KFRI Research Report 195

MUSHROOM CULTIVATION USING FOREST LITTER AND WASTE WOOD

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PEECHI, THRISSUR

December 2000 Pages: 28

CONTENTS

ABSTRACT

During the past decade, cultivation of edible mushroom has gained importance because of their nutritional value. Mushroom cultivation has also generated an opportunity for self-employment of large number of people. Though, organized sector has made decisive impact on production and processing of mushrooms, the potential of rural employment has been completely ignored. Popularisation of mushroom cultivation and transfer of technology can be effected through training programme organised by experts and local government authorities. In Kerala, the most commonly cultivated mushrooms are *Volvariella volvacea, Pleurotus* spp. and *Agaricus bisporus*. These are generally cultivated on agricultural waste materials. In this study, forest leaf litter, wood wastes and fallen trees have been examined for the cultivation of mushrooms. During the present study an attempt was made to cultivate various *Pleurotus* species using forest litter and wood wastes. It was found that among all the wood waste materials tested, leaf litter is the best substrate for cultivating *Pleurotus* species. Among different *Pleurotus* species, *P. florida* was the best in terms of yield. The quantity of mushrooms produced on leaf litter was higher compared to the other substrates. Mixed leaf litter yielded 1.55 kg of mushrooms from three harvests. Mushroom cultivation using wood logs, sawdust and wood shavings was not economical. Among the various methods of cultivation tried, polythene bag method yielded higher quantity of mushrooms. Training on mushroom cultivation for the benefit of the tribals at Vazhachal created awareness of the importance of edible mushrooms as part of the diet and generated enthusiasm among them to initiate mushroom cultivation for their own consumption as well as livelihood.

1. INTRODUCTION

1.1 What is a mushroom?

Mushrooms are a group of higher fungi, which belong to the class Basidiomycetes and the order Agaricales. They lack chlorophyll and cannot, therefore, synthesize their own food. Mushrooms depend on dead organic matter as saprophytes, on living plants as parasites or they co-exist with other living organisms as symbionts. They grow on grassy ground, rotten wood, leaf litter, dung, cellars and mines.

'Mushroom' is the fleshy spore-bearing organ or fruiting body of the Agaricales. Usually, the fruiting bodies are umbrella shaped structures, which produce spores in large numbers. These spores are minute, microscopic and are dispersed through wind. When they happen to fall on suitable substrates (like dead wood, straw, manure, litter or any other cellulose material), the spores germinate and develop into mycelia. As long as the condition is favourable for the mycelial development and growth, the mycelia continue to grow, ramify and absorb food from the substrate until they develop many fruiting bodies.

1.2 Types of mushrooms

A wide variety of mushrooms grow in nature. Some are edible and delicious, some are edible but less tasty, still others are unpalatable and a few are deadly poisonous. More than 2000 species of fungi are reported to be edible throughout the world and among these 283 are available in India (Purkayastha and Chandra, 1985). Of these, eight species are cultivated commonly in India and about 20 species have been cultivated for edible purpose in different parts of the world. *Agaricus bisporus* (Lange) Sing. (European or white button mushroom), *Volvariella* spp. (Chinese or paddy straw mushroom), *Pleurotus* spp. (Tropical or Oyster mushroom), *Lentinus*

edodes (Berk.) Pegler (Shiitake), *Flammulina velutipes* (Curt. ex Fr.) Karst. (Enotake) are the most popular among commercial growers. *A. bisporus* is extensively cultivated throughout the world contributing to about 75% of the total production. It requires a temperature of 15-18^{0}C during cropping, hence, cultivation has become popular in cooler hilly region. *Volvariella volvacea* (Bull. ex Fr.) Sing. is one of the most popular mushrooms in Southeast Asia. Its growth is well suited to tropical climate and can be cultivated easily on paddy straw. *Pleurotus* spp. can be cultivated in almost all parts of the world. They can grow on sawdust, straw, industrial and agricultural waste or any cellulosic material. *Auricularia* is generally grown on dead wood trunks or logs in forests and backyard. It is commercially cultivated on sawdust or logs. *L. edodes* is popularly known as Japanese brown mushroom. It is expensive due to its exotic taste, high food value and medicinal properties. It is grown either on sawdust or logs.

1.3 Food value of mushroom

Mushrooms have been considered a delicacy from ancient times. They provide high nutritive value to the diet in the form of proteins, carbohydrates, essential salts and vitamins. As a food item, the nutritive value of mushrooms lies between that of meat and vegetables. Chang (1980) reported that protein content of four popular edible mushrooms such as *Agaricus bisporus, Lentinus edodes, Pleurotus* spp. and *Volvariella volvacea* which are commercially cultivated in various countries, ranges from 1.75 to 3.63% of their fresh weight (Chang, 1980). The fat content in different species of mushrooms ranges from 1.1 to 8.3% on dry weight basis (Chang and Miles, 1993). The carbohydrate content of *Pleurotus* spp. ranges from 46.6 to 81.8% on a dry weight basis (Bano and Rajarathnam, 1982). The fibre content of these mushrooms is known to range between 7.4 and 2.76%. Fibre is considered to be an important ingredient in a balanced and healthy diet. Mushrooms are a good source of minerals also. It is estimated that the concentration of K, P, Na, Ca and Mg in *Pleurotus* spp. constitutes about 56 to 70% of the total ash content (Li and Chang, 1982). Edible mushrooms are a good source of several vitamins including thiamin, riboflavin, niacin, biotin and ascorbic acid (Crisan and Sands, 1978). The copper

content (12.2 - 21.9 ppm) was higher in all species of *Pleurotus* than other edible mushrooms (Chang and Miles, 1993). The major component of mushrooms is water constituting about 90% of the fresh weight.

1.4 Medicinal value of edible mushrooms

A large number of mushrooms are used for medicinal purposes. Lectin, a plant protein with medicinal properties is isolated from *Agaricus bisporus*. Volvatoxin A is the lectin isolated from *Volvariella volvaceae* (Lin *et al.*, 1973) and Pleurotolysin from *Pleurotus ostreatus* (Jacq. ex Fr.) Kummer (Bernheimer and Avigad, 1979). Antiviral substances are reported to be present in mushrooms (Goulet *et al.*, 1960). Takehara *et al.*, (1981) reported the antitumor activity of *Lentinus edodes*. The spores and fruiting body of *L. edodes* contained substances with antiviral activity against influenza virus infection in mice (Tsunoda and Ishida, 1969).

1.5 History of *Pleurotus* cultivation

The genus *Pleurotus* contains the highest number of species which are cultivated commercially compared to any other genera of Agarics. The *Pleurotus* species are currently gaining importance since they contribute to 2.7% of world's mushroom production (Chang and Miles, 1982). Most of the species of *Pleurotus* grow wild on dead logs, stumps or dead branches of living trees or on decaying organic matter during rainy season. It was first cultivated experimentally on tree stumps and sterilized straw by Falk (1917). Later, Kaufert (1935) cultivated them on sawdust and cereal mixture. Subsequently, Block *et al.*, (1958) successfully cultivated *Pleurotus* on sawdust. In India, Bano and Srivastava (1962) used straw for cultivation of *Pleurotus*. Jandaik and Kapoor (1974) and Rangaswami *et al.* (1975) introduced cultivation of *P. sajor-caju* (Fr.) Singer on an experimental basis using paddy straw and other crop refuse. Some of the common edible species of *Pleurotus* are *P. sajor-caju*, *P. sapidus* (Schulzer) Kalchbremer, *P. cornucopiae* (Paulet ex Pers.) Rolland, *P. flabellatus* (Berk. & Br), *P. ostreatus*, *P. eryngii* (DC ex Fr.)

Quel., *P. florida,* and *P. eous* (Berk.) Sacc. A few of them have been exploited for commercial cultivation.

1.6 Objectives of the study

In Kerala, *Volvariella volvacea, Pleurotus* spp. and *Agaricus bisporus* are the most commonly cultivated mushrooms. These are generally cultivated on agricultural waste materials. The potentials of using forest waste materials like leaf litter, wood wastes, fallen trees, etc. have not been exploited so far. These materials are available in our forests as well as in rural areas. It is against this background the present study was undertaken.

The specific objectives of the study are:

1. To standardize techniques for cultivation of edible mushrooms using forest litter and wood waste as growth substratum
2. To train the rural and tribal people to cultivate mushrooms.
3. To create general awareness among the rural and the tribal people the importance of mushrooms as food and potentials of cultivating them with minimum financial input and facilities.

2. MATERIALS AND METHODS

The following facilities/materials were made use of for the cultivation of mushrooms.

1. A mushroom-house, either a thatched shed or room with proper aeration (Temperature should range between 20-24°C and relative humidity between 80 and 95% in the mushroom house)
2. Mushroom cultures for the production of spawn
3. Substrates for spawn production and
4. Substrate for the cultivation of mushroom

2.1 Preparation of mushroom-house

A shed of 3.6 x 3.6 m was converted into a mushroom house for cultivating edible mushrooms and also for conducting different experiments. In order to protect the room from rodents and other animals, the roof of the shed was closed with wire mesh and provision was given for airflow inside the room by opening small ventilators. The windows of the room were closed with black polypropylene sheet in order to prevent the direct entry of sunlight. The temperature inside the room was maintained around 20 to 24°C and relative humidity at 80 to 95%. To maintain the required temperature, the floor was filled with pure sand and watered frequently. Wet fabric made out of jute (thin gunny cloth) was hung inside the room close to the windows in order to keep the room cool and to maintain high humidity.

2.2 Procurement of mushroom cultures

For the preparation of spawn of various mushroom species, live mushroom cultures were collected. Seventeen cultures of *Pleurotus* spp. were procured from various laboratories within the country for conducting cultivation experiments using leaf litter as substrate (Table1).

Table 1. Mushroom cultures procured and their source

Sl. No.	Name of species	Source
1	*P. citrinopileatus*	BCKV*, West Bengal
2	*P. cornucopiae*	NCMRT, Solan
3	*P. eous*	NCMRT, Solan
4	*P. eryngii*	BCKV, West Bengal
5	*P. flabellatus*	NCMRT, Solan
6	*P. florida*	TNAU, Coimbatore
7	*P. florida*	NCMRT, Solan
8	*P. florida*	BCKV, West Bengal
9	*P. ostreatus*	IARI, New Delhi
10	*P. ostreatus*	BCKV, West Bengal
11	*P. sajor-caju*	KAU, Vellanikkara
12	*P. sajor-caju*	IARI, New Delhi
13	*P. sajor-caju*	TNAU, Coimbatore
14	*P. sajor-caju*	NCMRT, Solan
15	*P. sajor-caju*	BCKV, West Bengal
16	*P. sapidus*	NCMRT, Solan
17	*P. sapidus*	BCKV, West Bengal

* BCKV-Bidhan Chandra Krishi Viswavidyalaya; NCMRT - National Centre for Mushroom Research and Training; KAU- Kerala Agricultural University; IARI- Indian Agricultural Research Institute; TNAU- Tamil Nadu Agricultural University

2.3 Preparation of spawn

Spawn is considered to be the mushroom seed, which is the vegetative mycelium of mushrooms grown in a convenient medium (Klingman, 1950). Various substrates either singly or in combination were used to grow the mycelium for the production of spawn. Small mushroom growers usually purchase spawn from spawn producers while big commercial farms make their own.

The success of mushroom cultivation depends to a large extent on the purity and quality of spawn used. Grain spawn is widely used by the growers. Spawn was prepared by using different types of grains such as *Triticum vulgare* Vill. (wheat), *Sorghum bicolor* (Linn.) Moench. (jowar) and Zea mays L.(maize). The larger grains carry a greater reserve of food material for mushroom mycelium and so the spawn prepared using large grains can withstand adverse conditions. On the other hand, the small grains provide more points of inoculum per gram of spawn, so the mycelium of the mushroom will cover the substratum faster than the large grain spawn. Good planting spawn should have the following characteristics: 1. Spawn should be free from contamination, 2. Each grain should be covered with mycelium and 3. Spawn should be fresh and white in colour. Old spawn will develop brown colouration.

2.3.1 Preparation of agar cultures

To multiply the mushroom culture procured from a culture bank or laboratory, it is necessary to inoculate the fungal culture in agar medium. Potato dextrose agar (PDA) was used as the medium for multiplying the culture. Direct isolation is another method of obtaining pure culture of mushroom. In this method, a small portion of mushroom tissue was aseptically transferred on PDA in petri dishes and incubated at 25^{o}C for growth of mycelium. Usually, the mycelium will cover the petri dish in 5 to 8 days. Either of these cultures was used for the preparation of mother spawn.

2.3.2 Preparation of mother spawn

Jowar was used as the grain for preparing spawn. The grains were cleaned thoroughly of chaff and dirt and soaked in clean water for 5-6 hours. They were then boiled till turned soft. Overboiling should be avoided since the grain will split open and starch will ooze out from the grain. The excess water was drained off and the grains were spread over a clean polythene sheet for cooling. The grains were then thoroughly mixed with Calcium carbonate 40 g ($CaCo_3$/kg$^-$ of grain). This mixture was then filled in narrow mouthed bottles/conical flasks, plugged with cotton and sterilised for 2 consecutive days at 100 kPa for 30 min. Calcium carbonate absorbed excess water and helped to avoid clumping of grains and also to maintain optimum pH. After sterilisation, the bottles were inoculated with mycelial bits from the mushroom culture raised in petri dishes and incubated at 25±1^{o}C for 3 weeks. The fungal mycelium covered the grain + $CaCo_3$ mixture within this period and this was used as mother spawn (Fig. 1).

Fig. 1 Fully grown mushroom spawn of *P. florida*

2.3.3 *Preparation of planting spawn*

Jowar was the medium used for preparing the spawn on a large scale. For large-scale production, the grain was cooked and mixed with CaCO3 as described earlier. Two hundred grams of the grain was then filled in polypropylene bags and plugged with cotton wool at one end and tied with rubber band. The bags were then sterilized at 121°C for 2 hr in an autoclave. When cooled, all the bags were inoculated with a few grains from the fully matured mother spawn, mixed and then incubated at 25±1°C for 15 days. During the incubation period, the whole surface of the grain was covered with mycelium and was ready for use.

Different materials like straw, sawdust and other grains like maize and wheat were also tested for preparing planting spawn. Straw spawn was prepared by cutting the paddy straw into 2 cm long pieces and soaked in water for 10 min. Calcium carbonate was added (2% w/w), mixed well and incubated as above (Chang and Li, 1982).

2.4 Cultivation of mushrooms

The substrates used for the cultivation of mushroom (*Pleurotus* spp.) were leaf litter of tree species such as *Xylia xylocarpa* (Roxb.) Benth., *Tectona grandis* L. f., *Terminalia paniculata* Roth, *Grewia tiliifolia* Vahl and *Terminalia bellirica* (Gaertn.) Roxb. collected from moist deciduous forest around KFRI. Freshly fallen leaf litter was collected and soaked in clean water for 12-16 hours in a large container. The excess water from the soaked litter was drained by keeping them in a clean basket. Subsequently, the litter was immersed in fresh water taken in a suitable container and boiled for 30 min for sterilising them. Excess water from the sterilised litter was drained and they were left for cooling after covering the top with a clean moist cloth.

2.4.1 Preparation of mushroom bed using leaf litter

Polythene bags (100 gauge) of 60 x 30 cm size were used for preparing the mushroom bed. The sealed portion of the polythene bag was tied at the end so that the bottom portion of the bed becomes round in shape and convenient for keeping them on stands or hung from top. Instead of polythene bags, polythene tubes were also used to prepare beds. For aeration, 20-25 holes (0.5 cm dia) were punched on the polythene bags. A steel rod, plastic tray and a mild disinfectant (Dettol) were kept on a clean table before preparing the bed. Hands were properly washed with the disinfectant before filling the bags. If the planting spawn was prepared in bottles, a clean iron rod was used to mix the grains inside the bottle.

Adequately mature spawn raised inside polypropylene packet or glass bottles was emptied in a clean disinfected plastic tray. The spawn was mixed thoroughly with hands to distribute them evenly. Initially, a small portion (about 50 g) of the spawn was distributed at the bottom of the tied polythene bag and a layer (5 cm thick) of litter was spread over the spawn. Spreading the spawn over each layer of litter was repeated until the bag was filled. The top five-centimeter length of the bag was kept unfilled to facilitate for tying the mouth of the polythene bag. The spawn was distributed along the sides of the polythene bag because the mushrooms grow outside from the sides of the bed. These beds were then hung from the top using plastic ropes (Fig. 2).

The bed can also be kept on racks made of iron or wood. Watering of the bed was avoided for the first 3 days. The temperature and relative humidity inside the shed was maintained between 20-24^{0}C and 80-95% respectively. Mycelium ramification (spawn running) throughout the leaf litter occurred within 10-12 days. Young pinhead shaped sporophores appeared after 12 days (Fig. 3).

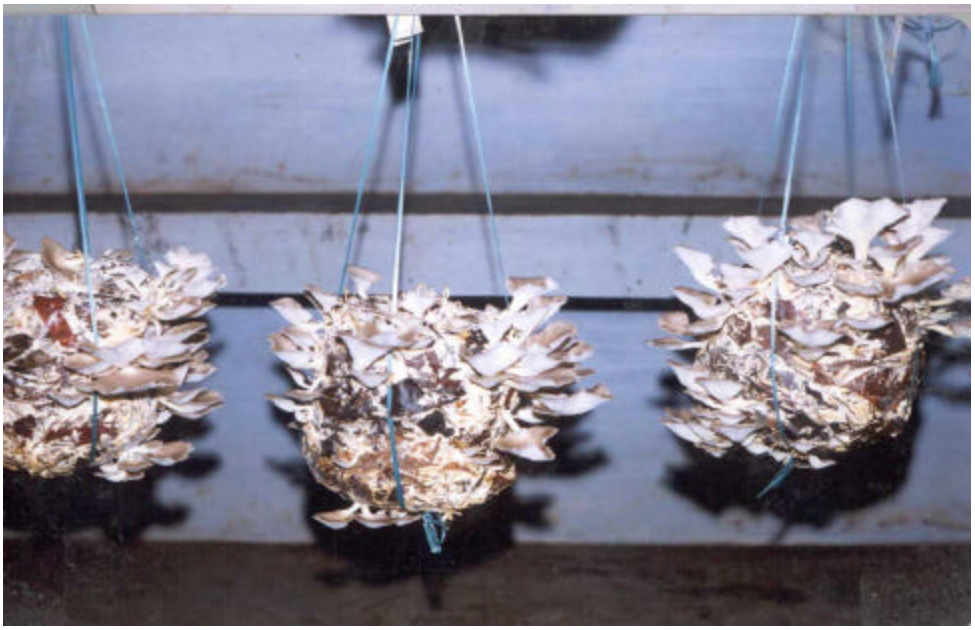

Fig. 2 Mushroom beds hung from the top

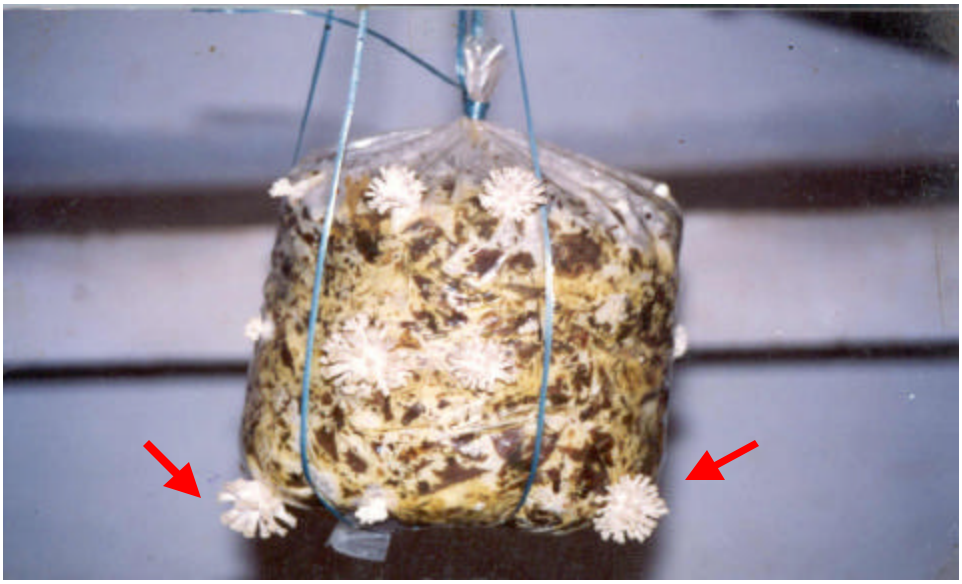

Fig. 3 Mushroom primordia of *Pleurotus florida*

At this stage, the polythene cover was cut open and the beds were watered 2-3 times a day for about 3 days to ensure 80-95% RH. From the pinhead initials, the mushrooms developed from the third day onwards and they were harvested after 3-4 days. Every day the doors and windows of the shed were opened for 30 min, to allow circulation of fresh air in the mushroom house. Also, sufficient amount of light was provided in the room, for formation of fruit bodies. Fully developed mushrooms were removed by cutting at the base of the mushroom. The right stage of picking is prior to the curving up of the margin of the pileus ie., before the mushrooms overmature. Care should be taken to maintain complete hygiene inside the shed. Aseptic condition was maintained starting from the preparation of bed to mushroom harvesting. Paddy straw was used as substratum (control) to compare the yield of mushrooms grown on different substratum. *Pleurotus* spp. procured from various sources were cultivated using leaf litter as prescribed previously. Harvesting was done three times from each mushroom bed within a period of 30-35 days.

2.4.2 Preparation of mushroom bed using sawdust

Pleurotus sajor-caju and *P. florida* were used for cultivation of mushroom on sawdust in polythene bags. Sawdust of rubber wood, which was available in plenty, was also used as the substratum for cultivation. The sawdust was soaked in clean water for 36-48 hr in order to soften it and to remove any toxic chemicals in the sawdust. The soaked sawdust was filled either in cloth or in clean gunny bags and the excess water was removed by pressing the bags. The sawdust was steamed for 45 min in an autoclave and then spread on a clean table to cool and to bring down the moisture content to 60%. It was then mixed thoroughly with CaCO3 (20g/kg) and subsequently filled in polythene bags and the mushroom spawn spread as a layer over it. The process was repeated as done in the case of leaf litter. The filled in bags were kept on wooden stands inside the mushroom shed. After the spawn running was completed, the bags were cut open and watered 2 times a day till the

mushroom primordia appeared. When the pinheads were developed into mushrooms they were harvested after 3-4 days. A minimum 3-4 harvest was taken during each cultivation.

2.4.3 Cultivation in sawdust using trays

For the cultivation of mushrooms in trays using sawdust as substratum, *Pleurotus sajor-caju* and *P. florida* were used. The sawdust for mushroom cultivation was prepared as above and approximately 2 kg of dry sawdust was taken in each tray and mixed with 200 g of spawn/tray. The top of the tray was covered with sawdust, and the surface of the tray closed with polythene sheet in order to maintain moisture inside the tray. Watering was done on every alternate day during spawn running and after the appearance of mushroom pinheads. These pinheads were allowed to grow into mushrooms and harvested within 3-4 days.

2.4.4 Cultivation on logs

Only *Pleurotus sajor-caju* was used for cultivation trials on logs. Rubber wood logs of 60 cm length and 20-25 cm dia were collected, dried for 10 days in the sun and soaked in water for 7 days. Every alternate day the soaking water was changed in order to check bacterial growth in the water. Inoculation was done after making 10 holes (2 cm dia and 2 cm deep) at a distance of 6 cm on the surface of the log. Each hole was filled with spawn and the hole was covered with moist cotton. The whole log was covered with polythene sheet and incubated at 22-30ºC. The inoculated logs were sprinkled with water as and when necessary. The polythene cover was removed when the primordia began to develop. The mushroom was harvested when they were fully mature.

2.4.5 Cultivation on wood shavings

Mixed wood shavings of *Tectona grandis* (Teak), *Artocarpus hirsutus* (Jack) and *Xylia xylocarpa* (Irul)) were collected from a nearby saw mill and soaked in clean water for 36 hr to soften the wood shavings and to drain the extractives in the wood. The excess water was drained off. Subsequently, the wood shavings were boiled for

45 minutes in a container and the excess water was removed from the boiled wood chips by keeping in a clean basket. The shavings were then mixed with mushroom spawn and prepared the bed as in the case of leaf litter (2.4.1).

2.4.6 Cultivation using different types of leaf litter

Leaf litter of different trees such as *Xylia xylocarpa, Terminalia paniculata*, and *Tectona grandis, Acacia auriculiformis* A. Cunn. ex Benth. and *Eucalyptus tereticornis* Sm. were used for cultivation of mushrooms. Fresh leaves of each species were collected and processed separately and prepared the mushroom bed as done in 2.4.1. Spawn of *P. sajor-caju* and *P. florida* was used for comparing the mushroom growth in different leaf litters. The beds were incubated in the mushroom shed. The mushrooms were harvested when they were ready and the weight of the mushroom recorded for each bag. Control bags were prepared with paddy straw.

2.5 Training on mushroom cultivation

One of the objectives of the project was to conduct training to demonstrate the various steps involved in mushroom cultivation. A one-day training was conducted for selected tribes and local people of Vazhachal and surrounding area to cultivate edible mushrooms using forest litter. The tribes were selected as the beneficiary because of the potential of adding the nutrient rich mushrooms in their daily diet. The mushroom cultivation was also expected to provide employment to the unemployed youths. The programme was arranged with the help of 'Kudumbasree' an autonomous body under Local Administration (Collectorate, Trichur) working for the welfare of rural and tribal people. The training was organised under 'Manaveeyam' programme. The venue of the training was Govt. Tribal School, Vazhachal. Tribals were identified from various tribal colonies of Athirapilly Panchayat.

3. RESULTS AND DISCUSSION

Among the different materials used for preparing the planting spawn, jowar was found to be the best and it yielded more mushrooms than other substrates (Table 2). Sivaprakasam *et al.,* 1994 reported that mushroom spawn prepared with jowar and bajara grains recorded higher yield of *P. sajor-caju* than spawn from other grains and substrates.

Table 2. Mushroom yield using spawn made of different types of materials

Substratum	Period taken to attain maturity (days)	Quantity of mushroom produced (kg)	Cost of substratum/ kg (Rs)	No. of spawn Packets/ kg
Wheat	20	1.35	10.00	5
Jowar	15	1.58	6.00	7
Maize	20	0.96	10.00	3
Sawdust	30	contaminated	--	3
Straw	25	0.37	1.00	9

Yield of mushrooms depended upon the type of spawn used (Quimio 1978; Munjal, 1975). The use of jowar grains has an added advantage from the economic point of view. This grain is cheaper than maize and larger number of spawn packets can be prepared per unit weight (Sivaprakasam, 1980). The mycelium of the mushroom covered the whole grain within 15 days. The mycelial growth rate also was faster on jowar when compared to other grains. On sawdust and straw, which were used for the preparation of spawn, the mycelial growth was very slow when compared to grain and it took about one month for the mycelium to cover the whole substratum. Also it was observed that the chances of contamination was more on spawn prepared with straw and sawdust since it required more days for maturing. Sivaprakasam and Kandaswamy (1982) reported that wood shavings, sawdust, bran and husk of rice

were poor spawn bases for *P. sajor-caju*. The faster growth of mycelium on grain may be attributed to the to presence of high amount of carbohydrates in the grains. Use of grain spawn appears to be preferable for mass production of mushrooms.

3.1 Cultivation of mushrooms using leaf litter

The total yield of mushrooms obtained from three harvests of all the 10 different species of *Pleurotus* is given in Table 3.

Table 3. Yield of *Pleurotus* mushrooms on 2kg of dry leaf litter

No.	Species	Yield of mushrooms
1.	*Pleurotus citrinopileatus*	0.21
2.	*P. cornucopiae*	0.56
3.	*P. eous*	0.48
4.	*P. eryngii*	0.57
5.	*P. flabellatus*	0.64
6.	*P. florida*	1.55
7.	*P. florida* (using paddy straw)	1.85
8.	*P. ostreatus*	0.85
9.	*P. sapidus*	0.35
10.	*P. sajor-caju*	1.33

Among the *Pleurotus* species tested, *P. florida* (TNAU) (Fig. 4) and *P. sajor-caju* (KAU) (Fig. 5) yielded more on leaf litter.

At the end of three harvests, *P. sajor-caju* yielded 1.33 kg of mushroom and in *P. florida*, the yield was 1.55 kg. The mushroom yield on control substratum was 1.85 kg. It was reported that the yield of sporophores of *Pleurotus* was related positively with cellulose content and cellulose: lignin ratio and negatively with the lignin

Fig. 4 *Pleurotus florida*

Fig. 5 *Pleurotus sajor-caju*

and *ortho- dihydroxy* phenolics content of the substrate (Sivaprakasam, 1980). Cellulose rich organic substances have been reported to be good substrates for the cultivation of mushrooms (Quimio, 1978). This may be the reason for the higher yield of mushrooms when paddy straw was used as the substratum. The colour of the mushroom, *P.sajor-caju* was more whitish in paddy straw where as, in leaf litter it was slightly brownish (Fig. 6).

Fig. 6 Colour variation of *Pleurotus florida*

The colour change may be attributed to the absorption of chemicals by the sporophores from the leaf litter. The yield from other species like *P. ostreatus*, *P. sapidus*, and *p. citrinopileatus* was not promising. In all the three, the yield was less than 1 kg. Low quantity of mushroom was harvested from leaf litter using the spawn of *P. eryngii*, *P. flabellatus* and *P. cornucopiae*. The lowest quantity of mushroom was obtained from *P. citrinopileatus*. It is reported that the ideal growth conditions required such as relative humidity, temperature and moisture content of the substrate vary from species to species (Chang and Miles, 1993). The optimal temperature for the development of fruiting bodies ranges from 10 to 28^0C, depending on the species, eg., *P .ostreatus* -14 to18^0C; *P sajor-caju* - 20 to 24 and *P. cystidiosus* - 26 to 28^0C. In the present experiment, the mushroom shed and spawn-running room was maintained at a temperature ranging from 22 to 24^0C and humidity of 85-90%. The variations in the microclimatic conditions may have influenced the growth of different mushrooms species. This may be the reason for the low yield of mushrooms from certain species. The conditions inside the shed were favourable for the growth of *P. sajor-caju* and *P. florida*. Since *P. sajor-caju* and *P. florida* were found to be the best for cultivation on leaf litter at the normal temperature prevalent in this area, all other experiments were conducted using these two species.

3.2 Cultivation using sawdust

The average quantity of mushrooms obtained from *P. sajor-caju* and *P. florida* were 675 g and 550 g respectively. The growth of the fungus on sawdust was slow. It took more than 18 days for the fruiting primordia to appear on the sawdust, whereas in leaf litter, it was only 12-13 days. The moisture content inside sawdust bed was high when compared to litter. This may be one of the reasons for obtaining low yield of mushrooms on sawdust.

The yield of mushroom obtained from sawdust in trays was very low. Average quantity of mushrooms obtained from *P. sajor-caju* and *P. florida* was 375 g and

256 g respectively. The maximum quantity of mushroom was obtained from the first harvest. The method of cultivation of mushroom is known to influence the production of sporophores (Smith, 1980). Polythene bag method recorded the highest yield of sporophores. This result is in conformity with the observation of Sivaprakasam and Kandasawmy (1982). The reason for increase of sporophores in poly-bag method may be due to more surface area of exposed sides and compactness of bed, which helps in retaining moisture. The reason for obtaining low quantity of mushroom in trays may be the drying up of the mushroom bed since the beds are prepared in open trays.

3.3. Cultivation on logs

Pleurotus sajor-caju was cultivated using rubber wood logs. The mushrooms appeared on logs after one month of inoculation. The yield was not very promising. An average of 189 g of mushroom was only obtained from each log. Chakravarthy and Sarkar (1982a) also had recorded low mushroom yield on log of *Mangifera indica* (179 g/log), *Artocarpus dakota* and *Casuarina equisetifolia* (27 g/log). When compared to the method of cultivation in polythene bag, this method appears to be very simple. However, this method cannot be used for large-scale production since the yield was significantly low.

3.4 Cultivation using wood shavings

Since the wood shaving was slightly bigger in size when compared to sawdust, it took about one month for completing the spawn running and another 5 days for production of mushrooms. From each bag an average quantity of 340 g of mushroom was obtained. The quantity of mushroom obtained from wood shavings was very low and not comparable with that obtained from leaf litter or paddy straw. Since the wood shavings are not easily available, the cultivation may not always be possible.

3.5 Cultivation using different types of leaf litter

The yield of *Pleurotus sajor-caju* mushrooms on mushroom beds filled with different types of leaf litter is given in table 4. The highest quantity of mushroom was obtained from mixed leaf litter. Among the individual species, *Terminalia paniculata*, *Xylia xylocarpa*, and *Tectona grandis* yielded 960 g, 758 g and 710 g respectively. Quantity of mushrooms harvested from *A. auriculiformis* and *E. tereticornis* was comparatively low. The initiation of the mushroom primordia also varied from species to species. It took 19 days for *A. auriculiformis* and 17 days for *E. tereticornis* litter and 14 to 15 days for the rest of the species for mushroom production. The decay rate of leaf litter of *A. auriculiformis* and *E. tereticornis* was reported to be very low when compared to that of other litters (Sankaran *et al.*, 1993). The low decomposability of acacia litter has been attributed to the high content of crude fibres in the phyllodes and also the presence of thick cuticle on the phyllode surface (Widjaja, 1980; Byju, 1989). The lignin content of acacia leaf litter was also higher compared to that of teak and *Xylia xylocarpa* (Kumar and Deepu, 1992; Sankaran *et al.*, 1993).

Table. 4 Mushroom yield from beds made up of leaf litter of different species

Name of species	Quantity of mushroom (kg) (Mean of three harvests)	day of first harvest
Xylia xylocarpa	0. 758	15
Terminalia paniculata	0. 960	14
Tectona grandis	0. 710	14
Acacia auriculiformis	0. 315	18
Eucalyptus tereticornis	0. 380	17
Mixed leaf litter	1.370	15
control (Paddy straw)	1.508	13

3.6 Training on mushroom cultivation

A one-day training was conducted on mushroom cultivation using forest litter for the benefit of tribals at Vazhachal area (Fig. 7). Altogether 77 tribes from different

Fig. 7 Introductory class on cultivation of edible

tribal colonies participated in the training programme. The selected tribal colonies were Kadar colony of Peringalkuth, Malayan colony of Thavlalkuzhipara, Kadar colony of Watchumaram, Kadar colony of Ambalappara, Kadar colony of Malakkappara, Kadar colony of Pokalappara, and tribals residing at Vazhachal. Mrs. Lathika Sundaran, Member, Athirapilly Grama Panchayat presided over the function and Mr. Shibu Chali, Standing committee Chairman (Welfare), Chalakkudy Block Panchayat inaugurated the function. An introductory class was given on several aspects of mushrooms like, various species of mushrooms in nature, edible and poisonous ones, food value, and the economics of cultivation. In another lecture, the preparation and maintenance of mushroom shed for keeping the beds for mushroom production was explained. The demonstration of some of the procedures for cultivation included boiling the leaf litter, draining and filling the polythene with leaf litter and mushroom spawn (Fig. 8).

Individual trainees were allowed to fill one bag each (Fig. 9). A pamphlet on 'Cultivation of Mushroom" (Koonkrishi) in Malayalam (Appendix) was released on the same day. A packet of mushroom spawn, polythene covers and a copy of the pamphlet were distributed to all the trainees to encourage mushroom cultivation.

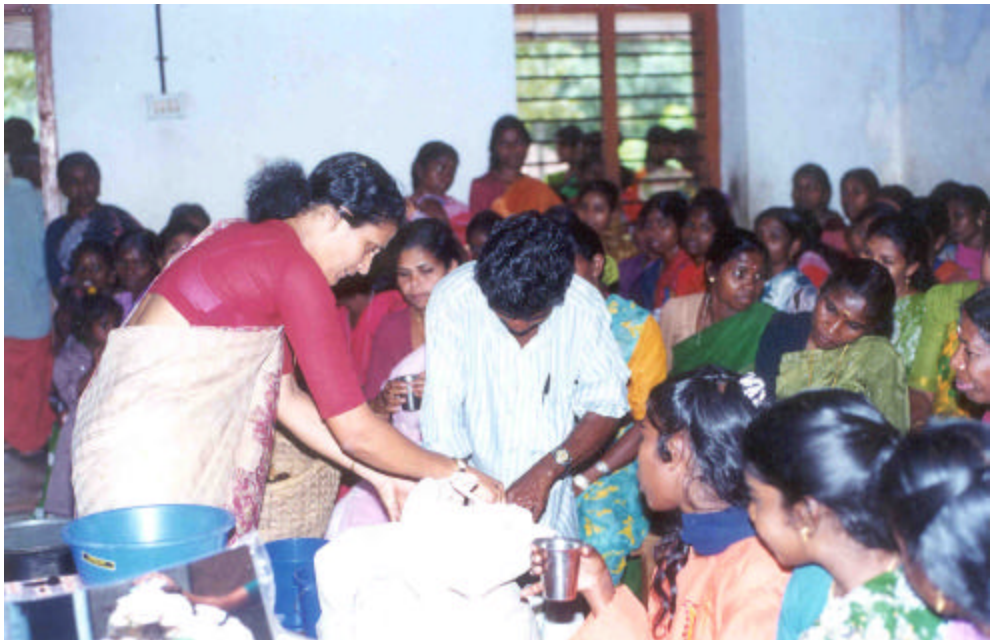

Fig. 9 A trainee fills the polythene bag with leaf litter and mushroom spawn

3.7. Economics of mushroom cultivation using leaf litter

Mushrooms play an important role in recycling carbon and other elements by breaking down the lignocellulosic plant residues. Mushroom cultivation using agricultural/ wood waste or leaf litter is one of the best and cheaper methods to produce quality protein. The production of food through mushroom cultivation is several times higher than from growing conventional agricultural crops. It is estimated that annual litter fall in tropical forests is between 5.5 and 15.3 t ha^{-1} (Laudelot and Meyer, 1954; Williams and Grey, 1974). A part of the leaf litter can be effectively utilized for the cultivation of mushrooms. The tribals can develop mushroom cultivation as a source of income.

A small unit, managed by one family (two members), can produce up to 1.5 kg of mushroom per day using leaf litter as the substratum (Table 5).

Table. 5 Investments/expenditure required for the production of 1.5 kg of mushroom using leaf litter

Sl. No	Item	Cost (Rs.)
One time investment		
1.	One room(12x12 ft) To be arranged by the beneficiary	-
2.	Modifying the room into mushroom shed	1000
Expenditure for one month		
3.	Spawn10 packets @Rs.10	100
4.	Polythene cover, disinfectant, tray etc.	300
5.	Miscellaneous	150
6.	Total	550

Production cost of 1.5 kg of mushroom x 30 days will be Rs.550. Selling cost of 45 kg (30x1.5kg) of mushroom @ Rs.50/kg will fetch an amount of Rs.2250. Mushroom produced at the cost of Rs.12.2 /kg (Rs. 550 for 45 kg) can be sold at Rs.50/kg after meeting all the recurring costs. Thus, producing about 45 kg of mushroom in a month can provide an income of (45kg x Rs. 50/kg - Rs.550) Rs.1700. Besides managing the mushroom production, they can carry out the normal work in the field and kitchen.

4. CONCLUSION

Mushroom production is an income generating environment friendly activity, which needs encouragement among rural and tribal households. The technique is simple and even a layman can adopt the technique very easily. Among wood waste materials and leaf litter tested as substrates, leaf litter was the best for cultivating *Pleurotus* species in terms of mushroom production. Mixed leaf litter yielded large quantity of mushrooms. Mushroom cultivation using logs and wood wastes such as sawdust and wood shavings was not economical in terms of yield. Cultivation using polythene bags yielded more quantity of mushrooms than the other methods. Among the *Pleurotus* species, *P. florida* was found to be the best for cultivation on leaf litter. Popularisation of mushroom cultivation and transfer of technology can be effective through training programme organised jointly by the experts and the Gramma Panchayat authorities. Mushroom cultivation offers self-employment for rural/tribal people and a source of additional income for housewives and villagers.

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