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Participant Handbook

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SKILLING CONTENT: PARTICIPANT HANDBOOK

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We also wish to extend our gratitude to all those who have reviewed the content and provided valuable inputs for improving quality and coherence.

This handbook will lead to successful roll out of the skill development initiatives in mushroom cultivation, helping greatly the various stakeholders particularly trainees, trainers and assessors. It is expected that this publication would meet the complete requirements of QP/NOS based training delivery. We welcome the suggestions from users, Industry experts and other stakeholders for any improvement in future.

About this book

This Participant Handbook has been produced as a simple reference for young moderately educated persons interested in mushroom cultivation. It has been observed that most farmers engage in simple activities which they are familiar with like the cultivation of crops and other pulses and vegetables. Most of them are not familiar with mushroom cultivation, that is, they lack knowledge and skills on how and where to grow mushrooms. This handbook is designed to impact the knowledge and skills to those who want to venture into mushroom production.

The objective of this handbook is to provide technical information on the growing of mushrooms to farmers so that they are able to produce mushrooms for subsistence as well as for commercial purposes using their limited resources. It is designed in such a manner that farmers can easily follow the steps for the production of mushrooms. First the handbook gives background on the value of mushrooms. This is then followed by simple production techniques for button and other mushrooms. The last section of the handbook deals with the harvesting, processing and marketing; financial, health and safety related issues of mushrooms. It is our hope that the handbook will help the farmers improve their knowledge and skills of producing mushrooms.

Throughout India, mushrooms have become a popular vegetable due to its culinary appeal as well as a source of vitamins and protein. In addition to their nutritional value, mushroom production is a very profitable enterprise which requires minimum land size. The by- product, spent mushroom compost is a valuable source of organic matter which is used in horticultural crop production.

Crop diversification has been promoted to impart sustainability and enhance farmers' income. People countrywide have started embarking on new agricultural activities to boost their income, amongst which are honeybee, poultry, exotic vegetable and to a lesser extent mushroom production. Land is limited for crops and this is one of the factor contributing to the people's need to look into mushroom which is grown indoors and the environment can be manipulated so that production can be carried out throughout the year.

The objective of this handbook is to provide information on the growing of mushrooms so that young educated farmers are able to produce mushrooms for food as well as selling for extra income using their limited resources. This can be achieved as:-

- Mushrooms are grown indoors and require minimum land size thus do not compete with other horticultural crops
- They can be grown in available rooms, which may be cottages, garages, basements, or any unused rooms at any rural or urban setting.
- Mushroom growing utilizes residues which might otherwise be considered useless, thus it is cheap to produce.
- Due to the short time taken from spawning to harvesting, mushrooms have a quick turnover. In fact in some cases the crop cycle is less than a month.
- Labour is available in rural areas for mushroom related activities and mushroom crop can be run as a part-time activity.
- Raw materials required for the cultivation of mushrooms are easily available in the rural areas.

Symbols Used


Key Learning Outcomes


Summary


Activity


Tips


Notes


Unit Objectives


Exercise

Table of Contents

S.No	Modules and Units	Page No.
1.	**Introduction**	**1**
	Unit 1.1 - Introduction to mushrooms	3
	Unit 1.2 - History of mushroom cultivation and global scenario	11
	Unit 1.3 - Different types of mushrooms under cultivation in India	16
	Unit 1.4 - Some basic terms and equipments used in mushroom cultivation	27
	Unit 1.5 - Steps in mushroom cultivation: spawn-compost-cropping-marketing	30
	Unit 1.6 - About spawn preparation, transport and storage.	34
2.	**Prepare and Pasteurize the Compost (AGR/N7813)**	**38**
	Unit 2.1 - Compost for button mushroom - raw materials, natural and synthetic compost, different formulae	40
	Unit 2.2 - Methods of compost preparation: phase I (wetting, mixing, outdoor aerobic compositing)	46
	Unit 2.3 - Phase II - Conditioning and pasteurization of compost in tunnels	51
	Unit 2.4 - Preparation of substrate for paddy straw mushroom, oyster and milky mushroom	57
	Unit 2.5 - Preparation of substrate for shiitake, king oyster, wood ear mushroom and their cultivation	63
	Unit 2.6 - RTF - Ready to fruit bags for small scale cultivation	72
3.	**Commercially Important Species of Mushroom (AGR/N7814)**	**74**
	Unit 3.1 - Selection of species for round the year cultivation based on climatic conditions and raw materials available	76
	Unit 3.2 - Basic requirements for site selection and starting mushroom cultivation	80
	Unit 3.3 - Farm design for compost and cropping of button mushroom for seasonal and round the year commercial cultivation	82
	Unit 3.4 - Procedure for cultivation of button mushroom	96
	Unit 3.5 - Farm design and procedure for cultivation of other mushrooms	99
4.	**Disease Control and Pest Management (AGR/N7815)**	**107**
	Unit 4.1 - Different types of diseases: Indicator moulds, fungal, bacterial, viral diseases, different insects affecting mushrooms	109
	Unit 4.2 - Methods to prevent diseases, sanitation, their control and cook out after cropping	124
	Unit 4.3 - Organic mushroom cultivation	128
5.	**Harvest and Post-harvest Procedures (AGR/N7816)**	**130**
	Unit 5.1 - Mushroom flushes: How many; how to harvest and pack mushrooms	132
	Unit 5.2 - Sun drying and pickling of mushrooms	138
	Unit 5.3 - Some mushroom recipes	141
	Unit 5.4 - Utilization of spent mushroom substrate	146

Table of Contents

S.No	Modules and Units	Page No.
6.	**Basic Entrepreneurial Activities for Small Enterprise (AGR/N9908)**	148
	Unit 6.1 - Fund generation, financial management and different sources	150
	Unit 6.2 - Project report for spawn lab for button mushroom	158
	Unit 6.3 - Project report for compost unit for button mushroom	173
	Unit 6.4 - Project report for cropping unit for button mushroom	179
	Unit 6.5 - Basic requirements for other mushrooms and project report for oyster /other	185
7.	mushrooms	194
	Health & Safety at the Workplace (AGR/N9903)	196
	Unit 7.1 - Standard operating procedures for cultivation of mushrooms	198
	Unit 7.2 - About health, allergies and basic facilities to workers	200
	Unit 7.3 - Safety practices at work place, precautions against fire and other hazards	202
	Unit 7.4 - Wild mushrooms and mushroom poisoning	205
8.	Unit 7.5 - About medicinal mushrooms and other related top	207
	Employability & Entrepreneurship Skills	211
	Unit 8.1 - Personal strengths & value systems	230
	Unit 8.2 - Digital literacy: a recap	236
	Unit 8.3 - Money matters	247
	Unit 8.4 - Preparing for employment & self employment	256
	Unit 8.5 - Understanding entrepreneurship	278
	Unit 8.6 - Preparing to be an entrepreneur	

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1. Introduction

Unit 1.1 - Introduction to mushrooms
Unit 1.2 - History of mushroom cultivation, national and global scenario
Unit 1.3 - Different types of mushrooms under cultivation in India
Unit 1.4 - Some basic terms and equipment used in mushroom cultivation
Unit 1.5 - Steps in mushroom cultivation: spawn- compost-cropping-marketing
Unit 1.6 -About spawn preparation, transport and storage.

Key Learning Outcomes

At the end of this module, you will be able to:

1. Discuss the benefits of cultivating and consuming mushrooms
2. Know about start of mushroom cultivation and the present scenario in our country and the world
3. Understand different types of mushrooms under cultivation in our country
4. Learn about the terminology and equipment used in mushroom cultivation and the basic steps in cultivation of mushrooms
5. Understand that what is the seed (=spawn) of mushroom, how it is prepared and necessary precautions for its transport and storage

UNIT 1.1: Introduction to Mushrooms

Unit Objectives

At the end of this unit, you will be able to:

1. Learn that what are mushroom and there are how many mushrooms in the world
2. Learn that whether mushrooms are plants or animals
3. Understand the benefits of growing of mushrooms to the farmers and environment
4. Learn about advantages of consuming mushrooms as a health food
5. Understand the medicinal benefits of consuming mushrooms

1.1.1 What are Mushrooms?

Humans have been collecting and consuming mushrooms since long time ago but their cultivation is a recent development. You must have seen mushrooms appearing in the lawns, around heaps of compost and in the fields, on wooden logs, etc after the rains and have wondered that what are these and from where these have come.

Fig 1.1.1 Varieties of mushrooms that are cultivated and consumed

Mushrooms are members of the fungi kingdom. Unlike higher plants, mushrooms do not have chlorophyll which helps plants to use water & carbon dioxide from earth and energy from the sun to make their own food. As mushroom cannot produce their own food, these depend on higher plants for food. Mushrooms obtain nutrients from organic materials like straw, dead wood, manure, dung, etc.

Mushrooms were earlier considered as plants. Now these are classified as a separate kingdom. That is, these are neither plants nor animals. In evolution plants evolved from lower organisms. Soon after that the fungi and animals also got separated (Fig 1.1.2). Plants make their own food. Fungi and animals depend upon other organisms. Cell wall of mushrooms is different from plants and animals. These characters and also the method of their nutrition, growth and reproduction, etc helped the scientists to group all fungi into a separate kingdom.

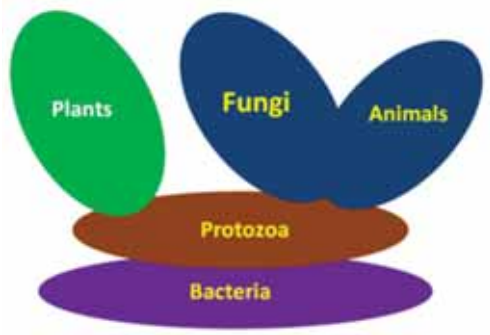


Fig 1.1.2. Evolution of five kingdoms of organisms on earth

There are large number of fungi in the world. An estimate is that that there are 1.5 million fungi. However, we have not been able to study all and scientists have studied only 1.1 lakh fungi out of which 14000 are mushrooms. All mushrooms are not edible. Some are even poisonous. Out of these only 3000 have been considered to be truly edible. However, it is not possible to cultivate all of these. Despite all the efforts it has been possible to cultivate only about 200 species out of which 60-70 are cultivated commercially and about 10 are cultivated on industrial scale.

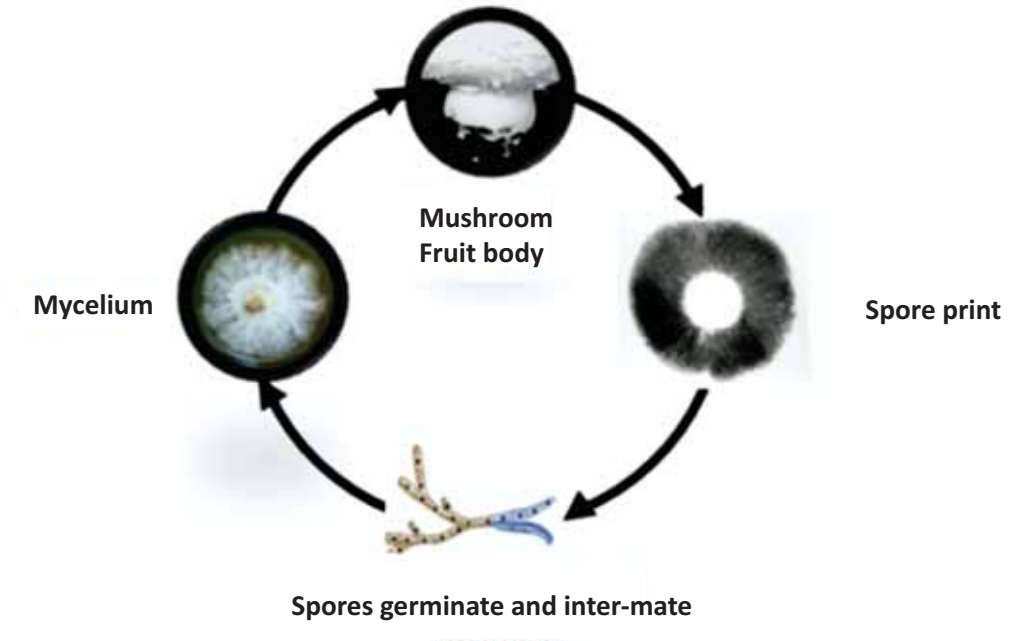


Fig 1.1.3. Life cycle of mushroom- the mushroom fruit body produces spores, that germinate, mate and the mycelium spreads in the soil or wood, etc. During proper season the mycelium turns into fruiting bodies

For most part of the life the fungi exist as thread like structure in the soil, wood, etc (Figure 1.1.3). In fact, one cubic centimetre of soil can have up to 8 miles long thread of fungi. The microscopic threads are called mycelium. These threads unite to form small structures that grow into structures with a cap and stalk, that is, mushroom. Thus mushrooms are nothing but the fruiting bodies of fungi. These fruiting bodies produce spores that help in spread of the fungus. You must have seen black mass of spores wherever fungi grow - on bread pieces, wet wooden pieces or even clothes left unattended for long time.

It must be understood that all fungi are not mushrooms. We also eat many fungi other than mushrooms. For example, any fermented food has yeast and yeast is a fungus. Many fungi are source of medicines. One of the first antibiotic to be developed from a fungus was penicillin. There are number of fungi that help trees to grow. In fact, without their association, many forest trees will have no or very less growth. Many fungi cause diseases in plants and animals. In this book we will be dealing only with useful fungi and that also only edible mushrooms.

1.1.2 Why to Grow Mushrooms?

In nineteenth century, we could produce food only for our survival. In the last century, we produced adequate food in many parts of the world and convenience was an important aspect. For example, the ready-to-cook, ready-to-eat foods were commonly available. The 21st century is going to be a century of functional foods, that is, the foods that not only meet our calorie needs but also have compounds beneficial for our health. Mushrooms fit into this category very well as we will see when we read about why to eat mushrooms.

Mushrooms are not only a quality food but also a way of utilizing agricultural wastes and generating wealth from the waste. The material left after growing mushrooms, commonly referred as spent mushroom substrate, can be processed into manure. Thus, mushroom cultivation is an important method to promote sustainable manure based farming. Addition of spent mushroom substrate is also reported to improve the soil health. The very fact that mushrooms can be cultivated on paddy straw and number of other agricultural wastes, many of which are just burnt, is sufficient reason to grow mushrooms. By growing mushrooms, we are not only creating a quality food but are also generating a healthy environment. More importantly, it leads to employment generation and women empowerment. With increasing population the land is shrinking and mushroom cultivation utilizes vertical space and requires minimal land making it possible to promote mushrooms in peri-urban and urban areas also. Mushrooms are considered to be the highest protein producers per unit area per unit time. To summarize:

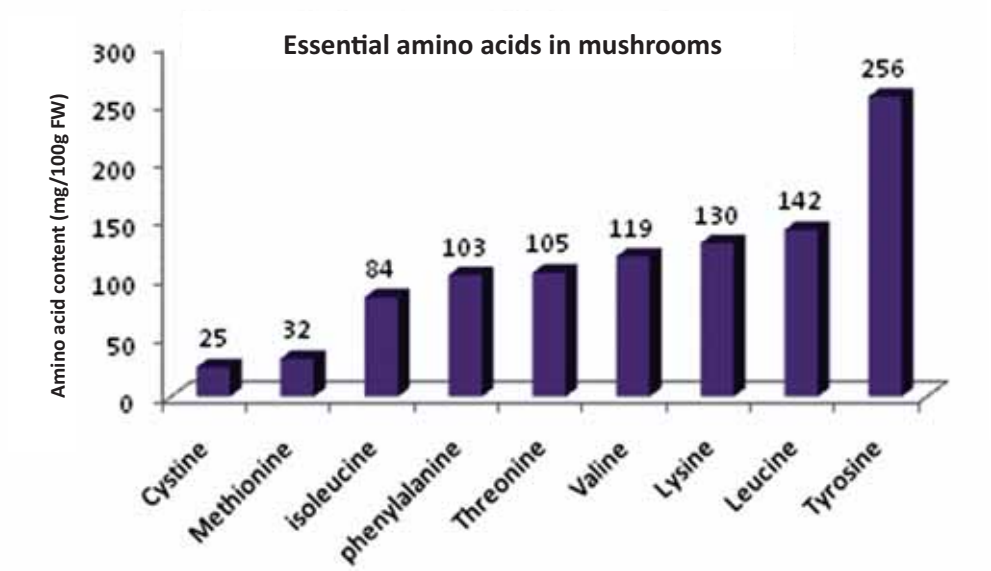
- Wastes like cereal straw are burnt by farmers, which cause air pollution and these can be used to grow mushrooms, which means we not only create wealth from the waste but also are reducing environmental pollution.
- Mushroom cultivation requires labour in addition to agricultural wastes. This creates employment for farmers (during lean season), women and school dropouts and other people interested in secondary agriculture. As everyone may not be able to grow mushrooms, so growing mushrooms may also add to the status.
- Mushroom is a cash crop and can add to the income of the farmers. Moreover, the cultivation of mushrooms can be integrated with the existing farming systems.
- Mushrooms are a quality food and their cultivation does not require much of land. These can even be grown in houses in urban and peri-urban areas.

1.1.3 Why to Eat Mushrooms?

In early days' mushrooms were collected from the forests and were considered as a delicacy and in some civilizations these were considered as the food for the kings. After cultivation of mushrooms, these have become available to all in large amounts. It has been realized that these are a quality food having health benefits. In fact, mushrooms are among the best vegetarian food available.

Mushrooms are a rich protein source having essential amino-acids and high digestibility. Mushrooms have all the nine essential amino acids required by human being (Fig 1.1.4.). Mushrooms have approximately two times more protein than in vegetables and 4-12 times protein than in fruits. Considering that number of people suffer from malnutrition, mushrooms can be an important way to combat this problem.

Mushrooms Contain All Nine Essential Amino Acids

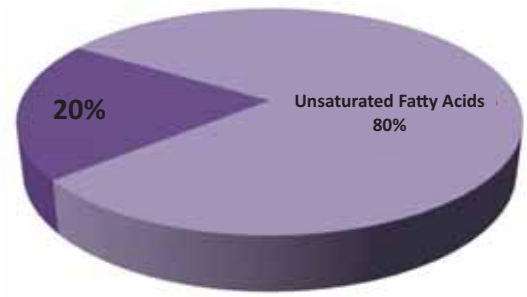


Content in *A. bisporus, L. edodes, Pleurotus* spp varies by 10%

Fig 1.1.4. Essential amino acids in mushrooms

Mushrooms are also good for heart as they have got low fat, no cholesterol, has more of unsaturated fatty acids (Fig 1.1.5) and some of the mushrooms have compounds like lovastatin that is known to lower the cholesterol in the blood. Moreover, mushrooms have low-sodium and high potassium content making it a suitable food for persons suffering from high blood pressure.

80% of the fatty acids in edible mushrooms are unsaturated



Content in *A. bisporus, L. edodes, Pleurotus* spp varies by 1%

Fig 1.1.5. Proportion of saturated and unsaturated fatty acids in mushrooms

The mushrooms are also considered delight of diabetics as it is a low calorie food with no starch and has also number of anti-oxidants. These are also rich in fibers and are also a very good source of Vitamins especially vitamin B complex. Mushrooms are the only vegetarian source of vitamin D (Figure 1.1.6). These are also rich in minerals, which also include copper (heart-protective) and selenium (anti-cancer).

Exposing mushrooms to UV light for one hour increased Vit D content 100 times

Fig 1.1.6. Mushrooms as a source of Vitamin D

Many of the mushrooms are known to have anti-viral properties and their consumption activates the immune system of the human body. Compounds from number of mushrooms have found applications in cancer research and number of them have been found to reduce the side effects of radio-therapy and chemotherapy. The benefits have been summarized in Table 1.1.1. Thus, it is important to grow mushrooms and eat mushrooms.

Table 1.1.1. The characteristics and benefits of mushrooms

CHARACTERISTICS	BENEFITS
High quality protein	Combats malnutrition
Low Sodium high Potassium	Controls hypertension
No Starch, low sugars	Delight of diabetics
No Cholesterol	Healthy heart
Rich in Fibre	Improves digestion
only vegetable with vit D	Cures Ricketsia
Folic acid. Vit B & minerals	Anit oxidant
Low calorie food	Reduces obesity
Selenium	Anti cancer property
Beta glucan and Terpenes	Improves immunity, liver

Tips

Are Mushrooms A Vegetarian Food?

- You have seen that mushrooms are neither plant nor animal, but are fungi.
- But these are cooked and consumed just like any other vegetable.
- All vegetarians eat lot of fungi. All the fermented foods like Idli, dosa, bread and number of other products vegetarians consume daily are rich in Fungi.
- Thus it is perfectly all right for a vegetarian to eat mushroom and treat mushroom like any other vegetable

Exercise

1. Why mushrooms cannot make their own food?

Ans:_____

_____

_____

2. Name the six most important mushrooms.

Ans:_____

_____

_____

3. Given below are pictures of six mushrooms (Shiitake, Oyster mushroom, Button mushroom, Wood ear mushroom, Paddy straw mushroom, Winter/bottle mushroom and Milky mushroom). Identify each of these. (For example first picture is of Paddy straw mushroom)

No	Answer	
a	Paddy Straw Mushroom	
b		

c		
d		
e		
f		
g		

4 . What are the two main advantages of growing mushrooms?

Ans:_____

_____

_____

5. What is the vitamin that is present in mushroom but is not found in any other vegetable?

Ans:_____

_____

_____

Notes

UNIT 1.2: History of Mushroom Cultivation and Global Scenario

Unit Objectives

At the end of this unit, you will be able to:

1. Learn when humans started experimenting with cultivation of mushrooms
2. Learn when actual cultivation started on scientific lines
3. Learn when the mushroom cultivation started attaining commercial scale
4. Understand what were the species under cultivation in different parts at early stages and how the diversification in mushroom species and their production has occurred in last few decades?
5. Lean when mushroom cultivation started in India, what are the different species under cultivation in our country

1.2.1 History

The prehistoric man, whose survival was based on hunting and gathering different products from the forests, must have observed mushrooms appearing from nowhere after rains on wood, land and other places and collected these and learnt to use them as food. There are evidences to show that the great early civilizations of the Greeks, Egyptians, Romans, Chinese, and Mexicans prized mushrooms as a delicacy, appreciated mushrooms for their therapeutic nature and, in some cases, used them in religious rites.

Even though man started growing crops more than 10,000 years ago, the cultivation of mushrooms is a relatively new phenomenon. There are reports of success in cultivation of mushrooms like *Auricularia* (600 AD), *Flammulina* (800-900 AD), *Lentinula* (1000–1100 AD) and *Volvariella volvacea* (1700 AD) in China; *Agaricus bisporus* in France in 1650, and *Pleurotus* in 1900 in USA (Figure 1.2.1). All these six species contribute maximum to world mushroom production today. The scientific approach to their cultivation started only in the beginning of the 20th century when it became possible to prepare pure culture by germinating spores or from tissues. These researches paved way for development of pure culture spawn. Thereafter, there were many changes like selection of white strain of *Agaricus* in America in 1926 by Lambert, development of grain spawn by Sinden in 1932, studies on compost by various workers that lead to development of short method of composting. We will learn about it in detail in subsequent module.

Table 1.2.1. Attempts on mushroom cultivation before 20th century

Mushroom cultivation- beginning		
Auricularia (Wood Ear Mush.)	600 AD	China
Flammulina (Enokitake)	800-900 AD	China
Lentinula (Shiitake)	1000-1100 AD	China
Agaricus (Button Mushroom)	1650 AD	France
Volvariella (Paddy straw Mush.)	1700 AD	China
Pleurotus aesteratus	1900 AD	America

Scientific cultivation started in last century.

Large scale cultivation after world war II.

1.2.2 Global Scenario

Even though button mushroom was being cultivated in France, USA, etc and was emerging as the dominant species representing mushrooms in West, there was work going on in East where pure culture of shiitake was made and inoculation techniques were developed. The information generated in the first half of 20th century paved way for large scale cultivation of mushrooms that essentially started after World War II both in West and East. In the beginning the focus was on button mushroom in West and shiitake in the East. Last few decades have witnessed a sharp rise in diversification in number of mushroom species that have been cultivated, world mushroom production, commercialisation accompanied with mechanisation and in many cases automation.

In first part of the 20th century the mushroom production at the global scale was very less. USA and Europe was focusing on button mushroom only whereas in Japan, China, etc, the focus was on shiitake, *Auricularia*, etc. Button mushroom was the dominant mushroom and formed the major component of global mushroom production. The mushroom production picked up only after World War II. The production of button mushroom was very less prior to 1950.

Today mushrooms are cultivated in more than 100 countries. The world mushroom production was only 0.17 million tonne in 1960 which at present must be more than 40 million tonne (Fig 1.2.2). This means that in last five decades the production has increased by more than 200 times. The growth was slow in earlier years and has picked up in the last two decades. One wonders how long this pattern will continue. It is estimated that it may reach 100 million tonnes or so by 2050 which will mean that on an average there will be 10 kg mushroom available to each person.

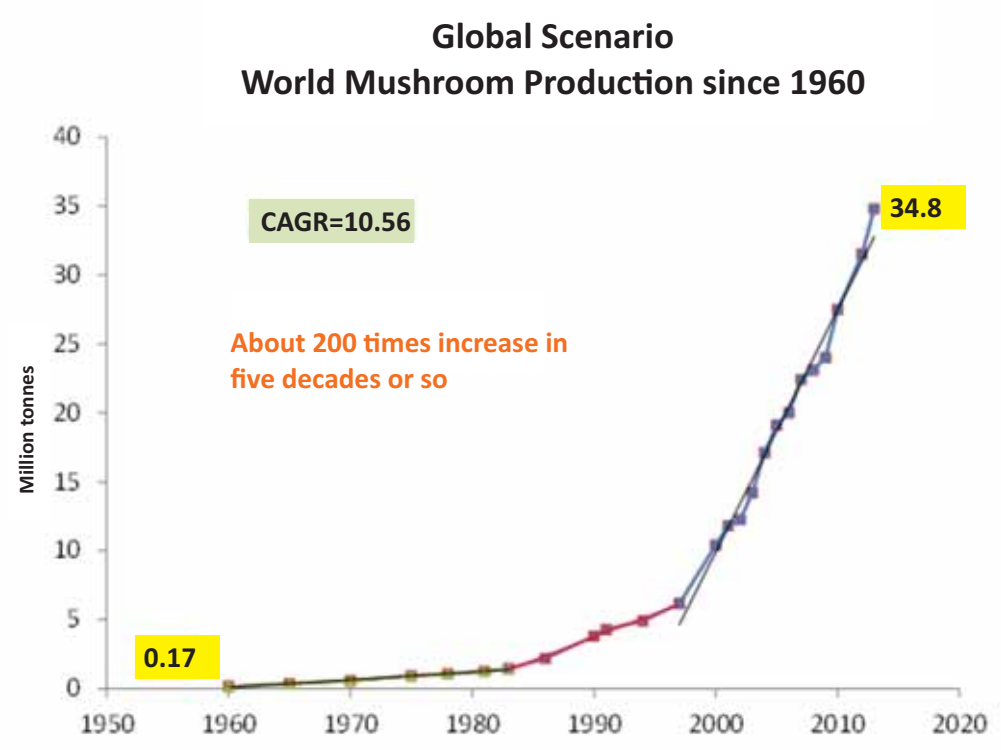


Fig 1.2.2. World mushroom production (1960-2013)

Relative contribution of mushroom in different countries

Mushroom had a different meaning in different parts of the world

	Button (%)	Shiitake (%)	Oyster (%)	Others (%)
US	98	1	0.9	0.1
Spain	80	15	5	0
China	9	25	15	51
Japan	0	11	2	87

Button was major mushroom in USA, Canda, Europe, Australia.By 2002 more than 99% of mushrooms other than button were cultivated in Asia only

Fig 1.2.3. Mushroom species under cultivation in different countries

Even though about 60 types of mushrooms are cultivated in different parts of the world, only six types of mushrooms account for 90 Percent of the world mushroom production (Figure 1.2.4). In 1950 when mushroom production was low, button was about 80 percent of world mushroom production, shiitake contributed 15 % and others were only 5%. Over decades there has been increase in production of button, but the production of other mushrooms has been much more as a result of which the relative contribution of button in world production is only 15% and it is no more world's number one mushroom. At present Shiitake is number one. It is however, not cultivated in our country though many growers have started showing interest. The technology for its cultivation is available.

Relative contribution of different species-2004

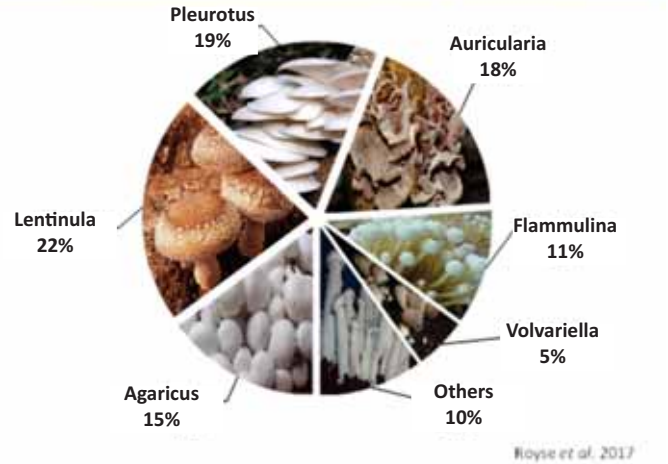


Fig 1.2.4. Relative contribution of different mushrooms to world mushroom production

At present China contributes about 87% of the world mushroom production. But it was not always so. Before 1970 there was very little production and even in 1978 the production of China was only 60,000 tonnes which is half of what we produce today (Fig 1.2.5). But in last four decades there has been sharp increase in mushroom production in China and now China produces about 36 million tonnes of mushrooms. There has been increase in number of species and at present about 60 species are cultivated. Till late the cultivation in China was done by small growers by growing mushrooms under natural conditions. In contrast to this mushroom cultivation in USA, Europe and Japan is mostly under controlled conditions.

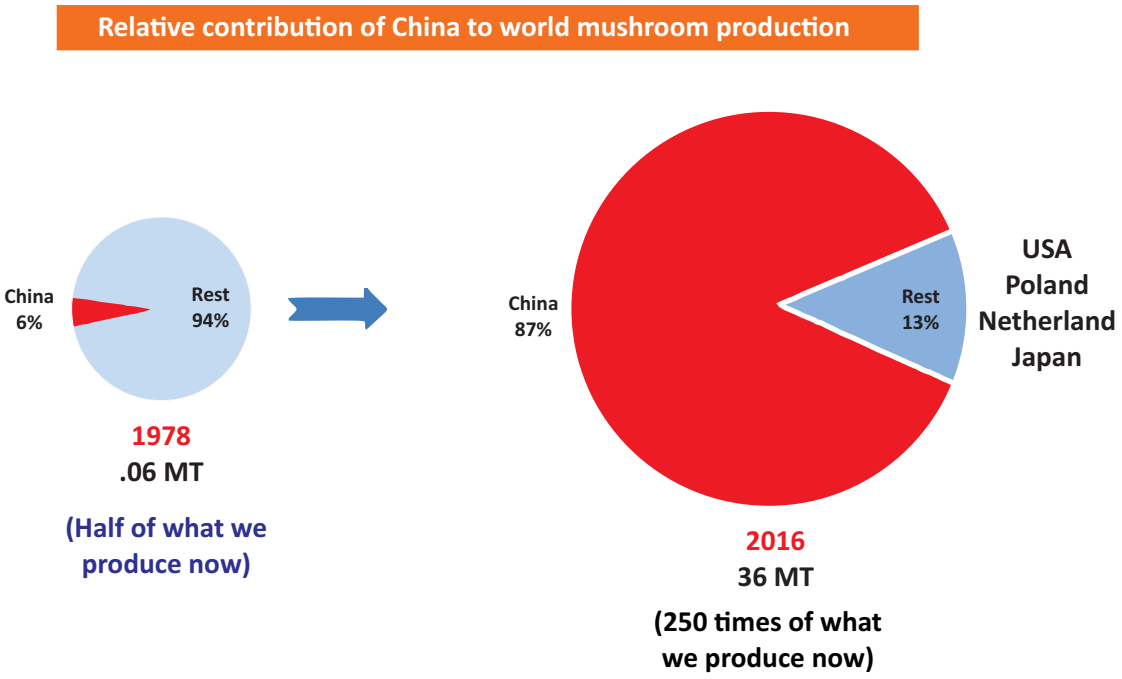


Fig 1.2.5. Changes in relative contribution to world mushroom production

In 1980 the cultivated mushroom available in China was similar to that available to us today, that is about 80 grams per person per year. Today, a Chinese eats on an average about 22 kg mushroom per year (Fig 1.2.6). Mushroom is an essential part of menu and has replaced meat to some extent.

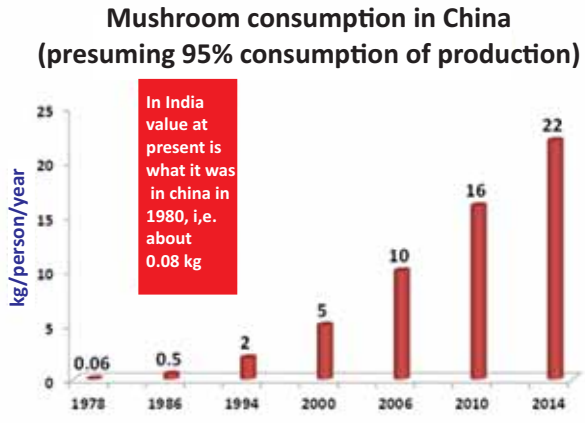


Fig 1.2.6. Changes in mushroom availability per person in China

Tips

- Cultivation of mushrooms picked up only after world war II
- Even though it is possible to cultivate 100s of mushroom species, but on global scale only six types contribute towards 90% of world mushroom production
- Different mushrooms are popular in different countries; Button is more popular in USA and Europe whereas shiitake, oyster and wood ear mushroom are more popular in East, particularly China, Japan and Korea

Exercise

1. Name the six important mushroom contributing 90% towards world mushroom production?

Ans:_____

_____

_____

2. Out of these six mushrooms which were cultivated outside China?

Ans:_____

_____

_____

3. How much mushroom is consumed by one person in India and China?

Ans:_____

_____

_____

4. Which mushroom is having maximum production in the world?

Ans:_____

_____

_____

Notes

_____

_____

_____

_____

_____

_____

UNIT 1.3: Different types of Mushrooms Under Cultivation in India

Unit Objectives

At the end of this unit, you will be able to:

1. Know when mushroom cultivation started in our country
2. Learn about the different mushrooms whose cultivation technology is available in our country
3. Know what are the different types of mushrooms under cultivation?
4. Know the regions within the country where these are cultivated and their relative contribution to total mushroom production in the country

1.3.1 History

Cultivation of button mushroom started in mid 60s in hilly region of Himachal and J& K. At present the mushroom production systems in our country are mixed type i.e. both seasonal farming as well as high-tech industry. Mushroom production in the country started in the 70s but growth rate, both in terms of productivity as well as production has been phenomenal. In seventies and eighties button mushroom was grown as a seasonal crop in hills, but with the development of the technologies for environmental controls and increased understanding of the cropping systems, mushroom production shot up from mere 5000 tonnes in 1990 to over 1,00,000 tonnes in 2010. Today, commercially grown species are button and oyster mushrooms, followed by other tropical mushrooms like paddy straw mushroom, milky mushroom, etc. The concentrated areas of production in India are the temperate regions for the button mushroom, tropical and sub-tropical regions for oyster, milky, paddy straw and other tropical mushrooms. Two to three crops of button mushroom are grown seasonally in temperate regions with minor adjustments of temperature in the growing rooms; while one crop of button mushroom is raised in North Western plains of India seasonally. Oyster, paddy straw and milky mushrooms are grown seasonally in the tropical/sub-tropical areas from April to October. The areas where these mushrooms are popularly grown are Orissa, Maharashtra, Tamil Nadu, Kerala, Andhra Pradesh, Karnataka and North Eastern region of India. Some commercial units are already in operation located in different regions of our country and producing the quality mushrooms for export. The present production of white button mushroom is about 85% of the total production of mushrooms in the country.

1.3.2 Mushrooms Suitable for Cultivation in India

Even though only few mushrooms have been cultivated by farmers in our country, the technology of large number of mushrooms has been evaluated. Till now more than 20 types of mushrooms have been cultivated in our country mainly at Directorate of Mushroom research Solan (Fig 1.3.1).

Fig 1.3.1. Species experimentally cultivated in india

We have varieties suitable for low temperature, medium temperature and high temperature. Before we talk about the status of mushroom cultivation in our country, let us see the various mushrooms available for different climatic conditions (Table 1.3.1).

Table 1.3.1. Mushrooms suitable for different climatic conditions

Climate	Mushroom suitable for cultivation
Temperate (10-20°C)	Button mushroom Oyster mushroom Winter mushroom Shiitake
Sub-tropical (20-30°C)	Summer button Oyster (Summer species) Wood ear mushroom Shiitake (summer variety)
Tropical (30-40°C)	Milky mushroom Paddy straw mushroom

1.3.2.1 Temperate Mushrooms

1. Button Mushroom

The button mushroom is most popular variety in our country (Fig 1.3.2). The major production is from Hi tech Projects. However, Hi tech projects faced several problems in successful production resulting in high cost of production. The main problems are diseases and quality of raw materials particularly, wheat/paddy straw, chicken manure and sometimes gypsum resulting in poor quality of compost and poor yield. Besides, high cost of imported cultures/ spawn, machineries and casing material are other impediments. In recent years even increasing cost of electricity has given severe blow to the mushroom industry. Several medium scale projects have started growing mushroom targeting big city markets utilizing indigenous machinery and equipment. However, during winter season hundreds of seasonal growers undertake button mushroom production particularly in Northern States targeting big cities like Delhi, Chandigarh, etc.

Fig 1.3.2. Button mushroom

Advantages

There are good opportunities in India both for domestic and export market for button mushroom.

I. Seasonal production is possible in big way in Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttaranchal, Bihar, West Bengal, North Eastern Region, Madhya Pradesh and other areas where temperature remains below 20°C during winter season. In this situation cost of production is low.

ii. Raw materials like wheat straw/ paddy straw, chicken manure are easily and cheaply available for making compost.

iii. Demand in the local markets is increasing due to increasing awareness about food and medicinal values of mushrooms and changes in food habits

iv. There is good market for post harvest products like pickle and soup powder.

Limitations

I. High cost of energy for year round production.

ii. Un-organized production and sale particularly by seasonal farmers.

iii. Lack of facilities to produce quality compost, casing material, spawn and processed products.

2. Oyster Mushroom

This mushroom has species suitable for both temperate and sub-tropical regions for temperate region *Pleurotus ostreatus*, and *P. fossulatus* (Kabul dhingri), *P. eryngii* (King oyster) (Figure 1.3.3) are ideal. The areas suitable for button mushroom are equally suitable for the cultivation of these species. Oyster mushroom can be easily sun-dried and hence shelf life is not an issue.

Advantages

I. It can be grown on wide range of agricultural wastes.

ii. It can grow in wide range of temperatures.

iii. Its conversion rate i.e. fresh mushroom production from the dry substrate is high (BE up to 100%, that is, 100 kg fresh mushroom from 100 kg dry straw).

iv. It is less prone to diseases and competitor moulds than other mushrooms.

v. Faster growth rate and simple and low cost cultivation technology.

vi. Suitable for rural areas and can create self employment.

vii. Easy post harvest processing particularly dehydration/sun drying.

Limitations

I. Spore allergy to certain people.

ii. Lack of sporeless commercial strain.

iii. Limited consumer demand in some parts of the country.

Fig 1.3.3. King oyster mushroom

3. Shiitake

This is one of the most popular mushrooms both as food and medicine (Fig 1.3.4). At global level it is number one mushroom. In India, its cultivation is negligible. Only some parts in North-East are attempting its cultivation, even though it occurs naturally in that part of the country and is collected and consumed by local inhabitants. However, experiments show that shiitake can be successfully grown on saw dust when temperature is about 18-20° C. There is good scope for the cultivation of this species in our country. This may become a popular variety in domestic market and has good potential for export.

Fig 1.3.4. Shiitake mushroom

4. Winter mushroom *(Flammulina velutipes)*

Flammulina velutipes, commonly referred as winter mushroom, is popular in East Asian countries and is known for its nutritional and medicinal value (Fig 1.3.5). It can be cultivated on saw dust of broad leaves supplemented with 10% wheat bran. This is a temperate mushroom fruiting in the temperature range of 10-14°C. This mushroom can be grown in variety of containers.

Fig 1.3.5. Flammulina velutipes

1.3.2.2 Sub-Tropical Mushrooms

1. Summer white button mushroom

This variety also belongs to genus *Agaricus - A. bitorquis*. Since it grows well in temperature up to 24°C, it is suitable for cultivation in subtropical region. However, it is sensitive to false truffle disease due to its production at higher temperature and thus the perfect pasteurization of compost and casing material is a must.

2. Oyster mushroom

Most of the oyster mushroom species are subtropical in nature and grow well in temperature range of 20-30°C. The most popular ones are *P. sajor-caju (*Fig 1.3.6), *P. flordia, P. flabellatus, P. eous.* These varieties particularly *P. florida* and *P. sajor-caju* are most popular in the country.

Fig 1.3.6. Pleurotus sajor-caju

3. Shiitake

There are strains of *Lentinula edodes* which can be grown in temperature range up to 24-25°C. Hence ideal in subtropical areas.

4. Wood ear mushroom

This mushroom (*Auricularia*) is fourth most popular mushroom in the world (Fig 1.3.7). It is collected and consumed in many states of North-East region of our country but this mushroom is not yet cultivated in India even though cultivation technology for this mushroom was standardized at this Directorate of Mushroom Research Solan in 1986. There is tremendous scope for its cultivation in temperature range of 20-30°C. It is considered good for health particularly for stomach and is consumed extensively in China

Fig 1.3.7. Wood ear mushroom

1.3.2.3 Tropical Mushrooms

1. Milky mushroom *(Calocybe indica)*

This is indigenous tropical mushroom most suitable for tropical regions (Fig 1.3.8 &9). At present this variety is being commercially cultivated in South India (Tamil Nadu, A.P. and Karnataka). Recently its production has started in North India.

i. It can be grown on wide range of agricultural wastes.

ii. It grows on higher temperature range (30-35°C).

iii. Attractive white mushroom with excellent keeping quality.

iv. Its conversion rate (BE) is very high (about 100%).

v. It is suitable for pickling and chutney.

Fig 1.3.8. Milky mushroom

Fig 1.3.9. Low cost structure for milky mushroom

2. Paddy straw mushroom *(Volvariella* spp.*)*

This variety is most popular for its taste and flavour in South East and far East Asian countries. Its flavour is excellent and cropping cycle is short. However, this variety has low yield and poor keeping quality. In India, its cultivation is restricted to Odisha state (Figure 1.3.10 & 11). It can be grown in temperature range of 25-40°C. Pasteurized paddy straw substrate supplemented with cotton seed hulls gives better productivity.

Fig 1.3.10. Paddy straw mushroom

Fig 1.3.11. Outdoor cultivation of paddy straw mushroom

India has tremendous potential for mushroom production and all commercial edible and medicinal mushrooms can be grown. To be successful in both domestic and export market it is essential to produce quality fresh mushrooms and processed products devoid of pesticide residues and at competitive rate. It is also important to commercially utilise the compost left after cultivation for making manure, vermi compost, briquettes, etc. for additional income and total recycling of agro-wastes.

1.3.3 Mushrooms Under Cultivation at Present

In India, we cultivate mainly four types of mushrooms viz., button, oyster, paddy straw and milky mushroom (Fig 1.3.12). Button mushroom is cultivated under both controlled conditions and as a seasonal activity. Other mushrooms are cultivated as seasonal activity. Button mushroom is cultivated in North India, Maharashtra, Gujarat and several other parts of India. Oyster is more popular in North East and also in other tropical and sub tropical parts of the country. Paddy straw mushroom is popular in coastal region of Odisha. This mushroom is cultivated almost throughout the year and possibly the only mushroom that is cultivated outdoors under shade of the trees. Cultivation of milky mushroom was initially confined to Southern parts of India and now it is spreading in North of the country (Fig 1.3.13).

Button Mushroom

Milky Mushroom

Oyster Mushroom

Paddy Straw Mushroom

Fig 1.3.12. Mushrooms under cultivation in India

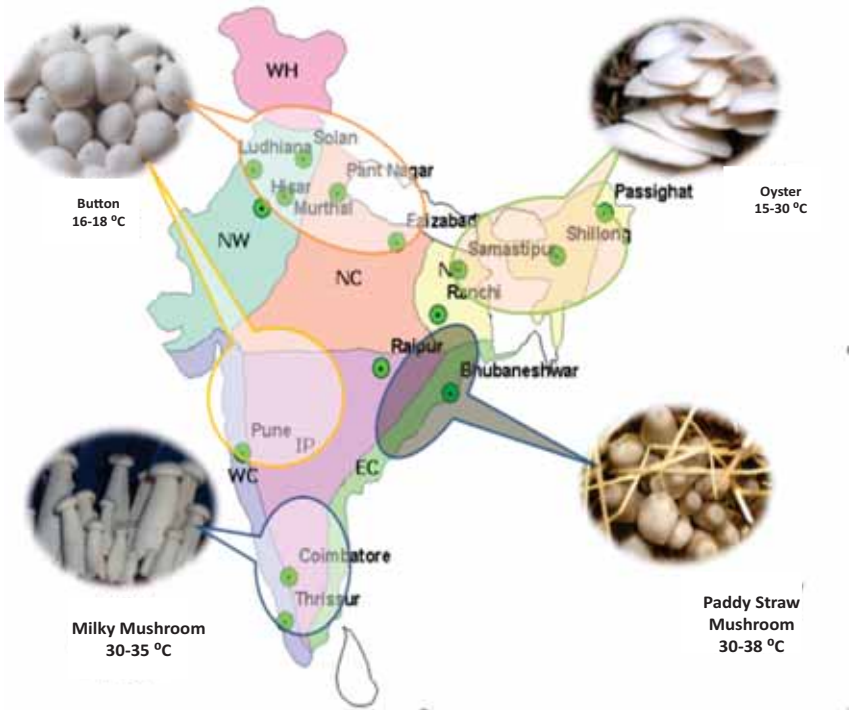
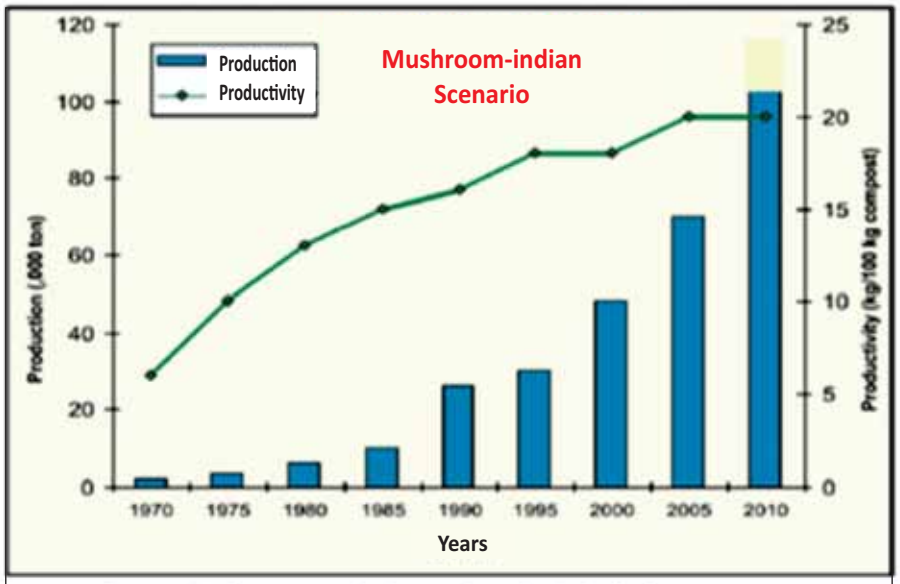


Fig 1.3.13. Major areas of cultivation of different mushrooms in india

The total estimated mushroom production in the country is around 1.3 lakh tonnes. Some of the mushrooms like truffles, morels, etc., are still collected from forests. Major contribution is by button mushroom followed by paddy straw mushroom (Fig 1.3.13).



Button Mushroom production and productivity in the country

Button	Oysyer	Milky	Paddy Straw, etc	Total Production
95,000	21,000	3,000	11,000	1,30,000

Fig 1.3.14. Production of different mushrooms in India

Exercise

1. Which is the most popular mushroom in Odisha?

Ans:_____

_____

_____

2. Which mushroom is cultivated outdoor in India?

Ans:_____

_____

_____

3. Which mushroom is having maximum production in our country?

Ans:_____

_____

4 . Which mushroom is India's contribution to the world?

Ans:_____

_____

_____

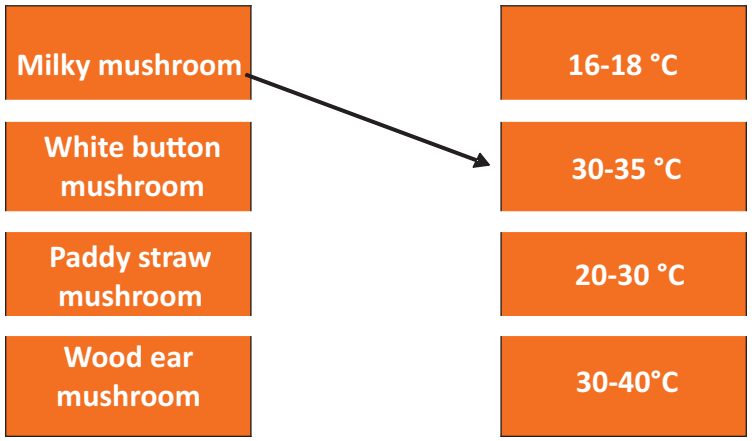
5. Maximum number of species of which mushroom are cultivated?

Ans:_____

_____

_____

6. Match the following with the suitable temperature range of fruiting (Hint ; Milky mushroom at 30-35°C):



Notes

UNIT 1.4: Some Basic Terms Used in Mushroom Cultivation

Unit Objectives

At the end of this unit, you will be able to:

1. Learn the meaning of commonly used words
2. Learn about some other terms used in mushroom literature

1.4.1 Some Commonly Used Terms

Every subject has some unique words. For example, when we talk to lawyers, doctors and other professionals, they commonly use some words which are not part of our vocabulary. Same is true for mushrooms. It is important to understand some of the words that will keep on coming again and again. For example, words like spawn, substrate, spawn run, casing, flush are used frequently in any book on mushrooms.

When we start it takes time to understand that spawn means the seed of mushroom, substrate is to mushroom what soil is to plants, that is any medium on which we grow mushroom. Casing soil is nothing but a mixture of soil and other materials used to cover the bags after the seed has grown inside the substrate. The spread of threads (hyphae) of spawn in the substrate is called spawn run. Mushrooms don't appear only once. After one harvest, these grow again on the same bags. These are referred as different flushes of mushrooms. Here are some the common terms you may come across while reading a book on mushrooms.

Actinomyces: Beneficial heat loving organisms that indicate a well made compost

Agar: A polysaccharide derived from sea weed used for solidifying culture media.

Agaricus bisporus: White button mushroom

AHU: Air Handling Unit, a system installed in cropping rooms for cooling, humidification and fresh air intake and air circulation

Aerobic: In presence of oxygen/fresh air

Anaerobic: In absence if oxygen/fresh air

Ascomycetes: A major class of fungi having sac like ascus in the fruit bodies

Auricularia : Technical name for wood ear mushroom

Bagasse: The crushed juiceless remains of sugarcane as it come from the mill.

Basidiomycetes: A major class of fungi having basidia in their gills.

Bioremediation: The process of correcting some harmful situations like polluted water, soils with harmful pesticides, dyes, etc. by using biological method

Bran: The outer layer of cereal grains separated from the kernel.

Casing: A layer of material, usually soil or peat mass or coir pith, placed on the surface of a substrate to regulate the humidity of the compost and to stimulate production of mushrooms.

Conditioning: Driving off the remaining ammonia from prepared compost at specific controlled temperature.

Culture: The growing of mushroom tissue in a medium under sterile conditions.

Flush – Term used for appearance of mushroom at intervals. A cropping cycle of mushrooms, from the moment they pop their heads above the casing.

Fruit body: The sexual spore bearing structure of fungi, that is Mushroom.

Fruiting: The process of mushroom formation and development

Functional food: Foods for special health use.

Gills: Spore bearing thin blades on the underside of mushroom cap.

Grain spawn – sterile grain inoculated with mushroom spores. The mycelium sprouts from the spores and retrieves food from the grain.

Lentinula edodes: Shiitake, a Japanese common name where shii refers to the tree and take means mushroom

Manual harvesting – pickers harvest the mushrooms by hand.

Mushroom: A macro fungus with visible fruit body that may be formed above or below the ground.

Mycelium – the fungal threads (comparable to plant roots) that appears as a network of white filaments which join together to form pinheads which develop into mushrooms.

Pasteurization: The removal of all inserts, pests, nematodes, harmful fungi and their spores

Pinhead: Very small initial of mushroom on casing soil

Phase-I: The initial steps in composting performed outdoors or in bunkers for button mushroom cultivation .

Phase-II: The process of composting inside tunnels for conditioning and pasteurization of compost of button mushroom.

***Pleurotus*:** Oyster mushrooms. There are number of species of pleurotus which differ in color, shape, etc

Spawn run: In the compost that has been mixed with grain spawn, the mycelium spreads in the compost and this is called spawn run.

Spawning: This is the process by which the spawn is introduced is mixed with ready compost. It is usually conducted in a separate room to avoid infection by other fungi and insects.

Spores – miniscule mushroom 'seeds' that are kept safe in the brown gills under the cap of the mushroom (almost impossible to see with the naked eye).

Stoma: A dense proliferation of mycelium forming on the surface of the compost and casing soil indicates vegetative and therefore non-fruiting growth.

Substrate: The material, usually organic, on which mushrooms grow.

Volvariella volvacea: Technical name for padddy straw mushrooms that grows at high temperature range of 30-40°C

Exercise

1. Complete the following (Hint given for first question)

1. Seed of mushroom is called	Spawn
2. Process of putting a layer of soil after spread of mycelium is called	
3. Process of compositing before putting in tunnel is commonly called	
4. Process of compositing inside tunnel if called	
5. The fungal thread that spread in compost is called	
6. The common name of *Lentinula edodes* is	
7. Common name of *Agaricus bisporus* is	

Ans:_____

_____

_____

Notes

UNIT 1.5: Steps in Mushroom Cultivation: Spawn-Compost Cropping-Marketing

Unit Objectives

At the end of this unit, you will be able to:

1. Understand different steps in mushroom cultivation
2. Know about different methods of spawning
3. Understand different methods of making substrate as per mushroom
4. Understand mushroom classification based on use: edible, supplement and medicinal
5. Know about types of mushroom suitable for cultivation in our country

1.5.1 Steps in Mushroom Cultivation

Mushroom growing requires proper knowledge of various steps of cultivation like spawn production, composting, cultivation and processing. Due to their short shelf life, it is important to understand marketing aspects as well.

Fig 1.5.1 Steps in mushroom cultivation

Cultivation technology is different for different mushrooms. However the basics steps are the same (Fig 1.5.1).

The first step before starting cultivation after acquiring complete knowledge is to procure spawn of good quality.

The next step is to prepare the compost of good quality. As we will see in subsequent chapters that method of preparing compost differs with the type of mushroom to be cultivated. Broadly it can be categorized into three categories: Composting of the materials, pasteurization of substrate using natural heat, steam or chemicals without compositing, and sterilization of the substrate by autoclaving (Fig 1.5.2).

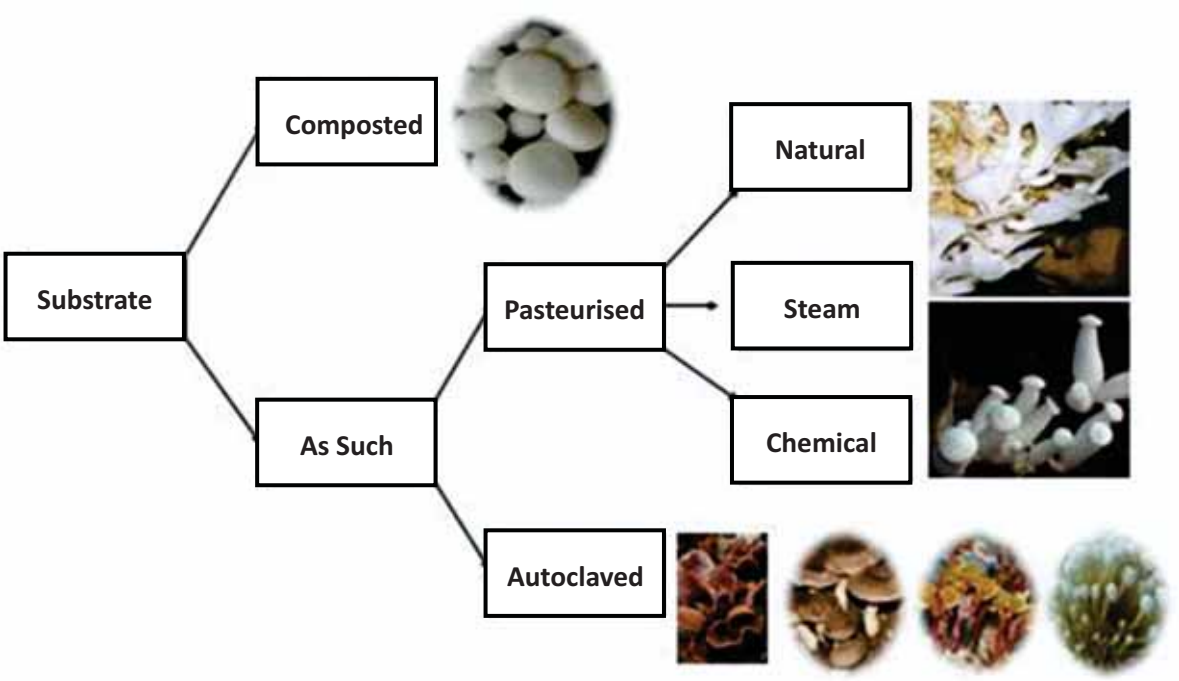


Fig 1.5.2. Different methods of preparing the substrate depending upon the mushroom

- Method of spawning, that is mixing of spawn in compost, will also vary. Firstly, the amount of spawn required will be different. For example, for 100 kg of compost in button we will need only half kg of spawn, where as in oyster we may need 2.5 kg and in milky mushroom we may require up to 5 kg spawn. The method of spawning will also vary. In some cases, it may be mixed thoroughly whereas in other cases it may be put layer wise. Further, spawning in some cases can be done in open under hygenic conditions whereas in other cases, particularly where the substrate has been autoclaved the spawning can be done only under sterile conditions before the laminar flow.
- Cropping method will also vary with mushroom. The first step is spawn run, that is allowing the fungus to spread throughout the substrate. In some cases, it is required to put a layer of casing material whereas in other cases fruiting can be obtained as such. In all cases, to induce fruiting some sort of change is required. For example in case of button mushroom temperature is lowered from 25 to 17 °C and carbon dioxide levels are lowered by giving fresh air. Carbon dioxide levels are measured as ppm, that is parts per million. Normal air has about 400 ppm of carbon dioxide.

- When we keep the room closed for spawn run in button mushroom the carbon dioxide levels can reach up to 10000 ppm. For inducing fruiting we will have to bring it down to 800-1500 ppm. In Oyster to induce fruiting both fresh air and diffused light is necessary. Similarly the cultivation steps vary slightly as we will study in the subsequent chapters.
- After harvesting the mushrooms have to be processed or sold as fresh. Different mushrooms have different shelf life. For example, paddy straw mushroom has to be sold and consumed same day, button and oyster can be sold up to next day whereas milky mushroom may stay good even after 2-3 days. Mushrooms like oyster can be easily sun dried whereas mushrooms like button needs to be canned. However, all the mushrooms can be pickled.
- Proper packaging of the mushrooms is necessary to get suitable prices. Packing in polythene bags without any aeration leads to accumulation of water and early damage to the mushrooms. Hence packing in punnets wrapped with proper film and with holes if needed is desirable.

World over mushroom cultivation has emerged as a major commercial activity that is undertaken on agricultural farms or commercial units established near such places. In India, mushroom cultivation in rural areas has emerged as an important activity for educated, school dropouts, women, landless people, etc. Considering the demand for quality foods, mushroom cultivation has emerged as an important avocation. However, before taking up this venture a thorough knowledge of the subject and scientific aptitude towards agriculture is mandatory. Mushroom cultivation is an important avocation and has all the potential of becoming an important rural industry in our country. The world mushroom industry can be classified into trade of

- Edible mushrooms
- Medicinal mushrooms and products
- Wild mushrooms

More than 70 percent of the world trade is related to edible mushrooms. About 20 per cent is related to medicinal mushrooms and their products and only less than 10 percent is related to trading of wild mushrooms.

1.5.2 Types of Mushroom Suitable for Cultivation

India is a country of diverse climates and temperatures vary over location and season. We have got temperate conditions in the hilly parts and the remaining part is mainly tropical/sub-tropical. There is seasonal variation in most of the areas and temperatures differ to a great extent in summers and winters. However, India has a large coastline of about 8,000 kilometers and temperatures in areas adjoining this do not vary much. Similarly, the conditions are mainly tropical in southern most parts of the country. We have seen in the previous unit that we have mushroom species that can grow below 15 °C (winter mushroom), between 16-20 °C (button, shiitake, king oyster etc.), between 20-30 °C (oyster and wood ear mushroom) and above 30 °C (milky and paddy straw mushroom). This implies that we can grow different mushrooms in different seasons and we can also select mushrooms depending upon our location. At present the four commonly cultivated mushrooms in the country are

I) Button mushroom (*Agaricus bisporus*)
ii) Oyster mushroom (*Pleurotus* spp.)
iii) Paddy straw mushroom (*Volvariella volvacea*)
iv) Milky mushroom (*Calocybe indica*)

The cultivation technology is available for number of other mushrooms like winter mushroom (*Flammulina velutipes*), wood ear mushroom (*Auricularia polytricha*), shiitake mushroom (*Lentinula edodes*), *Agrocybe aegerita, Macrocybe giganteum, Hericium* spp., medicinal mushrooms like reishi mushroom (*Ganoderma lucidum*) and others. We will be discussing the cultivation methods of some of these.

Exercise

1. Name the steps in mushroom cultivation.

Ans:_____

_____

_____

2. For cultivation of which mushroom it is must to compost the substrate?

Ans:_____

_____

_____

3. For which mushroom it is must to autoclave the substrate?

Ans:_____

_____

_____

Notes

_____
_____
_____
_____
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_____
_____
_____
_____

UNIT 1.6: About Spawn Preparation, Transport and Storage

Unit Objectives

At the end of this unit, you will be able to:

1. Know about the ingredients of spawn
2. Learn as to how to make grain spawn
3. Know about the precautions during transport and storage

1.6.1 Spawn Preparation

The planting material of mushroom is called spawn. Before starting spawn production, we prepare/procure culture of mushroom. Culture of mushroom is the fungal mycelium grown under sterile conditions on a suitable medium in a tube. Said simply, we take a part of mushroom or its spores and grow it artificially in a tube. The tubes have media like Potato dextrose agar (Extract of 200 g peeled potato in 1 litre water; Dextrose 20 g and Agar- agar 20 g), malt extract agar (malt extract 20 g; agar agar 20 g in 1 litre of water), etc. The media is sterilized (made free from living organisms) and all the work of preparing cultures is done under sterile conditions. The fungus from the culture is then grown on grains or any other suitable medium. The steps involved in spawn production are shown in figure 1.6.1. A brief of these steps include:

- Wheat, sorghum, pearl millet or any other grain can be used for making spawn. Wheat grains are the most commonly used substrate. The wheat grains are boiled partly so that the grains become slightly soft but do not burst. After this grains are kept on a sieve to drain out the excess water and are allowed to dry for evaporation of surface water.
- After this we add chalk/calcium carbonate (0.5%) and gypsum (2%) mix thoroughly and fill in bottles/ polypropylene bags.
- The bottles/bags are sterilsed in special equipment called autoclave. Autoclave can be imagined as a big pressure cooker. The bottles/bags are autoclaved for 1.5 hour at pressure of 22 pounds per square inch (psi). The temperature inside the autoclave reaches to about 127.8 ^{o}C.
- The bottles/bags are taken out, cooled and inoculated with mushroom culture and this operation is generally done before laminar flow (an equipment that has filters so that only sterile air comes out) or under totally sterile conditions.
- After this bottles are incubated (kept) at 25 ^{o}C for 2-3 weeks when the mushroom mycelium fully colonizes (covers) the wheat grains. To begin with, spawn is prepared in bottles using the culture grown in the test tube.
- Thereafter, spawn is made in polypropylene bags and the readymade spawn from bottles (commonly called mother spawn) is used as inoculum. That is, few grains of readymade spawn are added in each bag. It is not recommended to multiply spawn to spawn beyond one or two generations. Polypropylene bags are used as these are cheap and easy to transport.

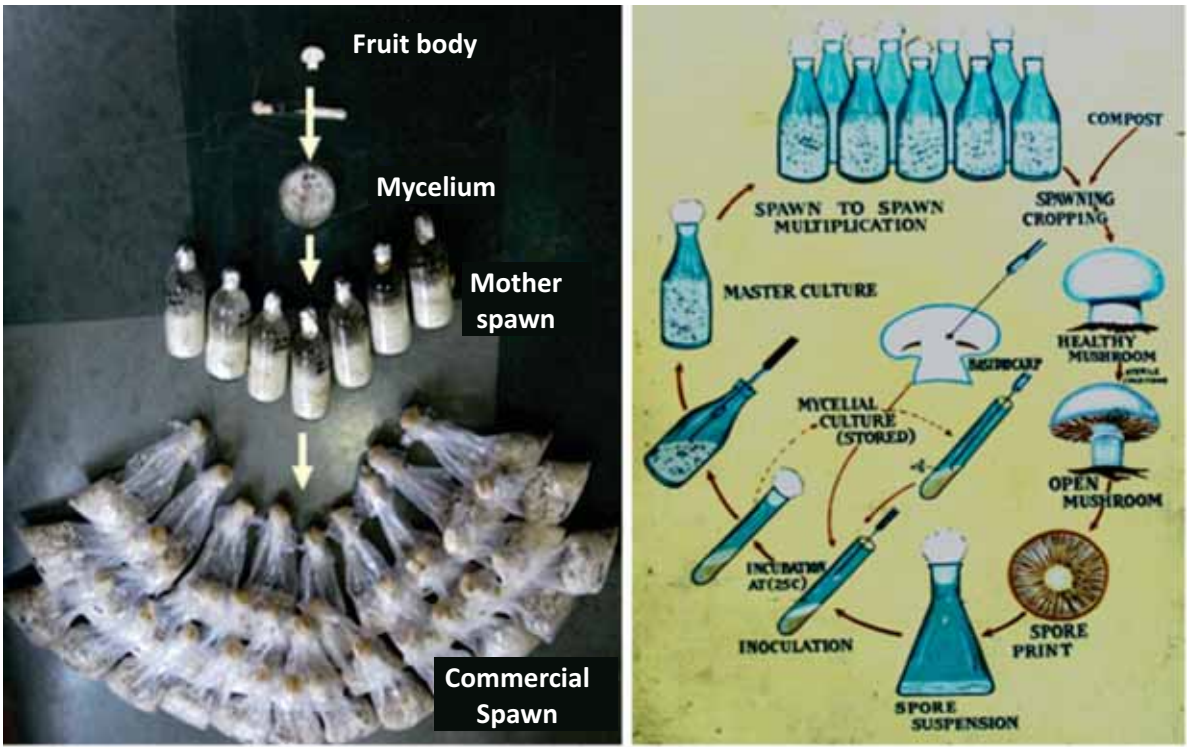

Fig 1.6.1. Different steps in preparation of spawn

1.6.2 Spawn Transport and Storage

Starting spawn production is one of the vocation and is first step in mushroom cultivation. However, it is not necessary that every mushroom grower should make his or her own spawn. Spawn can be procured from the government or private laboratories. However, while procuring, transporting and storing the spawn there are some important aspects that should be kept in mind.

- Wherever possible, freshly prepared spawn should be used because the mycelium is in the state of active growth.
- Try to inspect all the bags to ensure that no bag is contaminated, that is, having green, black growth of other fungi.
- Always note down the strain of the mushroom that is being procured and if possible ask for the label with details of the name of the strain, when it was inoculated and on which date it was ready, etc
- The mature spawn bags, that is polypropylene bags with grains fully colonized by mycelium should be packed in well ventilated cardboard cartons and stored at 2-4 ^{o}C. The spawn is transported from one place to another in refrigerated vans or during night when temperature does not rise above 32 ^{o}C.
- It is important that spawn bags are not exposed to heat and dust during transport.
- The spawn can be stored in any cool place away from dust but should not be frozen.
- Also ensure that the cotton plugs are opened only when the spawn is to be used.
- During spawning if we notice some bag with contamination, it should be removed and hands sterilised before continuing with the spawning.

1.6.3 Cotton Plugs, Poly-fill Plugs or Just Staple

Non absorbent cotton is most commonly used for making plugs of bags or bottles (Fig 1.6.2). In last few years spawn producers have realized that using poly- fill is better as it has no cellulose and it is cheap, almost 1/3rd the cost of cotton. In South India few mushroom growers have done away with plugs while making spawn of oyster or milky mushroom and instead just staple the bags. The process is shown in the Fig 1.6.3. The staple method may, however, be not applicable in button mushroom or other slow growing cultures.

Fig 1.6.2. Cotton plugs used in spawn making

Spawn bag is cut with sterilized scissor

Some spawn is added to pre-sterilized bag

Bag is folded

Bag is stapled

A stapled bag fully colonized by mycelium

Bags ready for use/ sale

Fig 1.6.3. Spawn to spawn preparation without use of cotton plugs

Activity

Visit nearby market and gather information on different types of mushroom being sold at vegetable vendors, malls and big fresh vegetable outlets. Gather information about consumer preferences and sale of different mushrooms.

Exercise

1. Why spawn should be transported under cool and dust free conditions?

Ans:_____

_____

_____

2. What are the materials that can be used for making plugs in place of non-absorbent cotton?

Ans:_____

_____

_____

3. What are the common grains used for making spawn?

Ans:_____

_____

_____

Notes