Maitake at a Glance

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INTRODUCTION

This overall perspective for growing maitake (*Grifola frondosa*) focuses on synthetic-log cultivation in specially-designed polypropylene bags with micro-filter windows. Included are how to prepare the growth substrate, regulate growth parameters (temperature, relative humidity, light and ventilation), and monitor fruiting-cluster development with vivid sequential images. A review by the first author with more detail including helpful notes on problem-solving will be published elsewhere.

Growers must be aware that it takes undivided attention to grow *Grifola frondosa*, a choice edible of biomedical importance (Nanba, 1995, 1997; Stamets, 1993, 1998). Do not share the same growing room of maitake with other mushrooms, since greater attention to detail is required, compared to growing other species. Observe how the mushroom grows in nature (Chen et al., 1998a, b, c). Before plunging into cultivation, keep in mind the characteristics of maitake with intricate structure, larger than usual size, and a great appetite for oxygen. Once you learn how to grow the mushroom, you will find it a most rewarding experience.

STRAIN SELECTION

A high percentage of *Grifola frondosa* strains, whether isolated from natural habitats or obtained from culture collections, do not fruit well, if at all (Huang, 1997; Stamets, 1993). This may explain Kirchhoff's (1996) inconsistent results in growing maitake.There are also differences among strains in biological and physiological characteristics. Testing and selecting strains before production is therefore essential. Fig. 1. shows the mycelial colonies on agar plates from a North American strain.

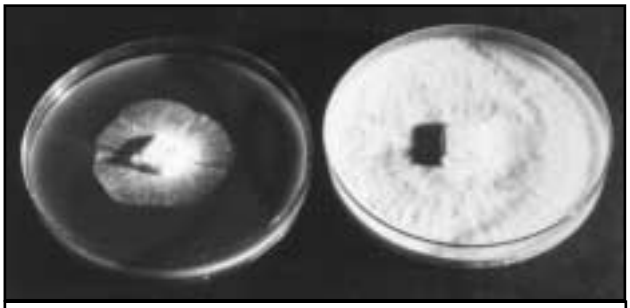

Figure 1: Maitake colonies with white mycelia on malt agar, 4 and 10 days after inoculation (Paul Stamets, President of Fungi Perfecti, Olympia, WA).

SOURCES OF OBTAINING SPAWN (in part)

Fungi Perfecti
Voice:1-800-780-9126
Voice: 360-426-9292
Fax: 360-426-9377
e-mail: mycomedia@aol.com
WWW: http://www.fungi.com
P. O. Box 7634-MGN, Olympia, WA 98507, USA

Field and Forest Products
Voice: 1-800-792-6220
Fax: 715-582-0181
e-mail: ffp@field-and-forest.com
N 3296 Kozuzek, Peshtigo, WI 54157, USA

Mushroom Factory
HCR 3, Box 3300,
Theodosia, MO 65761, USA

Mushroom People
Voice/Fax: 1-800-692-6329
e-mail: mushroom@thefarm.org
WWW: www.thefarm.org/mushroom
Box 220G, Summertown, TN 38483, USA

Skunk Bay Mushroom Farm
Voice: 360-638-1069
40455 Skunk Bay Rd. NE
(P.O. Box 283)
Hansville, WA 98340-9738, USA

Wylie Mycologicals
Voice: 519-534-1570
R. R. #1 Wiarton, Ont. Canada NOH2TO

SOURCES FOR CULTIVATION BAGS

Unicorn Imp. & Mfg. Corp.
Voice: 1-800-888-0811
Voice: 903-886-8282
Fax: 903-886-8878
WWW: www.unicornbags.com
113 Highway 24 (P.O. Box 272)
Commerce, TX 75429, USA

SUBSTRATE FORMULATION

Supplemented sawdust-bran substrates (adopted primarily from Wu et al., 1997):

Hardwood sawdust (fine + coarse), 3:1	75%
Wheat bran, coarse, not refined	23%
Sucrose	1%
Calcium compound	1%
lime ($CaCO_3 \cdot 6H_2O$) or gypsum ($CaSO_4 \cdot 2H_2O$)	
H_2O (moisture content)	60-63%
pH	5.5-6.5

Soil can be added to the substrate. Spent substrates (used substrates after harvest of the mushrooms) can also be used. Soil casing (soil-covered cultivation) has been reported to enhance the yield. For a wider perspective on substrate preparation and production practices, refer to the following reports (Chalmer, 1994; Chiu et al. , 1998; Huang, 1987, 1993, 1997; Kirchhoff, 1996; Lee, 1994, 1996; Royse and Gardino, 1997; and Stamets, 1993).

MANAGEMENT OF GROWTH PARAMETERS

Make special note on the set of growth-parameter requirements for each mushroom stage (Tables 1 and 2). Close attention should be given to regulate temperature, relative humidity, light and air exchange. Compared to spawn run (Fig. 2) and sometimes primordia initiation (Fig. 3), generally, for fruiting-cluster development, the temperature is lower, the intensity of light, the oxygen level and relative humidity are higher. For

TABLE 1: **Maitake synthetic-log cultivation in Japan**
(Huang, 1997, from 1994 Annual report of mushroom in Japan, p. 167-172).

	Spawn Run stage I	II	Primordia Initiation (in sealed bags*)	Fruiting-body development (in cut-opened bags)
Temp. ^{o}C	22-23 Air + 2 or +3 = ca. 24-25 in substrate		22-23 23 best for differentiation	16-18
R. H. %	70 air >60 <80		same as spawn run in sealed bag	85-95
Light lux	N/A I	50 II	50	200-500
CO2 Ventilation	mycelia tolerate higher CO2		< 0.3% (3000 ppm) bags 3-4 cm apart to allow ventilation	0.1% (1000 ppm) > 0.15% (1500 ppm) results in small /thin caps after 2-3 days cut bag (x on top) for ventilation
Time days	30-35 I	40 II	7	20-25

-mushroom production: ca. 3+1/2 months.
* heat sealed bags with microfilters for breathing used.
-fluctuation of temperatures should be minimized to avoid condensation.

TABLE 2: Maitake synthetic-log cultivation in North America
(adopted primarily from Stamets, 1993).

	Spawn Run (in sealed bags*)	Primordia Initiation (in sealed bags*)	Development of stems - fruiting bodies (in opened bags)	
Temp. ^{o}C	21-24^{o}C 70-75^{o}F	10-15.6^{o}C 50-60^{o}F 14**^{o}C	10-15.6 50-60	13-16 (18)^{o}C 55-60 (65^{o}F)
R. H. %	95-100	95	95	85-90
Light lux	N/A	100-500 upper limit > others	100-500	500-1000 upper limit > others
CO_2 Ventilation	(2-4 %) 0-1	(0.2-0.5%) 4-8	(0.2-0.5%) 4-8	(<0.1%) 4-8
Time day	14-30 growth	30 dormant (maturation)	5-10	10-14 14-21

-mushroom production: ca. 3+1/2 months
* heat-sealed bags with microfilters for breathing used
-relative humidity above 70% is not necessary for spawn run
**Royse D. J. and J. Guardino, 1997

greater access to oxygen for fruiting-cluster development, microfilters on synthetic bags for breathing are crucial (Fig 4 & 5). The top of the bag can be removed (Fig. 6 & 7), or slits can be made on the upper portion of the bag above the substrate level. Some punch holes on the bottom of the bag for drainage.

Figure 2: Spawn run (maturation stage), 30 days. Mature mycelia, white, with orange-brown discoloration indicating metabolic activities.

OBSERVATION OF HOW MAITAKE MUSHROOMS GROW

(spawn run + primordia initiation + fruiting-body development)

Growth (+ differentiation) is a continuous process. Each stage merges with the other. Overlapping descriptions are sometimes given.

SPAWN RUN (growth + maturation)

This is the vegetative mycelial phase leading to primordia initiation (also included).

- undifferentiated white mycelia
- white mycelia with orange brown discoloration.
- mycelial mat (or mycelial coat) on substrate surface
- uneven topography on mycelial surface

Grifola frondosa has a prolonged spawn run (Fig.2). Although mycelia can grow in the absence of light, a low level of light (50 lux) throughout the period of Maitake spawn run has been found to facilitate primordia initiation (Wu et al., 1997). In spawn run, a growth period is followed by a maturation period of metabolic activities leading to primordia initiation at increased light (200 lux), ample oxygen and high humidity within the sealed bag.

PRIMORDIA

- dark gray amorphous mass on mycelial surface developed in sealed bags with ventilation.

- dark grayish black mounds develop into globular, ball-like, primordia (Fig. 3), dotted with exudates, sometimes light yellow. Do not wipe off the exudates.
- development of primordia leading to formation of fruiting-clusters.

FRUITING BODY DEVELOPMENT

(primordia stage, brain stage, cauliflower stage and cluster-flower stage)

Several distinct morphological stages as above can be observed in typical maitake strains and successful management of growth parameters in each stage of production. These maitake clusters are produced by synthetic-log cultivation without soil casing:

Figure 3: Large, grayish black primordia, globular, ball-like, often dotted with exudates (above). Primordia and further development (below).

• THE BRAIN STAGE
As the dark grayish black primordia grow, convoluted folds appear on the surface, as if a brain (Fig. 8).

• THE CAULIFLOWER STAGE
Further growth includes unfolding of the convoluted folds on the surface of the dark primordia (Fig. 9) into overlapping young pilei (caps) formed in a cluster (Fig. 10). This is followed by elongation of the lateral stems, each with a young pileus (cap) on the upper portion. The stems are highly and repeatedly branched, sharing a short and chunky base. This stage is a "cauliflower" look alike (Fig. 11), when the color of the fruiting body becomes lighter to almost white.

• THE CLUSTER FLOWER STAGE
As the mushroom continues to grow, overlapping fan-shaped caps in a cluster are developed along the elongated stems, creating the cluster flower stage (Fig.12). The color of the mushroom becomes progressively lighter during the intricate
morphogenesis from the dark grayish-black primordia. Depending on strains, maitake mushrooms progress from grayish brown when young to light gray, grayish white or light brownish yellow when older.

TIMELY HARVEST

• Harvest before mushroom petals (caps + lateral stems) droop or curve downward.
• Harvest before the white basidiospores are released.
• If the ripe fruiting cluster with a clearly detectable pleasant mushroom aroma is left unattended, the fruiting body may become softened, giving off foul fishy smell.

Figure 4: Maitake synthetic-log production in North America by Skunk Bay Mushroom Farm, Hansville, WA, USA (Bob Ames).

Stop misting with water a day before harvest to prevent bacteria intrusion. Proceed with caution to harvest these large but fragile maitake fruiting bodies. With one hand holding the base and supporting the weight of the big cluster, cut off the thick base with a small sharp knife with the other hand (Stamets, 1993). Wrap the harvested mushrooms in rice paper, then store them at 35^{o}F (1-2^{o}C) in refrigeration, giving an expected shelf life of 2 weeks. Maitake fruiting efficiency (yield) is generally low (0.5 -1 lb or 2 lbs/ bag). Virtually all are sold at fresh market.

Figure 5: Maitake synthetic-log production in North America by Skunk Bay Mushroom Farm, Hansville, WA, USA (Bob Ames).

Figure 6: Maitake fruiting clusters produced by synthetic-log production in China.

Figure 7: Maitake fruiting clusters produced by synthetic-log production in China.

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Figure 8: The Brain Stage. As the dark grayish-black primordia develop, convoluted folds appear on the surface, resembling a brain.

Figure 9: Post brain stage I. Further growth of the brain stage includes unfolding of the convoluted folds on the surface.

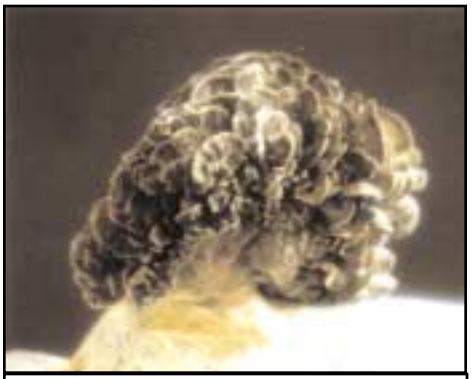

Figure 10: Post brain stage II. Unfolding of the convoluted folds further developed into overlapping young pilei (caps) formed in a cluster.

REFERENCES

Chalmers, Williams, 1994. Cultivation of the Maitake mushroom. Mushroom World, June, 1994.

Chen, Alice W., Robert B.Cooper, Nia Lai Huang and Sheng Hua Han, 1998 a, b. *Grifola frondosa* (Maitake): Ecology and Morphology , The Mushroom Growers' Newsletter, March and June, 1998.

Chen, Alice W., Paul Stamets, Robert B. Cooper, Nian Lai Huang and Sheng Hua Han, 1998c. *Grifola frondosa* (Maitake): ecology and morphogenesis. Nanjing, China: Science and Cultivation of Mushrooms.

Chiu, G. P. , P. L. Sun and S. H. Chong, 1998. High-yield cultivation of *Grifola frondosa* and nutritional analysis. Journal of Edible Fungi of China, Mar. 1998, 17(3):31-33 (in Chinese).

Huang, Nian-Lai, 1987. *Grifola frondosa*, in Huang, N. L. (ed.): Edible Fungi. Nanjing, China: Nanjing University Press, pp. 677-681 (in Chinese).

Huang, Nian Lai, 1993. The Cultivation of *Grifola frondosa*, in Huang, N. L. (ed.): The Encyclopedia of Chinese Edible Fungi. Beijing, China:The Agricultural Press, pp. 275-276 (in Chinese).

Huang, Nian Lai, 1997. Japanese *Grifola frondosa*, in Huang, N. L. (ed.): Cultivation of Eighteen Precious and Delicious Edible Fungi. Beijing, China: Chinese Agricultural Press, pp. 145-153 (in Chinese).

Kirchhoff, Burkhard, 1996. Investigations of genotypes and substrates for the fruiting body production of *Grifola frondosa* (Dick. : Fr.). Royse, Daniel J. (ed.): Mushroom Biology and Mushroom Products. State College, PA: PENN State University Press, pp. 432-441.

Lee, E., 1994. Production of Shiitake, Oyster and Maitake in Connecticut. Mushroom News, Mar. 1994, 11-14.

Lee, E., 1996. Production of Shiitake and Maitake Mushrooms in Connecticut. Mushroom News, 44(2), 6-11.

Nanba, H. , 1995. Activity of Maitake D-fraction to inhibit carcinogenesis and metastasis. Annals of the New York Academy of Sciences, 768: 243-245.

Nanba, H. 1997. Maitake D-fraction: Healing and preventive potential for cancer. Journal of Orthomolecular Medicine, 12, 43-49.

Royse, Daniel J. and J. Guardino, 1997. Specialty mushrooms: Enokitake and Maitake. 45 (2), 28-31.

Figure 11: The cauliflower stage. Lighter, almost white, the developing mushroom cluster has overlapping petals with elongated lateral stems, each with a young cap on the upper portion resembling a cauliflower.

Stamets, Paul, 1993. Growing gourmet and medicinal mushrooms. Berkeley, CA: Ten Speed Press.

Stamets, Paul, 1998. Mycomedicinals, an informational booklet on medicinal mushrooms. Olympia, WA: MycoMedia.

Wu, Jing lun, G. Z. Lin, M. Z. Fu and Z. C. Wei, 1997. *Grifola frondosa*. Huang, N. L. (ed.): Cultivation of Eighteen Precious and Delicious Chinese Edible Fungi. Beijing, China: Chinese Agricultural Press, pp. 130-145 (in Chinese).

Figure 12: The cluster flower stage. Mature fruiting cluster with overlapping petals (caps + lateral stems) extending outward, resembling a cluster flower.

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