Review Article

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Review Article on Mushroom Cultivation

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ABSTRACT

Edible mushrooms are collected from the wild. They are currently threatened by deforestation. A survey was carried out and to gather information on their household consumption, income generation and to determine how their cultivation could improve rural livelihood. Mushrooms are sources of food, income and of medicinal value. The market for mushrooms continues to grow due to interest in their culinary, nutritional, and health benefits. They also show potential for use in waste management. However, as fungi, mushrooms have life cycles very different from those of green plants. The choice of species to raise depends both on the growth media available and on market considerations. Oyster mushrooms, which grow on many substrates, are easiest for a beginner. Shiitake mushrooms already have earned considerable consumer demand. Only two mycorrhizal mushrooms, morels and truffles, have been commercially cultivated. Mushroom cultivation offers benefits to market gardens when it is integrated into the existing production system. A careful analysis of potential markets must be the first step in deciding whether to raise mushrooms to sell. Mushrooms are cultivated only on small scale but efforts are underway to extend improved methods of its cultivation to the rural communities, thereby providing them with alternative livelihood and thus ease the pressure on the forests.

INTRODUCTION

The forest contributes to all aspects of rural life, providing food, fodder, fuel, building materials and household items. People have harvested mushrooms from the wild for thousands of years for food and medicines. Of the estimated 1.5 million species of fungi, about 10,000 produce the fruiting bodies we call mushrooms. While commercial harvesting of wild mushrooms continues today, most of the world's supply comes from commercial mushroom growers. The Chinese first cultivated shiitake (*Lentinula edodes*) mushrooms around 1100 AD, with domestication efforts beginning centuries earlier. White button mushrooms (*Agaricus* spp.), most familiar to Americans and Europeans, were first domesticated in France in 1650. Commercial production began in the United States in the 1880s. *Agaricus* is the leading mushroom crop worldwide and accounted for 99 percent of the 1997 United States' mushroom production. Oyster mushrooms (*Pleurotus* spp.) were more recently domesticated, and now rank second in world production. Shiitake mushrooms, which are very popular in Asian cultures, rank third. Many other edible mushrooms, such as straw and wood ear mushrooms, are gaining in popularity. Mushrooms (fungal sporocarps) represent one of the world's greatest untapped resources of nutritious and palatable food and they possess extensive enzyme complexes, which enable them to flourish successfully on a wide variety of inexpensive substrates, such as lignin, cellulose, hemicelluloses, pectin and other industrial wastes which are not suitable for animal feed. Mushrooms, which are used as food, are assuming greater importance in human diets worldwide than ever before. Edible mushrooms are considered as healthy food because their mineral content is higher than that of meat or fish and most vegetables (Chan, 1981).Furthermore, it is known that the protein content of fresh mushrooms is about twice that of vegetables and four times that of oranges (Chan, 1981). Mushroom are prized for their exclusive flavor and deliciousness; they are rich in proteins, contains less fat, less carbohydrate and salt and rich in fiber and have high vitamin B_{12} and folic acid, which are uncommon in vegetables. High availability of lysine and tryptophan and other amino acids usually absent in cereals make them ideal food for patients suffering from hypertension, diabetes and obesity.

Edible mushroom proteins contain all nine amino acids essential for man and they are especially rich in lysine and leucine, which are lacking in most staple cereal foods (Li and Chang, 1982). Mushrooms are devoid of starch and low in calories and other carbohydrates. Apart from their nutritional value, mushrooms have potential medicinal benefits (Chan, 1981). They are an ideal food for diabetics and over-weight people. The introduction of the National Mushroom Development Project in 1990 (Sawyerr, 2000) to produce exotic mushrooms such as *Pleurotus* species brought about small scale mushroom farms mostly for the urban unemployed while technologies developed for the Straw mushroom, *Volvariella volvacea*, the most preferred, have not been adequately transferred to the rural communities for the improvement of their livelihood.

Roughly 300 mushroom species are edible, but only 30 have been domesticated and 10 are grown commercially. Button, oyster, and shiitake mushrooms make up about 70 percent of the world's production. During the past 30 years, mushroom production worldwide increased twenty-fold, with much of that increase occurring in the 1980s and 1990s. Increased demand for specialty mushrooms (everything besides *Agaricus*) has been particularly strong. Asian countries continue to dominate world production and consumption; however, consumption in the United States has increased sharply in recent years, providing potential opportunities for mushroom growers.

Mushroom production is completely different from growing green plants. Mushrooms do not contain chlorophyll and therefore depend on other plant material (the "substrate") for their food. The part of the organism that we see and call a mushroom is really just the fruiting body. Unseen is the mycelium—tiny threads that grow throughout the substrate and collect nutrients by breaking down the organic material. This is the main body of the mushroom. Generally, each mushroom species prefers a particular growing medium, although some species can grow on a wide range of materials.

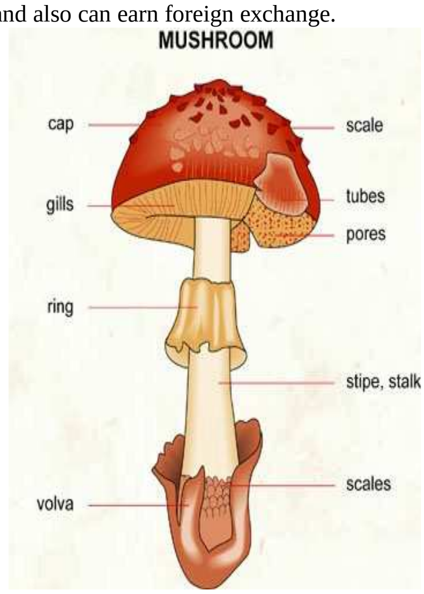
Mushrooms play a significant role in forest ecology, as they help decompose dead plants and animals, including dead trees, branches, leaves, fruits, seeds and animal droppings on the ground. In organic soil, 90% of dead plants are made up of wood with cellulose and lignin, which makes them decay very slowly. Mushrooms produce an enzyme to decompose these substances more rapidly and create nutrients for other plants and microorganisms, thus completing the natural forest growth cycle. Mushrooms themselves are tasty, popular to eat and a beneficial source of nutrients for people too. Much of Asia's environment is suitable for cultivating many different types of mushrooms. In addition, the low costs associated with growing mushrooms helps farmers get started and make relatively quick and good financial returns, positively contributing to the country's economy.

Mushroom production is labor and management-intensive. Specialty mushrooms are not a "get rich quick" enterprise. On the contrary, it takes a considerable amount of knowledge, research, planning, and capital investment to set up a production system. You must also be prepared to face sporadic fruiting, invasions of "weed" fungi, insect pests, and unreliable market prices.

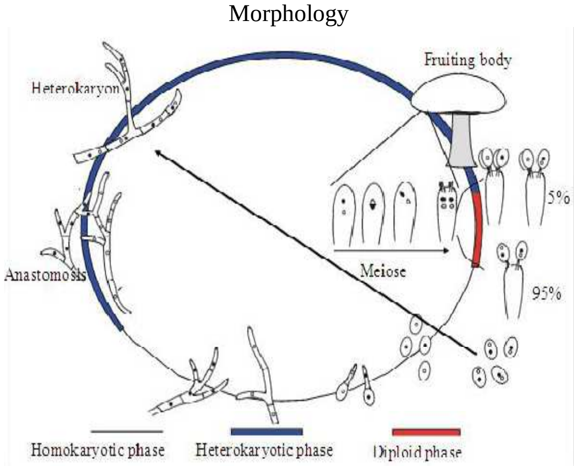
In past, the mushroom industry concentrated mainly on the production of fresh, canned and dried mushroom for food. Thus, the industry had only one leg. In the present era, due to high pressure work demands which are considered to cause greater stress to the human body and to result in the weakness in the immune system, a variety of proprietary products based on mushroom nutriceuticals and pharmaceuticals have already been produced and marketed. This trend expected to increase with wider consumer satisfaction and acceptability. This is the second leg of the industry and is soon expected to become the dominant segment of the industry. This two segment of the mushroom based industry will not complete but will complement each other.

What is Mushroom

Mushrooms are the fleshy fungi which constitute a major group of lower plant kingdom. The mushroom is a common fungal fruit body that produces basidiospores at the tip of club like structures, called basidia, which are arranged along the gills of the mushroom. Beneath the mushroom, in the soil, is the mold colony itself, consisting of a mat of interwined hyphae, sometimes several feet in diameter. The mushroom first appear as white tiny balls consisting of short stem (stipe) and a cap (pileus), which begin to open up like an umbrella. The delicate membrane or veil (velum) enveloping the cap tears off, if allowed to develop fully, and lamella (gills) radiating from the stalk in to the cap become visible. These gills become darkened as the basidiospores (seeds) develop into millions and fall to the ground for starting their lifecycle once again for second generation of mushroom. Since mushrooms grow independently of sunlight so they can be grow in complete darkness but darkness is not an essential prerequisite. They are relatively fast growing, do not require fertile soil, since grow on composted or uncomposted agro-wastes additional to floor, air space is also utilized resulting in higher production. It is a labour intensive indoor activity which can help the landless, small and marginal farmers to raise their income, diversity economic activity and can create gainful employment especially for unemployed/under-employed youths, weaker section of the society and women folk. It produces nutritious food from unused resources, available surplus in India (25 million tones of agriculture waste) and also can earn foreign exchange.



Morphology

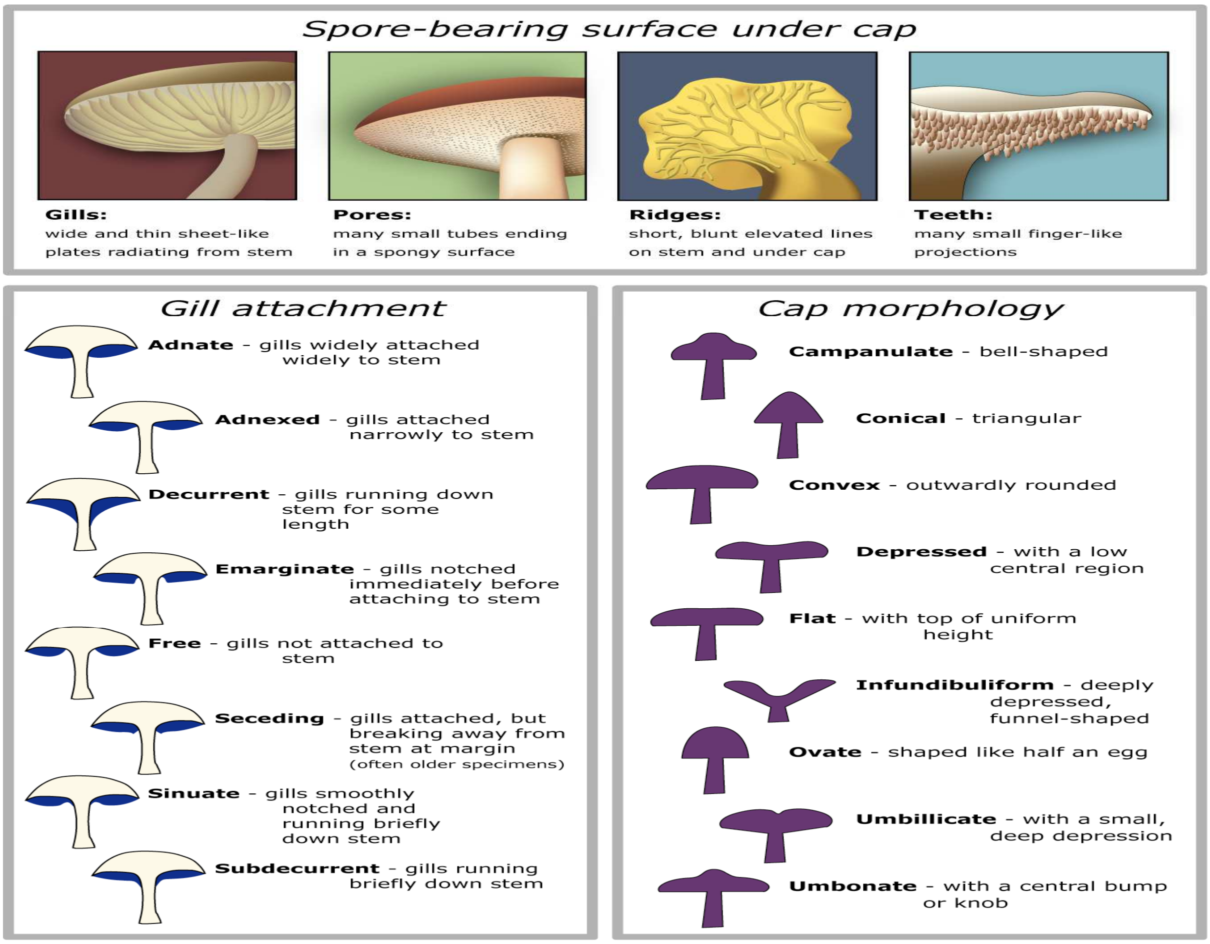


life cycle

What makes up a Mushroom

1. **Cap:** The top part of the mushroom that grows upward. When fully grown, mushroom caps will spread out like an umbrella, e.g. the Straw Mushroom, Champignon Mushrooms, etc. Caps of some mushrooms (like the Phoenix Oyster Mushroom, Oyster Mushroom, and Abalone Mushroom) are more flat and may be indented in the middle.
2. **Gills:** The underside of the mushroom cap that has thin sheets connecting in a row around the stalk, and extends upward to the tip of the mushroom cap. The gills of some mushrooms are connected tightly to the stalks, some have pores, and others have teeth.

3. **Stalk** or **Stipe:** Stalks of each type of mushroom are different in size and length. Normally, stalks are cylindrical. The bottom part of the stalk is big and gets slimmer as it nears the top. The top part of the stalk joins the cap or gills. The skin outside the stalk of some mushrooms is rough while some are scaled like nets (**Reticulum**). Inside the stalk some mushrooms are loosely woven with fiber similar to sponges, while others are bound together tightly. This makes the stalk hard, soft or crispy; the texture varying according to the type of mushroom.
4. **Spore:** Mushroom spores are basidiospores, which are produced in the gill area. Mushroom spores are very small and basically colorless. When these spores gather into cluster, they will be a similar color to that of the gills. Different types of mushrooms have differently shaped spores. If the mushroom cap is put on a piece of paper in a sheltered area, spores will fall on the paper spreading along the gills' lines.
5. **Ring:** Mushroom rings are thin tissues connecting the caps around stalks. When mushroom caps spread out, the tissues fixed between the caps and stalks will break and there will be some tissues left on stalks that will look like thin film wrapping. Types of rings can be used to classify types of mushrooms.



6. **Volva:** Located at the base of the mushroom. Depending on the type of mushroom, the thickness of the Volva will vary. The Volva is left over from the wrapping tissues of budding mushrooms. When mushrooms grow, they will push these tissues out and stalks will push the caps upward, leaving the tissues below.
7. **Mycelium:** Mycelium is a cluster of fiber woven tightly together. Some mushrooms have tightly gathered mycelium around the base of the stalk. Some mycelium contains rough fibers, while others contain fine ones.

Note: Each type of mushroom may not have all of these components. Most of them have caps and stalks while other components vary depending on the type of mushroom.

Food value of Edible mushrooms:

- Mushrooms play a very important dietary role in human nutrition and health worldwide when used as a dietary supplement.
- On a dry weight basis, mushrooms are made up of about 30% protein (Oei 1996) and this protein is endowed with all the essential amino acids. Mushrooms are low in calories and carbohydrates, are almost cholesterol free and are high in vitamins and minerals, all of which serve as important essential requirements for human health (Chang and Miles 1997).

Nutritional and Medicinal values of mushrooms

Meeting the food demand for the increasing population from the limited land resource is a big challenge for our Indian democracy in this vulnerable climate change era. In addition to this, wide spread malnutrition and associated diseases are more common among the economically poor population. This compels us to search for cheap alternative quality nutritional sources for our huge population. Non green revolution otherwise referred as mushroom farming is one among the apt ways to meet this challenge because mushrooms grow on wastes without requiring additional land besides its exceptional nutritional and medicinal properties.

Table 1 Composition of cultivated mushrooms and common vegetables per 100g

Name	moisture	Protein % Dry weight basis	Carbohydrates %	Fat gm	Calories kcal
Mushrooms	91.1	26.9	4.4	0.3	16
Green beans	88.9	21.6	7.7	0.2	35
Green peas	74.3	26.1	17.7	0.4	98
Lima beans	66.5	22.2	23.5	0.8	128
Celery	93.4	20.6	3.7	0.2	18
Cauliflower	91.7	28.8	4.9	0.2	25
Cabbage	92.4	18.4	5.3	0.2	24
Brinjal	92.7	15.1	5.5	0.2	24
Potato	73.8	7.6	19.1	0.1	83
Beetroot	87.6	12.9	9.6	0.1	42

Nutritional Values of Mushrooms

Indian diet is primarily based on cereals (wheat, rice and maize), which is deficient in protein. Supplementation of mushroom recipe in Indian diet will bridge protein gap and improve the general health of socio-economically backward communities. Earlier mushrooms were considered as an expensive vegetable and were preferred by affluent peoples for culinary purposes. Currently common populace also considers mushroom as a quality food due to its health benefits. Mushroom is considered to be a complete, health food and suitable for all age groups, child to aged people. The nutritional value of mushroom is affected by numerous factors such as species, stage of development and environmental conditions. Mushrooms are rich in protein, dietary fiber, vitamins and minerals. The digestible carbohydrate profile of mushroom includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols and sugar acids. The total carbohydrate content in mushroom varied from 26-82% on dry weight basis in different mushrooms. The crude fiber composition of the mushroom consists of partially digestible polysaccharides and chitin. Edible mushrooms commonly have insignificant lipid level with higher proportion of polyunsaturated fatty acids. All these result in low calorific yield from mushroom foods. Mushrooms do not have cholesterol. Instead, they have ergosterol that acts as a precursor for Vitamin D synthesis in human body. Similarly, ergosterol in button mushroom is converted in to vitamin D2 when exposed to UV radiation or sunlight. The protein content of edible mushrooms is usually high, but varies greatly. The crude protein content of mushrooms varied from 12-35% depending upon the species. The free amino acids composition differs widely but in general they are rich in theronine and valine but deficient in sulphur containing aminoacids (ethionine and cysteine). Nutritive values of different mushroom are given below table: Nutritive values of different mushrooms (dry weight basis g/100g).

Table 2 Nutritive values of different mushrooms (dry weight basis g/100g)

Mushroom	Carbohydrate	Fiber	Protein	Fat	Ash	Energy kcal
Agaricus bisporus	46.17	20.90	33.48	3.10	5.70	499
Pleurotus sajor-caju	63.40	48.60	19.23	2.70	6.32	412
Lentinula edodes	47.60	28.80	32.93	3.73	5.20	387
Pleurotus ostreatus	57.60	8.70	30.40	2.20	9.80	265
Volvariella volvaceae	54.80	5.50	37.50	2.60	1.10	305
Calocybe indica	64.26	3.40	17.69	4.10	7.43	391
Flammulina velutipes	73.10	3.70	17.60	1.90	7.40	378
Auricularia auricula	82.80	19.80	4.20	8.30	4.70	351

Courtesy: Stamets, 2005 *(A.bisporous, P. sajor-caju, Lentinula edodes)*, FAO, 1972 (*Pleurotus ostreatus,V. volvaceae*), Doshi and Sharma, 1995 (*Calocybe indica*), Crison and Sand, 1978(*Flammulina velutipes* and *Auricularia spp*).

Mushrooms comprise about 80-90% of water, and 8-10% of fiber. In addition to these, mushroom is an excellent source of vitamins especially C and B (Folic acid, Thiamine, Riboflavin and Niacin). Minerals viz., potassium, sodium and phosphorous are higher in fruit bodies of the mushroom. It also contains other essential minerals (Cu, Zn, Mg) in traces but deficient in iron and calcium.

Medicinal Values

Since thousands of years, edible fungi have been revered for their immense health benefits and extensively used in folk medicine. Specific biochemical compounds in mushrooms are responsible for improving human health in many ways. These bioactive compounds include polysaccharides, tri-terpenoids, low molecular weight proteins, glycoproteins and immunomodulating compounds. Hence mushrooms have been shown to promote immune function; boost health; lower the risk of cancer; inhibit tumor growth; help balancing blood sugar; ward off viruses, bacteria, and fungi; reduce inflammation; and support the body’s detoxification mechanisms. Increasing recognition of mushrooms in complementing conventional medicines is also well known for fighting many diseases.

Medicinal values of the some important mushroom are given below:

1. Good for heart

The edible mushrooms have little fat with higher proportion of unsaturated fatty acids and absence of cholesterol and consequently it is the relevant choice for heart patients and treating cardiovascular diseases. Minimal sodium with rich potassium in mushroom enhances salt balance and maintaining blood circulation in human being. Hence, mushrooms are suitable for people suffering from high blood pressure. Regular consumption of mushrooms like *Lentinula, Pleurotus* spp. decreases cholesterol levels. The lovastatin obtained from *Pleurotus ostreatus* and eritadenine obtained from shiitake has the ability to reduce blood cholesterol levels.

2. Low calorie food

The diabetic patients choose mushroom as an ideal food due to its low calorific value, no starch, little fat and sugars. The lean proteins present in mushrooms help to burn cholesterol in the body. Thus it is most preferable food for people striving to shed their extra weight.

3. Prevents cancer

Compounds restricting tumor activities are found in some mushrooms but only a limited number have undergone clinical trials. All forms of edible mushrooms, and white button mushrooms in particular, can prevent prostate and breast cancer. Fresh mushrooms are capable of arresting the action of 5-alpha-reductase and aromatase, chemicals responsible for growth of cancerous tumors. The drug known as Polysaccharide-K (Kresin), is isolated from *Trametes versicolor* (*Coriolus versicolor*), which is used as a leading cancer drug. Some mushroom-derived polysaccharides have ability to reduce the side effects of radiotherapy and chemotherapy too. Such effects have been clinically validated in mushrooms like *Lentinula edodes, Trametes versicolor, Agaricus bisporus* and others. Selenium in the form of selenoproteins found in mushrooms has anticancer properties. According to the International Copper Association, the mushroom's high copper levels help to reduce colon cancer besides osteoporosis.

4. Anti-aging property

The polysaccharides from mushrooms are potent scavengers of super oxide free radicals. These antioxidants prevent the action of free radicals in the body, consequently reducing the aging process. Ergothioneine is a specific antioxidant found in *Flammulina velutipes* and *Agaricus bisporus* which is necessary for healthy eyes, kidney, bone marrow, liver and skin.

5. Regulates digestive system

The fermentable fiber as well as oligosaccharide from mushrooms acts as a prebiotics in intestine and therefore they anchor useful bacteria in the colon. This dietary fiber assists the digestion process and healthy functioning of bowel system.

Table 3 Medicinal values of some important mushrooms

Mushroom	Compound	Medicinal property	Courtesy
Ganoderma lucidum	Ganodericacid, Beta-glucan	Augments immune system Liver protection Antibiotic properties Inhibitscholesterol synthesis	Lin and Zhang, 2004 Wang et al., 2007 Moradali et al., 2006 Komoda et al., 1989
Lentinula edodes	Eritadenine Lentinan	Lower cholestrol Anti-cancer agent	Enman et al., 2007
A. bisporous	Lectins	Enhance insulin secretion	Ahmad, 1984
P. sajor-caju	Lovastatin	Lower cholesterol	Gunde and Cimerman,1995
G. frondosa	Polysaccharide Lectins	Increases insulin secretion Decrease blood glucose	Horio and Ohtsuru, 2001
Auricularia auricula	Acidic Polysaccharides	Decrease blood glucose	Yuan et al., 1998
Flammulina velutipes	Ergothioneine Proflamin	Antioxidant Anti cancer activity	Bao, 2008, Ikekawa et al., 1985
Trametes versicolor	Polysaccharide-K (Kresin)	Decrease immune system depression	Coles and Toth,2005
Cordyceps sinensis	Cordycepin	Cure lung infections Hypoglycemic activity Cellular health properties Anti-depressant activity	Li et al., 2006 Hypoglycemic activity Ko et al., 2009 Nishizawa et al.,2007

6. Strengthens immunity

Mushrooms are capable of strengthening the immune system. A diverse collection of polysaccharides (beta-glucans) and minerals, isolated from mushroom is responsible for up-regulating the immune system. These compounds potentiate the host's innate (non-specific) and acquired (specific) immune responses and activate all kinds of immune cells. Mushrooms, akin to plants, have a great potential for the production of quality food. These are the source of bioactive metabolites and are a prolific resource for drugs. Knowledge advancement in biochemistry, biotechnology and molecular biology boosts application of mushrooms in medical sciences. From a holistic consideration, the edible mushrooms and its by-products may offer highly palatable, nutritious and healthy food besides its pharmacological benefits. Still there are enough challenges ahead. Until now, how these products work is elusive and vast number of potential wild mushrooms are not explored. The utility of mycelia is paid little attention but it has tremendous potential, as it can be produced year around with defined standards. Knowledge on dose requirement, route and timing of administration, mechanism of action and site of activity is also lacking. Work is under progress in various laboratories across the world to validate these medicinal properties and to isolate new compounds. If these challenges are met out in the coming days, mushroom industries will play a lead role in neutraceutical and pharmaceutical industries. The increasing awareness about high nutritional value accompanied by medicinal properties means that mushrooms are going to be important food item in coming days and at places may emerge as a substitute to non-vegetarian foods. Growing mushroom is economically and ecologically beneficial. Consuming mushroom is beneficial in every respect. Thus mushrooms are truly health food, a promising neutraceutical.

Cultivated edible mushrooms:

Presently about a dozen fungi are cultivated in over 100 countries with a production of 2.2 million tones. Five genera, Agaricus, Lentinus, Volvariella, Pleurotus and Flammulina, contributed about 91 percent of total production. White button mushroom has the largest share (56%) followed by shiitake (14%), paddy straw (8%), oyster (7.7%) and others (13%).

E.g.:*Agaricus brunnescens*
Lentinus edodes
Volvariella volvacea
Pleurotus spp.

Poisonous mushrooms

The poisonous species called toadstools. Incapable of causing infection but produce toxic substances. This poisonous substances collectively known as mycotoxins and result in mycetismus.The most deadly mushrooms are the death cap, destroying angles and fool' cap. Death cap principle toxic mixture of α and β-amanitin and phalloidin.

Note: mushroom may also cause illness if they are taken with alcohol.

e.g.: *Amanita virosa*
Amanita verna
Amanita muscaria
Amanita phalloides

Diseases of mushrooms

Mushrooms are attacked by various diseases of fungal, bacterial and viral origin like higher plants. Fungal diseases: brown plaster mould, green mould, wet bubble disease, brown spot disease etc. Bacterium causes bacterium blotch on mushrooms. Viral diseases: brown disease, water stipe, x-disease and dieback.

Key environmental factors to consider for mushroom cultivation

Temperature – Temperature is important for the healthy growth of mushrooms. The correct temperature for the growth of fibers in each type of mushroom is a little higher than the correct temperature for the growth of the mushroom cap. For example, Straw Mushrooms grow well at 38-40degree Celsius, which is the best temperature for producing spores. Fibers grow well at 35-38 degree Celsius while caps grow at 30 degree Celsius. If it is too hot, mushroom caps will be small and open faster than usual. But if it is too cold, fibers will grow slower or even stop growing. Seasonal temperature variations can dramatically affect mushroom growth cycles. For example, growing Straw Mushrooms in the summer usually takes 7 days for caps to appear, while it takes 8-12 days during the rainy season, and 15-18 days or more, or sometimes no cap at all, during the winter.

Dampness – Dampness is essential for the growth of fibers, as well as the production and growth of the caps. But if it is too damp inside the caps, fibers will be soaked and die. The wet small caps will gather at the meeting point between fibers and caps, making it impossible to pass food to the mushroom caps. They will then wither and eventually die. If it is too dry, mushrooms will shrivel up and will not grow.

Light – Even though light is necessary for the growth and assembly of fibers and in order to produce mushroom caps, it is not essential for the mushrooms' growth. On the contrary, light darkens the mushrooms' color, unlike growing them in the dark (which whitens them). Although just an aesthetic difference, color considerations can be important for the marketability of produce, for example, white straw mushrooms are much more popular among consumers than darker gray crops.

pH Levels – The pH level is important for the growth of mushrooms. Straw mushrooms are neutral or a little acidic. If there is too much acid, bacteria will not grow and they will be less able to digest molecules. Fibers in the straw mushroom will then get less food. This will reduce the number of mushroom caps. A suitable pH level for straw mushrooms and other mushrooms is between 5 and 8.

Oxygen – In every stage of mushroom growth oxygen is needed, especially when the caps are coming out and after they have bloomed. If there is too much carbon dioxide in the mushroom bed, fibers will grow slower or stop growing, the mushrooms will grow abnormally and their skin will be affected.

CAPITAL INPUTS:

Land and Building

Land admeasuring to around 200 sq.mtrs. With built up area of 100 sq.mtrs is adequate.

Land may cost Rs.60,000/- whereas cost of building could be Rs.2.50 lacs.

Plant and Machinery

It is advisable to undertake thorough market survey before finalizing actual capacity.

Assuming capacity of 600 kgs. Per day, the annual capacity would be 180 tones considering 300 working days. Following machines shall be required.

Item	Quantity	Price (rs)
Tray-type dehydrator	1	70,000
Steam-jacketted kettle	1	65,000
Can steamer	1	20,000
Blanching equipments	1	25,000
Straight-line exhaust box with electric motor, gear box etc	1	45,000
Canning retort with attachment	1	35,000
Stacking trays	200	80,000
Baby boiler	1	60,000
Laboratory equipments	---	35,000
Total		4,35,000

Miscellaneous Assets

Some other assets like furniture & fixtures, working tables, storage racks, SS utensils, plastic tubs, etc. shall be required for which a provision of Rs. 60,000/- is made.

Utilities

The power requirement will be 30 HP whereas per day water requirement will be 1000 liters. including that for potable and sanitation purposes.

Raw and Packing Materials

Materials like spawn, wheat or barley straw, formalin, insecticides etc. shall be required for cultivation whereas small quantity of salt and citric acid will be required for processing. Packing materials like cans for processed mushrooms and plastic bags for fresh mushrooms and corrugated boxes, labels, box strapping etc. shall be required.

Table 4 Manpower requirements

Particulars	Nos.	Monthly salary (Rs).	Total monthly salary (Rs.)
Skilled workers	2	2,250	4,500
Semi-skilled workers	2	1,650	3,300
Helpers	4	1,250	5,000
Salesman	1	2,500	2,500
		Total	15,300

Table 5 Details of the project

Item	Amount (Rs in lacs)
Land and building	3.10
Plant and machinery	4.35
Miscellaneous Assets	0.60
P&P expenses	0.75
Contingencies @ 10% on Land and Building & plant and machinery	0.75
Working capital Margin	1.15
Total	10.70
Means of finance	
Promoter's contribution	3.20
Term loan from bank/FI	7.50
Total	10.70
Debt equity ratio	2.33 : 1
Promoters contribution	30%

Spawning:

For the successful cultivation of any mushroom on a small scale or commercial scale, one of the most important requirements, is the seed of that species/variety. **Spawn-a pure culture of the mycelium grown on a special medium-**is the mushroom seed, comparable to the vegetative seed in crop plants. The production of spawn is done by professionals in the laboratory under controlled conditions of temperature, light and humidity. Spawn can be produced either by germinating basidiospores or by culturing small pieces of vegetative mycelium of a mushroom on a suitable substrate. The successful of mushroom cultivation and its yield depend to a large extent on the purity and quality of the spawn used.

The media used for maintenance, multiplication and preservation of mushroom culture are: potato Dextrose agar (PDA), yeast potato Dextrose agar (YPDA), Malt extract agar and Rice bran decoction medium.

Requirements

- Pure culture of mushroom
- Cereal grain
- Calcium sulfate
- Calcium carbonate
- Glucose bottle/milk bottles/polypropylene bags
- Cotton
- Alkathene sheets
- Rings for bags
- Autoclave
- Laminar air flow cabinet
- Incubator/storage room
- Wire guage balance
- Bunsen burner
- Water

Pure Culture Preparation

Pure culture of mushrooms can be prepared either by multi-spore or by tissue culture. Multi-spore culture is made from spore print that can be obtained by hanging a alcohol sterilized fresh fruit body on a loop of wire above a petriplate/sterilized paper. Spores are serially diluted and transferred to sterile potato-dextrose-agar (PDA) or malt-extract-agar (MEA) culture slants. These slants are then incubated at 25°C ± 2°C for 2 weeks to obtain pure culture. For tissue culture, mushroom after alcohol sterilization is cut longitudinally into 2 halves and bits from collar region (i.e. junction of cap and stalk) are transferred to pre-sterilized PDA or MEA culture medium, which is, incubated at 25°C ± 2°C in BOD incubator for one week. Mycelium from growing edges is carefully transferred to MEA/PDA slants and again incubated for 2-3 weeks to obtain pure cultures.

Spawn production cycle

1. Preparation of mother spawn

Step-1 Select healthy and clean cereal grains

↓

Step-2 Boil grains in water (15-20 min.)

↓

Step-3 Remove excess water on sieve

↓

Step-4 Dry grains in shade (4 h)

↓

Step-5 Mix $CaCO_3$ (0.5%) & $CaSO_4$ (2%) on dry wt. basis

↓

Step-6 Fill 300 g grains in glucose/milk bottle

↓

Step-7 Plug and autoclave at 22 p.s.i. for 1.5 to 2 h

↓

Step-8 Inoculate growing mycelium of desired strain using laminar flow

↓

Step-9 Incubate in BOD at 23+20C for 20-25 days (shake bottles after 10 days)

↓

Step-10 Master spawn is ready

2. Preparation of commercial spawn

Step-1 Use polypropylene bags instead of bottle

↓

Step-2 Up to autoclaving (Step 1 to 7) is same as of mother spawn

↓

Step-8 Inoculate with 10-15 grams of mother spawn per PP bags

↓

Step-9 Incubate at 23+20C in incubation room (Shake bags after 7-8 days)

↓

Step-10 Commercial spawn is ready in 2-3 weeks

Observation: At the time of boiling of grain in water, observe the grain for their intact nature. Observe the inoculated grain during incubation at regular intervals for the appearance of white mycelium on the grain as well as for the appearance of contaminants.

Results: Appearance of silky whitish growth completely covering the grain indicates the preparation of spawn.

Storage: Store the spawn, if not needed immediately, at 0-4°C in a refrigerator for a maximum period of 6 months. Spawn, if stored at low temperature, should be allowed to attain room temperature (25°C) before being used for spawning the compost.

Transport: transport the spawn, in refrigerated vans after its purchase or at night when the temperatures are low, as higher temperature (above 32°C) is detrimental to mushroom mycelium.

Types of spawn:

1. Virgin spawn: when the spores of the mushroom fungus fall on suitable substrate and the environment is also suitable they germinate and form a mat of mycelium. This is dug out and use as spawn.
2. Fake spawn: when the beds are fully covered with mycelium before a crop of mushroom appears, the compost is collected, broken, dried and use fresh to inoculate other new beds.
3. Brick spawn: A mass consisting of horse and cow dung manure and loam mixed with water, tapped out in a layer two inches thick and cut in to pieces when half dry. These pieces are then inoculated with the old spawn by making a hole in each and after the spawn grows through the entire piece.
4. Grain spawn: spawn grain as a base. Larger grains carry a greater reserve of food material per grain of mushroom mycelium.

Methods of spawning

1. Double layer spawning: scattering the spawn on tray bed when half filled with compost and then after the complete filling of the tray. The spawn is gently pressed with fore finger uniformly each time and trays are covered with newspaper sheet.
2. Top spawning: after filling the tray up to the bim with compost, the spawn planted just above the surface and then a thin layer of compost is spread out because if the spawn is at the top of the compost it dries up quickly.
3. Through spawning: the whole of the spawn mixed throughout the compost.
4. Shake-up spawning: one week of spawning the compost is thoroughly shaken up, and replaced in the trays.
5. Active mycelium spawning: develop in Germany. Carefully run trays of spawned compost, are used for spawning of further trays.
6. Super spawning: fresh pasteurized trays are planted as usual. This referred to as preliminary spawning. After two weeks the compost from each tray is mixed with the compost from newly pasteurized trays and packed firmly.

General protocol for mushroom cultivation

Mushrooms may be grown successfully in a variety of places. Commercial and amateur mushroom cultivation is done indoors. The various installation and required for mushroom cultivation vary with the size of a mushroom house. The space requirements necessary for successful production are (1) The location should easily accessible so that the manure and casing soil can be brought in and removed conveniently; (2) The room should be well ventilated; (3) Direct sunlight should not fall on the mushroom bed; (4) The room temperature should not exceed 15°C during the growing period; (5) Location for growing mushroom should not be too moist and should be at such a site where there should be good fresh water supply, availability of the fertilizers for making compost and a good market for the sale of the mushrooms. Mushrooms have been grown successfully in cellars, garages and in abandoned rooms.

The protocol for cultivation of mushroom requires following steps:

1) Preparation of compost
2) Filling of tray beds with compost
3) Spawning (inoculation) of beds
4) Casing
5) Watering of beds
6) Harvesting of mushrooms
7) Storage

Requirements

- Mushroom house
- Cement concrete platform (14×7 meters) for preparing compost
- Tray beds (wooden trays made of pinus or deodar wood, 100×50×22cm)
- Compost ingredient
- Spawn (mushroom seed)
- Casing soil
- Sprayer with a fine nozzle
- Box for gathering mushrooms
- Sterilization facility
- Wooden mould (it consist of three wooden boards: one end board and two side-boards, fastened with a clamp with notches at the top)
- Wooden board (25×12cm) with handle for compressing the compost
- Newspaper sheet
- Lime or carbonate of lime
- pH meter

Procedure

1. Preparation of compost

Composting done in two phases: The preparation of mushroom compost is usually done in two stages. The breakdown of raw ingredients begins in Phase I. Phase I is characterized by building the raw ingredients into long rectangular piles approximately 2 m high called "ricks" or "windrows" (figure to the left). These stacks are then periodically turned, watered, and formed. This phase is essentially a microbiological process resulting in release of energy and heat. To favor the development of relatively high temperatures, aerobic conditions are maintained by aerating the compost during repeated mixing or turning. Temperature fluctuations during this phase are paralleled by similar changes in the numbers of thermophilic (heat loving) bacteria. These organisms start to grow rapidly and release energy in the form of heat. Thermogenesis by microorganisms initiates the heating of Phase I and also produces heat in Phase II. The internal temperature of a compost pile can reach up to 80^{o}C. Traditional Phase I composting lasts from 7 to 14 days depending on the condition of the material at the start and its characteristics at each turn. It is considered complete when the raw ingredients have become pliable and are capable of holding water. The odor of ammonia should be sharp, and the color of the compost is dark-brown in color, indicating caramelization and browning reactions have occurred.

It is primarily the control of the environment that distinguishes Phase II from Phase I. Typically, compost is loaded into wooden trays, which are stacked, and then placed in specially designed rooms where the environmental conditions can be manipulated (figure to the right). Phase II is commonly referred to as peak-heating and may be initiated by steam. Pasteurization is accomplished early in the Phase II operation and is necessary to kill many insects, nematodes, and other pests or pathogens that may be present in the compost. Pasteurization requires air and compost temperatures of 66^{o}C for a minimum of 2 hours. Once pasteurization is accomplished, cool air is introduced into the Phase II room to assure adequate oxygen, and to help dissipate ammonia. An important function of Phase II microbes that survive the pasteurization process is the conversion of residual ammonia into protein. Because ammonia is lethal to the mushroom mycelium, it must be removed by the end of Phase II. A stage is reached when the available food supplies for organisms inhabiting the compost become quite limiting, hence their activity decreases. The substrate is now set for mushroom to take over, and the substrate is said to be 'selective' for the growth of the mushroom. Once the odor of ammonia is no longer present, Phase II is over and the compost temperature can be dropped to 24^{o}C for the addition of the mushroom mycelium, called "spawning."

E.g.: A.bisporus consists of the following constituents (for 25 tray beds):

- Chopped wheat straw 300.0 kg
- Wheat bran 15.0 kg
- Ammonium sulfate 6.0 kg
- Superphosphate 7.5 kg
- Urea 2.4 kg
- Potassium sulfate 3.0 kg
- Gypsum 30.0 kg
- Saw dust 10-12 kg

Preparation of compost

1. Wet the saw dust by spraying water or leaving it overnight after mixing all the constituents except wheat straw.
2. Spread the wheat straw over the cement floor on the following day and wet it thoroughly by sprinkling water.
3. Spread the pre-mixed constituents over the wheat straw surface and mix thoroughly.
4. Stack this mixture into a pile of 1.30metres wide and 1.30metres high, using indigenously fabricated wooden-mould.
5. Allow the compost to decompose for 28-30 days under aerobic conditions in the compost pile.
6. Dismantle the heap repeatedly and prepare pile again and again at periodic intervals by placing the outer compost inside and inner compost layers in the outer periphery, the process called turning of the compost pile, to obtain uniform fermentation of the entire pile. Watering is to be done in the first two turnings.
   For good results, periodic turning of the pile should be done according to the following schedule:
   First turning: 6th day, add more fertilizers and wheat bran
   Second turning: 10th day, add gypsum and more water
   Third to seventh turning: After every 3 days. 25th day should normally be the last day for turning the compost.


Observation: well spread compost will be brown to dark brown in colour and free from ammonia in colour.

2. Filling of Tray Beds

a) Spread the prepared compost on the platform.
b) Mix 3kg of calcium carbonate to it.
c) Fill the compost in all corners and edges of a tray.
d) Compress firmly the compost in the tray using a wooden board.
e) Leaving 1 cm clear space on the top of the tray.

3. Spawning

Spawning means planting mushroom mycelium, growing on a suitable substrate, in the compost. Government and non government agencies prepared and sold the mycelium. NCMRT-National center for mushroom research and training, chambaghat, solan (HP), India one such central government institute.



Mycelium of mushroom propagated vegetatively on sterilized cereal grain is known as "spawn". Commercial mushroom growers purchase spawn from any of about a dozen spawn companies. Farmers have a choice of growing different strains, ranging from smooth white, off-white, cream, to brown capped mushrooms. These strains vary in flavor, texture, and growing requirements. Spawn is introduced and thoroughly mixed into the compost with a special machine that mixes the compost and spawn with small tines or finger-like devices (figure below and to the right). After spawning, the compost is maintained at approx. 24^{o}C, and relative humidity and CO_2 levels are kept high to minimize drying of the compost. The spawn will begin to grow and produce a thread-like network of mycelium throughout the compost. Complete colonization of the compost usually requires 12-20 days, depending on the spawning rate and environmental conditions.

a) Perform the spawning by spreading the spawn on tray beds when half filled with compost and again after the tray is filled completely. During spawning, the spawn is gently mixed with fore-fingers and pressed uniformly each time.
b) Cover the trays with newspaper sheets.
c) Sprinkle water on newspaper sheets, to provide humidity.
d) Stack the inoculated trays vertically, one over the other, depending on the height of the room.
e) Continue water spraying twice a day or less depending upon available humidity in the atmosphere throughout the spawn running and cropping period.

4. Maintain temperature of the room between 24 and 25°C for 12-15 days for running of the spawn, i.e. formation of mycelium strands all over the tray beds.

Observation: observe for the white cottony mycelium over the compost surface and colour of the compost that changes from dark to light brown which is indicative of successful completion of spawn running period.

5. Casing

Casing means covering the compost with a thin layer of soil or soil like material after the spawn has spread in the compost (spawn run).To promote mushroom formation, casing soil is added as a surface layer (1.5 - 2 inches deep) on the colonized compost. The important transition from the vegetative to the reproductive stage of mushroom takes place in the casing layer, which is usually a mixture of peat and limestone. Mushrooms form only after the compost is covered with a layer of casing material. In addition to stimulating fruit body formation, the casing layer provides moisture essential for high yields and anchorage for the developing mushrooms. Casing materials do not provide any nutrients to the mushroom mycelium. Environmental conditions after casing are the same as during spawn growth. The compost temperature is kept around 24^{o}C for up to 5 days after casing to allow for the spawn to grow through the casing layer. Before the mushroom "pins" (primordia) start to develop, later is applied intermittently to raise the moisture level of the casing layer to field capacity. Most mushroom is grown in a place with high relative humidity and not much light. Some fungi use light as their signal to form fruiting bodies, but not mushroom the casing layer provides all the signal that is needed. Some mushroom facilities are actually in underground caves, but more commonly "mushroom houses" are built. These facilities are somewhat like small barns, with relatively small rooms so that humidity and temperature can be more easily controlled.

Soil has been the universal casing material. But all soils as such cannot be used as 'casing soil' with advantage, so it is especially prepared soil that can be used for casing. In India, a number of mixtures have been recommended:

a) Well rotten cow dung, mixed with light soil in 3:1 ratio
b) Soil and sand in the ratio 1:1
c) Farm yard manure and gravel, ratio 4:1
d) Farm yard manure and loam ratio 1:1
e) Soil peat mixture 2:1
f) Spent compost, sand and slaked lime (4:1:1) and nematicide mixture.

Casing mainly prepare in three steps:
1) Preparation of casing soil
2) Sterilization of casing soil
3) Casing the Beds

1) Preparation of casing soil:
a) Mix four parts of spent compost with one part of sand to which 5kg of slaked lime per cubic meter of compost is added.
b) Treat the mixture with nemagon, a nematicide, by spraying or sprinkling it at the rate of 5ml per cbm.
c) Leave the material in a pile (1.20M ×1.0M) under a tree shade for a period of one year, turning it every 4 months.
d) Sieve the spent compost, which turns into black soil in one year, for removal of undecomposed lumps.

Observation: observe the casing soil for black colour and pH. A pH between 8.0 and 8.5 is the most suitable for mushroom yield. Adjust pH, if desired, by the addition of lime or carbonate of lime or free stone to the casing mixture.

2) Sterilization of casing soil:

Sterilize the casing material either by the chemicals (formalin, chloropicrin, methyl bromide or vapam) or by heating or by steam from boiler through perforated pipes and temperature raised to 70-75°C and maintained for 6 hours. The purpose of sterilization is to kill harmful microorganisms (fungi, nematodes, and insects).

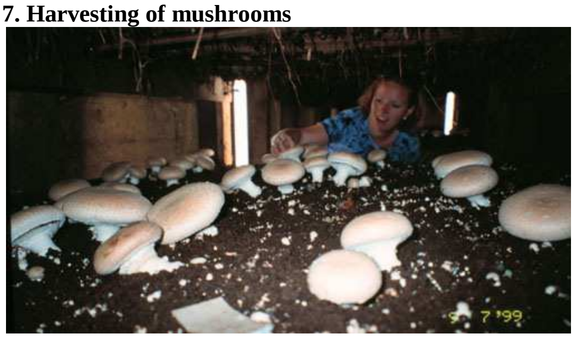
3) Casing the beds:
a) Remove the newspaper sheets from the spawned beds after 3 weeks.
b) Gently press the compost with 2-2.5 cm thick layer of sterilized casing material

Pining: Primordia or "pins" are knots of mycelium that eventually develop into mushrooms (figure to the left).Once the mycelium has reached the surface of the casing layer, the mushroom is induced to pin by reducing both the air temperature (to 16-18^{o}C) and the CO_2 concentration (to 0.08%). Fruiting occurs in well-defined flushes or breaks with the first harvestable mushrooms appearing 18 to 21 days after casing.

6. Watering the beds: spray the beds over the casing soil with a fine nozzle of a sprayer to maintain relative humidity between 70 to 80 per cent.

Observation: observe the beds for mushroom crop which can be expected after 5 to 20 days. Mushrooms mostly appear in-“flushes” and at a temperature of 15°C, it generally takes 7 to 8 days to come to the button stage from the first appearance of the formation of a pin-head. There is an interval of 8 to 10 days between flushes.

7. Harvesting of mushrooms



Harvest the crop everyday (in the morning and evening depending upon the market demand) to get a good quality of mushrooms (the cap still being tight to its stalk is the right stage to harvest the mushrooms.) Harvesting is done by holding the cap with fore-fingers slightly pressed against the soil and twisted out. The mycelial strands and soil particles clinging to the base of the stalk are cut of with a knife. Specially desingned wooden box is used for collection of mushrooms from multistoried trays, each provided with the hooks for resting it against the side board of the mushroom tray.

8. Storage: Store the mushrooms at 4°C in a refrigerator for a few days to avoid the quality deterioration, because mushrooms are a highly perishable commodity. The white colour turns brown and then black in a couple of hours at high summer temperature. Soon after water oozes out and the mushrooms become unfit for cooking.

Mushroom culture industry requires

1. Skilled person: persons trained in manual work like culture technique, spawn technique, sterilization technique, harvesting, packaging, storage.
2. Junior technicians: class-X pass with one year training in culture practices. Environmental control, spawn making, harvesting.
3. Senior technicians: B.Sc in agriculture with mushroom culture as a major subject marketing and sales, green house, poly house, training.
4. Scientist: persons having Msc/phd in manager the field of agriculture/ microbiology.

Salient features

1. 100%risk free project: running cost is very low and not require heavy machinery.
2. Low working capital: raw material is waste use so capital cost is low.
3. Very high returns use waste and get income
4. Easy financing and long term business.
5. Pollution free environment friendly project.

Limitation

There is a progressive increase in the demand for mushroom spawns from the regions. The National Mushroom Development Project which was the sole producer and distributor throughout the country could not meet the demand. Mushroom growers encountered problems such as low yield and inaccessibility to viable spawns, especially that of *Volvariella volvacea*A number of mushroom growers had also been trained to produce their own spawn using the transfer method. There is no quality control in the private laboratories of the growers due to lack of technical know-how and no consultations are made periodically with the Research Institutes to ensure the quality of their products. Growers who patronise these spawns face problems such as loss of vigour in spawn run and contaminations.

Limitation for mushroom:

- High cost of energy for year round production.
- Unorganized production and sale particularly by seasonal farmers.
- Lake of facilities to produce quality of compost, causing material, spawn and processed products.
- Limited consumer demand in some part of the country.
- Spore allergy to certain people.

Table 6 World production of mushrooms (metric tons)

Countries	1997	2007
China	5,62,194	15,68,523
United states of America	3,66,810	3,59,630
Netherland	2,40,000	2,40,000
Poland	1,00,000	1,60,000
Spain	81,304	1,40,000
France	1,73,000	1,25,000
Italy	57,646	85,900
Ireland	57,800	75,000
Canada	68,020	73,257
United kingdom	1,07,359	72,000
Japan	74,782	67,000
Germany	60,000	55,000
Indonesia	19,000	48,247
India	9,000	48,000
Belgium	NA	43,000
Australia	35,485	42,739
Korea	13,181	28,764
Iran	10,000	28,000
Hungary	13,559	21,200
Viet Nam	10,000	18,000
Denmark	8,766	11,000
Thailand	9,000	10,000
Israel	1,260	9,500
South Africa	7,406	9,395
New Zealand	7,500	8,500
Switzerland	7,239	7,440
Other countries	85911	59297
Total world production	21,86,222	34,14,392

Importance of mushroom cultivation in India

1. Mushroom cultivation is labour intensive activity.
2. Mushroom harvesting is not automatic process.

3. It helps in maintaining the cycle of nature by decomposing agro residues.
4. Good source of high quality of protein rich in vitamins and minerals. It is good for vegetarian population.
5. It provide excellent opportunity to educate rural youth and provide job.
6. Opportunity to use wastelands.
7. Rural women which are educated or uneducated easily handle.

Mushroom: production and marketing

Marketing is getting the right product, to the right people, at the right price, at the right time and in the right way. Marketing of fresh mushrooms all over the world is not very organised except the auction system in Netherlands. Producers make direct efforts to bring the produce to the super markets and 'wholesale distributor' element is mostly missing. However, trade in the processed (canned and dried) is sizeable and organised.

Summary

Mushroom which is also known as vegetarian non veg. It is contains major amount of nutritious material. And its cultivation is easy process. It mainly require waste material as a substrate, and mushroom contains several enzymes which decomposes dead organic matter and transform in to simpler form. So, today mushroom cultivation is growing sector especially for rural people. Who fulfill their demand via mushroom cultivation which is also possible in indoor activity. And today according to population growth the demand of nutrition reach food is essential. Mushrooms are major food for these people who buy at normal prize and live a healthy life. At the last but not least it is a big growing sector for future.

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