CHAPTER -1
INTRODUCTION

Mushrooms were used even before man understood the nature of other organisms (Quimio, 2014). Mushroom cultivation started in the ancient times for their nutritional value and flavor (Chakraborty 2011). Mushrooms, also called 'white vegetables' or 'boneless vegetarian meat' contain ample amounts of proteins, vitamins and fiber apart from having certain medicinal properties (Thakur *et al*., 2013, Meng *et al*., 2016). Mushrooms have rich nutritional value with high content of proteins, vitamins, minerals, fibers, trace elements and low calories and cholesterol (Wani *et al.*, 2010, Rajeshbabu *et al*., 2012). Oyster mushroom was collected as wild specimen from the forest of Florida and later its spread in several countries around the world as most cultivated oyster mushroom species. This Oyster mushroom is very commonly grown in India under seasonal growing conditions at temperature ranging between 20-28ºC, but growth stops at air temperature above 28°C (Thakur *et al*., 2001). Out of the over total 200 species of fungi being reported as edible, 20 of them are cultivated for their edible purposes in different parts of the world. Oyster mushrooms are characterized by the rapidity of the mycelial growth and high saprophytic colonization activity on cellulosic substrates. They have the ability to directly break-down cellulose and lignin bearing materials without fermentation (Thakur *et al*., 2014). Cultivation of any type of mushroom implies principles of microbiology, environmental engineering and solid state fermentation in the conversion of domestic agricultural, industrial, forestry wastes into food for humans (Thakur *et al*., 2012). *Pleurotus florida* white oyster mushroom, is white in color from primordial head head formation to maturity, and this mushroom also grows in bunches. The pileus of this mushroom is with thin margins, smooth and pileus thickness is lesser as compared to *P. ostreatus* and *P. sajor-caju. Pleurotus ostreatus* is the second most cultivated edible mushroom worldwide after *Agaricus bisporus* (Sanchez, 2010). The main materials for the production of mushroom were tree stumps and wood logs. In 1995 the innovation of the cultivation of mushroom after the successful cultivation of *Agaricus bisporus* paved the way to the cultivation of *P. ostreatus* on wood. Today *A. bisporus* is widely cultivated throughout the world. Currently large-scale commercial production of *A. bisporus* was reported in North America, European country like the Netherland, France and Asiaan countries (Sonnerberg *et al.*, 2011). The agricultural waste constitutes mainly of cellulose,

hemicellulose and lignin. Lignin fraction which is generally considered as recalcitrant in nature, but in mushroom fields this fraction has remained as the material of choice as mushroom possesses the specific type of hydrolytic enzyme system with capacity of utilizing lignin for fruit body production (Bokaria *et al.,* 2014).

Mushrooms production in India has became very popular in almost all the states of the country having temperate, sub tropical and tropical climate (Thakur *et al.,* 2011). The seasonal production of tropical and subtropical species of oyster mushroom in different states of India as well as the industrial units has risen to about 15-20,000 tons per year (Verma, 2013, Thakur *et al.,* 2013). In North Bengal area people belonging tribal community collect mushrooms from forest and consume for nutrition. Here mostly oyster mushroom (*Pleurotus sp*) is cultivated by the rural people of North Bengal. However milky mushroom commonly known as summer mushroom (*Calocybe indica*) is being introduced relatively as a new addition among mushroom growers. *C. indica* was first recorded from west Bengal, India (Purakayashta 1974). A first attempt on the induction of fruit bodies of *C. indica* in culture was made by Purkayastha and Chandra (Purkayastha and Nayak, 1981). The advantages of this mushroom over other mushrooms are its very attractive fruiting body, pleasing milk white color, long shelf life, more nutritious and less time to grow (Bokaria *et al.,* 2014, Navathe *et al*., 2014). Cultivation of button mushroom (*Agaricus bisporus)* is mainly prepared from a mixture of agro-organic materials subjected to a composting process for growth and development of sporocarp (Colak, 2009). The compost for production of *A. bisporus* is generally produced from wheat straw, straw bedded horse manure, chicken manure and gypsum (Straatsma *et al.,* 1993). There are mainly two distinct phases in the preparation of compost for *A. bisporus*; phase I during which raw material are mixed, wetted and stacked with considerable dry matter losses and phase II, which includes pasteurization and conditioning treatment to produce a selective and pathogen free substrate (Yilmaz *et al.,* 2007). During phase I, fungal and bacterial activity produces large quantities of heat. Temperature ranges (80-85°C) in the compsting matreila. The casing layer is an essential part in the artificial culture of *A. bisporus* in artificial compost (Yilmaz *et al.,* 2007).

Edible mushrooms are a popular and valuable food, low in fats but high in minerals, essential amino acids, unsaturated fatty acids, vitamins and fibres (Afieroho *et al.,* 2013). Mushrooms having potential medicinal effects attributed to the presence of bioactive compounds like terpenoids, steroids, phenolics and alkaloids (Chien *et al.,*

2015; Zhang *et al*., 2016, Meng *et al.*, 2016). One of the compounds Ergosterol can be present either in free form or esterified with fatty acids (that is ergosteryl esters). Being an important factor for membrane fluidity in fungi and yeast, free ergosterol is located predominantly in cell membranes (Yuan *et al.*, 2008). Several researchers have already investigated the ergosterol content of cultivated and wild mushrooms (Villares *et al.*, 2014). Shao *et al.*, (2010 & 2015) investigated different parts of button mushrooms at various development stages but did not detect any esterified ergosterol in these samples. Organisms are well protected against free radical damage by enzymes such as superoxide dismutase and catalase or compounds such as ascorbic acid, tocopherols and glutathione.

Ergosterol has been linked with antioxidative activity and is the natural precursor of vitamin D2, which is formed from the former under UV light irradiation (Shao *et al.*, 2010; Phillips *et al*, 2016). There is no doubt that edible mushrooms are nutritionally sound tasteful food source for most people and can be a significant dietary component for vegetarians. Prior epidemiological studies have shown that the intake of natural antioxidants is allied with reduced risks of several diseases like diabetes and anti inflammatory disease. Laboratory and clinical studies suggested that the diet supplemented with fruit and vegetables had beneficial effects on diabetes (Adams *et al.*, 2014). Modern drugs including insulin control blood glucose level only when they are regularly administered but they have several side effects (Upadhyay, 1996). Hyperglycemia is characterized by the increased level of glucose in blood associated the the alteration of metabolisms (Rushita *et al.*, 2013). Contributory factor in the pathogenesis of diabetes also comprises of oxidative stress (Sonawane *et al.*, 2013). Mushrooms have a history of traditional use in oriental therapies and modern clinical practices continue to rely on mushroom derived preparations (Ferreira *et al.*, 2010). Edible mushrooms and their constitutive active compounds have been described to have beneficial effects on hyperglycemia and hypercholesterolemia. White button mushroom has high content of acidic polysaccharides, dietary fiber, and antioxidants including vitamins C, B12, and D, folate-ergothioneine and polyphenol (Mattila *et al.*, 2002) suggested that it has potential anti-inflammatory, hyperglycemic and hypocholesterolemic effects. Given the high dietary fiber and antioxidants in button mushroom may be advantageous in lowering the dietary glycemic load (Jeong *et al.*, 2010).

The use of spent mushroom substrate (SMS) as well as spent mushroom compost (SMC) compost in growing agricultural crop has been recognized in recent times as a possible means of enhancing sustainable agriculture (Jonathan *et al.,* 2011, 2014, Barman *et al.,* 2015). Spent mushroom substrate has been reported to contain nutrients which could be used for the growth of useful plants. These materials are generally non-toxic to the cultivated plant crops; and it could be used as soil amendment for crop systems (Jonathan *et al.,* 2014). In the crop system to provide the balanced nitrogen and carbon source for the growing plants, SMS further degraded in the soil humus which is very important to maintain soil structure, good aeration, and water holding capacity and maximize the fruit crop productivity (Adedokun *et al.,* 2013). The addition of spent compost to agricultural field has been found to be an effective soil manure and conditioner and has been found to increase the yield of some leafy vegetables crops (Kadiri *et al.,* 2010; Barman *et al.,* 2015). The SMS has potential to bio-remediate several agricultural grade fungicides and pesticides (Ahlawat *et al.,* 2011). The yield and quality of different crops systems increase upon using the SMS as manure alone or combination with inorganic fertilizer (Ahlawat *et al.,* 2011). Spent mushroom substrate is being used for disease suppression of plant. Plant diseases like *Pythium*-damping off, apple scab, cucumber anthracnose caused by fungal pathogen have been found to be suppressed by using water extract of SMS treatment (Parada *et al*., 2012). Kwak *et al*., (2015) used water extract of SMS as an eco-friendly disease control agents. SMC extract was successfully applied as bio-control agents to suppress the *Fusarium* wilt of tomato by Adedeji *et al.,* (2016). Antagonistic activity of SMC extract against a broad range of plant pathogens have been demonstrated by Isah *et al*., (2014). Up to 55% disease index was reduced by the treatment of spent mushroom compost (SMC) against *Fusarium oxysporum* in tomato plant (Adedeji *et al.,* (2016). Disease severity caused by *Fusarium oxysporum, Sclerotium rolfsii* and *Rhizoctonia bataticola* was reduced by SMS treatment (Ahlawat *et al.,* 2011). Spent mushroom substrate (SMS) having bio-agents, supply nutrition to the soil as well as helps in management of soil-borne plant pathogens (Verma *et al*., 2017). In the rural areas of North Bengal, agro-waste and organic materials are available in plenty amount, which often end up in waste thus contributing to the pollution woes. The major part of North Bengal including Terai and Dooars are located in the foothills of the Himalaya and having large and small sized tea gardens in both banks of river Tista. Tea plantations are abundant in this region and form a major part of the economy of this region. The people of rural ethnic groups of

this region are very much dependent on tea gardens for their economy. Besides tea garden, paddy cultivation is one of the most important crops in North Bengal. The economy of southern part of North Bengal is basically based on paddy crop. So a huge amount of paddy straw as well as pruned tea leaves is produced every year in North Bengal. Tea waste includes discarded tea leaves and tender stems of tea plants if which not disposed properly, can pollute the environment like soil, water and air (Chowdhury *et al*., 2016). Depending on the crops grown, cropping intensity and productivity in different regions of India, there is a large variability in generation and management of these crop residues. In some part of West Bengal paddy straw and husk is used as domestic fuel or in boilers for parboiling rice. Paddy straw as well as wheat straw is being used for compost preparations which are generally utilized for button mushroom cultivation.

Hence the present investigation was undertaken with the following aims and objectives to develop suitable year long cultivation strategy of three popular edible mushrooms in order to fulfill the demand of mushroom as nutritional food for the common people of North Bengal and to explore organic crop production using the spent mushroom substrate (SMS) and spent mushroom compost (SMC) for sustainable agriculture.

Objectives

a. Development of cultivation methods of *Calocybe indica* (milky mushroom).
b. Preparation of compost and their utilization for cultivation of *Agaricus bisporus* (Button mushroom).
c. Standardization of cultivation practices for different *Pleurotus* species throughout the year.
d. Evaluation of biochemical constituents in Milky, Button and Oyster mushrooms during their growth and development.
e. Evaluation of antioxidant and antidiabetic properties of Milky, Button and Oyster mushroom.
f. Field evaluation of spent mushroom substrate for crop improvement