Part I Shiitake

Chapter 3

Shiitake Log Cultivation

SHIITAKE LOG CULTIVATION IN BRAZIL

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Introduction

Figure 1. Major geographic regions in Brazil (Northern, Central-Western, Northeast, Southeast and Southern) and localization of main shiitake growers (both log and bag cultivation)

Traditionally, Brazilian people do not consume edible mushrooms. It is estimated that the annual consumption in Brazil is only from 30-60g per capita, while the per capita consumption is 3.5kg in Germany, 2kg in France, 1.6kg in the US and 1.3kg in Italy. About 60% of the national production in Brazil is consumed as fresh mushrooms, and the other 40% is used by the food processing industry. In recent history, the consumption of mushrooms has increased, largely due to the fact that they have started to be considered as healthy, fresh, and nutraceutical food products. These new concepts of health and "healing" food have increased the interest in the commercial exploitation of shiitake in Brazil since 1980. Today, shiitake and other mushrooms are produced in several different states of the country (Fig. 1).

The main mushroom growers are concentrated in the south and southwestern regions due to climactic conditions, the high concentration of Oriental immigrants there, and the higher socioeconomic development in those regions. Although shiitake culture is not typically common in hot climates, several strains have been selected and shiitake production with these selections has shown good results.

Agaricus bisporus is the most produced and commercialized mushroom in Brazil, followed by shiitake, oyster mushroom, and *Agaricus blazei*. Mushroom production is generally performed on a small scale, most frequently as an alternative crop by which small farmers can diversify their agricultural production and increase their income. Due to its easier cultivation, the growing market and the low initial cost of investment, shiitake cultivation is more frequently being considered as an alternative crop. The number of shiitake farmers is increasing, and growers and investors across the country have become interested in the production of this mushroom.

For individuals interested in production as a hobby or for limited local sale, shiitake growing can be quite rewarding. Commercial production, however, requires a substantial commitment of time and money. As with any agricultural commodity, profits depend on the grower's production and marketing skills, as well as on market supply and demand. The technology and information on the economics of production in Brazil is still in the early stages of development.

Shiitake Log and Inoculation

In Brazil, *Eucalyptus* logs are the most common tree species used for shiitake cultivation. *Eucalyptus* is cultivated throughout

Brazil, and is faster growing and less expensive than other tree species. *Eucalyptus* logs can be harvested four to six years after planting. There is not much information comparing the various eucalyptus species, but on average the productivity is about 0.6-1.5kg per log life of 12-14 months. The main species of *Eucalyptus* used for shiitake cultivation are *E. grandis*, *E. saligna*, *E. urophilla* and their hybrids. *Eucalyptus citriodora* has also been used but it has been refused by some producers because of its strong odor, as this is the wood that produces the essence commonly used in sauna and room deodorant sprays. The bark of *E. citriodora* is also thinner and smoother than other *Eucalypt* species, which results in greater log dehydration (Figs. 2).

The dehydration delays mushroom growth and therefore the productivity of shiitake is lowered. Logs of other tree species, such as avocado, ipezinho, and acacia have been tested on a small scale, and have shown some positive results, but unfortunately, no scientific data has been recorded.

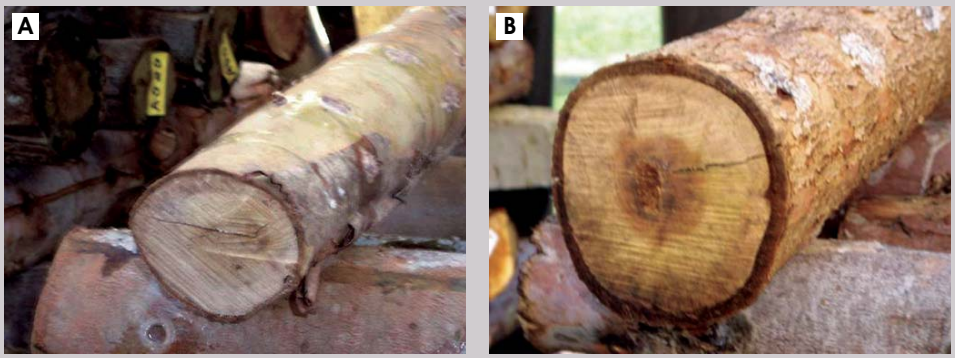

Figure 2. Eucalyptus logs **A**: Logs of Eucalyptus citriodora showing a thin and smooth bark **B**: Eucalyptus grandis presents a thick and rough bark

After using special drills to make the holes, inoculation is done manually, employing either inoculators or funnels. To use a manual inoculator, a farmer will fill it with sawdust-based spawn, and then push a piston in the top of the inoculator to insert the spawn into the hole (Fig. 3A). When using the second type of manual inoculator, sawdust-based spawn is put in a tank of about 500g, and then a lateral piston in the base of the tank is activated and makes a horizontal movement that inserts the spawn into the hole (Fig. 3B). The funnel method also uses a sawdust spawn. In this case it is put into the funnel and then introduced into the hole using a solid cane of plastic, aluminum or wood (Fig. 3C). In all cases, the filled holes are then sealed with a sealing sponge and a mixture of 80% paraffin and 20% pitch (Fig. 3D).

Figure 3. Inoculations using traditional inoculators **A**: Manual **B**: With an inoculum tank **C**: Using a funnel and solid cane to introduce sawdust based inoculum **D**: The brush used is made by steel and sponge.

Growing conditions

Brazilian shiitake growers incubate logs both in open systems under trees or under net shade and in controlled systems inside acclimatized buildings. The open incubation systems have many problems due to the high incidence of birds and insects such as ants and termites, and the difficulty of uncontrollable climatic conditions. To solve these problems, growing houses are covered by dried grasses, plastic, or metallic panels (Figs. 4). These houses offer greater climatic controls but most of them have only a top cover and some lateral protection using plastic sheeting or nets.

After inoculation, logs are usually incubated using the crib stack as shown in the Figures 5A and B, but some farmers gather inoculated logs together and maintain them under plastic film (Fig. 5C). The method shown in Figure 5C maintains humidity

more effectively, thereby diminishing the frequency of required irrigations and enhancing the mycelial growth rate. However, the maintenance of humidity above 95% in association with high temperatures, favors the growth of competitor fungi, such as *Trichoderma*.

Figure 4. Controlled systems **A**: Growing houses covered by dry grasses **B**: Plastic **C**: Metallic covers

Brazil is a large country and climatic conditions are quite variable. The zones where shiitake is cultivated have average temperatures ranging from 20 to 30 ℃ and relative air humidities from 60 to 90%. In central Brazil, the relative humidity is very low and the winds are strong, but growers in this region have cultivated shiitake in controlled conditions that increase the humidity and offer protection from the wind. In others parts of the country the winters are cold and dry while the summers are hot and humid. This climate allows for the cultivating of shiitake practically all year long although high productivity is only possible in winter periods. The productivity varies from 600 to 1,500g per log. The logs are 1m long and 12-15cm of diameter on average. The first flush occurs 3-8 months after the spawn run, with variations according to the tree species, fungal isolate and temperature. Where the temperatures are low, the spawn run periods are longer, and where the temperatures are higher, the spawn run periods are shorter. The shiitake cultivated have shown different colors and morphological aspects, but in general, Brazilians prefer the light-colored mushrooms (Figs. 6).

Figure 5. Spawn run of inoculated logs in organized stacks **A**: Under a house covered by grasses **B**: Metal **C**: Under plastic film

Figure 6. Mushrooms of shiitake isolates **A**: UFV 73 **B**: UFV 52 growing in log of Eucalyptus grandis

Pests and diseases

A number of diseases can destroy growing shiitake or compete with them for nutrients. Some insects and animal pests can also reduce yields or quality. Insects that might present a problem for the Brazilian producers of shiitake in logs include ants, termites, springtails, lizards, and some *Lepidoptera* and *Coleoptera* beetles and moths. These pests attack logs during the phases of spawn running and fructification and they feed on the mycelium or compete for the space and substrate with shi-

itake mycelium. The most frequent fungal contaminants in *Eucalyptus* logs are *Stemonitis axifera*, *Trichoderma*, *Schizophyllum*, and *Hypoxylon* (Figs. 7).

Shiitake has been also attacked by slugs and ants and the larvae of mushroom flies (Figs. 8). Birds also feed on shiitake. The usual recommendation for the producers of mushrooms is to use preventive control of plagues and diseases instead of any agrochemical products. Natural methods of control are encouraged, such as the use of citronella oil, and luminous traps or fruit juices traps for the control of flies. Beer traps are used for the control of slugs. Neem[1] is also often used as biological insecticide. Despite the availability of these natural methods, some producers still use chemical insecticides.

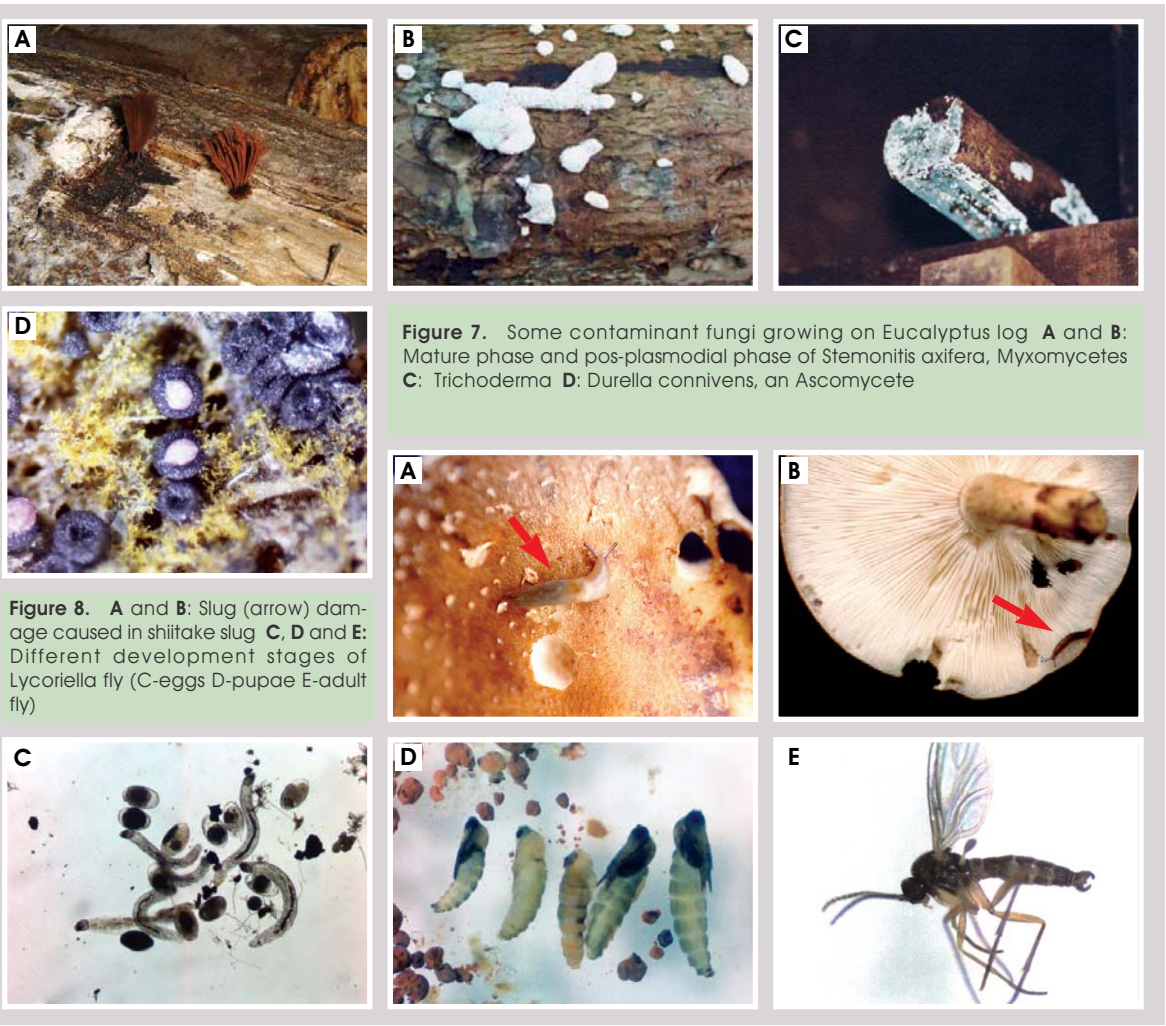

Figure 7. Some contaminant fungi growing on Eucalyptus log **A** and **B**: Mature phase and pos-plasmodial phase of Stemonitis axifera, Myxomycetes **C**: Trichoderma **D**: Durella connivens, an Ascomycete

Figure 8. **A** and **B**: Slug (arrow) damage caused in shiitake slug **C**, **D** and **E**: Different development stages of Lycoriella fly (C-eggs D-pupae E-adult fly)

Comparison with Bag Cultivation in Brazil

In Brazil, few shiitake producers use the process of bag cultivation because it is a highly specialized process that must be conducted in buildings with tight control of temperature, light, and moisture, and also includes the need to acquire an autoclave and boiler for substrate sterilization (Figs. 9). The risk of contamination and loss is much higher with substrate bags than with natural logs, particularly for inexperienced growers. Moreover, there is also the difficulty of finding the specific plastic bags required for this type of culture. It is usually necessary to import them, which increases the production costs. In addition, it is still difficult to obtain shiitake spawn appropriate for bag cultivation in the local market. However, because of the shorter production time and the possibility of exploitation of lignocellulosic wastes, the culture of shiitake in bags has captured the interest of many producers. The main substrates for bag cultivation of shiitake are lignocellulosic wastes, including wood sawdust and agricultural wastes, as cereal straws and the sugarcane bagasse that is abundant in Brazil. Additionally, corncobs and eucalyptus barks have also been tested and showed great potential (Cavallazzi *et al.*, 2003; Santana *et al.*, 2003) (Fig. 10).

[1] neem: an Indian tree, whose leaves have been used to extract some substances and used in biological control

Figure 9. Equipment for substrate sterilization for bag cultivation **A**: Boiler **B**: Autoclave

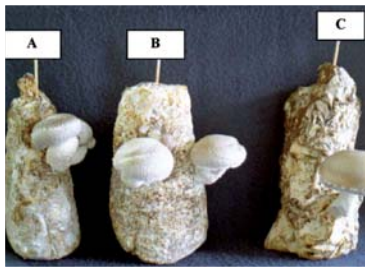

Figure 10. Shiitake (UFV-73) on substrate after 60 days of spawn run **A**: Eucalyptus sawdust **B**: Corncob **C**: Eucalyptus bark

Market of Shiitake in Brazil

Marketing of shiitake in Brazil is a relatively new business. Local buyers and outlets for the small-scale shiitake producers include restaurants, bed and breakfasts, vacation resorts, organic retailers and markets, supermarkets, and farmers markets. As more consumers become aware of the special culinary characteristics of shiitake, demand is likely to increase. In the producer market, 1kg of fresh shiitake in bulk varied from USD3-4, USD4-5 when packed and USD15-17 per kg when dehydrated. In the supermarkets and stores, fresh shiitake can be purchased for about USD8-17 per kg.

The basic production cost, not including money spent on water, energy, housing, machinery and human labor, is about USD882 per 1,000 logs (Table 1). Each log produces 0.6-1.5kg of mushrooms, so the harvest from 1,000 logs is about 600-1500kg for 12-14 months. If bulk fresh shiitake is sold for USD3.50 per kg, the earnings are then from USD2,100-5,250. So the net income can be from USD1,218-4,368 per 1,000 logs for 12-14 months.

Table 1. The basic cost with accessories needed for shiitake logs cultivation (1,000 logs)

Item	Quantity	Value in USD
Inoculators	5	130
Spawn (1 ℓ / 10 logs)	100	190
Paraffin (1 ℓ / 30 logs)	34	65
Pitch (0.20kg / 30 logs)	6	12
Logs	1,000	300
Drill (drill bit)	2	65
Driller	1	120
Total cost		882

Feasibility study of the shiitake cultivation considering a cycle of 14 months was carried out by a group of São Paulo State using 1,000, 2,000, 3,000 and 4,000 *Eucalyptus* logs. The production scales of 2,000 and 4,000 logs presented the lower production costs per kg of fresh mushroom, around USD3.25 and the highest profits, approximately 34%. The economic viability analysis was proven favorable for the greater production scales, with the best results for 2,000 logs and 4,000 logs (Paula *et al*., 2001). This cost is increasing since *Eucalyptus* logs have mainly been used as charcoal by steelworks, and new types of wood have been looked at for shiitake cultivation. The formation of grower cooperatives and year-round producers has been increased and can greatly aid in the process of helping small producers to deliver reliable, fresh supplies of mushrooms to the market.

Transfer of Mushroom Cultivation Technology

Annually, during FARMER WEEK that takes place at the Federal University of Brazil, more than 1,000 farmers get together to participate in some 250 courses offered by professionals of this institution. Since 1986, one of these courses has been "Shiitake cultivation in *Eucalyptus* logs" (Figs. 11). The course and training related to production and processing of shiitake are offered at the University or in the cities when they are requested by associations or cooperatives of agricultural producers.

Figure 11. Aspects of a course in the "Farmer Week" **A**: Participants making holes **B**: Inoculating **C**: The participating group

Conclusions

Mushrooms have become one of the most exciting new crops in Brazil and their cultivation offers an opportunity for both small and large agriculture operations in Brazil. The demand for shiitake is increasing, and the mushrooms are becoming popular among Brazilian people. Mushroom culture will be a common activity in the future, because fungi-forming mushrooms can utilize many potential agricultural and industrial wastes that could be pollutants, and transformed into high quality food. In the future this industry will feed poor peoples, even though at the moment mushrooms are eaten mainly by rich people in Barzil.

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