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## Cultivation of Shiitake mushroom - A potential agro-industry for hilly areas of North eastern India

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### Abstract

The survival and economic prosperity of various ethnic people of North eastern India largely depends upon rationale utilization and sustainable development of its local resources. Recently, Japanese wood mushroom commonly called as shiitake or golden oak mushroom [*Lentinula edodes* (Berk) Sing] has been explored for its large scale cultivation and production leading to conservation of biodiversity and economic upliftment of the local people. Shiitake mushroom is in high demand in the local markets due to its unique characteristic taste and usefulness in health care such as diabetes, hypertension, tumours, antiviral and as immunostimulant. On taking up its commercial cultivation one can earn a net profit of Rs. 4000 to 11,000 per annum from a mushroom cultivable shed of the size 4×4 m<sup>2</sup>.

**Keywords:** Biodiversity, Forest conservation, Japanese wood mushroom, Shiitake mushroom, Golden oak mushroom, *Lentinula edodes*, Rural economy, North eastern India.

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### Introduction

Mushrooms (fungal sporocarps) represent one of the world's greatest untapped resources of nutritious and palatable food and they possess extensive enzyme complexes, which enable them to flourish successfully on a wide variety of inexpensive substrates, such as lignin, cellulose, hemicellulose, pectin and other industrial wastes which are not suitable even for animal feed<sup>1,2</sup>. Mushrooms are prized for their exclusive flavour and deliciousness; they are rich in proteins, contain less fat, less carbohydrate and salt and rich in fibre and have high vitamin B<sub>12</sub> and folic acid, which are uncommon in vegetables. High availability of lysine and tryptophan and other amino acids usually absent in cereals make them ideal

food for patients suffering from hypertension, diabetes and obesity<sup>3</sup>. Food values of four mushrooms species, viz. *Lentinula edodes* (Berk) Sing, *Agaricus bisporous* (J.E. Lange) Sing, *Pleurotus sajor-caju* (Fries) Sing and *Volvariella volvacea* (Bull. ex Fries) Sing is given in Table 1<sup>(Ref. 4, 5)</sup>.

Shiitake (*shee-tah-kay*) is an edible mushroom (belonging to the family Tricholomataceae and Basidiomycetes group) whose name is derived from "shii" tree (*Castanopsis* spp.) and "take", a Japanese word for mushroom (mushroom from the shii tree). It is native to Japan, China and other East Asian countries. Shiitake mushroom, also known by the names Japanese wood mushroom or Chinese black mushroom or Golden oak

mushroom or Oriental black mushroom is scientifically called as *L. edodes*. It is the most popular and second most important edible mushroom in the world, cultivated in Japan, China and other East Asian countries. In 1994, its total production was estimated to be 826,200t, which was 16.8% of the total world production out of which 632,000t was produced in China alone<sup>6</sup>. For a long time this mushroom has been valued for its unique taste and flavour and as a medicinal tonic. Presently, numerous scientific investigations have established the nutritive value and medicinal benefits of *L. edodes* in lowering blood cholesterol level, possessing anti-tumour, antiviral activity, etc. It is liked by the consumers because of its characteristics taste and flavour and presence of a chemical, which reduce plasma cholesterol level in the blood. Shiitake has been revered in Japan and China as both food and medicine for many years. Wu Ri, a famous physician from Chinese Ming Dynasty (1368-1644 AD), wrote extensively about this mushroom, noting its ability to increase energy, cure colds and eliminate worms<sup>3</sup>.

Shiitake mushroom grows in nature on the dead wood of a number of hard wood trees mainly oak trees (*Quercus dealbata* Hook.f. &

Table 1: Nutrient contents of various mushrooms<sup>4,5</sup>

Contents	Mushroom species			
	<i>Lentinula edodes</i>	<i>Agaricus bisporous</i>	<i>Pleurotus sajor-caju</i>	<i>Volvariella volvacea</i>
Crude protein (%)	13.4-17.5	24.0-34.8	26.6	21.2
Crude fat (%)	4.9-8.0	1.7-8.0	2.0	10.1
Total carbohydrate (%)	67.5-78.0	51.3-62.5	50.7	58.6
Crude fibre (%)	7.3-8.0	8.0-10.4	13.3	11.1
Free nitrogen (%)	59.5-78.0	44.0-53.5	35.0-47.0	47.5
Ash content (%)	3.7-7.0	7.7-12.0	6.5	10.1
Amino acid content (mg/100g)				
Leucine	7.9	7.5	7.0	4.5
Isoleucine	4.9	4.5	4.4	3.4
Valine	3.7	2.5	5.3	5.4
Tryptophan	-	2.0	1.2	1.5
Lysine	3.9	9.1	5.7	7.1
Threonine	5.9	5.5	5.0	3.5
Phenylalanine	5.9	4.2	5.0	2.6
Methionine	1.9	0.9	1.8	1.1
Histidine	1.9	2.7	2.2	3.8

Thoms., *Q. lamellosa* Sm., *Q. serrata* Hook.f. & Thoms., etc.); chestnut trees (*Castanopsis chinensis* Hance, *C. fordli* Hance, *C. lamontii* Hance); *Elaeocarpus* spp. (*E. chinensis* Hook.f. ex Benth., *E. japonicus* Siebold., *E. lanceaefolius* Roxb.; *Lithocarpus* spp. (*L. calophyllus* Chun ex C.C.Huang & Y.T.Chang, *L. glabra* Nakai); *Betula* and *Carpinus* species. The various tree species graded as preferred species for cultivation of shiitake mushroom are given in Table 2<sup>(Refs. 7, 8)</sup>.

North eastern India falls within "Indo-Burma" centre of biodiversity 'Hotspot' of global significance. There are eight states including Sikkim Himalaya covering 262,179 sq. km. and which supports a total human population of



Fig 1 (a-f): a. A pile of wood logs of *Quercus* species; b. Wood dowel made of wood of *Alnus nepalensis*; c. Cut wood surface showing cracks; d. Wood logs fitted with inoculated wood dowels; e. Shiitake mushroom grown on wood logs (budding stage); f. Shiitake mushroom grown on wood logs (full bloom stage) ready for harvesting.

39,035,582 with a population density of about 149 people per sq. km. (2001 census). The region is rich in forest diversity and coverage. Many species of oak, chestnut,

alder are grown plenty in the forest of most parts of North eastern India. Among the oak trees, *Q. dealbata* is identified as the best species for cultivation of shiitake mushroom. It is cultivated round the year by adopting suitable strain either, those which can fruit at 20°C or which fruit between 10-15°C and those fruiting around 10°C. In India, sporadic attempts about its experimental cultivation have been made in recent years on synthetic logs<sup>9-11</sup>, on wood logs<sup>12</sup> and on potato glucose solution<sup>13</sup>. The present study reports the detailed cultivation technique of shiitake mushroom based on the available local resources and knowledge system.

**Materials and Methods**

The detailed cultivation procedure for *L. edodes* is as follows:

**Log preparation:** Shiitake mushroom mycelium is saprophytic and wood rotting in nature. It mainly grows on dried wooden logs absorbing nutrients from the cambium. The outer bark layer protects the growing mycelium from various mould competitors. As a rule, the thin-barked low-density species provide relatively quick mushroom production but only for a short time period and hence thick-barked species give better result in long run. Regardless of thickness, the bark must be intact on the log. Although it grows on any size and age of logs, but the logs with 10-20 cm diameter and from 15-20 years old trees are most suitable while smaller logs are used as firewood (Fig. 1a). The time of felling or cutting the trees is also equally important. The most suitable period is from mid autumn to late winter when the log contains highest amount of

**Table 2 : Trees suitable for wood log for cultivation of Shiitake mushroom<sup>7,8</sup>**

Botanical name	Common English and Manipuri name (Italics)	# Rating
<i>Acer nigrum</i> Michx.f.	Black maple	2
<i>Acer pictum</i> Thunb.	Japanese maple	2
<i>Alnus nepalensis</i> D. Don	Himalayan alder ( <i>Pareng</i> )	2
<i>Betula lutea</i> Michx.	Sweet birch	3
<i>Betula nigra</i> Murith	Red birch	3
<i>Carpinus laxiflora</i> (Siebold & Zucc.) Blume	Harn bean	4
<i>Castanea crenata</i> Siebold & Zucc.	Japanese chestnut	4
<i>Castanopsis cuspidata</i> Schottky	Shii	4
<i>Castanopsis hystrix</i> A. DC.	<i>Thangji</i>	4
<i>Castanopsis sieboldii</i> (Makino) Hatus.	Shii	4
<i>Juglans regia</i> Linn.	<i>Heijuga</i>	1
<i>Lithocarpus pachyphyllus</i> (Kurz)Rehd.	<i>Kuhi</i>	3
<i>Ostrya virginiana</i> Mill.	Iron wood	4
<i>Quercus acutissima</i> Carruthers	Oak	4
<i>Quercus alba</i> Linn.	White oak	4
<i>Quercus dealbata</i> Wall.	<i>Sahi-kuhi</i>	4
<i>Quercus lamellosa</i> Sm.	<i>Uyung</i>	4
<i>Quercus serrata</i> Hook.f.	<i>Uyung</i>	4
<i>Schima wallichii</i> (DC.) Korth.	<i>Usoi</i>	3

# Rating: 4=Excellent, 3=Good, 2=Fair, 1=Poor.

carbohydrate and other organic substrates. Moreover, the outer protective layer, bark is also tightly attached with the woody portion. The log should contain a moisture content of 45-55% at the time of felling. If the moisture content of the log is less than 20% then there will be no growth. The pH of the log should be between 4.5 to 5.5. If the moisture content is more than 60% with a pH higher than 7.0 it will be contaminated with other moulds. Such logs are left as such for 25-45 days, which results in the lowering the moisture contents to 40-50%. Sometimes the logs are immediately inoculated; if the moisture content is optimum as further drying will result in excessive moisture loss.

**Spawn preparation:** In nature, the shiitake mushroom propagates and spreads from spores produced by the mushroom. However, for cultivation, spore germination is unreliable. Instead, logs are inoculated with actively growing fungus. The fungus is first adapted to wood by growing it directly on small piece of wood. Active fungal cultures intended as inoculums for mushroom cultivation are called spawn. Shiitake mushroom spawn preparation is generally done in soft wood dowels for which Himalayan elder (*Alnus nepalensis* D. Don) wood is very suitable (Fig. 1b). Saw dust can also be used. There are certain established formulae for spawn preparation (Table 3).

**Table 3 : Common formulae for spawn preparation**

Formula - I	Formula - II
Wood dowel (1000 g)	Saw dust (800 g)
Rice bran (80 g)	Rice bran (200 g)
Sucrose (5 g)	Sucrose (30 g)
Potassium nitrate (4 g)	Potassium carbonate (6 g)

Spawn prepared on the wood dowels of *A. nepalensis* are ready for inoculation.

**Spawning the logs:** Inoculation or spawning is the introduction of the live shiitake fungus into wood logs. A one-time inoculation produces mushroom for 6-10 months a year and continue to produce for 5-6 years. Inoculation can be done during spring months. Shiitake mycelium grows between 5-30°C but the most optimum temperature is 20-26°C. Low temperature (14-20°C) is favoured during spawning of logs so that there is minimum chance of mould competitors. For spawn inoculation, small cylindrical holes of 1 cm diameter and 1.5-2 cm deep are made on the logs with the help of drilling machine. The holes are made at a distance of 20-30 cm (long axis) and 6 cm between each row. The holes between two rows are alternate in position. The dust spawn or wood dowel should not be fitted tightly into the holes. The holes are sealed with paraffin wax to prevent loss of moisture, to prevent contamination by undesirable microorganisms and to allow the spawn to grow within the confines of the log. The spawning should mostly be done in aseptic condition. Never cultivate on fresh wood logs. First the tree are felled down and the logs cut suitably at 4-5 feet in

length and kept for 25-45 days till colour changes or till the crack appear on the cut wood surface (Fig. 1c).

**Crop management:** Inoculated logs are kept in an open place where the physical conditions are most favourable for mycelium growth. The inoculated logs are kept in a flat pile, so that there is minimum light exposure i. e. proper sun shed with good bed (Fig. 1d). Cemented floor is more suitable which protects the logs from white ants or other insects. Just after inoculation, for 2-3 months water may not be sprayed. Then water should be showered once in a week as the budding season approaches, adequate supply and soaking of water probably twice a day is necessary. Good diffused sunlight is necessary during the budding period but direct exposure to sunlight should be avoided. The piles should be covered with either straw or gunny bags to prevent excessive water loss of the logs. The vegetative growth in the logs will be completed within 8-10 months depending upon the culture strain and type of wood used. For fruit body induction, it requires temperature shock or temperature drop, high humidity and enough light. The logs for fruiting are either sprayed with cold water or immersed in a tank of cold water. If the logs are immersed in cold water during summer they should be kept for 24 h in cold water (15-18°C) while during winter they should be kept for 2-3 days at 10-15°C. The logs are then leaned against the support. The cropping area is kept moist to maintain high relative humidity. The temperature should be maintained at 15-20°C and humidity around 80-90%. Mushrooms grown on the surface of the wood logs can be harvested up to 3 times

and after a rest for 30-40 days they are again watered to get more mushrooms. It can be repeated up to 3-4 times/year and logs will produce good crop and high yield up to 5-6 years after that the wood decays. After 5-6 years of cultivation, the wood logs are generally decayed.

**Harvesting and drying process:** Harvesting can be started after 8-10 months of inoculation. Harvesting or plucking the fruiting bodies manually by first pressing and twisting is the most suitable practice. Harvesting should be done a little before full bloom for long distance transport and preservation (Fig. 1e). For immediate consumption and sale in the local market, the mushroom should be harvested when fully bloomed (Fig. 1f). For drying, the harvested mushroom should be kept on fine bamboo mats under high diffused sunlight. Direct sunlight should be avoided. Water should be totally avoided. Completely dried mushroom can be packed and sealed in polythene bags for storing, transport and selling.

## Results and Discussion

Initially the spawn of shiitake mushroom was purchased from Japan costing @ Rs. 1000 per 1000 inoculated wood dowels (weighing 1 kg) including transport charge. Now-a-days, the spawn is successfully prepared in authors' laboratory, whose production cost is Rs. 200 per 1000 inoculated wood dowels. The successful cultivation of 1800 inoculated wood dowel need around 90 wood logs which can be accommodated / cultured in cultivation shed of 4×4 m<sup>2</sup> area and can yield around 120 kg of fresh mushroom per annum fetching a sum of

Rs. 12,000 in the local market. The income is against the total input expenditure of Rs. 8000, including the cost of the wood log (otherwise the logs would have been sold as firewood) which is one time expenditure in 5-6 years period. Therefore, the net profit in the first year of harvesting is Rs. 4000 while the net profit in the subsequent years will be around Rs. 11,000 every year and will continue till 5-6 years.

Conservation and sustainable utilization of biological resources and economic upliftment of the people/community inhabited within biodiversity 'hotspot' is the prime concern worldwide. Shiitake mushroom cultivation is gaining ground in many parts of the world. A vast account of research has been done on Shiitake's medicinal properties and shows that it has ability to fight tumours and viruses and enhances the immune system. Primary chemical constituents of shiitake include polysaccharides (lentinan), erastadenin (lower cholesterol level in animals), proteins, fatty acids and vitamins (D, B<sub>2</sub>, B<sub>12</sub>). Regular consumption of shiitake mushroom can be a good dietary supplement to fight malnutrition in poor rural population like in North eastern India. Currently, the total world worth of the pharmaceutical and nutraceutical products derived from the mushrooms is estimated more than \$ 1.2 billion<sup>3</sup>. Cultivation of shiitake in the United States began in the early 1970's and sale of \$ 27 million in 2000 was recorded against \$ 11 million in the year 1993<sup>(Ref.14)</sup>.

### Conclusion

Shiitake mushroom cultivation can be taken up in most hilly areas of North eastern India because of its suitable

agro-climatic conditions and the large availability of suitable wood logs. It does not require high technique for cultivation and vast land area. No manure or fertilizer or insecticides are required. Cultivation of shiitake mushroom is part time job needing one hour labour a day. The traditional practice in the hilly areas of North eastern India is that most of the tree species (suitable for cultivation of shiitake mushroom) are cut down as firewood which exerts a lot of pressure on the forest structure leading to biodiversity loss. But the wood logs felling for cultivation of shiitake can be used for many years (5-6 years), hence frequent cutting down of trees is not necessary, thereby exerting less pressure on forest composition and structure. Side by side the local community may start cultivation of those tree species in their private lands, community lands and other wastelands. This is not only useful in mushroom cultivation, but it will also keep the area green and environment good. As *jhum* cultivation is very popular in the vast North-eastern India, cultivation of shiitake mushroom can reduce the intensity of *jhum* cultivation, thereby helping in conservation of rich biodiversity of the "hotspot" region. The problem of unemployment will be solved to a great extent through this venture and upliftment of the rural economy.

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