Part I. Mushrooms

Chapter 1

Introduction to Mushroom

WHY GROW MUSHROOMS

Tricita H. Quimio
University of the Philippines at Los Banos, the Philippines

Mushrooms in History and Different Regions

Views & Comments

Mushrooms for development

In the West, mushrooms are regarded as a luxury food. But the work of various aid agencies in promoting them

the one billion Chinese favour the Straw Mushroom, which plays a large role in Chinese cuisine the world over. It is simple to grow, likes the hot, humid conditions of the tropics and even flourishes in the open air, all of which promise it a major role in future mushroom development schemes. Mushrooms are even being tried as an alternative crop to the opium poppy in the heroin producing regions of Southeast Asia.

The Oyster Mushroom is even more suited for expansion throughout the Third World, as it

Figure 1. Mushrooms for development

Mushrooms have been part of our human diet since time immemorial. They were used as food even before man understood the use of other organisms. Undoubtedly, mushrooms were one of man's earliest foods, and they were often considered an exotic and luxurious food reserved for the rich. Today mushrooms are food for both the rich and the poor. They can be grown anywhere as long as the conditions for their growth and cultivation are provided. Available mushroom technologies range in complexity from very high to amazingly low.

Figure 2. Fruiting bodies of *V volvacea*

Figure 3. Straw mushroom beds

Mushrooms have been variously considered as a hedge against famine or a possible cancer cure. They do certainly have enormous potential for feeding third world peoples. In the West, mushrooms are regarded as a luxury food. But in many developing countries of the world, mushrooms can mean cash for the poor (Fig. 1) and a new source of nutrition. Even landless peasants can grow mushrooms as a valuable crop as long as they have the proper technology, the proper substrates, and the planting material called spawn. In some villages of India, it has been reported that farmers are growing mushrooms right in their own homes or immediate surroundings. Villagers growing mushrooms can rapidly begin to bring in more cash than some local landowners.

Figure 4. Harvesting of straw mushroom

Figure 5. Fruiting bodies of oyster mushroom

In some poor countries of Asia, the tropical Chinese straw mushroom (*Volvariella volvacea*) (Fig. 2) is grown in very simple traditional ways. This mushroom likes the hot humid conditions of the tropics and can be cultivated on beds (Fig. 3) made up of agricultural wastes such as straw or banana leaves. Within 2 weeks, fruitbodies are ready to be harvested (Fig. 4).

Figure 6. Oyster Mushroom houses made of grasses

Figure 7. Oyster mushroom growing on sawdust beds outdoor

Oyster mushrooms (*Pleurotus* spp.) (Fig. 5) are even more suited throughout the third world areas that are rich in plant wastes such as sawdust, sugarcane bagasse and others. Moreover, composting–the difficult preliminary step for button and straw mushroom–is not required for oyster mushroom cultivation.

The oyster mushroom growing houses can be constructed of mud as in some villages in India, or made of bamboo and dried leaves as in most of Asia (Fig. 6). In cooler areas, oyster mushrooms may even be grown outdoors if they are shielded from excessive sun (Fig. 7). Oyster mushrooms are easily dried to provide for a longer shelf life and export possibilities (Fig. 8).

Figure 8. Dried oyster mushrooms ready for export

Benefits Derived from Mushrooms and Growing Mushrooms

Nutrition of the mushrooms

The popularity of mushrooms is still based not on the nutrients that they contain but mostly on their exotic taste and their culinary properties, whether eaten alone or in combination with other foods. It is not well known that mushrooms are full of nutrients and can therefore make a very important contribution to human nutrition. Table 1 shows the food value obtained from cultivated mushrooms compared with other common foods.

Table 1. Food value of the different cultivated mushrooms (% fresh weight)

Mushrooms/ food item	Protein	CHO	Fat	Calcium (Ca)	Thiamine (Vit. B_1)	Riboflavin (Vit. B_2)	Iron (Fe)	Niacin (Vit. B_3)
Pleurotus Pulmonarius	2.9 (26-35)*	5.66	1.79	3.14	0.20	0.22	3.40	7.72
Volvariella volvacea	3.8 (25-29)*	6.00	0.60	3.00	0.10	0.17	1.7	8.30
Agaricus Brunnescens	3.5 (24-34)*	11.4	0.40	2.40	0.10	-	trace	5.85
Lentinula edodes	7.5 (13-17)*	6.50	0.93	3.00	-	-	1.90	7.60
Auricularia polytricha	4.8 (4-8)*	7.16	0.50	3.15	0.08	0.19	3.60	4.00
Potato	2.0	9.10	0	11	0.10	0.04	0.70	0.04
Milk	3.5	4.90	3.9	118	0.04	0.17	0.10	0.17
Fish	14-20	2-3	1-2	15	60	1.20	1.50	1.20
Egg	13	2.0	13.3	68	18	0.27	1-15	0.27
Meat	21	-	3.6	8.3	0.10	0.29	2.52	29.00
Carrot	1.2	9.3	0.3	39	0.06	0.06	0.8	0.06

Compiled from various sources. *Numbers in parenthesis are dry weight data.

(Source: *Tropical Mushroom Cultivation* by T.H.Quimio, 2002)

Protein is one of the most important nutrients in food, being particularly important for building body tissues. Mushrooms with protein content ranging from 3-7% when fresh to 25-40% when dry can play an important role in enriching human diets when meat sources are limited. The protein content is almost equal to that of corn, milk, and legumes, although still lower than meat, fish and eggs. As a dietary source of protein, mushrooms are superior to most fruits and vegetables with the exception of beans and peas. Mushrooms can be eaten fresh or cooked, unlike other protein sources such as soya and yeast that have to be processed or disguised in some manner before they are acceptable on the table.

Mushrooms also contain all the essential amino acids as well as the commonly occurring non-essential amino acids and amides. Lysine, which is low in most cereals, is the most important amino acid in mushrooms. Mushroom protein is indeed a valuable addition to the human diet.

Mushrooms also rank quite high in their vitamin content, which includes significant amounts of Vitamin C. Although devoid of Vitamin A, mushrooms make up for that with their high riboflavin, thiamin and cyanocobalamin (Vit. B_{12}) content, the latter usually being found only in animal products. Their content of the anti-pellagra vitamin–niacin–is nearly equivalent to the levels found in pork or beef, which are considered to be the richest sources of this vitamin. Mushrooms are also good sources of minerals such as calcium, potassium, sodium and phosphorous in addition to folic acid, an ingredient known for enriching the bloodstream and preventing deficiencies. Iron is also present in an appreciable amount in mushrooms and together with phosphorous, can provide a good proportion of the recommended daily dietary needs. Mushrooms are low in sodium, making them ideal for persons with certain types of heart and kidney ailments.

As health food and medicinal

For the past 20 years, interest in the medicinal aspects of mushrooms has greatly been stimulated by the large number of scientific studies conducted on mushrooms. Folklores have provided clues for potential sources of medicine from mushrooms as well as from herbal plants. Using modern approaches, scientists have isolated and identified specific components that can either destroy or at least debilitate three of mankinds' killer diseases: cancer, heart disease and AIDS. As a result, a vast body of scientific literature concerning mushrooms has been published since the 1970s, mostly in hospitals and research institutions in Europe, Japan, China and the United States.

Figure 9. Fruiting bodies of *Ganoderma lucidum*

Figure 10. *Ganoderma* tea

The most recent introduction of a medicinal mushroom is *Ganoderma* spp. The fruiting bodies (Fig. 9) have traditionally been used for medicinal purposes and for thousand of years, have been regarded by the Chinese to be a high quality herbal medicine. It has been used clinically since ancient times in China for the treatment of fatigue, coughing, asthma, indigestion, neurosis and a variety of other diseases. Early reports indicated the ability of *Ganoderma* to improve body functions, increasing its healing ability while maintaining a healthy and long life. It is now well established from *in vitro* and *in vivo* studies that *Ganoderma* can help fight viral diseases, and modern research has proven its anti-tumor and interferon-inducing actions. Considerable data now indicates that

Ganoderma basidiocarps have several components responsible for the inhibition of HIV multiplication. Today, *Ganoderma* is available in many countries in the form of dried fruiting bodies, capsules, tonic and instant teas (Fig. 10), and is grown in culture all over Asia. In California, *Ganoderma* is sold in Chinese stores in dry forms, without the need for pre-processing into teas. Being a tropical fungus, this mushroom can be widely cultivated using sawdust and other tropical agricultural wastes such as palm fibers, coconut wastes and rice straw.

Pleurotus spp., oyster mushrooms, are also good sources of beta-1,3/1,6-glucan. These molecules (called pleuran) stimulate the immune system of the body to help fight abnormal cells as well as boost the system against the damaging effects of chemo and radiation therapies used to kill tumor cells. *Pleurotus* also contains mevinolin and related compounds which inhibit reductase, an enzyme used in cholesterol biosynthesis. The consumption of oyster mushrooms can lower the cholesterol levels in the body. Vita-Glucan tablets and elixirs, formulated from purified glucan extracted from *P. ostreatus*, are now available for strengthening the immune system and lowering serum cholesterol levels to prevent heart disease. According to much folklore, *Pleurotus* can also prevent high blood pressure, impart long life and vigor and assist people in recovering from fatigue. It can also prevent hangovers, constipation and is an aphrodisiac.

Other edible and cultivated mushrooms with reported scientific medical evidence are *Lentinula edodes* (shiitake), *Agaricus blazei* (himematsutake), *Agaricus brunnescens* (champignon) and *Grifola frondosa* (maitake). Those are known to induce the formation of interferon, a defense mechanism against some virus infections, and have displayed hypocholesteromic activity.

Use of agricultural wastes as substrates

Mushrooms are grown on some organic substrates, mostly waste materials from farms, plantations or factories.

Figure 11. Rice straw

Figure 12. Sawdust

These otherwise useless by-products can therefore be recycled to produce value-added mushrooms. Currently, millions of tons of agricultural wastes are discarded, burned and neglected. In the process of mushroom growing, however, environmental pollution from such practices may be reduced. Examples of such agro-wastes in abundance in the tropics are straw (Fig. 11), corncobs, grass, sawdust (Fig. 12), sugarcane bagasse, cotton waste (Fig. 13), oil palm waste, coffee pulp, water hyacinth plants (Fig. 14), coconut husks, tree leaves, branches and logs (Fig. 15). These all can be used alone or in combination to create mushroom growing substrate. With moderate effort and careful management, the very people hungry for food can have within their grasp a new food source in the form of cultivated mushrooms.

Figure 13. Cotton waste

Figure 14. Water hyacinth plants

Income and job generation

Figure 15. Logs for growing mushrooms

Mushroom growing is labor-intensive, and for countries where jobs are scarce, mushroom growing can create jobs both in semi-urban and rural areas. In fact, some technologies can use family labor thus providing all members of the family with employment.

The labor of out-of-school youths (Fig. 16) and even school children (Fig. 17) can also be utilized, especially as the bagging of substrate and related operations can be easily done by children. A big factory in Indonesia hires some 50 teen-age girls (Fig. 18), who trim the mushrooms ready for canning and for export. Mushroom growing is also recommended as a project in a cooperative where division of labor is practiced. One group may be engaged in spawn production, another group will do the substrate preparation, and still another group can take charge of growing condition management.

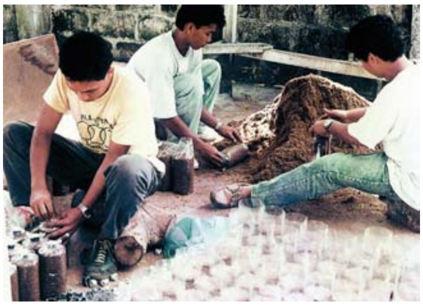

Figure 16. Out-of-school youths filling mushroom bags

Figure 17. School children helping in bagging sawdust for *Pleurotus* cultivation

Figure 18. Girls trimming straw mushroom

Resulting compost used for soil conditioner and animal feed

The used compost that remains after harvesting mushrooms may still be recycled for use as animal feeds and soil conditioner. Earlier studies of the author have demonstrated that spent compost of both *Volvariella* and *Pleurotus* had increased crude protein content compared with raw straw. Poultry feeding trials showed that spent compost fed to broilers resulted in greater weight gains compared with commercially used feeds. Low intake and low digestibility however were observed in trials with sheep using *Volvariella*-cropped rice straw/banana leaf compost. Research at the Hebrew University in Jerusalem included the production of a highly digestible nutritious feed for cattle and sheep from *Pleurotus* cotton waste/straw compost.

Numerous studies have indicated that mushroom composts made from wheat straw and other supplements gave comparable or higher yields of such selected vegetables as cabbage, beans, celery and cauliflower when compared with those grown using poultry manure. In Puerto Rico, *Pleurotus* spent-compost made from sugarcane bagasse, has been used by local nursery growers as a good substitute for the expensive commercial fertilizers used in soil conditioning. The spent compost is further composted in the open air, covered with plastic for 4-8 more weeks before it is dried, bagged and distributed to nursery owners.

Case Studies Showing Economic Aspect of Mushroom Cultivation in Rural Areas

Case 1. Village contract growing of *Pleurotus* sawdust bags in the Philippines

The objective of this project was to pilot contract oyster mushroom growing and use the revenues for further expansion of mushroom growing in the rural area. This activity was successfully demonstrated in several small villages near the University of the Philippines which provided appropriate funding support to the participants and where a central laboratory prepared the seeded mushroom bags for fruiting. The support was mainly for the building of small (5 × 5m) mushroom houses made up of nipa and sawali (Fig. 19) or styrofoam.

Each month, 2,000 bags (Fig. 20) were delivered to each of the participants (one from each village in the community). Resulting harvest was individually sold, to provide installment payments for the bags and the house. After 4 months when the project cost of PHP*20,000 (USD400) was recovered, the growers were taught to prepare their own bags, with the spawn provided by the central laboratory.

Figure 19. Mushroom house made up of bamboos, sawali, and nipa roof

Figure 20. Sawdust bags ready for delivery to contractual growers

* PHP (Philippine Peso, PHP1≒USD0.02 in May 2003

Table 2. Financial aspect of the project for each village

1. Total cost (loan)

Total amount of loan	PHP20,000 (USD400)
(for house and 2 deliveries of 2,000 bags)	PHP8,000+ (2×PHP6,000)
- Growing house	PHP8,000 (USD160)
(made up of nipa roof and sawali walls, wooden shelves, screened door, floor area of 10m^2)	
- Price for 2,000 bags (PHP3 per bag)	PHP6,000 (USD120)

2. Estimated income per month

Volume of production per month	350kg
(total production - loss during storage, handling and delivery)	(410kg - 60kg)
Net sales per month	PHP10,500 (USD210)
(total production × price per kg)	(350kg×PHP30)

3. Pay back of loan (for 4 months)

Collection per month to pay back loan (50% of income)	PHP5,250 (USD105)
	(PHP10,500 / 2)

* The loan can be fully paid back for 4 months

(Source: *Manual on Mushroom Cultivation* by Peter Oei, 1991)

One of the problems encountered was the difficulty of providing the proper temperature (lower than 30℃) for mushrooms to fruit abundantly. This was not a problem during the cool season from December to February when growers would enjoy abundant harvests. There were also some initial problems of bag delivery which made cost and expenses relatively high. The problem in marketing was not due to lack of buyers of mushrooms but the lack of production. Supply does not meet the high demand from traders and restaurants.

Case 2. Bed production of the straw mushroom in the Philippines

This project was done in a small farming community in the province of Cebu where a foundation provided funds to the contract participants, mostly family-based groups. The spawn and supervision was provided by a laboratory, which was also funded by the foundation. Bedding materials consisted of 45cm long, 10cm wide bundled rice straw (Fig. 21) or dried and bundled banana leaves (Fig. 22). Rice straw that was hard to bundle was chopped and molded into a bed (Fig. 23). Each 2m-bed would need at least 60 bundles and each family had to prepare 20-40 beds per month. The laboratory bought the harvested mushrooms back for marketing so the grower had no problem marketing their own produce.

Figure 21. Preparation of beds and spawning of straw mushroom

Figure 22. Dried and bundled leaves

Growers are expected to harvest at least 2.5kg of fresh mushrooms per growing cycle of 23 days. First flush would bring 2kg, and second flush, 0.5kg at the interval of 7-10 days. Each family therefore would produce at least 95kg of fresh buttons (Fig. 24, 25) and would have a net income of at least PHP2,000 (USD40) after removing the cost of spawn, production overhead/pesticides, monthly payback of loan and interest, as well as the monthly depreciation of their fixed investment in the form of water drum, sprayer and plastic sheets which have an expected 3-year life span.

Figure 23. Small beds for *Volvariella*

Figure 24. Harvested *Volvariella*

Figure 25. Packed straw mushroom for sale

Table 3. Monthly financial state of case 2

Volume of production per month	95kg
Gross Income per month	PHP2,850 (USD57)
(volume of production × price per kg)	(95kg×PHP30)
Total expenses per month	PHP696.43 (USD13.93)
- Spawn (5,500mL bottle/bed)	PHP440 (USD8.80)
- Production overhead/pesticides	PHP200 (USD4)
- Depreciation of investment	PHP37.77 (USD0.75)
- Monthly pay-back of loan and interest	PHP18.66 (USD0.37)
Net Income per month	PHP2,153.57 (USD43)*

* The usual farmer's income in the rural Cebu area is PHP1,500 (USD30)

(Source: *Manual on Mushroom Cultivation* by Peter Oei, 1991)