CHAPTER 2
REVIEW OF LITERATURE

2.1 History of Mushrooms

Hippocrates first mentioned mushrooms medicinal value in 400 B.C. The first mention of mushroom cultivation, distinct from a chance of appearance in the field was in 1652. The first record of year-round commercial production was in 1780. When a French gardener began to cultivate mushrooms in the underground quarries near Paris. Gardeners introduced mushroom growing to North America by using dark areas underneath greenhouse benches to grow mushrooms. In 1894 the first structure specifically designed to grow mushroom was built in Chester County, Pennsylvania, which is usually referred to as the mushroom capital of the world (Lo and Wasser 2011). Since ancient times, mushrooms have been regarded as the ‘Food of the Gods’. The Pharaohs of ancient Egypt believed they had magical powers, while the Chinese used them for their health-giving properties (Chu et al. 2002).

Mushroom was first cultivated in India in 1940, however, its systematic cultivation was first attempted in 1943. Department of Agriculture, Solan, Himachal Pradesh, started the work on a small scale to grow mushrooms. In India, commercial cultivation of mushrooms had been with the joint effort of scientists and farmers (Chang and Miles 2004). Annual mushroom production has increased to 80,000 ton in 2006 from a mere 1,000 ton in 1981. Fifty percent of this is produced by marginal and small production units and the rest by industrial establishments. Mushroom husbandry is now one of the major sources of income for farmers of many states like Haryana, Uttar Pradesh, Punjab, Uttarakhand, Himachal Pradesh and Tamilnadu (Ekonem and Ubengama 2002).
“Without Leaves, without buds, without flowers,
Yet they form fruit.”
“As food, as a tonic and as a medicine,
Mushrooms are wonderful are creations of nature.” (Chang and Miles 2004).

2.2 Mushroom

Mushrooms are fleshy, spore-bearing fruiting body of fungi belonging to the subdivision of Basidiomycotina of the class Hymenomycetes. Basidiomycetes include many of the familiar fleshy mushrooms. They are promising resource of physiologically functional food and as material for the development of medicines, pharmaceutical product, such as drugs, dietary supplements and healthy cosmetic products. Mushrooms have very high nutritional value being rich in proteins, vitamins and minerals. The body of the mushroom stores nutrients and other essential compounds, and when enough material is stored and the conditions are right they start to fruit - produce mushrooms (Zhong and Tang 2004).

2.3 Morphology

The basidiospores of mushrooms grow in the soil or on degraded organic substrates as a filamentous tubular, septate, microscopic structures called hyphase. This organized network of mycelium is biodynamic and often forms thick stands called rhizomorphs. The individual hypha growing form a single basidiospore is normally monokaryotic and homokaryotic. Clamp connections and ladder formation in the hyphase ensure dikaryotic and heterokaryotic mycelia forms. The fruiting body or the basidiocarp consists of a thick stalk called the stipe on which an umbrella - shaped pileus rests. Pileus is also known as cap. The stipe is mostly cylindrical, fleshy and swollen at the base. At the lower surface of
the pileus numerous plate like radiating structures which extend from the stipe are present (Liang et al. 2011).

**Figure 2. 1** *Pleurotus ostreatus* (Oyster Mushroom)

*Pleurotus ostreatus* is an edible species, commonly known as the oyster mushroom (Hestbjerg et al. 2003). *Pleurotus* is an efficient lignin-degrading mushroom and can grow well on different types of lignocellulolosic material (Palmieri et al. 2001).

**Figure 2. 2** *Calocybe indica* (Milky Mushroom)

*Calocybe indica* (Milky Mushroom) are white in color, gills and stalks white. Mushrooms large with long, thick fibrous stalk. It can be grown on
substrates containing lignin, cellulose and hemicelluloses, straw of paddy, wheat, ragi, maize, bajra, cotton stalks, sugarcane bagasse, wastes, dehulled wastes etc. *Calocybe indica* is of Indian origin. It has become the third commercially grown mushroom in India, after button and oyster mushrooms (Mary and Sahana 2014).

### 2.4 Taxonomical Classification of Mushrooms

Fungi are regarded as being the second largest group of organisms in the biosphere after the insects. Known fungal species constitute only about 5% of their species in the world. Out of about 70,000 described species of fungi, it has been suggested that around 14,000 to 15,000 species produce fruiting bodies of sufficient size and suitable structure to be considered as macrofungi (mushrooms), of these, about 5,000 of the species are considered to possess varying degrees of edibility, and more than 2,000 species from 31 genera are regarded as prime edible mushrooms. But only 100 of them are experimentally grown, 50 economically cultivated, around 30 commercially cultivated, and only about 6 to have reached an industrial scale of production in many countries. Furthermore, about 1,800 are medicinal ones. The number of poisonous mushrooms are relatively small (approximately 10%), of these some 30 species are considered to be lethal (Chang and Buswell 2008).

### 2.5 Cultivation

The cultivation of mushrooms can be both a relatively primitive farming activity, and a high technology industry. In each case, however, continuous production of successful crops requires both practical experience and scientific knowledge. Mushroom cultivation is both a science and an art. The science is developed through research; the art is perfected through curiosity and practical experience. Mushroom growth dynamics involve some technological elements, which are in consonance with those exhibited by our common agricultural crop
plants. For example, there is a vegetative growth phase, when the mycelia grow profusely; and a reproductive growth phase, when the umbrella-like body that we call mushroom (Martinez et al. 2001).

Table 2.1 Taxonomic classification of *P. ostreatus* and *C. indica*

<table>
<thead>
<tr>
<th>Taxonomical Position</th>
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<tr>
<td><strong>Pleurotus ostreatus</strong> (Oyster mushroom)</td>
<td><strong>Calocybe indica</strong> (Milky Mushroom)</td>
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<tr>
<td>Scientific Classification</td>
<td>Scientific classification</td>
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<tr>
<td>Kingdom : Fungi</td>
<td>Kingdom : Fungi</td>
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<tr>
<td>Phylum : Basidiomycota</td>
<td>Division : Basidiomycota</td>
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<tr>
<td>Class : Agaricomycetes</td>
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<td>Order : Agaricales</td>
<td>Order : Agaricales</td>
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<tr>
<td>Family : Tricholomataceae</td>
<td>Family : Lyophyllaceae</td>
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<tr>
<td>Genus : <em>Pleurotus</em></td>
<td>Genus : <em>Calocybe</em></td>
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<tr>
<td>Species : <em>ostreatus</em></td>
<td>Species : <em>indica</em></td>
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*Pleurotus ostreatus* is the second most cultivated edible mushroom worldwide after *Agaricus bisporus*. It has economic and ecological values and medicinal properties. Mushroom culture has moved toward diversification with the production of other mushrooms. Edible mushrooms are able to colonize and degrade a large variety of lignocellulosic substrates and other wastes which are produced primarily through the activities of the agricultural, forest, and food-processing industries. Particularly, *P. ostreatus* requires a shorter growth time in comparison to other edible mushrooms. The substrate used for their cultivation does not require sterilization, only pasteurization, which is less expensive. Growing oyster mushrooms convert a high percentage of the substrate to fruiting bodies, increasing profitability. *P. ostreatus* demands few environmental controls, and their fruiting bodies are not often attacked by diseases and pests, and they can
be cultivated in a simple and cheap way. All this makes *P. ostreatus* cultivation an excellent alternative for production of mushrooms when compared to other mushrooms (Sanchez 2010). *C. indica* a tropical edible mushroom, is popular because it has good nutritive value and it can be cultivated commercially on a large scale. Paddy straw used as a substrate in milky mushroom. Paddy straw mushroom is a popular variety among people because of its distinct flavour. Pleasant tastes, higher protein content and shorter cropping duration compared to other cultivated mushrooms (Mary and Sahana 2014).

### 2.6 Nutritional and medicinal properties of *P. ostreatus* and *C. indica* Mushrooms

Traditionally, the most popular preservation technologies for the reduction of microbial contamination of food and pathogens in particular, have been the manipulation of water activities, pH, heat treatments, addition of chemical preservatives and the control of storage temperature of foods (Manas and Pagan 2005). Food preservation is the process of treating and handling food in such a way so as to stop or slow down spoilage, prevent food-borne illness, and at the same time maintain its nutritional value, density, texture and flavor. Processing of food has to satisfy stringent requirements with respect to human safety, free from microbiological, physio-chemical contamination, organoleptic and nutritional quality, aesthetic appeal, total compliance with food laws and environmental safety regulations and extended shelf life (Clark 2006). The greatest difficulty in feeding man is to supply a sufficient quantity of the body building material protein. The other three nutritional categories are: the source of energy food carbohydrates and fats, accessory food factors vitamins and inorganic compounds which are indispensable to good health (Shimizu and Anzai 2001). Furthermore, mushroom protein contains all the nine essential amino acids required by man. In
addition to their good proteins, mushrooms are a relatively good source of the following individual nutrients: fat, phosphorus, iron, and vitamins including thiamine, riboflavin, ascorbic acid, ergosterine and niacin. They are low in calories, carbohydrates and calcium. Mushrooms also contain a high proportion of unsaturated fat (Pieroni et al. 2005).

Healthy nutrition and diet are gaining importance not only in the everyday life of human beings, but also in the treatment of chronic diseases. Mushroom are recognized worldwide as medicinal foods rich in nutrition by Doctors. The Food and Drug Supplementation (FDA) has officially designated mushroom as "Healthy foods" (Babu and Rao 2013). Mushroom are reputed to possess antiallergic, anti-cholesterol, anti-tumour and anti-cancer properties and it is rich source of protein, vitamins, fats, carbohydrates, amino acids. Appreciable amount of dietary fibre is present in their fruiting bodies which are important for the regulation of physiological functions in human beings like regulation of digestive tract. Moreover, mushroom are low in nucleic acid contents which make them an ideal food for patients suffering from diabetes, obesity and hypertension (Manzi et al. 2001).

Biologically active (bio-active) compounds offering demonstrated physiological benefits for consumers have been identified in plants and plant-based food products (Lindequist et al. 2005). Bio-active compounds such as phenolic compounds catechin, epicatechin and rutin were detected and quantified. β-carotene, quinones, cerebrosides, isoflavones, catechols, amines, triacylglycerols, sesquiterpenes, steroids, organic germanium and selenium have been implicated in offering health benefits over and above basic nutritional requirements (Ramesh and Pattar 2010). These compounds among many others are used as ingredients in the manufacture of functional foods and nutraceuticals.
The effectiveness and uniformity of these products is dependent upon the preservation of bioactive compounds throughout the value-added chain (Rama and Jacob 2000). Medicinal properties of edible mushroom have been exploited for treating various health conditions including cancer. The recent explosion of biochemical knowledge into the molecular underpinnings of human cancer had radically altered our basic understanding of the malignant state and has laid the foundation for the design of novel strategies for prevention, diagnosis and treatment of cancer (Kim et al. 2013).

2.7 Processing and preservation of mushrooms

Several published experimental clinical studies have reported that mushrooms dietary supplementation may increase innate immunity and exhibited the beneficial effects on the health. Mushrooms dietary supplementation analysis found that mushroom consumption was associated with better diet quality and improved nutrition. The use of mushroom dietary supplements as adjunctive therapies for the treatment of many disease in the body (Novaes et al. 2011). However, research articles have examined the effects of medicinal mushrooms supplementation treated many disease (Niedzielski et al. 2014). Therefore, new protocols for the purpose of conducting clinical trials are required to elucidate the possible mechanisms of action and clinical benefits of these fungi with respect to the survival time, clinical progression and quality of life in diseased patients (Dayong et al. 2007). Nutrients, such as vitamins and minerals, are best derived from food sources. However, you might find it difficult to eat a balanced diet on a regular basis. Mushrooms supplements can help you get the nutrients lack from regular diet (Hossain et al. 2003) The greatest need for added protein, fat food generally in the overpopulated lands of the orient where the diet is limited to certain foodstuffs. Efforts to improve diet of such people by the incorporation of
mushrooms dietary novel foods have met with great value in this needy populations (Milovanovic et al. 2003).

Processing of mushroom is necessary to develop suitable post-harvest techniques for its prolonged preservation and usage. Many times grower faces problem of over saturation of market and distress at highly non-remunerative prices. The retention of fresh mushroom at various level such as grower, whole seller, retailers and consumers further results in deterioration in quality of the produce and economic loss. Presently, long-term preservation of mushroom by drying, canning and pickling are in vogue. These value added products not only reduces the post-harvest losses but also enhances the additional income to the mushroom growers and provide nutraceutical low fat, protein rich food to the consumers (Muresan et al. 2012).

The preservation of mushrooms through drying, dates back many centuries and is based upon sun drying techniques. Mushrooms are highly perishable in nature, with extremely short shelf life as they contain moisture in the range of 87 to 95% wet basis (w.b.). The protein content of this tropical mushroom is 32.3% and the crude fibre is about 41% (Milovanovic 2003). Therefore, their processing to the forms of more stable product is important. Long term preservation methods such as canning, pickling and drying are most commonly used methods of preservation of mushrooms to make the product available throughout the year (Ertekin and Yaldiz 2001). Mushroom can be processed in many other ways to extend their shelf life such as drying. Drying reduces bulk quantity, thus facilitating transportation, handling and storage. Although sun-drying is economical, mechanical drying speeds up the process, prevents losses, ensures use of safer drying temperatures and produces superior product compared to sun drying. Dehydrated mushrooms are used as an important ingredient in several
food formulations including instant soups, pasta salads, snack seasonings, stuffing, casseroles, and meat and rice dishes (Nachiket et al. 2007).

2.8 Drying of mushrooms and its importance in preservation

Finding a method to achieve an extended shelf life would benefit both the food industry and consumers. Dried mushroom can be used in many different types of products. Furthermore, elevated temperatures during drying enhance enzymatic reaction that can result in improved flavor of dehydrated mushroom (Rama and Jacob 2000). Pre-treatment methods and drying may contribute to the deterioration of both the eating quality and the nutritive value of a food product. Advances in drying technology and standardization techniques in compound analysis allow for the possibility of using drying for the development of functional foods and nutraceuticals. The selection of the type of dryer or drying system used for a specific situation is based upon the product’s characteristics and drying behavior, as well as the end product required (Beaudry et al. 2003).

Benefits of dehydrating mushrooms, as water is removed, taste is deliciously concentrated as a result is a convenient food with a taste may be better than the original. No preservatives or chemical additives were added in the dehydrated mushrooms as a result is 100% natural food that will stay tasty and nutritious for many months, it can be stored sixth months than the fresh mushrooms, original storage and it don’t require the ongoing electrical drain of a refrigerator or freezer. Pre-treatment of mushroom for storage, regardless of method used is an important step in preserving the produce. It helps the food product keep its natural colour, and kills off enzymes that can cause food spoilage (Ashok et al. 2013). In addition to making dried foods that cost less, dehydrators can help to save money in several ways (Nagy et al. 2011).
2.9 Mushrooms as a source of medicine

Potentially harmful Reactive Oxygen Species (ROS) are produced as a consequence of normal aerobic metabolism. The reactive species is usually inactivated in vivo by a variety of antioxidant. Antioxidant are deployed to prevent generation of ROS or to scavenge those formed. Thus, oxidatively induced tissue damage is minimized. However, deficiency of antioxidant defences may lead to oxidative stress, which might be associated with a variety of disorders, diabetes, arthritis and cancer (Spiteller et al. 2001). Chinese herbs have been used for diet therapy to exhibit significant antioxidant activity (Jones and Janardhanan 2000).

Mushrooms are traditionally used in Chinese medicine and are commonly used for pharmaceutical purpose and health foods. A number of medicinal mushrooms have recently been reported to possess significant antioxidant activity observed in Pleurotus ostreatus, Pleurotus florida, Pleurotus rimasus, Calocybe indica and Ganoderma lucidum. All mushroom showed significant antioxidant activity. The role of free radicals has been implicated in a large number of diseases (Ekonem and Ubengama 2002). The antioxidant activity of the mushroom is of significant importance in exploiting their therapeutic potential. Mushrooms represent a major and as yet largely untapped source of powerful new pharmaceutical products. The most significant medicinal effect of mushrooms and their metabolites that attracted the attention of the public in the recent year is their antitumor property (Didukh 2001). Many pharmaceutical substances with potent and unique properties were isolated from mushrooms and distributed worldwide. Many of them are not strictly pharmaceutical products but represent the novel class of dietary supplements of approximately 10,000 known species of mushrooms, 2000 are safe and 300 have significant pharmacological properties (Vamanu 2012).
Cancer is the second largest single cause of death in children and adults claiming over 6 million lives each year worldwide. It is the sum of all the processes, which transform normal healthy alive cells into abnormal damaged denatured cells. Cancer or neoplasm is defined as a mass, growth of which is in coordinate with the surrounding normal tissues and that persists in the absence of inciting stimulus. Cancer develops when cells no longer follow the normal pattern of the controlled growth (Costa et al. 2010). More than 50 mushrooms species have yielded potential immunoceuticals, which exhibit significant anticancer activity in experimental animal systems (Kidd 2000). The protein bound polysaccharides isolated from the mushrooms have been used as an immune therapy agent in the treatment of cancer in Asia over 30 years. A large number of mushrooms derived compound both cellular components and secondary metabolites have been shown to affect the immune system and could be used to treat a variety of disease status (Song et al. 2013).

Mushrooms are useful against cancer and are known in China, Russia, Japan, India and Korea as well as the United States and Canada. A large number of antitumor agents are produced by both micro and macro fungi (Borchers et al. 2004). At least 651 species representing 182 genera of hetero and homo basidiomycetes mushrooms contain antitumor or immunostimulating polysaccharides (Bezivin et al. 2003). Medicinal mushrooms occurring in South India namely *Ganoderma lucidum, Calocybe indica, Phellinus rimosus, Pleurotus florida, Pleurotus pulmonarius* and *Pleurotus ostreatus* possessed profound antioxidant and antitumor activities. Investigations also demonstrated that mushrooms have significant antimitagenic and anticarcinogenic activities. Thus, Indian medicinal mushrooms are potential sources of antioxidant and anticancer compounds (Ajith and Janardhanan 2001). The ability of some mushrooms to
inhibit tumour growth and enhance aspects of the immune system has been a subject of research for approximately 50 years (Borchers et al. 2008).

2.10 Value addition of products and popularization

Value addition is the process of taking a raw commodity and changing its form to produce a high quality end products. Value addition is defined as the addition of time, place and form utility to a commodity in order to meet the tastes and preferences of consumers. Most commonly value-added products derive from fruit or vegetables that are transformed into gourmet food items. Typical value added products include jams, jellies, preserves, fruit sauces and spreads, pickles, preserved vegetables, tapenades, hot chili sauces, extra virgin appellation olive oils, herb-flavored olive oils and vinegars, and salsas. Any product can be considered value-added if it is originally grown by the farmer and increased in value "by labor and creativity. Value-added products are now being developed by small to medium scale farmers who do their own processing and sell direct to customers through farmers markets, individual and direct wholesale orders (Hoa and Wang 2015). Value-added products significantly enhance farmers businesses, affording them a steady income throughout the year. Indian mushroom industry is still predominantly production and trade of the fresh produce, processing too is restricted to the preservation rather than the real value-addition. Almost entire domestic trade is in the fresh form while all the export in the preserved form (Petrovic et al. 2014).

Current era is characterized by greater awareness about quality and above all, with the demand for the readymade or ready to make food products. Value can be added to the mushrooms at the various levels and to varied extent, right from grading to the readymade snacks or the main course item. In market a variety of mushrooms medicinal preparations in the form of soup powder, tablets,
capsules, ketchup, candy, pickle, biscuits, burger, hot dog, patties, cheese
sandwiches, stuffed dosa, biryani, fritters, and poached eggs and also these
products are gaining importance day by day (Sullivan et al. 2006). Improved
and attractive packaging is another important, whereas attractive and labeled over
wrapped trays are in vogue in the developed countries (Ban et al. 2014).
Attractive packaging of the value added products is yet another area which may
be called the secondary value addition. While small growers may add value by
grading and packaging, industry may go for the processed products for better
returns as well as improvement in the demand which shall have cascading
positive effect on the production (Kosanic et al. 2012). Packaging plays very
important role in handling, marketing and consumption of the produce and
products, protects the quality during the storage and transport, keeping in retail
and storage with the consumer. Packaging of mushrooms from the production site
upto the consumer including packaging for export market is an important aspect
of post-harvest handling. Generally the packaging increases the consumer
confidence in the product. If the packaging and storage is not done properly,
mushrooms not only deteriorate in their saleable quality but also in nutritional
quality due to enzymatic changes (Kaul 2001).

All the above mentioned literature review relates the potential benefits of
mushroom resources as a human food for centuries, these are utilized all over the
world due to their delicate taste, flavor, nutritional values and medicinal
properties. Moreover, these literature reports proves, among all the species,
*P. ostreatus* and *C. indica* have not been utilized more due to lack of awareness
about the nutritive value, functional properties and little aversion among people.
Keeping this in mind, the present study was designed to create awareness about
the nutritive value, increase the utilization and extend the shelf life of food
products from selected edible mushroom.