Chapter – 1

INTRODUCTION

Mushrooms have been part of our human diet since time immemorial. They were used as food even before man understood the use of other organisms. Undoubtedly mushrooms were one of the man’s earliest foods, and they were often considered an exotic and luxurious food reserved for the rich. Today mushrooms are food for both the rich and the poor. They can be grown anywhere as long as the conditions for their growth and cultivation are provided.

The popularity of mushrooms is still based not on the nutrients that they contain but mostly on their exotic taste and their culinary properties. Whether eaten alone or in combination with other foods. Protein is one of the most important nutrients in food, being particularly important for building body tissues. Mushrooms with protein content ranging from 3-7% when fresh to 25-40% when dry can play an important role in enriching human diets when meat sources are limited. The protein content is almost equal to that of corn, milk and legumes, although still lower than meat, fish and eggs. As a dietary source of protein mushrooms are superior to most fruits and vegetables with the exception of beans and peas.

Mushrooms can be eaten fresh or cooked, unlike other protein sources such as soya and yeast that have to be processed or disguised in some manner before they are acceptable on the table. Mushrooms also contain all the essential aminoacids, non essential aminoacids and amides. Lysine, which is low in most cereals, is the most important amino acid in mushroom (Yang et al., 2001). Mushrooms also rank quite high in their vitamin content which includes significant amounts of vitamin C, although devoid of vitamin A, mushroom make up for that with their high riboflavin, thiamin and cyanocobalamin (vitamin B12) content, the later being found only in animal products (Chang and Miles, 1989; Matilla et al., 2000; Manzi et al., 1999, 2004). Mushrooms are also good source of minerals such as calcium, potassium, sodium and phosphorous. Iron is also present in an appreciable amount in mushroom and together with phosphorous, can provide a good proportion of the recommended daily dietary needs.

Mushrooms for medicinal purposes have been used for about 100 years. In Chinese medicine, dried mushrooms are used as diuretics and some other species have recently been getting attention as carcinostatic substances (Mizuno, 1995; Wasser and Weis, 1999). During the
1970s, Japanese researchers found that antitumour compounds in some mushroom species, were infact polysaccharides whose basic structure was beta glucan. Mushrooms are also effective against diabetes, ulcer and lung diseases (Quimio, 1976).

Mushrooms with their flavor, texture, nutritional value and high productivity per unit area have been identified as an excellent food source to alleviate malnutrition in developing countries (Eswaran and Ramabadran, 2000). Further high biofuel prices have caused an increase in food prices and food scarcity in many countries (World Bank, 2008).

The cultivation of edible mushrooms has been accepted as a biotechnological process for conservation of various lignocellulosic, agricultural, industrial, forestry and horticultural wastes or their by-products into proteins, especially in developing countries. It is being realized, that mushroom cultivation is a viable alternative venture for minimizing the ever increasing protein malnutrition gap and multitude of allied problems in these countries. There should be no doubt that current trends in the cultivation of mushrooms will not focus to increase the food production only, but will also emphasize their importance to medical research, beverage industry, pharmaceuticals and even cosmetics.

Since cultivated mushrooms can grow on agricultural and industrial wastes, they constitute a source for obtaining food protein from such wastes, and thus they can be marshaled to aid in solving many problems of global importance including protein shortages, resources recovery and environmental management. Different plant waste materials were used as substrates for mushroom cultivation (Zadrazil, 1980).

So far about 25 species of more than 2,000 edible fungi are widely accepted for human consumption but only, a few of them are commercially cultivated. During the past few decades, mushroom cultivation has spread throughout the world (Chang and Miles, 1982). Total mushroom production worldwide has increased more than 18 fold in the last 32 years, from about 350,000 metric tons in 1965 to about 6,160, 800 metric tones in 1997 (Chang, 1999).

About 2000 species from more than 30 genera, are regarded as prime edible mushrooms, but only about 80 species are grown experimentally, 40 cultivated economically, around 20 cultivated commercially and only 4-5 are produced on an industrial scale (Chang, 1990). Only three edible mushrooms, Agaricus bisporus (white button Mushroom) volvariella spp. (paddy straw Mushroom) and Pleurotus spp. (Oyster Mushroom) are in commercial or semi commercial
cultivation in India. From a production stand point, the white button Mushroom has the highest
growth rate and potential for production. However, cultivation of oyster Mushrooms have been
more common since the end of the last century, when the infrastructure of oyster Mushroom
growing was much improved and therefore capital requirements for white button Mushroom.
The genus *Pleurotus*, though relatively new to mushroom industry, has gained much popularity
world over and is presently believed to be potential rival of commonly cultivated white button
Mushroom (*Agaricus bisporus*).

Cultivation of oyster Mushroom *Pleurotus* spp. has increased greatly throughout the
world during the last few decades. In 1997 it accounted for 14.2% of the total world edible
mushroom production. Its popularity has been increasing due to its ease of cultivation, high yield
potential and high nutritional value. Although commonly grown on pasteurized wheat or rice straw, it can be cultivated on a wide variety of lignocellulosic substrates, enabling it to play an
important role in managing organic wastes whose disposal is problematic. *Pleurotus* spp. have
been used by human cultures all over the world for their nutritional value, medicinal properties
and other beneficial effects.

*Pleurotus* spp. Commonly known as oyster mushroom or Dhingri mushroom is
extensively cultivated throughout the world and contributes about 24.1% (0.909 million metric
tones) of the total world mushroom production of 3.772 million metric tones (Chang and Miles,
1991; Munshi and Ghani, 2003). The annual production of oyster mushroom touched 0.91
million metric tones in 2000. Almost all species of genus *Pleurotus*, occur commonly as wood
decomposers in forests throughout the world. In many countries *Pleurotus* spp. are collected
and cultivated as choice edibles (Chang *et al.*, 1981).

Oyster mushrooms provide good nutritional value. Yang *et al.* (2001) reported crude
protein content, on dry weight basis, as 15.4% and 23.9% in *P. cystidiosus* and *P. ostreatus*
respectively. They contain about 60% carbohydrates (dry weight) within the ranges from other
edible mushrooms (Crisian and Sands, 1978; Bano and Rajarathnam, 1988). Oyster mushroom
has no starch, low sugar content and high amount of fibre, hence it serves as the least fattening
food (Osei, 1996).

Oyster mushrooms are also known to have multiple medicinal properties. Oyster
mushrooms naturally produce mevinolin (lovastatin) in portions of the fruiting bodies (Gunde-
Cimerman, 1999). Mevinolin inhibits the key enzyme in cholesterol biosynthesis in the liver and reduces cholesterol absorption (Bobek et al., 1998). Gunde Cimerman (1999) showed its effectiveness as an anticancer agent, while Gerasimenya et al. (2002) found it useful in decreasing the toxic effects of common cancer drugs. Moreover it has been demonstrated to have antibacterial properties (Wasser and Weis, 1999). In addition to antiviral, anti-inflammatory and immune modulation activities (Jose et al., 2002). Species of Pleurotus like Pleurotus pulmonarius and Pleurotus ostreatus, exhibited strong anti-inflammatory and immunomodulatory properties due to their chemical composition (Selegean et al., 2009; Lavi et al., 2010).

Pleurtous is found abundantly in Kashmir valley, Drass (Ladakh district) and Jammu. Nature has gifted Jammu and Kashmir state with huge number of fresh fungi, majority of which are yet unexplored. Three species of Pleurotus are commonly available in J&K state. P. fossulatus, P. flabellatus and P. mambranacens. Commercial cultivation of Pleurotus specie was introduced in the state by number of organizations since long and a good amount of reasonable work has been done on various aspects of this mushroom in SKUAST-Kashmir. Its cultivation on different agrowastes and because of its medicinal importance, but the major constraint in the speedy popularization of this crop are diseases and pests, which happen to be devastating and perpetuate easily from one season to another.

Like all other crops, mushrooms are also affected adversely by a large number of biotic and abiotic agents/factors. Among the biotic agents, fungi, bacteria, viruses, nematodes, insects and mites cause damage to mushrooms directly or indirectly. A number of harmful fungi are encountered in compost and casing soil during the cultivation of white button mushroom. Many of these act as competitor moulds thereby adversely affecting spawn run whereas others attack the fruit bodies at various stages of crop growth producing distinct disease symptoms. At times there is complete crop failure depending upon the stage of infection, quality of compost and environmental conditions. General distribution of various competitor moulds and pathogenic fungi is as follows: I. Those occurring mainly in compost include: Olive green mould (Chaetomium olivaceum and other spp.), Ink caps (Coprinus spp.) Green moulds (Aspergillus spp. Penicillium spp. and Trichoderma spp.), Black moulds (Mucor spp., Rhizopus spp.) and other (Myriococcum praecox, Sporotrichum sp., Sepedonium sp., Fusarium spp., Cephalosporium spp., Gliocaldium spp., and Papulospora spp.). II. Fungi occurring in compost
and in casing soil: White plaster mould (*Scopulariopsis fimicola*): Brown plaster mould (*Papulospora byssina*), Lipstick mould (*Sporendonema purpurescens*), False truffle (*Diehliomyces microsporus*) and green moulds. III. Fungi occurring on and in casing soil and/or on the growing mushrooms: Cinnamon mould (*Peziza ostracoderma*), wet bubble (*Mycogone pertinosa*), Dry bubble (*Verticillium fungicola*), Cobweb (*Cladobotryum dendroides*), Pink mould (*Trichothecium roseum*) and green moulds. IV. Fungi attacking the fruit bodies only: Fusarial rot (*Fusarium* sp.)

At any phase of growth an undesirable growth or development of certain moulds can occur and can adversely affect the final mushroom yield. Weed fungi have been considered as a major factor contributing to low productivity of mushroom in India particularly under seasonal cultivation. *Coprinopsis* sp. alone causes 94.4% loss in production (Sharma, 1997). Therefore, a careful production and management system is a pre-requisite for successful cultivation of mushrooms. It has been reported that most of the competitor molds were completely inhibited by fungicides, plant extracts or bio-agents from the cell free extracts of different fungi under *in vitro* and *in vivo* conditions (Wilson *et al.*, 1994; Tewari, 2005; Mishra and Singh, 2010; Sangeetha *et al.*, 2011).

Fungal contamination is a big problem in cultivation operations of *Pleurotus*. The most common antagonistic and mycoparasitic fungi, hindering the *Pleurotus* cultivation are: a) *Trichoderma* spp., *Penicillum* spp., *Aspergillus* spp., *Chaetomium olivaceum*, *Verticillium fungicoli*, *Neurospora*, *Fusarium* spp., *Sitophila*, *Cladobotryum dendroides* etc. *Fusarium* rot is reported to be devastating disease in the crop production of mushrooms. It is occurring in almost all countries of world, where cultivation of this crop is in practice including India. It is also commonly occurring in mushroom houses in the Kashmir valley number of workers have recommended fungicidal treatment for management of this disease but growers are reluctant to use these chemicals as they inhibit the growth of the *Pleurotus* mycelium also (Rai and Vijay, 1992) and are non economical and results in environmental pollution. The present studies will be carried out to develop economically viable and eco-friendly management of this devastating disease of *Pleurotus* spp.

Hence with this feedback, present studies have been undertaken to investigate “Integrated management of *Fusarium* rot (*Fusarium oxysporum*) of dhingri mushroom (*Pleurotus sajor-
caju) through botanicals and biocontrol agents” with the following objectives:

- To isolate, characterize and identify the pathogen responsible for the disease, and
- To have integrated management of *Fusarium oxysporum* through use of botanicals and biocontrol agents.