

## MUSHROOMS IN BIODIVERSITY AND FOOD SECURITY OF SIKKIM

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### ABSTRACT

**T**oday, man is more health conscious and with resources becoming limited, he has left no stone unturned to derive the best from nature. Mushrooms provide the natural way to good health and in a place like Sikkim in India, which is a hotspot of biodiversity; there is no dearth of such fungi. With the indigenous culture and knowledge, the natives identify the edible ones by traditional methods. Mushroom picking for food with the onset of monsoon showers have been customary in Sikkim amongst the different communities. In recent times, mushroom growing is becoming popular because it adds to the income of especially those growers having no or insufficient land. Thus, a good number of potential mushroom species have been exploited from nature till date and have been in use for food and medicinal purposes since ages by the indigenous communities of Sikkim.

**KEYWORDS:** *medicine, edible mushrooms, poisonous mushrooms, food security*



Chiplae Cheaoc found near bamboo grooves, bears leathery texture



*Termitomyces heimii* most commonly found near termite mounds

## INTRODUCTION

The decreasing trend of arable land and increasing food demand necessitates food production which not only augments the deficits but is also nutritious and easily available. Mushroom along with other microbial biomass like yeast, algae and single cell protein (SCP) are often referred to as alternative sources of food. Microbial biomass has been used for human consumption since time immemorial either directly as human food like mushroom or indirectly like brewers' and baker's yeast, curd, yoghurt etc. Another group of microbial biomass called single cell protein (SCP) obtained from bacteria, fungi and algae are also used as supplements to human food and animal feed only after processing of microorganisms. In this context, production of mushroom and single cell protein is gaining momentum as one of the fastest growing biotechnological industries with multi-million dollar annual trade. However, mushroom cultivation is unique as it is the most efficient and economically viable biotechnology process for the conversion of lignocelluloses waste materials into high quality protein food.

Mushrooms are fruiting body of certain fungi belonging to Basidiomycetes and Ascomycetes groups, some are edible and many are poisonous and non-edible. They are an accepted ideal food item, rich in protein, low in fat and carbohydrates and an efficient tool for recycling of organic wastes. There are more than 10,000 species of mushrooms and about 2000 of them are considered edible. Of these, less than twenty five species are widely accepted as food item and only about a dozen of them have been artificially cultivated.

Button, oyster and Chinese mushrooms are commonly used for human consumption. Mushrooms are rich in high quality protein, thus they are called 'Vegetarians Meat'. Owing to their very low content of carbohydrate, mushrooms are suitable ingredients in the diet of diabetic individuals. They are also rich in vitamin and minerals. They have pleasant flavour and delicious to eat. Delicacy of mushroom makes the most preferred food of the young and old in the present day.

Many mushroom species are found wild in Sikkim especially with the onset of monsoons. Nature has bestowed its best in this paradise for the luxuriant growth of this wonder crop. Sikkim, being the distinctive hotspot of rich biodiversity has also served as the habitat of a wide variety of mushroom species (*Cheaeoe*), be it the commonly cultivated oyster or naturally growing morsels. The climatic conditions here are such that mushroom cultivation can be done throughout the year. Mushrooms' being an integral constituent of dietary intake of all populace of Sikkim, nutrition and employment generation through this innocuous fungus is nature's blessing. Mushroom production has tremendous potential in Sikkim because of its congenial climate (tropical to alpine) and availability of low-cost waste materials. Since long, mushroom has been considered as a delicious and preferred food item among the indigenous communities of Sikkim, but its commercial cultivation has not yet been popularized (Borah *et al.* 2010).

### **Nature's boon**

In nature, a number of species of mushrooms are found mainly during the rainy season, on almost all types of soils, on decaying organic matter, wooden stumps etc. The climate of Sikkim and the forest vegetation especially, support the growth and multiplication of varied mushroom flora. Mushrooms have profound biological, ecological and economical impact in the Sikkimese society. The first monsoon shower is an indication to the mycophagists to go in search of their most awaited delicious food in the meadows, woods, foothills, near termite mounds, etc. This practice of hunting wild edible mushrooms has been followed for generations by the indigenous communities.

The wild edible mushrooms collected from different places are in good demand and is an item of trade for a few in the remote areas of the state. In the local markets, the buyers are natives only, as the confidence of outsiders can never be

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- ? turns garlic blue or black when cooked together
- ? turns a silver coin black when rubbed against it
- ? tarnishes a silver spoon when cooked with it
- ? has scales, warts or other types of rough surfaces
- ? has a ring or annulus in the middle of the stalk
- ? has a stipe, a cup or saucer like structure at the base
- ? is comparatively soft and the skin cannot be easily peeled off
- ? is colourful and quite attractive
- ? is generally bitter or sour in taste with unpleasant smell

**Characteristics of safe mushroom:**

- ? Mushroom grows on wood
- ? Slugs or other insects eat the mushroom
- ? Squirrels, rabbits, or other wildlife eat the mushroom
- ? Ring on the middle and cup at the base of the stalk are not present together
- ? Mushroom is dried, boiled, salted or pickled in vinegar

**Indigenous tests or some age-old practices:**

- ? Colour of mushroom soaked water turns blackish when some brinjal pieces or its flowers are dipped into the water indicates that the mushroom is poisonous
- ? Silver or copper articles would turn blackish when immersed in a dish of poisonous mushrooms
- ? Garlic flakes take a dark colour when added to water along with poisonous mushrooms
- ? Unusual changes in colour of onion and brinjal occur while cooking along with poisonous mushrooms
- ? Milk curds immediately in contact with poisonous mushrooms

**Some more facts about mushroom:**

- ? Some mushrooms that are edible when fresh and young become poisonous when they are old, hit by frost or if they decay
- ? Most mushrooms are more dangerous to young children, the aged and the very ill
- ? A chance of poisoning is negligible if cultivated species like oyster mushroom, paddy straw mushroom, milky mushroom and button mushroom are used as food item
- ? Wild mushroom should not be consumed without proper identification or knowledge
- ? Liquor should be avoided along with a mushroom dish
- ? Pumpkin or broad beans when consumed along with mushrooms can cause food poisoning
- ? Mushroom is not taken along with meat or other protein source.

Large number of mushroom species grow wild in nature and some of them are well known to the people of Sikkim as '*Kaloongae cheaoe*', '*Chiplae cheaoe*', '*Kotuchae cheaoe*', '*Chamrae cheaoe*', '*Konnae cheaoe*', '*Jharae cheaoe*', '*Tuktuke cheaoe*', '*Giddae cheaoe*' etc. Till date about 200 such species, some having food and medicinal value have been reported (Srivastava, 1983; Das, 2010). Other less known species are also found and some have been in use since long back. A few of the most common species found in Sikkim are described.

***Auricularia auricula*** This species is commonly known as black ear mushroom as it possesses ear like leathery and soft gelatinous cap of dark tan colour. The stalk is very short or absent at times. It possesses a leathery texture and hence not much preferred by the locals. These mushrooms are usually found on cut logs or felled *Alnus* logs during rainy days.

**Agaricus spp.** These mushrooms are sporadically found in the soils during the rainy season. They bear an almost round cap, usually white or brownish in colour with a smooth or sometimes scaly surface. The stalk is central, short and fleshy. It is attracted for its firm flesh. Some of the edible species commonly found are *Agaricus augustus*, *A. campestris*, *A. caesarea*.

**Lycoperdon spp.** These mushrooms are of globose to pyriform structures, borne singly or in clusters, creamy white in colour and slightly pubescent with small black bristle tips. Species like *L. elongatum* and *L. emodense* are inedible, grows amongst grasses, while *L. perlatum* and *L. pyriform* are edible at young stages growing on fallen leaf litter and decaying tree trunks respectively (Srivastava, 1983; Das 2010).

**Pleurotus spp.** It is locally known as *Kannae cheaoe* or *Kotuchae cheaoe*. The pileus is central, broad, often sessile and smooth with colour varying in shades of white. The stalk is absent sometimes and when present it is short and lateral. *P. citrinopileatus* and *P. ostreatus* are commonly found growing on tree trunk and decaying wood, and are greatly preferred for the delicious taste.

**Termitomyces clypeatus** This mushroom is found around the termite mounds, characterised by the prominent cone like pointed, dark-coloured projection at the centre of the cap. The stalk is central, solid and long above ground. This is one of the most delicious mushrooms found in nature and its curry emits chicken like flavour during cooking (Borah and Gogoi, 2006). It is the most dominant species among all the wild edible mushrooms of Sikkim.

**Termitomyces heimii** It is locally known as *Kaloongae cheaoe* and is associated with termite nests. A patch of veil is always present at the top of the pileus and the skin peels off easily. The stalk is long and swollen near the attachment with



Naturally growing *Pleurotus* spp. generally not eaten due to the leathery texture

the cap. The portion of the stalk underground is longer than that above ground. The natives relish the taste of this delicious mushroom which is similar to that of fried bamboo shoot.

***Termitomyces mammiformis*** It is most popular among the natives as *Jharae chea*. This mushroom emerges from sandy soil under bamboo trees. The pileus is white in colour with silvery, shining and smooth surface. The stalk is white and solid. The mushroom is delicious but due to its small size, the volume is much reduced after cooking.

***Termitomyces microcarpus*** It is one of the most prevalent species of Sikkim. This mushroom is associated with colonies of ants and anthills, which grows profusely in bamboo grooves from beneath fallen bamboo leaves (Kalita and Rathaiah, 1995). It grows in clusters of enormous numbers like wild flowers. It becomes pulpy after cooking and with a meat-like taste, it is one of the best species.

## **Mushrooms as food**

Mushrooms have been providing the natural way to good health since ages. They are considered as a delicacy and occupy a place between meat and vegetables from nutrition point of view.

### **Dietary benefits of mushroom**

- i) Mushrooms are referred to as “vegetarian meat” as it is rich in protein (35%).
- ii) Mushrooms are suitable diet for the obese persons as these are low in calories (32 KCal / 100g fresh mushroom) and low in fat (max. 0.3%).
- iii) Mushrooms are suitable for diabetic patients with low carbohydrate content and no starch.
- ii) Mushrooms can be called 'heart food' because they contain ergosterol which converts into Vitamin D in the human body. The deadly cholesterol is absent.
- iii) Its high fibre content *i.e.* >1% makes it suitable for those having constipation.
- iv) Mushrooms are also beneficial for acidity/gastritis problem due to the presence of more than 1% alkaline ash.

### **Nutritive values of mushroom**

**Protein:** Compared to cereals, pulses, fruits and vegetables, the protein content of mushroom is much higher on dry weight basis. Usually the protein content of cultivated mushrooms ranges between 2.5-3% on fresh weight basis and 20-35% on dry weight basis. The mushroom protein is of good quality with high digestibility (70-83%) properties. Mushrooms and cereal diets are complement to each other, as both together make most of the essential amino acids available which cannot be otherwise synthesized by the human body. Cereals are deficient in two essential amino acids, *viz.* lysine and tryptophan. But mushrooms are rich in these two amino acids apart from most of the essential amino acids like leucine, isoleucine, valine, threonine, tyrosine and phenylalanine. The other two essential amino acids, methionine and cysteine are however, less in mushroom but present in cereals.

**Vitamins:** Mushrooms are rich source of Vitamin B complex (thiamine, riboflavin and niacin) and vitamin C (ascorbic acid). They also contain folic acid and vitamin B12, which are not found in green vegetables. The vitamins present in mushrooms are not lost during cooking.

**Minerals:** The minerals like potassium, sodium and phosphorous are abundantly found in mushrooms. Moreover, potassium: sodium (K:Na) ratio is very high in mushrooms; hence, they are ideally suited for hypertension patients. On the contrary, the higher K:Na ratio can be of some concern to patients with renal dysfunction.

**Carbohydrate:** The carbohydrate content in mushrooms varies from 4-5% which includes chitin, hemicelluloses and glycogen. Its sugar content is very less.

**Starch** is almost absent.

The fresh mushrooms contain high moisture content to the tune of 85-90%.

## Therapeutic uses

- i) **Blood cholesterol retardant:** Mushrooms possess specific substances that reduce the blood cholesterol level. The species like *Agaricus bisporus* can bring down the blood cholesterol level by 34%, while *Lentinula edodes* can reduce the effect by 35%.
- ii) **Hypoglycemic effect:** The extremely less percentage of carbohydrate and fat content in oyster mushroom makes it useful for diabetic as well as obese persons. *Coprinus comatus* is also known to have anti-diabetic properties.
- iii) **Anti-cancer activities:** *Pleurotus ostreatus*, *A. bisporus* and *L. edodes* can suppress tumour growth by 40%.
- iv) **Antiviral effect:** The influenza and polio viruses can be regressed by a crude extract of shiitake mushroom. Some species are also known to be effective against the HIV of AIDS.
- v) Preventive as well as curative properties for liver diseases and gastroenteric ulcers have been reported in winter mushrooms (*Flammulina velutipes*).

Over the time, mushrooms have thus proved itself as a perfect food irrespective of age groups and also for the expectant mother. Mushrooms are therefore, rightly referred to as “God's own food” in some instances.

## Mushrooms as a means of livelihood

Mushroom picking for food with the onset of monsoon showers have been customary in Sikkim amongst the different communities. In recent times, mushroom growing is becoming popular because it adds to the income of especially those growers having no or insufficient land.

Sikkim is bestowed with the best climatic conditions favouring mushroom cultivation throughout the year with easily available raw materials. Mushroom growing is an eco-friendly activity as it utilizes the wastes from agriculture, poultry, brewery, etc. and in turn produces fruit bodies with excellent nutritional and medicinal attributes. There is ample scope for mushroom industry to thrive here successfully and can become a lucrative business for the unemployed rural youth, housewives and an additional income source for the farmer.

Although all types of edible and medicinal mushrooms are cultivated now a days, only Oyster mushroom and Button mushroom are suitable for growing in the state where conducive environmental conditions exist.

## Oyster Mushroom

The name of oyster mushroom is due to its resemblance to the shell of sea oyster. Oyster mushroom is the most widely cultivated mushroom in India owing to its simple cultivation technology, low production cost and its adaptability. It possesses highest bioconversion ability *i.e.* more than 60%. It thrives well in a moderate range of temperature 20-30°C and requires 80-85% humidity. Its growing season is longer especially in Sikkim. It can be grown for ten months or almost throughout the year.

**Growing season** The best temperature range for oyster mushroom cultivation being 20° to 25°C, in Sikkim, the suitable months of the year for growing this crop is April to November. However, abrupt fluctuation in temperature results reduced production.

**Species** The species *Pleurotus florida*, *P. cornucopia*, *P. citrinopileatus*, *P. flabellatus*, *P. ostreatus*, *P. sapidus*, *P. sajorcaju* (grey oyster mushroom) can be successfully grown here. *P. sapidus* and *P. sajorcaju* do better during the warmer part of the year (May - August). Although, the species *P. eous* is most beautiful with the attractive pink colored fruit bodies, cannot be cultivated on commercial basis because of its less yield potential and slightly leathery texture.





*Pleurotus citrinopleatus* performs well during winters in Sikkim



*Pleurotus sapidus* suitable for warmer months

**Substrate** In India, as early as 1962, Bano and Srivastava reported mass production of oyster mushroom on straw based substrates and obtained increased yield by using paddy straw. The cellulosic agriculture byproducts available here of maize, jowar, bajra, wheat, rice, mustard/tori etc. or even sawdust are suitable for growing this mushroom. However, paddy straw is the best substrate and easily available. The straw should be of good quality and not exposed to rain. Maize is extensively cultivated crop in Sikkim. Its stalks, leaves or hulled cobs can also be used but the method requires extra labour.

**Cultivation method** Cultivation of oyster mushroom can be done by following methods, viz; I) Polybag culture/polythene bag method and II) Cube culture method. The most convenient is Polythene bag method (Gogoi, Rathaiah, and Borah, 2006).

### **Button Mushroom**

White button or European button mushroom (*Agaricus bisporus*) is a temperate mushroom, extensively cultivated throughout the world covering about 40% of the total production. This mushroom requires cool temperature below 20°C and the optimum temperature for fruiting is 15-18°C. This is one of the delicious mushrooms preferred worldwide and suitable for canning industry because of its superior texture and other culinary properties. In Sikkim, the button mushroom can be grown under natural conditions during winter season from mid September to mid December. Haryana and Punjab, the two largest producers of button mushroom in the country have well developed farms with controlled environment and follow short method of compost making for the production of button mushrooms. These facilities are presently not available in Sikkim. Moreover, there is a dearth of the base material *i.e.* wheat straw, which is best amongst other substrates like paddy and barley. The long method of compost making can be followed under natural conditions and this method in Sikkim, provide only one date of sowing during the year.



*Agaricus bisporus* not commonly grown due to lack of wheat straw

**Production technology** Button mushroom is grown on specially prepared substratum called compost. Hence button mushroom production requires sound knowledge and experience of compost making. The process of compost preparation is called composting during which chemical and physical changes occur of the substrate. Many mesophilic and thermophilic organisms control the process and make nutrients readily available to the mushroom mycelia.

**Materials required for compost preparation:**

- ? Base materials Straw of wheat/ paddy or barley. However, wheat straw is the best.
- ? Carbohydrate rich materials Molasses.
- ? Nitrogen rich materials Ammonium sulphate/ Urea/ Calcium Ammonium Nitrate (CAN).
- ? Animal feeds Wheat bran or rice bran.
- ? Muriate of potash (MOP)/ Single super phosphate (SSP) and trace element.
- ? Gypsum

For better composting, a minimum of 300kg of straw is required or else the required temperature does not develop inside the heap.

**Compost formula** Several compost formulae have been developed over time at different research institutes and standardized for compost preparation.

**Methods of composting:** There are two methods of compost making:

**a) Short method:** - This method takes around 16-20 days and requires about 3-4 turnings during composting period with production of more compost per unit weight of ingredients used. The compost produced by this method is free from diseases and pests. However, the method requires heavy investment and is carried out in two phases I. outdoor composting. II. Indoor pasteurization and conditioning.

**b) Long method:** - This method takes about 28-30 days and requires 5-9 turnings during composting period with less compost per unit weight of ingredients used and prone to disease and pest infestation. In Sikkim condition, the long method of compost preparation can be followed. The advantage is that it is cheaper and carried out in completely outdoor condition. But when composting is made in outdoors, it must be protected from rains by covering with polythene sheet or tarpaulin to prevent leaching of nutrients, which may affect the yield.

**Paddy Straw mushroom**

Paddy straw mushroom also known as 'Chinese straw mushroom (*Volvariella volvacea*) and milky mushroom (*Calocybe indica*) are tropical mushrooms. These mushrooms require a temperature range of around 20-40°C for spawn run and 28-30°C for fruiting. A high relative humidity of 85-90% and diffused sunlight are essential factors for the growth of these mushroom. The cultivation of these mushrooms would be possible in Sikkim during the summer season (June August) at lower altitude under green house condition.

**Production technology** This mushroom is very fast growing. It takes only 14 days from spawning to harvest under optimum climatic conditions and method of cultivation is easy. It tastes better than oyster mushroom. However, its keeping quality is very poor and productivity is less compared to the huge quantity of straw required for cultivation. The other main hindrance in production of *Volvariella* sp. is that the cultures degenerates very fast during sub culturing in the off season and it should be always incubated at 28° C.

Cultivation of paddy straw mushroom can be done by three methods, viz. (i) Standard bed method (ii) Hollow bed method (iii) Cage method. The fruit bodies should be harvested at egg stage as the taste gradually decrease with the age of the fruit bodies thereafter.



*Hypsizygus ulmarius*, this hybrid has good potential during warm season



*Pleurotus eous* also has aesthetic values



*Pleurotus florida* most commonly cultivated, has good production potential



Mushroom units coming up in the state

## **Milky mushroom**

The cultivation method of milky mushroom is almost similar to that of oyster mushroom. Milky mushroom has a good shelf life and a good texture which is retained after cooking. This mushroom is known to have the highest biological efficiency, up to 140%.

**Production technology** The method of bed preparation is same as in oyster mushroom. However, the boiled straw should be sun dried for 30 minutes to 1 hour to bring down the moisture content to 60-70%. Spawning is done at the rate of 5% and spawn run is completed in 15-20 days. The poly bag is not opened and the bed is cut in to two beds of about 20cm height. The exposed surfaces of the two beds are covered with 1-2cm casing (casing composition is same as in button mushroom). For cropping the beds are kept in special type of cropping room *i.e.* Horticultural polyhouse with roof of UV stabilized low density polythene film together with Netlon Agro shade of 75%. Pinheads appear 6 to 10 days after casing and the second and third crop comes up at 10 days interval. A mist of water is sprayed everyday on casing soil. Mushrooms should be harvested before the cap is fully open.

## **Mushroom for entrepreneurship development**

Sikkim, is one of the suitable places for mushroom production/cultivation. There is potential for mushroom industry to thrive in the state and provide lucrative job opportunities especially to the rural youths and farm women and generates an extra income for the farmers. The climatic conditions along with the availability of the cheap raw materials make Sikkim one of the potential areas for cultivation of different types of mushroom and hence, the prospect of building up a thriving cottage industry is tremendous (Borah, 2007). However, the mushroom production is still in its infancy and only a small fraction of the farming community is engaged in small scale seasonal production of mushrooms.

The availability of quality spawn and marketing aspects are the major areas that need to be explored and learned about. Improper product promotion, misconception that mushroom as a whole are poisonous, lack of knowledge about its nutritional and medicinal value, shorter self life, lack of processing facilities, transportation problems and high price are the major problems in the marketing of mushrooms. The NGOs, Co-operative Societies, the State Department of Agriculture or individuals with sound knowledge on mushrooms can take the initiative to procure quality spawn from reliable sources for the farmers and develop organized marketing for disposal of produce of these mushroom cultivators.

Sikkim being famous for its tourism industry, creates a high demand for mushroom delicacies in the hotel business. Mushroom processing unit is another big avenue in itself, which will be more profitable and also employment generating. To set a mushroom based industry; there should be regular supply, which in turn is dependent on round the year cultivation. Sikkim being an organic state, organic compost is one of the prime inputs in Agriculture. Spent mushroom beds, can be used for vermicompost production along with other organic household wastes (Ahlawat and Tewari, 2005). Vermicompost production can thus, be another source of income.

In the present hour of global food crisis, if the loopholes are properly mended, the mushroom industry would provide better options for employment and income generation.

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