Compost and Casing of Mushroom in Indian Perspective: A Brief Review

Abstract

The Himalayas, the Western Ghats, and the highlands of northeast India are all temperate areas where mushrooms have been successfully grown. Recently, mushroom farming has become a popular kind of self-employment for many unemployed people. It is past time that mushroom growers and consumers in India learned about the therapeutic and dietary benefits of both farmed and wild kinds of mushrooms. The majority of all mushrooms are white button mushrooms, accounting for around 73 percent of the market. Compost is necessary for cultivating white button mushrooms. The substrate in which the mushroom mycelium grows and eventually produces fruiting bodies is compost. The critical shift from vegetative growth to the reproductive stage occurs in the coating material, which is a nutritionally deficient medium is called casing layer. This layer plays a vital part in the formation of mushrooms. The most crucial process in mushroom cultivation is composting and casing, which has an impact on the crop's productivity, quality, and market value.

KEYWORDS: Mushroom cultivation, Compost, Casing, yield, medicinal value.

Introduction

Mushrooms are a wonderful source of digestible proteins, carbohydrates, fibres, and vitamins because they have a combination of culinary, medical, and nutraceutical qualities (Heleno et al., 2010). Mushrooms are a type of macroscopic fungi that lack chlorophyll and so require a substrate to thrive. Mushrooms create enzymes that break down intricate organic material and take the soluble components from the substrate (Chang and Miles, 1989). Nowadays, mushrooms are grown and consumed all over the world for their flavour and delicacy, especially in Asian nations like China and India. Although 80 percent of the population in India is vegetarian, there is not enough protein produced to meet the needs of such a large portion of the population. To address the protein shortages caused by the expanding population, mushrooms are an alternate protein dietary source. As most mushrooms grow on lignocellulosic materials of agricultural origin, forest litter, and garden debris, mushroom gardening is also valued for waste management. A good source of protein, vitamins, and minerals, edible mushrooms are known to have a variety of uses in food and medicine, particularly in Southeast Asia, India, Europe, and Africa.

They have the ability to be grown in both temperate and tropical climates and gathered year-round both commercially and naturally. because it contains ligno-cellulolytic enzymes that can help turn cellulose and lignin into usable carbs like glucose. Additionally, mushrooms are a fantastic dietary source to help combat the issue of hunger in developing nations. In addition to being rich in minerals like vitamin D, this cheap edible product also has the ability to prevent cancer, HIV-1 AIDS, and a host of other ailments. It may be cultivated all around the world and throughout the year from affordable starting materials because it is an economical and environmentally beneficial crop to farm (Kumar and Mahajan 2022).

Good composting and casing materials are needed for successful commercial mushroom cultivation. As a result, the current study reviews the status of the composite and casing research scenario as well as potential barriers to the country's mushroom business and local producers' growth into new markets.

The process of growing button mushrooms includes a number of processes, including the preparation of compost and its spawning, which is done at a temperature of 25 °C before being lowered to 16 °C and carbon dioxide levels of roughly 1000-1500 ppm (Singh, 2016). The most crucial process in mushroom cultivation is composting and casing since it significantly affects the crop's productivity, quality, output, and market value.

Compost

The substrate in which the mushroom mycelium grows and eventually produces fruiting bodies is compost. A number of mesophilic, thermophilic bacteria and fungi that break down plant wastes and other organic and inorganic materials produce it as a byproduct of the fermentation process. The physical, chemical, and biological conditions that encourage the commencement of pin head formation for fruit body creation are provided by the compost in which it develops vegetatively and the nutritionally deficient casing soils.

Status of compost and casing research in Indian Perspective

The Department of Agriculture, Himachal Pradesh, in conjunction with the Indian Council of Agricultural Research (ICAR), New Delhi, under the project "Development of mushroom farming in Himachal Pradesh," undertook the first systematic attempt to cultivate *A. bisporus* in India in 1961 at Solan. The brief method of composting, which Sinden and Hauser invented in 1953 and is widely used worldwide. Shandilya standardised compost compositions and the quick process of composting in India (1976).

The wide spectrum of microbial variety can be seen in mushroom compost, which is a particularly good example. It is a highly complex biological process that transforms a low-value substance into a high-value product by using numerous species of bacteria, fungi, and actinomycetes (Tiwari, 2009). In the recycling of agricultural wastes, microorganisms are crucial (Singh and Nain, 2014).

Economic and Environmental Aspects of Mushrooms

According to Martnez-Ibarra E et al. (2019), mushrooms have emerged as one of the most promising resources for promoting quick socioeconomic growth. It has been noted that mushroom farming generates revenue for the country and helps to reduce poverty in rural areas. The cultivation of mushrooms generates a significant amount of direct and indirect employment opportunities in marketing, cultivation, and labor-intensive management operations that provide potential for processing businesses (Islam MK et al 2013). Mushroom farming requires minimal capital, low technical expertise, and it is even possible to grow mushrooms indoors on a modest scale and quickly earn a high return on investment. Women from both rural and urban areas can grow mushrooms in their homes like raising chickens with little investment (Easin MN et al 2019, Islam MK et al. 2013). According to Martnez-Ibarra E et al. (2019), mushrooms are crucial to the ecological management of ecosystems. Mushroom production indirectly involves the bioconversion of organic materials, which creates chances for the recycling of organic matter and lowers pollution.

Composting

Approximately 385 million tonnes of agricultural waste are available in India each year, but only about half of them are used. India will become a significant mushroom producing nation in the world if 1% of these crop leftovers are employed for mushroom growing (Tewari and Pandey, 2002). Currently, India practises both the long (pile) and short (Phase I and II) techniques of composting for the production of *A. bisporus.* Regardless of the varied proportions of components employed, the pile composting method suggested by Sinden and Hauser (1953) takes 4 to 6 weeks to complete the process in 7 to 8 turnings (Suman and Sharma, 2007). The short method of composting included an outdoor aerobic phase lasting 10 to 15 days (phase I), followed by an interior pasteurisation phase (57°C for 6 to 8 hours) and an indoor conditioning phase (45°C for 7 to 8 days) inside an insulated bunker (phase II) (Beyer, 2005; Sinden and Hauser, 1953).

220 g of dry substrate materials are needed to create 1 kilogramme of mushrooms. N:P:K-33:10:25enterprises/mushroom-production/button mushroom-production 2/3 recommends that each tonne of compost include 6.6 kilogramme of nitrogen, 2.0 kg of phosphate, and 5.0 kg of potassium, which translate to 1.98 percent N, 0.62 percent P, and 1.5 percent K on a dry weight basis. When staking, a good substrate should have a C: N ratio of 25–30:1, and 16–17:1 for final compost.

a. Short Method of composting

Short method was used to create wheat straw-based compost, which was done in two stages: phase I involved composting outside while periodically turning the raw materials, and phase II involved peak-heating the compost indoors, which was done in three stages: prepeak heating, peak heating, and postpeak heating (Gerrits, 1984). The entire mixture was composted throughout the course of two phases that lasted for 18 days (Shandilay et al., 1980). Pre-wetting occurs in two to three days, and then the concrete floor is composted outside for seven days.

i. Paddy straw is stacked and given enough water, fertilisers, wheat bran, molasses, and other ingredients during the initial stage of compost manufacturing. On the first day of stacking, supplements like chicken dung or soybean flour were sprinkled over the pile. The whole thing is mixed thoroughly with the straw and made into a stack (almost 5 feet high, 5 feet wide and of any length can be made with the help of wooden boards).

ii. The stack is turned and again watered on the second day.

iii. The stack is turned a second time on the fourth day by adding gypsum and watering. On the twelfth day, when the compost's colour turns dark brown and it begins to give off a potent ammonia odour, the third and last turning is performed. The pasteurisation phase is the next step.

iv. In order to kill unwanted microorganisms and competitors and turn ammonia into microbial protein, the compost created by the microbe-mediated fermentation process needs to be pasteurised.

v. The entire procedure is completed in a steaming room with a continuous 60 °C air temperature for 4 hours. The final compost should have a granular texture, a moisture content of 70%, and a pH of 7.5. It should be dark brown in colour, sweet-smelling and unobtrusive, and free of nematodes, insects, and ammonia.

vi. The substrate is cooled to 25°C when the procedure is finished.

b. Long Method of composting

i. The long method of composting is typically used in locations without steam pasteurisation facilities.

ii. After preparing the substrate for composting, the first rotation is performed using this approach roughly six days later.

iii. The second turning is performed on the tenth day, and the third one—when gypsum is added—is performed on the thirteenth day.

iv. On the sixteenth, nineteenth, and twenty-second days, the fourth, fifth, and sixth turnings are provided. The seventh turning is administered on the twenty-fifth day after adding 10 percent BHC (125 g), and the eighth turning is administered on the twenty-eighth day after which it is determined whether the compost has an ammonia odour.

v. The compost is only ready for spawning if there is no ammonia odour; otherwise, a few additional turnings are supplied at a three-day interval until there is no ammonia odour.

It is thought that thermophilic fungi considerably improve compost quality (Eicker, 1977). Using thermophilic fungi *Scytalidium thermophilum, Humicola insolens, Chaetomium thermophile, Emericella nidulans,Thermoascus aurantiacus, Myriococcum albomyces, Malbranchea sulfurea, Torula thermophila, Stilbella thermophila and*

Thermomyces lanuginosus, compost can be produced with little environmental (Salar and Aneja, 2007).

Three different levels of the impact of these fungi on the development of mushroom mycelia and mushroom production have been described. First, they reduce the amount of ammonia in the compost, which would otherwise prevent the mushrooms mycelium from growing. Second, they immobilise nutrients in a way that the mushroom mycelia seem to be able to use. Third, as has been shown with *Scytalidium thermophilum* and several other thermophilic fungi, they may have a growth-promoting influence on the mushroom mycelia. Straatsma et al (2000) .'s results, which showed a two-fold increase in the yield of mushrooms on inoculated compost as compared to the pasteurised control, demonstrated the efficiency of *S. thermophilum* in compost preparation for *A. bisporus*.

What is Good Compost?

Finding appropriate compost is crucial since it forms the cornerstone of successful mushroom cultivation. A good compost should be dark brown in colour, not oily or sticky, have a distinct sweet, unoffensive smell that is free of ammonia, be 65 to 67 percent moist, and have a pH of 7.2 to 7.8. Except for the fire fangs (Actinomycetes), there should be no observable growth of other unpleasant species, and it should be devoid of insects and nematodes.

Spawning

Spawning is the process of combining spawn with compost. The various spawning techniques are listed below:

- **(i) Spot Spawning**: Spawning lumps are placed 20–25 cm apart in 5 cm-deep holes dug in the compost. Later, compost is used to cover the holes.
- **(ii) Surface Spawning**: The spawn is blended to a depth of 3-5 cm after being equally distributed in the compost's top layer. A thin layer of compost has been placed on top of the area.
- **(iii) Layer spawning:** Similar to surface spawning, three to four layers of prepared spawn mixed with compost are then coated with a thin layer of compost.

At a rate of 7.5 ml/kg, the spawn is incorporated throughout the entire mass of compost. Compost, or 500–750 g per 100 kg (0.5 to 0.75 percent). Running Spawn The period of time between spawning and casing when the mycelium completely colonises (grows through) the mushroom compost is known as the spawn run.

After the spawning process is complete, the compost is placed in polythene bags (90x90 cm, 150 gauge thick, with a capacity of 20–25 kg per bag), trays (often made of wood, with a 1–1/2 m length), or shelves, and is then either covered with a newspaper sheet or polythene. It takes the fungal bodies around two weeks (12–14 days) to colonise when they emerge from the spawn. The cropping chamber is kept at a constant temperature of 23 20 C. Any temperature over that required for the purpose will hinder spawn growth, while any temperature below that would slow down the spawn run. A higher-than-average CO_2 content would be advantageous, and the relative humidity should be approximately 90%.

Casing

Casing is a crucial agronomic procedure for top-dressing spawn run compost with a layer of suitable soil mixture (Tandon et al., 2006). The quality of the compost and casing material utilised has a higher impact on *Agaricus bisporus* production. The critical shift from vegetative growth to the reproductive stage occurs in the capping layer, which is a nutritionally deficient medium. This layer plays a vital role in the creation of mushrooms. On uncased mushroom beds, fruit body formation can occasionally occur, but it is impossible to produce any quantity. Therefore, it is crucial to cover the composted spawn run with the proper casing material. For developing mushroom sporophores, casing typically provides anchorage and vital reserves (Shandilya, 2002). According to local availability and suitability, various types of casing materials are used in our nation (Table1).

The casing material should be highly porous, capable of retaining water, and have a pH between 7 and 7.5. Due to the lack of peat moss, which is thought to be the ideal casing material, mixes such as garden loam soil and sand (4:1), decomposed cow dung and loam soil (1:1), wasted compost (2–3 years old), sand, and lime are frequently utilised. Before use, the casing soil should either be steam sterilised, treated with formaldehyde (2%) and bavistin (75 ppm), or pasteurised (at 66–70°C for 7-8 hours). Before the material is utilised for casing, the treatment must be completed at least 15 days in advance. In the manufacture of mushrooms, many case materials are employed.

Table 1:Different type of casing material		
S.No.	**Casing material**	**Author**

1)	One year old spent compost, sand and soil in the ratio of 4:1:1 (v/v/v) after treating it with steam, nemagon or formalin.	Mantel (1973)
2)	Farm yard manure + three years old spent compost (1: 1, v/v) for better yield in *A. Bisporus.*	Shandilya and Agarwala (1983)
3)	Farm yard manure+ forest soil (1:1) gave high yield	Singh *et al*. (1985)
4)	FYM + waste compost + soil (2:1:1, v/v) for better yield	Saini and Prasher (1992)
5)	Burnt rice husk, farm yard manure and soil in ratio of 2:1:1 (v/v)	Saini and Prashar (1993)
6)	Spent compost + FYM (1:1)	Singh *et al.* (2001)
7)	Farm yard manure (FYM) + loam soil (l: 1, v/v) is being used as a standard casing material in India for the cultivation of *A. Bisporus.*	Raina *et al*. (2002).
8)	Well rotten farmyard manure and coir pith in the ratio of 4:1 (v/v) recorded a significant increase in yield of about 14 and 12 per cent over control	Suman and Paliyal (2004)
9)	Vermicompost leached + FYM based vermicompost-leached + farm yard manure (1:2:2 v/v/v) resulted in significantly higher yield (18.51 kg/100 kg compost) followed by the combination of municipal waste vermicompost- leached + farm yard manure (1:2 v/v, 18.36 kg/100 kg compost) in case of *Agaricus bisporus*.	Jariyal and Shandilya (2005)
10)	Press mud + coir pith (3:1) was found to be better in terms of improvement in water holding capacity, electrical conductivity and organic content so as to qualify as an ideal casing mixture.	Bhatt *et al.* (2006)
11)	Spent compost, farm yard manure, sand and garden soil (1:1:1:1) gave the highest yield	Singh *et al*. (2007)
12)	Coconut coir pith + vermicompost + FYM + sand gave highest yield	Ram and Holker (2009)
13)	FYM + spent compost + sand + soil (1:1:1:1) was found to be the best for getting higher yield and fruiting bodies.	Ratnoo and Doshi (2012)
14)	Farm Yard Manure and Spent mushroom Substrate (FYM+SMS, 3:1)	Suman (2012)

	found to be high yielding casing mixture, which took minimum casing run period together with superior fruit body quality as compared to and Farmyard Manure and Vermi Compost (FYM+VC, 3:1).	
15)	FYM : garden soil : sand (2:1:1) showed best result in yield as well as biological efficiency.	Sharma *et al.* (2013)
16)	Coconut coir pith + vermicompost + FYM + saw dust + sand gave highest yield	Chandra *et al.* (2014)

Characteristics of a good casing:

- Able to release toxic gases during cropping
- Good water holding capacity
- Greater pore space %
- Absence of harmful bacteria.
- pH needs to be just slightly alkaline.
- Should have a suitable decomposition.
- Free of ions and heavy metals.

Treatment of casing soil:

Casing soil is treated with pesticides or pasteurised with steam to destroy numerous pests and disease propagules present in the casing mixture.

1. Chemical treatment of casing mixture :

• Formaldehyde treatment can be used to disinfect casing. The formaldehyde solution is made by combining 2 litres of formalin (4% a.i.) with 40 litres of water to get a solution that is 2% formaldehyde. This solution is used to fully wet the capping mixture before it is covered with a polythene or tarpaulin sheet. The capping material is then formed into a rectangular pile. At least two weeks should pass after the treatment before casing is carried out. In other words, as soon as compost has spawned, casing should be made and treated. When applying the casing mixture to the beds, it must be guaranteed that there are no residues of formalin.

2. Pasteurization of casing mixture:

• Casing can be pasteurised on farms that have equipment for pasteurising compost using steam. Casing soil is placed in trays, which are then layered one over the other in the pasteurisation room, for the pasteurisation of the casing mixture. In order to raise the temperature of the casing mixture to 65–70°C, steam is added. This temperature is then maintained for 6–8 hours. At this temperature, all hazardous microorganisms—including mushroom nematodes—are destroyed. Useful bacteria like Pseudomonas, which aid in the introduction of fruit bodies, are not destroyed by this temperature and can stay there for 7-8 hours. The best outcome is obtained by pasteurising soil in a container.

Why Casing is required:

Casing promotes in the rapid growth of vegetative growth into mushroom. There won't be any mushroom growth if casing isn't done. If mushrooms are growing at all, it is very little. Additionally, casing contributed to the compost's optimum moisture level.

Fruiting

The fruit body initials, which initially appear in the form of pin heads and start growing and gradually develop into button stage, depend on favourable environmental conditions, including temperature (initially 23 2°C for about a week and then 16 °C), moisture (2-3 light sprays per day for moistening the casing layer), humidity (above 85 percent), proper ventilation, and CO2 concentration (0.08-0.15%). Fruiting bodies are gathered by rotating counterclockwise after they reach the right size and shape.

The Strategies and policies for Developing Mushroom Industries in India

(1). At the beginning, the strategy is not to use highly mechanized technologies as in the large mushroom farms in industrialized countries, but to promote cottage style enterprise for the rural poor in thousands of small mushrooms sheds, constructed using locally available materials .

(2). After that, move towards gradual introduction and familiarization of the art of large scale commercial cultivation techniques. This was the path China followed from its humble beginnings to its current status as the world’s leading mushroom production powerhouse.

(3)Increasing awareness about the nutritional and vegetable status of mushrooms and their role in bridging the protein gap and fighting malnutrition through mass and print media in regional languages. Awareness should be created about their medicinal properties like presence of anticancerous substance, their role in diabetes control, heart diseases, hypertension and boosting immune system.

(4). Select appropriate target strains of different mushrooms grown on seasonal basis so that an attempt could be made to obtain yields all year-round.

(5). Make use of existing lignocellulosic residues and waste from agricultural activities and agroindustries.

(6). Create employment opportunities, particularly for women and the youth in rural areas, and control/reduce pollution.

(7). Emphasize quick-investment-return mushrooms, and select relatively fast growing species that can be harvested within 3 to 4 weeks after spawning, thus generating immediate benefits.

(8). Promote mushrooms species demonstrated to generate potent nutriceuticals with superior immune-enhancing attributes: species whose natural products include unique bioactive compounds that can make people healthier and fitter.

(9) Inclusion of mushroom technology in national schemes of government like MANREGA to create rural employment among women and rural youths.

(10) Establishment of dedicated training centres on mushrooms with state of the art facilities for end to end hands on training for cultivation of different mushrooms.

(11) There is a need to establish quality spawn laboratories in the entire country so as to provide healthy and quality spawn to the mushroom growers .

(12) Organized marketing system for mushrooms should be formed at the national level. Formation of cooperative societies at village level should be encouraged.

(13) Mushroom cultivation and processing may be brought under various agricultural subsidies policies of the state government to encourage mushroom farming.

(14) A good number of processing units for mushroom processing may be established in major mushroom producing states of the country.

Conclusion

Mushrooms are incredibly nutrient-dense foods that can be produced from lignocellulosic waste. They now make up a new food category that is expanding most quickly and are increasingly popular with today's health-conscious population. Mushrooms have the ability to transform lignocellulosic waste into a variety of products that benefit people in many ways, such as food, health products, and medicines, animal feed, fertilisers, environmental protection and regeneration, eradicating poverty, promoting human health, and stopping environmental degradation. Another benefit of these initiatives, which can be labor-intensive, is the potential for mushroom farming to create new employment possibilities. Therefore, it can be inferred that materials for composites that will preferentially encourage the growth of the mushroom's mycelium and materials for casing that stimulate the maximal formation of pin heads for fruit body synthesis should be used.

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