CULTIVATION OF EDIBLE MUSHROOM IN INDIA: PRECAUTIONS, OPPORTUNITIES AND CHALLENGES

***Vikas Kumar, [1]Subha Chandra, M.P., [1]Shancy, S.C., [1]Sabnam, V.S. and [1]Lamya, T.V.**

**Department of Silviculture and Agroforestry, College of Forestry, Vellanikkara*
**Kerala Agricultural University, KAU, Thrissur, Kerala 680656, India*
[1]Dept. of Microbiology, Kerala Veterinary and Animal Sciences University, Thrissur, Kerala
Email: vkskumar49@gmail.com

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Abstract: Mushroom cultivation has enormous potential to improve food security and income generation, which in turn can help boost rural and peri-urban economic growth regularly. These mushrooms grow on sawdust, wood, cereal straws or millet like wheat, bajra, jowar and rye mixed with calcium source (chalk-powder and gypsum). The substrates for cultivation of these mushrooms were steam pasteurized/sterilized, and no chemicals/pesticides were used during the cultivation of these mushrooms. Almost all the specialty mushrooms are lignicolous mushrooms, meaning lignin loving. The medium is sterilized after in heat resistant glass bottles or polypropylene bags at 121°C and 15 lbps pressure or for 2 hours at 100°C and inoculated with pure primary culture of *Agaricus bisporus*. The medium is incubated at 25°C and soon gets impregnated with mushroom mycelium. Sphagnum peat moss is the most commonly used material for casing. Harvestable mushrooms appear 18 to 21 days after casing.

Keywords:

INTRODUCTION

Mushrooms can play an important role contributing to the livelihoods of rural and peri-urban dwellers, through food security and income generation. Mushrooms can make a valuable dietary addition through protein and various micronutrients and, coupled with their medicinal properties, mushroom cultivation can represent a valuable small-scale enterprise option. There has been 1200 species of fungi that considered to mushrooms, with at least 200 species showing various degree of edibility (Chang, 1999). Twelve species are commonly grown for food and/or medicinal purposes, across tropical and temperate zones, including the Common mushroom (Agaricus), Shiitake (Lentinus), Oyster (Pleurotus), Straw (Volvariella), Lion's Head or Pom Pom (Hericium), Ear (Auricularis), Ganoderma (Reishi), Maitake (*Grifola frondosa*), Winter (Flammulina), White jelly (Tremella), Nameko (Pholiota), and Shaggy Mane mushrooms (Coprinus). The commercial market dominated by White button mushroom (*Agaricus bisporus)*, Oyster mushroom (*Pleurotus* spp) and Tropical paddy straw mushroom (*Volvariella* spp.), recently cultivation of Milky mushroom (*Calocybe indica*) has been started (Rai et al., 2005).

Mushrooms belong to the kingdom of Fungi, a group very distinct from plants, animals and bacteria. Fungi lack the most important feature of plants: the ability to use energy from the sun directly through chlorophyll. Thus, fungi depend on other organisms for food, absorbing nutrients from the organic material in which they live. The living body of the fungus is mycelium made out of a tiny web of threads (or filaments) called hyphae. Under specific conditions, sexually compatible hyphae will fuse and start to form spores. The larger sporeproducing structures (bigger than about 1 mm) are called mushrooms. No leaves, no buds, no flowers yet fruits, this is the miracle played only by mushroom. This unique fruit is basically a gift of nature to the poor as evident from its appearance on thatched house and rotten woods just after first shower (Verma et al., 2013). A mushroom (or toadstool) is the fleshy, spore-bearing fruiting body of a fungus, typically produced above ground on soil or on its food source (Rai et al., 2005). Increasing knowledge opened more and more dimensions of its utility provoking extensive cultivation of mushroom worldwide and its popularization in every sphere of life as well as in every sects of the society.

The yield potential of a crop species is often difficult to realize due to loss caused by biotic and abiotic stresses. In Mushroom also a number of extremely harmful pests and diseases cause losses both in quality and quantity of the produce. Mushroom themselves being pose special problems in adopting chemical control measures, particularly against diseases. The problem of pesticide residue is rather more alarming in mushrooms as the waiting time is very small. Hence strains with genetic resistance or tolerance to the biotic and abiotic stresses should be the preferred strategy (Ahlawat, 2003). Mushrooms are highly perishable and get spoiled due to wilting, veil-opening, browning, loss of texture, aroma, flavor etc. Most of the mushrooms being high in moisture and delicate in texture cannot be stored for more than 24 hours at the ambient conditions prevailing in the tropical country like India. Once the fruiting body matures, degradation process starts and it becomes un-consumable after sometime. Development of

*Corresponding Author

brown colour is the first sign of deterioration and is a major factor contributing to quality losses. Researchers suggested that mushroom spoilage might be caused by the action of bacteria on the mushroom tissue and browning of mushroom was due to a combination of auto enzymatic and microbial action on the tissue. The enzyme, polyphenol oxidase, in the presence of oxygen and the substrate catalyses the oxidation of colourless phenolic compounds into quionones which combine with amino acid derivatives to form highly coloured complexes thus making them highly unacceptable and therefore, should be disposed off as soon as possible (Kaul and Dhar, 2007).

Mushroom cultivating consists of five steps such as composting (Phase I and Phase II), spawning, casing, pinning, and cropping.

Phase I composting

The preparation of compost occurs in two steps referred to as Phase I and Phase II composting. Making Mushroom Compost This phase of compost preparation usually occurs outdoors although an enclosed building or a structure with a roof over it may be used. Phase I composting is initiated by mixing and wetting the ingredients as they are stacked in a rectangular pile with tight sides and a loose center. Once the pile is wetted and formed, aerobic fermentation (composting) commences as a result of the growth and reproduction of microorganisms, which occur naturally in the bulk ingredients. There must be adequate moisture, oxygen, nitrogen, and carbohydrates present throughout the process, or else the process will stop.

Phase I composting period from 7 to 14 days, depending on the nature of the material at the start and its characteristics at each turn. Synthetic compost requires the addition of ammonium nitrate or urea at the outset of composting to provide the compost microflora with a readily available form of nitrogen for their growth and reproduction. Nitrogen supplements in general use today include brewer as grain, seed meals of soybeans, peanuts, or cotton, and chicken manure, among others. The purpose of these supplements is to increase the nitrogen content to 1.5 percent for horse manure or 1.7 percent for synthetic, both computed on a dry weight basis. Substitutes for or complements to corn cobs include shredded hardwood bark, cottonseed hulls, neutralized grape pomace, and cocoa bean hulls. There is a strong ammonia odor associated with composting, which is usually complemented by a sweet, moldy smell. As a by-product of the chemical changes, heat is released and the compost temperatures increase. At the end of Phase I the compost should be a chocolate brown color; soft, pliable straws; moisture content of from 68 to 74 percent; and strong smell of ammonia. When the moisture, temperature, color, and odor described have been reached, It means that Phase I composting completed. To every 100kg of straw and manure add 1.5kg of gypsum and 1 2kg of urea or ammonium sulphate.

Phase II composting

There are two major purposes to Phase II composting such as Pasteurization and remove the ammonia. Pasteurization is necessary to kill any insects, nematodes, pest fungi, or other pests that may be present in the compost. Remove the ammonia which formed during Phase I composting. Ammonia at the end of Phase II in a concentration higher than 0.07 percent is often lethal to mushroom spawn growth, thus it must be removed; generally, a person can smell ammonia when the concentration is above 0.10 percent.

Phase II takes place in one of three places, depending on the type of production system used. These are zoned system, bed or shelf system and bulk system. A high temperature Phase II system involves an initial pasteurization period during which the compost and the air temperature are raised to at least 145°F for 6 hours. This can be accomplished by heat generated during the growth of naturally occurring microorganisms or by injecting steam into the room where the compost has been placed. After pasteurization, the compost is re-conditioned by immediately lowering the temperature to 140°F by flushing the room with fresh air. Thereafter, the compost is allowed to cool gradually at a rate of approximately 2° to 3°F each day until all the ammonia is dissipated. Phase II system requires approximately 10 to 14 days to complete. In the low temperature Phase II system the compost temperature is initially increased to about 126°F with steam or by the heat released via microbial growth, after which the air temperature is lowered so the compost is in a temperature range of 125° to 130°F range. During the 4 to 5 days after pasteurization, the compost temperature may be lowered by about 2°F a day until the ammonia is dissipated. At the end of Phase II the compost temperature must be lowered to approximately 75° to 80°F before spawning (planting) can begin. The nitrogen content of the compost should be 2.0 to 2.4 percent, and the moisture content between 68 and 72 percent. The end of Phase II it is desirable to have 5 to 7 lbs. of dry compost per square foot of bed or tray surface to obtain profitable mushroom yields. It is important to have both the compost and the compost temperatures uniform during the Phase II process since it is desirable to have as homogenous a material as possible.

Phase III Spawning

Mushroom compost must be inoculated with mushroom spawn (Latin word means to spread out) if one expects mushrooms to grow. The mushroom arises from thin, thread-like cells called mycelium. Fungus mycelium is the white, thread-like plant often

seen on rotting wood or moldy bread. Mycelium propagated vegetatively is known as spawn. Spawn is just equivalent to the seed of a plant, although, it is only pure mushroom mycelium (vegetative part of fungus) growing on a sterilized grain medium (in case of solid spawn). The grain medium prepared by boiled grains of cereal or millet like wheat, bajra, jowar and rye mixed with calcium source (chalk-powder and gypsum). The medium is sterilized after in heat resistant glass bottles or polypropylene bags at 121°C and 15 lbps pressure or for 2 hours at 100°C and inoculated with pure primary culture of *Agaricus bisporus*. The medium is incubated at 25°C and soon gets impregnated with mushroom mycelium. This spawn would be ready for use in 2–3 weeks. Once the grain is colonized by the mycelium, the product is called spawn. The time needed for spawn to colonize the compost depends on the spawning rate and its distribution, the compost moisture and temperature, and the nature or quality of the compost. Spawn can be refrigerated for a few months. The mycelium grows in all directions from a spawn grain, and eventually the mycelium from the different spawn grains fuse together, making a spawned bed of compost one biological entity. A complete spawn run usually requires 14 to 21 days.

Spawning is carried out as follows:

I. Grains of spawn should be separated from each other as thoroughly as possible as the spawn is spread over the surface of the compost.
II. Spawn should be mixed evenly throughout the compost.
III. Conditions should be kept as sterile as possible (Wear clean clothing and footwear, wash your hands before carrying out spawning, tools should be sterilized in, formalin or some other antiseptic which will not damage the mushroom).
IV. Do not add spawn to compost while the temperature of the compost is above 30 degrees centigrade. (34 degrees will kill the mycelia).
V. If there is any ammonia present in the compost (ie: through composting being incomplete), the mycelia is not likely to grow.

Phase IV Casing

Casing is a top-dressing applied to the spawn-run compost on which the mushrooms eventually form. A mixture of peat moss with ground limestone can be used as casing. Casing should be able to hold moisture since moisture is essential for the development of a firm mushroom. The most important functions of the casing layer are supplying water to the mycelium for growth and development, protecting the compost from drying, providing support for the developing mushrooms and resisting structural breakdown following repeated watering. Supplying as much water as possible to the casing as early as possible without leaching into the underlying compost provides the greatest yield potential. Casing does not need nutrients since casing acts as a water reservoir and a place where rhizomorphs form. Rhizomorphs look like thick strings and form when the very fine mycelium fuses together. Mushroom initials, primordia, or pins form on the rhizomorphs, so without rhizomorphs there will be no mushrooms.

Sphagnum peat moss is the most commonly used material for casing. Sphagnum can range from brown (young, less decomposed, loose textured, surface peat) to black (compact, more decomposed, deep dug) and may be processed differently at the harvest site. Peat moss-based casing does not require pasteurization because the material is free from pathogens, weed molds and nematodes that may reduce mushroom yield. One 6-ft^3 compressed bale when mixed with water and 40 lb of limestone will cover about 125 ft^2 of compost surface at about 2 inches depth.

Casing inoculum (CI): It is sterilized mixture of peat, vermiculite and wheat bran that has been colonized by mushroom mycelium. It is mixed with casing to decrease cropping cycle time, improve uniformity of mushroom distribution over the bed and improve mushroom cleanliness. Mycelium from the casing inoculum colonizes the casing layer while it fuses with the underlying mycelium of the compost. This allows more breaks per crop or more crops per year.

Phase V Pinning

Mushroom initials develop after rhizomorphs have formed in the casing. The initials are extremely small but can be seen as outgrowths on a rhizomorph. Once an initial quadruples in size, the structure is a pin. Pins continue to expand and grow larger through the button stage, and ultimately a button enlarges to a mushroom. Harvestable mushrooms appear 18 to 21 days after casing. Pins develop when the carbon dioxide content of room air is lowered to 0.08 percent or lower, depending on the cultivar, by introducing fresh air into the growing room. Outside air has a carbon dioxide content of about 0.04 percent. The timing of fresh air introduction is very important and is something learned only through experience.

Generally, it is best to ventilate as little as possible until the mycelium has begun to show at the surface of the casing, and to stop watering at the time when pin initials are forming. If the carbon dioxide is lowered too early by airing too soon, the mycelium stops growing through the casing and mushroom initials form below the surface of the casing. As such mushrooms continue to grow, they push through the casing and are dirty at harvest time. Too little moisture can also result in mushrooms forming below the surface of the casing. Pinning affects both the potential yield and quality of a crop and is a significant step in the production cycle.

Phase VI Cropping

The terms flush, break, or bloom are names given to the repeating 3- to 5-day harvest periods during the cropping cycle; these are followed by a few days when no mushrooms are available to harvest. This cycle repeats itself in a rhythmic fashion, and harvesting can go on as long as mushrooms continue to mature. Most mushroom farmers harvest for 35 to 42 days, although some harvest a crop for 60 days, and harvest can go on for as long as 150 days. Mushrooms are harvested in a 7- to 10-day cycle, but this may be longer or shorter depending on the temperature, humidity, cultivar, and the stage when they are picked. When mature mushrooms are picked, an inhibitor to mushroom development is removed and the next flush moves toward maturity. Mushrooms are normally picked at a time when the veil is not too far extended. Air temperature during cropping should be held between 57° to 62°F for good results. This temperature range not only favors mushroom growth, but cooler temperatures can lengthen the life cycles of both disease pathogens and insects pests. The relative humidity in the growing rooms should be high enough to minimize the drying of casing but not so high as to cause the cap surfaces of developing mushrooms to be clammy or sticky. Water is applied to the casing so water stress does not hinder the developing mushrooms; in commercial practice this means watering 2 to 3 times each week. Outside air is used to control both the air and compost temperatures during the harvest period. Outside air also displaces the carbon dioxide given off by the growing mycelium. The more mycelial growth, the more carbon dioxide produced, and since more growth occurs early in the crop, more fresh air is needed during the first two breaks. The amount of fresh air also depends on the growing mushrooms, the area of the producing surface, the amount of compost in the growing room, and the condition or composition of the fresh air being introduced. Experience seems to be the best guide regarding the volume of air required, but there is a rule of thumb: 0.3ft/hr when the compost is 8 inches deep, and of this volume 50 to 100 percent must be outside air.

Opportunities

Mushrooms can be successfully grown without access to land, and can provide a regular income throughout the year. Cultivation is also independent of weather, and can recycle agricultural by-products as composted substrate which, in turn, can be used as organic mulch in growing other horticultural crops, including vegetables. Mushroom cultivation is highly combinable with a variety of other traditional agricultural and domestic activities, and can make a particularly important contribution to the livelihoods of the disabled, of women and the landless poor who, with appropriate training and access to inputs, can increase their independence and self-esteem through income generation. Cooperatives and community groups can collaborate in set-up and production costs, harvesting and marketing. Working in joint ventures or partnerships with regional agroindustries, universities or wholesalers can help reduce vulnerability and opportunities and risk for small-scale producers, and provide access to training and other forms of support.

Precautions need during mushroom cultivation

Precautionary measures will hygiene in and around the farm is the most important key to get the success in Mushroom farming. Visitors should be kept to a minimum, and the areas they can access restricted. No pesticides should be used. Listed below are a number of general hygiene aspects to consider; Maintain cleanliness in and around the farm. Dust filters must be replaced after each cycle. Workers dresses should be cleaned all the time. Use double door system and all the opening of Growing rooms should be provided with insect-proof nets. Substrate must be prepared only on a cemented platform disinfected with 2% formalin solution. Use healthy spawn free from contaminants. Use a foot-dip (with germicidal solution-Potassium per magnate/ bleach or 3%formalin) before entering the growing area/rooms. All machinery, work floors and tools must be disinfected before filling with 2% formalin solution. Cook out the compost and casing soil at the end of each harvest. Keep the compost temperature at 70° Celsius for 8 hours. Remove of all the used compost, casing soil and mushroom stalks etc after harvesting as quickly as possible. Disposing area must be at least 2 km away from farm. Disinfection of culture rooms before each new cycle with 5% formalin solution and close all air passage for 24 hrs (Maheshwar, 2013).

Challenges

Establishing larger scale mushroom cultivation systems can be more labour and management intensive. All production systems, to some extent, are vulnerable to sporadic yields, invasions of ‘weed’ fungi, insect pests, and unreliable market prices for traded goods. One of the most important aspects of growing mushrooms for commercial purposes is the ability to maintain a continuous supply for chosen market outlets, and if the mushroom enterprise is one of many livelihood activities, producers need to become multi-skilled to manage several enterprises successfully. The initial challenges which mushroom growers have to face include determining the most suitable mushroom to grow and identifying a spawn supplier, organizing available resources to develop a growing system, and assessing requirements for supplying different marketing outlets. In spite of these, starting with home production is an advisable approach.

Various reasons have been cited for this neglect, including: a lack of technical capacity in production techniques with poorly equipped government

supported advisory services resulting in interested farmers having to seek technology on their own; comparatively few studies on tropical mushrooms; and a lack of technical skills to produce spawn with suitable strains often hard to find. The market can present an additional constraint in some regions as the prices of mushrooms are out of the range of most local consumers and unable to compete with other protein sources like beef, beans or eggs for a place in the average family diet. As a livelihood diversification option, mushroom cultivation has enormous potential to improve food security and income generation, which in turn can help boost rural and peri-urban economic growth (Marshall and Nair, 2009).

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