the average specialty mushroom farm in the United States produced approximately 52,000 pounds of mushrooms with gross

sales of about \$150,000. United States production of oyster and shiitake mushrooms appears in Figure 1.

Shiitake and oyster mushrooms are the best-known specialty mushrooms, and probably the easiest to market. *Auricularia* spp. (wood ear), *Volvariella volvacea* (straw mushroom), *Flammulina velutipes* (enokitake), *Grifola frondosa* (maitake), and *Tremella fuciformis* (white jelly or fungus ear) are also increasing in popularity. *Volvariella volvacea* (straw) mushrooms are



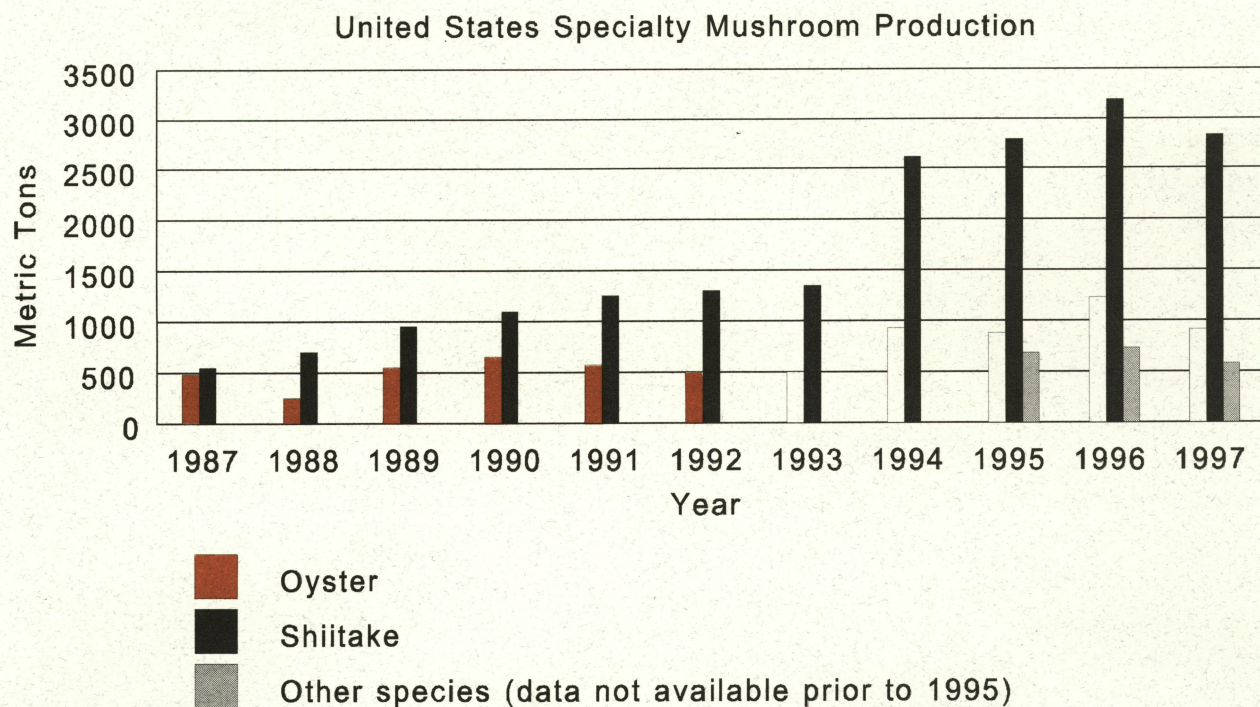


Figure 1. United States specialty mushroom production for 1987-1995. Data provided by the United States Department of Agriculture National Agricultural Statistics Service.

the easiest to grow, produce mushrooms in as little as 4 days, and are adapted to areas with high temperatures. They are not as popular with consumers as button, oyster, or shiitake mushrooms, but still account for 6 percent of the world's production. *Ganoderma lucidum* (reishi), *Hericium erinaceus*, and *Hypsizygus marmoreus* (bunashimeji) are medicinal mushrooms used primarily in Asia. Medicinal mushrooms require specialized marketing in the United States.

Production facilities

Mushrooms lend themselves to many different growing systems from simple and inexpensive to highly sophisticated and expensive. This publication was written only to provide an overview of opportunities and risks for potential mushroom growers. Sources providing detailed, how-to cultural information are listed at the end of this bulletin. Much information on state-of-the art

mushroom production and marketing may also be found on the Internet. Be aware that some production techniques are patented and require payments to patent holders if they are used.

Shiitake has long been grown on sections of logs about 3ft in length. Oak is the preferred species, although beech, chestnut, and other hardwoods have been used in the United States. Gambel or scrub oak (*Quercus gambelii*) is found in parts of the Intermountain West and can be used for shiitake production. Other oak species suitable for growing shiitake are native to Oregon and California. For outdoor production, log sections are inoculated with spawn (a starter mix of fungal mycelium and sawdust or grain) and set aside to allow the fungi to develop. Shade cloth is often used to protect logs stored outdoors from excessive drying caused by direct sunlight. The development period is called the spawn run and can last 6 to 18 months, depending on the log

species, diameter, moisture, and temperature. At the end of the spawn run, the logs are transferred to a cool, moist raising yard where the mushrooms develop and are harvested. In outdoor systems, most shiitake production occurs in the spring and fall. Greenhouses and converted farm buildings are used to produce winter crops. A single log may bear five crops of mushrooms. Some other mushroom species can also be grown in basic, nonmechanical facilities.

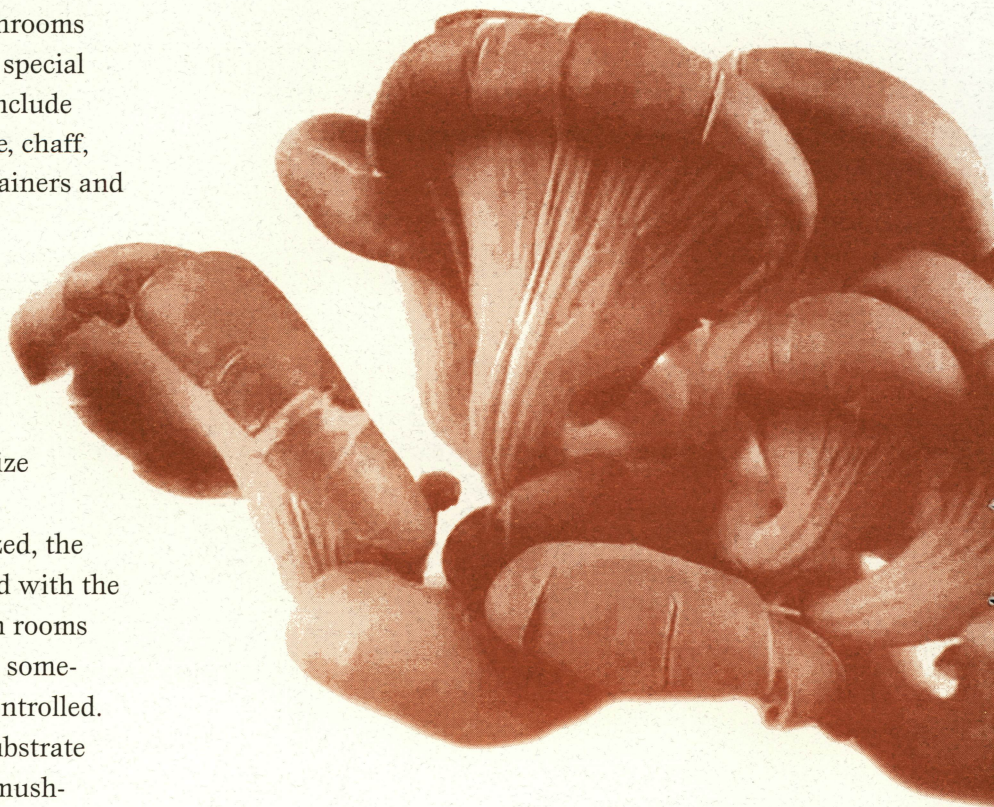
Much of the increase in mushroom production is due to the development of high-yield systems that depend on precise environmental controls. In 1988, shiitake production in the United States was equally divided between natural logs and synthetic logs made from sawdust, straw, corncobs, and various amendments. Eight years later, synthetic log production doubled and now makes up more than 80 percent of the total. By using synthetic logs, growers can harvest shiitake mushrooms year-round and produce three to four times the yield in one tenth the time natural logs require.

High yields and rapid production cycles with most mushroom species require specialized facilities. Substrates (materials the mushrooms grow in) are blended and packaged into special plastic bags or jars. Typical substrates include sawdust, grain, straw, corn cobs, bagasse, chaff, and other agricultural byproducts. Containers and substrate are then either pasteurized or sterilized to remove contaminating microorganisms. Hot water baths can be used for pasteurization, but sterilization may require a commercial steam sterilizer. Some growers compost substrates outdoors and then sterilize them inside heated sheds.

After being pasteurized or sterilized, the substrate-filled containers are inoculated with the desired fungi and placed into spawn run rooms where temperature, humidity, light, and sometimes atmospheric gases are carefully controlled. When the spawn run is complete, the substrate may need additional treatments before mush-

rooms develop. Many mushroom species require changes in temperature, moisture, substrate, and/or light to begin fruiting. Large-scale, highly technical facilities are expensive to construct and operate. Whether you use a basic or sophisticated production system, growing mushrooms is labor intensive.

A third option for mushroom production is to harvest mushrooms from the wild. In the Pacific Northwest, large quantities of morel, chanterelle, matsutake, and bolete mushrooms are harvested each year. Offsetting the advantage of no production facilities are high labor costs, unpredictable crops, inclement weather, and increased transportation. Although researchers have made progress in domesticating morel mushrooms, most are still harvested from the wild. To learn more about wild mushroom harvests, refer to the *For more information* section later in this publication.



Management

Commercial mushroom production requires high levels of management input and skill. A common mistake new growers make is to believe that growing mushrooms is easy. Each species requires specialized treatment to produce consistent yields of high-quality, marketable mushrooms. Another common mistake is to start too large and diversify too soon. As mentioned earlier, mushroom growing is labor intensive. It is easy to quickly become overwhelmed with the physical requirements of mixing and sterilizing substrates, ordering and inoculating with spawn, maintaining environmental controls, harvesting and processing mushrooms, marketing, business management, and many other tasks that go with a commercial enterprise.

Trying to learn a single crop is difficult enough, and mastering several different mushroom crops at once may be impossible. Some spawn suppliers offer starter kits and instructions. Using small starter kits will allow you to gain some experience with different mushroom crops with minimum investments in time and money. Keep detailed production and financial records to evaluate which crops show commercial promise.

As with any other crop species, not all mushrooms are created equal. Different strains or lines of shiitake, for example, vary in color, size, shape, firmness, cultural requirements, and yields.

Only the largest mushroom growers produce their own spawn. Spawn culture is highly technical and requires specialized facilities and equipment. Most growers rely on companies that specialize in producing high-quality spawn for their culture material.

If you are not already experienced in mushroom production, start small and expand slowly. Take time to learn all you can about growing and selling

mushrooms while you gain some practical experience. Study the market and decide which types of mushroom crops and production systems would be enjoyable, feasible, and profitable for you. Join growers' organizations and subscribe to newsletters about mushrooms. Universities sponsor conferences and workshops on specialty farming in general and mushroom farming in particular.

Marketing

The greatest challenge all specialty farmers face is marketing. Deciding what to grow, where and how to grow it, who makes up the target market, and how to package and advertise are just a few of the things that go into marketing. A thorough study of mushroom production and marketing is imperative before buying equipment and starting even a small-scale operation.

The demand for specialty mushrooms is huge, particularly in Asian countries. Trying to market internationally, however, is beyond the resources of most small and medium-sized companies. China produces nearly 1.5 billion pounds and Japan more than 300 million pounds of shiitake each year. Likewise, national markets in the United States are dominated by large companies and produce brokers. Most small-scale mushroom farmers in the United States focus on local markets. Specialty mushrooms are best known and most widely used among certain Asian cultures, and local sales may be best in areas with large populations of Asian-Americans. Mushrooms are sold fresh, dried, or processed. According to the U.S. Department of Agriculture, most specialty mushrooms grown in the United States are sold fresh.

For wholesale, consider locally-owned or operated groceries, restaurants, and health food stores. You can make direct sales to customers through farmers markets, subscriptions, and on-farm sales. Forming a cooperative with other growers in your area can improve marketing by increasing quantities and variety. Particularly for dried or processed mushrooms, you might con-



sider selling direct to consumers through mail order or the Internet. Whatever your marketing strategy, remember that quality and grading are critical in producing and selling mushrooms. Before deciding on any market strategy, thoroughly explore local, state, and federal regulations that will affect your growing, processing, and shipping.

Opportunities and risks

Mushrooms offer small-scale growers several advantages. Growing facilities range from logs stacked outdoors under a shade cloth to sophisticated production chambers with precisely controlled temperatures, humidity, and light. Specialty mushrooms are high value crops, typically selling at wholesale prices of \$3 to \$6 per pound. Depending on the production system, you can grow large quantities in a small space.

Mushrooms can be delicious and are rich in proteins, vitamins, and minerals while containing little fat. Demand for exotic culinary mushrooms has greatly increased in recent years and shows no sign of slowing. Certain mushroom species reportedly provide health benefits, including anti-cancer and anti-viral properties and the potential to reduce cholesterol and the risk of heart disease. With alternative medicine becoming more widely accepted, opportunities for health foods and dietary supplements should continue to increase.

Researchers have developed methods of effectively and economically producing many species of edible mushrooms. These production

systems use agricultural waste products, including straw, chaff, sugar beets, corncobs, waste paper, sawdust, coffee grounds, livestock manure, slaughterhouse wastes, and other materials. Once the substrate has been broken down during mushroom production, it can be sold for organic fertilizers and compost.

With opportunities, however, come risks. If you grow mushrooms outdoors, weather is an important consideration. Mushrooms are strongly affected by temperature, humidity, and light. A cold snap, heat wave, or drought can reduce yields or favor the development of undesirable “weed molds.” Outdoor production also generally provides lower yields and longer production times than are available with indoor facilities. Outdoor-grown mushrooms also fruit seasonally, producing crops when supplies are greatest and prices are lowest. People are not the only ones who enjoy fresh mushrooms. Insects and animal pests can become serious pests for mushroom farmers, especially with outdoor operations.

Indoor growers also face challenges. Precision-controlled indoor facilities are expensive to build, operate, and maintain. Operating and maintaining environmental controls require a certain degree of technical expertise. Cleanliness is critical in controlled environment production systems to ensure high-quality products free of potentially toxic contaminants. Pest control is also critical because some insect pests, such as fungus gnats, flourish under the same conditions that favor mushrooms. With high yields and short production cycles, harvest windows are short.

Whether you grow mushrooms indoors or out, labor should be a serious concern. Mushroom production is labor intensive. Before expanding beyond a small operation that you can maintain yourself, ensure that you have a consistent supply of laborers willing to work for you at competitive wages. Be prepared to provide training for your workers. Know and comply with worker protection regulations.

While demand for specialty mushrooms has increased greatly in recent years, so has production. Between 1986 and 1994, worldwide production of shiitake mushrooms increased 158 percent and oyster mushrooms by 371 percent. At the same time, the prices growers received dropped. For United States' shiitake growers, prices decreased from \$5.42 per pound in 1986 to \$3.09 per pound in 1997. From 1995 through 1997, wholesale prices for oyster mushrooms decreased from \$2.49 to \$1.90 per pound. Only increased yields and shortened production cycles have kept growers profitable. Oyster and shiitake mushroom production in the United States peaked in 1996 and decreased in 1997 (figure 1).

The development of improved production methods and increased demand has motivated large companies around the world to start growing mushrooms. Increased competition means that growers must carefully consider and manage marketing. Be prepared for market slumps caused by overproduction. Good practices include having backup plans in place for selling to alternative markets or preserving and storing your mushrooms for later sales.

Another challenge growers face is liability. Oyster mushrooms, for example, produce spores that cause allergic reactions in some people. Provide the appropriate safety equipment for your workers, including masks or respirators to protect them from fungal spores. Know what to do if an employee experiences an allergic reaction. Perhaps a greater concern is the risk of being sued by a consumer who becomes ill and accuses you of selling contaminated produce. Agricultural waste products used for substrates sometimes contain

pesticides, medicinal residues, and other chemicals that can be concentrated during recycling. They may also contain toxic microorganisms, such as aflatoxin. You can reduce liability risks by ensuring your substrates are free of pesticides and other toxins; using only high-quality, commercially-grown spawn; and maintaining hygienic conditions and excellent production records. Liability insurance would also be advised.

Be cautious about claims of medicinal and health-related properties. While mushrooms have long been used as medicines and health foods, supporting scientific evidence for their use is often sketchy, at best. In selecting mushroom crops, stay with those proven safe for human consumption. Don't experiment! Remember that some fungi produce deadly toxins. Safe and effective research on the effects mushrooms have on humans requires highly specialized training and facilities, and is closely regulated by health agencies. Avoid unsupported health claims in your marketing. Ensure that you meet or exceed local, state, and federal laws regarding production and marketing of food products. Products marketed as medicinal must meet United States Food and Drug Administration regulations.

In conclusion

Specialty mushrooms offer small-scale growers opportunities, however, there are risks. Do your homework before investing in land or production facilities. Read several books by different authors to get a balanced view of mushroom farming. Treat claims of quick and easy profits with great skepticism. Visit several mushroom growers outside your area to gain a grower's-eye-view of what it is like to produce and market mushrooms. Join mushroom growers' organizations and attend conferences and workshops. Calculate your costs for starting and operating a mushroom farm, including labor costs. Determine break-even points and the time you will need to recapture your investment. Be conservative in estimating yields, sales, and profits. Plan on supporting your mushroom operation with savings or off-farm

work until you pass the break-even point. In short, give yourself every chance for success.

For more information

Extension publications

The University of Idaho has many pamphlets, video tapes, and software packages on establishing and operating agricultural enterprises. To order publications or a catalog, contact Agricultural Publications, University of Idaho, Moscow, ID 83844-2240. The Internet address is <http://info.ag.uidaho.edu>. Publications of particular interest include:

Forming a cooperative. CIS 840.

Business and the family. CIS 940.

Licenses and legal requirements. CIS 941.

Conduct your own garden research. CIS 1041.

Marketing your produce directly to consumers. EXT 742.

Specialty farming in Idaho: Is it for me? EXT 743.

Specialty farming in Idaho: Selecting a site. EXT 744.

Special Forest Products. CIS 952.

Cultivation of Shiitake on Natural and Synthetic Logs. 1997. D. Royse. Order by contacting the Publications Distribution Center, Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. Phone: 814-865-6713.

Government publications

The USDA Forest Service has many publications on harvesting special forest products, including mushrooms. Many of these publications can be downloaded from the Internet or ordered from on-line catalogs. An excellent starting point is: USDA Forest Service Pacific Northwest Research Station, P.O. Box 3890, Portland, Oregon 97208-

3440, phone: (503) 808-2592. [Http://www.fs.fed.us/pnw/](http://www.fs.fed.us/pnw/).

Two publications of particular interest from the PNW Research Station are:

Molina, R., et al. 1993. *Biology, Ecology, and Social Aspects of Wild Edible Mushrooms in the Forests of the Pacific Northwest: A Preface to Managing Commercial Harvest*. PNW-GTR-309.

Hosford, D. et al. 1997. *Biology and Management of the Commercially Harvested American Matsutake Mushroom*. PNW-GTR-412.

Books

Many books are available on growing and using mushrooms. For a detailed list consult *Books in Print* at your library or bookstore. Some examples include:

Przybylowicz, P. and Donoghue, J. 1989. Shiitake Growers Handbook. Kendall/Hunt Pub. Co., Dubuque, IA.

Stamets, P. 1993. Growing Gourmet and Medicinal Mushrooms. Ten Speed Press, Berkeley, CA.

Weber, N. 1995. A Morel Hunter's Companion. Thunder Bay Press, Lansing, MI.

Journal articles

Royse, D. 1997. Specialty Mushrooms and Their Cultivation. Horticultural Reviews, Volume 19, pp 59-97. ISBN 0-471-16529-8.

Internet

The Internet provides access to hundreds of sources of information on mushroom cultivation and use.

About the author

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