Part Ⅱ Mushroom for Better Life

Chapter 8

Mushroom for a Living

COPRINUS MUSHROOM CULTIVATION IN THAILAND

Praphant Osathaphant
Maejo University, Thailand (praphant@mju.ac.th)

Thailand has an environment that is appropriate for growing many kinds of mushrooms, including even some temperate mushrooms that are cultivated in the north. Agricultural wastes from the fields can be used as growing substrates and labor costs are still low. *Coprinus* mushrooms are called "Shaggy Ink Cap" in Thailand, "Shaggy Mane" or "Lawyer's Wig" in North America and Europe, and "Chickenleg mushrooms" in China. *Coprinus* mushrooms have long been a favorite among mushroomers.

Coprinus mushroom belongs to *Coprinus*, Coprinaceae, Agaricales, Basidiomycetes. Its scientific name is *Coprinus comatus* (Muller: Fries) S.F. Gray. This mushroom can adapt to a wide variety of indoor and outdoor substrates. A *Coprinus* mushroom's fruiting body has a cap 4-10(15)cm high and 3-4(5)cm thick, vertically oblong, dingy brown at first, soon white, and decorated with ascending scales. The gills are crowded, white to pale, long, broad and slightly attached or free to the stem. The stems are 6-12(15)cm long by 1-2cm thick, equal, hollow, bulbous at the base, and adorned with a movable, membranous collar-like ring, that separates from the cap margin as the mushrooms enlarge (Fig. 1). The natural habitats are in grass by roadsides, on rubbish heaps or lawns, and particularly on recently disturbed soil. The mushrooms appear in the late summer and fall throughout the temperate regions of the world. *Coprinus* mushroom has very short production cycle of 1-2 month, from substrate preparation to the end of harvest. It is cultivated by shelf method indoor or bundle method outdoor in Thailand.

Figure 1. Fruiting bodies of Coprinus comatus

Indoor Cultivation of Coprinus Mushroom (Shelf Method)

The indoor cultivation of *Coprinus* mushroom is performed throughout the year. This mushroom grows well in organic compost whose ingredients are partially decomposed or degraded.

Substrate materials

Thailand is an agricultural country, and produces a lot of agricultural wastes. These wastes include rice straw, soybean pod husks, corn stems, corncobs, sorghum stems, dried banana leaves and stems, dried grass, fresh and dried water hyacinth, sawdust, and others (Fig. 2).

The yield of fresh *Coprinus* mushroom from soybean pod husk waste compost is about three to four times higher than from rice straw. Thai farmers grow a great deal of soybean annually, and the crop yield is about

Figure 2. Dried rice straw

270,000 tons per year. This results in a large amount soybean pod husk waste materials available for growing mushrooms.

Compost preparation

The rice straw should be fresh and clean, not old or dirty. This straw should be chopped into pieces 40-50cm long, by hand or mechanically. The chopped rice straw should then be immersed in water and thoroughly soaked for 4-6 hours, depending on the capacity of straw to absorb and retain the moisture. Some growers irrigate the straw directly until it is saturated with water (Figs. 3 and 4). Other easily decomposable agricuitural wastes can be also used to replace rice straw.

Figure 3. Rice straw waste compost

Figure 4. Soybean pod husk waste compost

Formula 1 takes about eight days for preparing composts and formula 2 takes about five days. Formula 1 requires more time than formula 2 because formula 1 does not make use of dried animal dung, which contains many microorganisms that promote fermenting.

100kg of dried rice straw or soybean pod husk or other agricultural wastes is put inside a wooden box of 1.5 ×1.5 ×0.5m. Water and 2% fertilizer 16-20-0 can be added gradually and the mix fermented for three days. After that initial processing the wooden box is taken off and the fermenting composts are turned and 1% limestone is added. After three days, the fermenting compost is turned and thoroughly mixed by means of a mechanical mixer, and supplemented with 5% rice bran, 2% fertilizer 15-15-15 and water when needed. The mixed and supplemented compost is then piled up and covered with plastic sheets. Fermentation is continued for another two days. Using this formula, it takes about eight days to prepare the substrate compost.

100kg of dried rice straw or other agricultural wastes such as dried soybean pod husks are put inside a wooden box of 1.5 ×1.5 ×0.5m. Water, 1-1.5% urea or ammonium sulphate, 5-10% dried animal dung and 1% limestone can be added gradually and the mixture fermented for three days. After that, the wooden box is taken off, the compost is turned over and 1-2% double superphosphate and 1-2% gypsum is added and the whole thoroughly mixed by means of a mechanical mixer. The mixed and supplemented compost is then piled up and covered with plastic sheets. After two days, the fermenting compost is turned over again. Using this method, it takes about five days to prepare the compost and turn the fermenting compost two times.

Table 1. Formulations of substrate materials

Formula 1	Unit by weight	Formula 2	Unit by weight
Dried rice straw or other agricultural wastes	100	Dried rice straw or other agricultural wastes	100
Fertilizer 16-20-0 (Ammonium phosphate sublphate)	2	Urea or ammonium sulphate	1-1.5
Limestone	1	Dried animal dung (chicken, cow, pig etc.)	5-10
Rice bran	5	Limestone	1
Fertilizer 15-15-15 (Compound fertilizer)	2	Double superphosphate*	1-2
		Gypsum	1-2

*Formula 2: 16-20-0 fertilizer or 20-20-0 fertilizer can be used instead of urea and double superphosphate

Spawn preparation

The spawn for cultivating *Coprinus* mushrooms in Thailand is available in two forms; grain spawn and compost spawn. In grain spawn preparation, 10kg of sorghum grains are boiled in 15 ㍑ water until 20% of the grains have cracked. The excess water is drained off and the grains are cooled in sieves. The grains should be turned several times with a spoon to assist quick cooling. The prepared grains are then filled into 300cc bottles or polypropylene bags of about 150-200g per bottle or bag and then the spawn and containers are sterilized in an autoclave for 45 minutes at 15 psi. After sterilization, the bottles are inoculated with bits of agar medium colonized with mycelium (Fig. 5) and then incubated at 21-27℃ in a dark place. The mycelium completely spreads through the grains in about two weeks (Fig. 6).

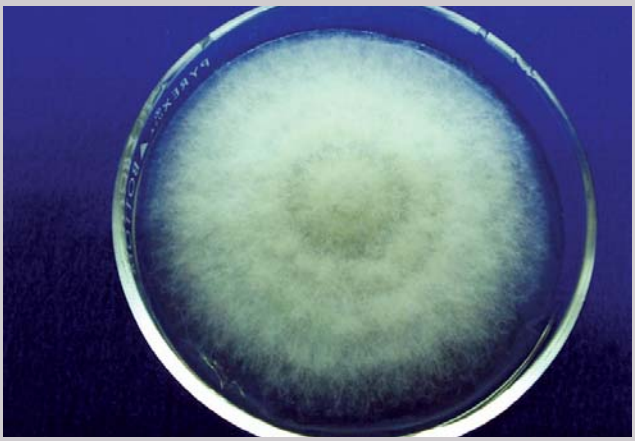

Figure 5. Pure culture of Coprinus comatus

Figure 6. Grain spawn of Coprinus comatus from sorghum seeds

Filling

Before filling the compost into shelves, the compost is broken into small pieces by a machine and growers may also add with some supplements such as rice bran. The compost is packed into the shelves in the mushroom growing house. The post-fermented compost is poured from the plastic baskets onto the shelf and this is repeated until each shelf has the allotted amount of compost. The layer of compost is about 8-10 inch thick. The compost is then flattened by hand from both sides of the shelf. Generally, the width of a shelf is 1-1.2m and the length of a shelf vary depending on the length of the mushroom growing house.

Pasteurization and substrate inoculation

When the compost is completed, steam is blown into the house to maintain the temperature at 65-70℃ for 4-6 hours (Fig. 7). When the room temperature has cooled gradually down to 35℃ with the door closed, the spawn is inoculated about 2cm deep into or on top of the cooled compost. The amount of spawn used is 2.5-3% of the dry weight of the compost but this proportion can be adjusted to a grower's preference.

Figure 7. Steam generator for pasteurization

Fructification

After spawning, the temperature of the mushroom growing house is maintained at 38-45℃ with the door closed during the three day period of spawn running. No water and light are needed, but aeration is required. Three days later, actinomycetes and some thermophilic fungi usually develop in and on the beds with the mycelia of *Coprinus* (Figs. 8, 9, 10, 11, 12, 13, and 14). After this period, growers sprinkle the beds with water and the growth of the actinomycetes and Humicola will be retarded, but the *Coprinus* will continue to grow. On the fifth day after spawning, primordia of fruiting bodies usually appear on the surface of the beds (Chang, 1982) (Figs. 15, 16, 17, and 18).

Figure 8. Partial colonization on rice straw compost

Figure 9. Partial colonization on soybean pod husk compost

Figure 10. Full colonization on rice straw compost

Figure 11. Full colonization on soybean pod husk compost

Figure 12. Mycelium of Coprinus comatus growing on compost

Figure 13. Shelf cultivation of Coprinus comatus on rice straw compost

Figure 14. Shelf cultivation of Coprinus comatus on soybean pod husk compost

Figure 15. Primordia formation of Coprinus comatus

Figure 16. Fruiting bodies of Coprinus comatus on rice straw compost

Figure 17. Fruiting bodies of Coprinus comatus on soybean pod husk compost

Figure 18. Fruiting bodies of Coprinus mushroom on soybean pod husk compost

Mushroom growing houses

The popular size of mushroom growing house for *Coprinus* mushrooms is 4 ×6 ×2.5m or 6 ×8-12 ×2.5m (W ×L ×H) (Fig. 19). Mushroom growing houses can be classified into two types, those built for temporary use and for long term use. A temporary typical mushroom growing house is made of thatch and bamboo or wooden poles and shading net (Fig. 20). The long term mushroom growing houses are constructed with a bamboo wooden frame and is lined inside with 0.4mm film of polyethylene plastic sheet for maintaining the relative humidity during mushroom fruiting or controlling the steam during peak heating of composts. These houses are covered outside with the best available dried grasses and leaves.

Figure 19. A mushroom growing house made up of plastic sheet and shading net

Figure 20. A mushroom growing house made up of dried grasses and bamboo wooden frame

Outdoor Cultivation of Coprinus Mushroom (Bundle Method)

Selection for growing

In the field, *Coprinus* mushrooms usually appear among agricultural wastes such as rice straw, soybean pod husk, and corncobs, along the edges, sides, and ends of the bed. Some of the mushrooms also grow on the soil around the base of the bed. The amount and quality of these soil grown mushrooms depending on the fertility and physical properties of the soil (Chang, 1982).

In Thailand, mushroom growers usually select paddy fields for growing *Coprinus* mushroom after the rice harvest. The land should be elevated and without disturbance from termites, ants, or snails, as these pests can seriously disturb the growth of mycelia. Paddy fields are best used for large scale production. The best lands for *Coprinus* mushroom cultivation are those near water sources with good ventilation and plenty of sunshine, where the soil is fertile and slightly loose.

Land preparation

The land on which *Coprinus* mushrooms are to be grown should first be smoothed. The land surface might be soil for outdoor or concrete for indoor cultivation. If the land surface is soil, fruiting bodies can grow on this. For the concrete surface, it is easy to wash and spray or irrigate with 0.1% chlorine solution or 2% formalin solution. To produce clean fruiting bodies, growers should lay a plastic sheet on the soil surface before piling the substrate materials.

All the soil bases should run in an east-west direction so that the rice straw beds can receive a uniform amount of sunlight and maintain equal temperatures on the long sides, for it is on these sides that most of the mushrooms will grow (Chang, 1982).

Soaking and stacking rice straw for preparing substrate beds

Figure 21. **A**: Dried straw is piled neatly in the wooden box **B**: Rice straw bundle is tied with the rope **C**: The wooden box is taken off from the rice straw bundle **D**: Size of rice straw bundle

The rice straw should be immersed in water, and thoroughly soaked for 4-6 hours, depending on the capacity of straw to absorb and retain the moisture. Preparing a substrate for outdoor cultivation is a different procedure from preparing a substrate for indoor cultivation because outdoor cultivation is similar to natural cultivation while indoor cultivation is much modified.

A rope is laid on the bottom of a wooden box (30×40-50×30cm), and 35kg of dried straw is piled neatly in the box (Fig. 21A). The rice straw bundle can then be tied tightly with the rope and the wooden box taken off (Figs. 21B and C). The size of these rice straw bundles is 25-30cm in diameter and they weigh 3-5kg each (Fig. 21D).

Soaking in the mixture of hot water and additives

The substrate materials usually have limited nutrients available for the growth of mushrooms, and mushroom growers should add some nutritional additives to the substrate materials. These additives consist of 2% urea or ammonium nitrate fertilizer, 1% yeast, 1% sugarcane meal, 1% limestone and 0.1% magnesium sulphate. The mixture of additives and water is boiled at a temperature maintained at 80-90℃. At this temperature, the substrate materials will absorb nutrients more quickly. The hot water will also kill insects and weed fungi in the substrate materials. The substrate materials are immersed in the mixture of hot water and additives for 5-10 minutes (Fig. 22) or irrigated with this mixture until the nutrients have been absorbed by the substrate materials (Fig. 23).

Figure 22. Substrate materials immersed in the mixture of hot water and additives

Figure 23. Substrate materials irrigated with the mixture of hot water and additives directly

Spawn inoculation

After the temperature of the substrate material has decreased to 40-45℃, it can be inoculated with spawn. One bottle of spawn should be used for 2-3 bunches. Spawn is inserted into the substrate material, which has been scooped out to a depth of 15cm at intervals of 10-15cm around the substrate beds. The inserted spawn is then covered with the displaced materials. Next, the beds are covered with thin black or blue plastic sheets and then further covered on the upper part of each bed with dried rice straw mats or Manila hemp sack to protect the beds from exposure to direct sunlight (Fig. 24). The temperature of the room is maintained at 35-45℃ during the period of spawn running. No water and ventilation are needed in this period. The mycelium completely spreads through the substrate materials in about 5-6 days.

Figure 24. A mushroom growing house for outdoor cultivation

Care of the beds and fructification

After the five to six day period of spawn running, the primordia of fruiting bodies usually start to appear on the surface of the beds. The beds should be covered with a thin plastic sheet and straw mats. In this period, more ventilation is given. If the moisture content is too low, water should be supplied along the two sides. Under these conditions, it usually takes one to

two days from the appearance of minute fruiting bodies until the mushrooms are ready for harvesting. They can be harvested at least once a day in the evening. Chang (1982) reported that there are often mushrooms in different stages of development growing close together; therefore care needs to be exercised during harvesting. The harvestable fruiting bodies should be carefully separated from the straw base by lifting them, shaking them left and right, then up and down, and finally twisting them off. This prevents damage to the growing mycelium and the developing primordia. In Thailand, it is customary to pick at the early stage of fruiting.

The harvesting time can last for 20-30 days or longer. The yield may reach 60 to 100%, depending on cultivation technology, the spawn, the supplements, the care of the beds and environmental conditions.

Fruiting bodies should be picked before there is the slightest hint of the gills turning black. If picked when no basidia have matured, fruiting bodies can be kept in cold storage for 4-5 days. Moreover, they can be preserved by submerging them in cold water and storing them under refrigeration at a temperature of 8-10℃.

Profitability of Coprinus Mushroom Cultivation in Thailand

This species adapts to a wide variety of indoor and outdoor substrates. Although the commercial cultivation of this mushroom is limited by its predisposition to disintegrate into an inky mess, this mushroom is fantastic for those who can consume it within two days of picking.

A novel antibiotic has been isolated from this species and is currently being characterized by American researchers. Ying (1987) reported that "inhibition rates against Sarcoma 180 and Ehrlich carcinoma are 100% and 90% respectively" (Stamets, 1993).

People like consuming this mushroom, and this species can grow easily both indoor and outdoor cultivation. The price of fruiting bodies is quite high when compare to other mushrooms. Cost and benefit of *Coprinus* mushroom production in Thailand is good, and the net profit per 100 packets of dried rice straw (3kg weight per packet) is THB[1]5,570 (USD143.56) by bundle method while the net profit by the shelf method is THB9,700 (USD250). The biological efficiency of this mushroom production is 66.67% and 75% respectively. The production period for this mushroom is quite short and last only an average of one month. Mushroom growers can grow from 10-12 crops per year and produce a large income.

Table 2. Cost and benefit of Coprinus mushroom production of bundle method (for 1 month)

Item	Quantity	Cost per unit inTHB	Production cost in THB
Rice straw	100 packets	5	500
Rope	100 pieces	2	200
Additives	17 kg	40	680
Spawn	25 bottles	10	250
Fuel			200
Labor			300
Plastic sheet			200
Water and electricity			100
Total Production Cost			THB2,430 (USD62.63)
Yield			200 kg
Price per kg			THB40
Total Income			THB8,000 (USD206.19)

* Biological effeciency = 66.67%

Note: Number of dried rice straw packets is 100. (3kg weight per packet)

Source: Aeutrakul, Anon.

Net profit = Total income-Total production cost
= THB8,000-THB2,430= THB5,570 (USD143.56)

[1] THB (Thai Baht, USD1 ·, THB38.8 in March, 2005)

One *Coprinus* mushroom grower produces 6-7.2 tons a year on average. The estimated productivity is 600kg of *Coprinus* mushrooms from 900kg of dried rice straw. A farmer can grow about 10-12 crops per year and produce the income of THB55,700-66,840 (USD1,435.57-1,722.68) per year in Thailand.

Table 3. Cost and benefit of shelf method (for 1 month)

Item	Quantity	Cost per unit	Production cost in THB
Fixed production cost			
- Growing house 6 × 8m			12,000
- Shelf (iron)			12,000
(wood)			8,000
(bamboo frame)			2,000
- Water sprinkling system			800
- Ventilator			4,500
- Steamer (200 ℓ drum)	2	7,500	15,000
or steamer with stove			35,000
- Compost chopper			10,000
- Water sprayer			1,200
- pH meter (Kasetsart University)			450
- Thermometer			85
Variable production cost (cost per crop per one growing house)			
- Substrate materials	400kg	THB4/kg	1,600
- Supplements	30kg		1,200
- Fuel			300
- Spawn			800
- Labor			3,000
- Water and electricity			300
- Chemicals and hormone			500
- etc.			200
- Depreciation in value of equipments of equipments			400
Total production cost			THB8,300 (USD213.92)
Yield			300kg
Price per kg			THB60
Total Income			THB18,000 (USD463.92)

* Production period is 30 days. Biological Efficiency = 75 %

Note : The price of mushroom fruiting bodies by shelf method is different from bundle method because time of study is different.

Net Profit = Total income-Total variable production cost

= THB18,000-THB8,300= THB9,700 (USD250)

A farmer can grow about 12 crops per year and produce the income of THB116,400 (USD3,000) per year in Thailand.

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