CHAPTER 5
DISCUSSION

Oyster mushrooms are one of the most popular edible mushrooms and belong to the genus *Pleurotus* and the family Pleurotaceae. Like oyster mushroom (*Pleurotus ostreatus*), many of *Pleurotus* mushrooms are primary decomposers of hardwood trees and are found worldwide. The type species of the genus *Pleurotus* (Fr.) Quel.is *P. ostreatus* (Jacq. et Fr.) Kummer. This mushroom has basidium with four basidiospores and a tetra polar mating system. Its hyphae have clamp connections and most members of the genus, excepting a small minority, have ammonitic hyphal system. Approximately 70 species of *Pleurotus* have been recorded and out of which about 30 species are now being cultivated in different part of India. Determination of a species is difficult because of the morphological similarities and possible environmental effects. Some reports indicate partial compatibility between them, implying the possibility for the creation of another species.

Oyster mushroom is one of the most popular mushrooms in North Bengal and a large number of growers are now cultivating oyster mushroom throughout the year. Three growing media were used to evaluate the mycelial growth characters of four species of oyster mushrooms (*Pleurotus ostreatus, P. sajor-caju, P. djamor* and *P. florida*) such as potato dextrose agar (PDA) and malt extract agar (MEA) and water agar (WA). Their mycelial growth completed on the 8th day at 25-27^{0}C. In the present study, results revealed an increase in the growth rate as the incubation temperature was increased from 24 to 28^{0}C which was also reported by Thulasi *et al* (2010). Besides malt extract agar showed highest growth rate followed by the potato dextrose agar and water agar was lowest. Initiation of mycelial growth was also analysed and it was found that the growth of *P. florida* initiated earliest (20hrs of incubation) in malt extract agar while in case of potato dextrose agar it took 23 h but in water agar it took longest period to initiate the colonization. Asghar *et al* (2007) also mentioned the average maximum growth was obtained on malt extract agar (MEA) than on potato dextrose agar (PDA) medium at 25 ºC under humid (65 – 80% RH) conditions.

In the present study, four different species were taken into consideration and they were separated depending upon their morphological as well as molecular characterizations. *Pleurotus ostreatus* commonly known as black oyster mushroom was characterized depending upon their morphological structure such as light blackish fruiting body, smaller pileus structure as well as the basidium consisting four of basidiospore. Spores were very small and oval shaped. On the other hand, *Pleurotus sajor-caju*, commonly called as grey oyster mushroom characterized based on its greyish fan shaped large fruiting body with small oval or kidney shaped basidiospore attached with tetrasporic basidium. Besides this, the white oyster mushroom *P. florida* characterized by the bright white fruiting body along with its decurrent gills and kidney shaped small spore attached to the basal part with the basidium. Pink oyster mushroom, *P. djamor* is a new introduction in North Bengal was also characterized with its distinct pink fruiting body with very small stipe. It was also observed that sometimes, the stipe absent or very small in size. The results revealed that spore of all the species were very small (1.8-5µm) and spores of *P. djamor* was found to be smallest among the investigated Pleurotus species. In this present investigation, all the species were identified using 18S rDNA sequencing and they all were identified by as *P. ostreatus*, *P. sajor-caju*, *P florida* and *P. djamor* and the sequence deposited in the NCBI Genbank.

Different substrates were investigated to determine the growth and yield of different species of oyster mushroom. Kang (2004) suggested that environmental factors include temperature; relative humidity affects the production of oyster mushroom. He also stated that increased growing room temperature decreases the relative humidity. A higher temperature promotes fruiting body metabolism, which results in high carbon dioxide production. Three species of oyster mushroom (*Pleurotus ostreatus, P. sajor-caju,* and *P. florida*) which were being cultivated in this region. Out of these three mushrooms, *P. ostreatus* and *P. sajor-caju* are generally cultivated in summer as it grows in a temperature between 25-33^{0}C while *P. florida* is generally cultivated during winter as it requires 15-20^{0}C for its growth. The present study revealed that optimum temperature for the cultivation of *Pleurotus sajor-caju* is 20-28^0 C, *P. ostreatus* 20-25^0 C and *P. florida* was 18-20^0 C as reported by Roy *et. al* (2014). *Pleurotus ostreatus* was cultivated using four different substrates throughout the year. Paddy straw, wheat straw and saw dust was used singly or in combine form. Growth of mycelia, initiation of fruiting body as well as yield and biological efficiency was evaluated throughout the

year in different substrates. Seasonal productivity of *Pleurotus ostreatus* was observed and the results indicated that the cultivation of *Pleurotus sajor-caju* and *P. ostreatus* possible during summer and rainy season while the cultivation of *Pleurotus florida* suitable for winter season and can grow up to early summer. Different available substrates used for the cultivation of *Pleurotus* species and the results revealed that the paddy straw and wheat straw is much more suitable for the cultivation singly as well as in combination. Saw dust also showed a very good amount of production in case of *Pleurotus sajor-caju* while paddy straw in combination with wheat straw showed better yield in case of *P. ostreatus* and *P. florida*. Pathmashini *et al* (2008) studied on the three different substrates using3 strains of *P. eryngii* such as Pe-1(native to Bangladesh), Pe-2 (germplasm collected strain from China) andPe-3 (germplasm collected strain from Japan). Results revealed that on saw dust and rice straw and their growth and yield parameters were investigated. Pe-1 on saw dust showed the highest biological yield and efficiency (73.5%) than other strains. Also the mycelium run rate and number of fruiting bodies were higher in Pe-1 than other two strains. The quality of mushroom strains was near about similar. On saw dust, the yield and efficiency were better than those cultivated on rice straw, however, on straw; the mushroom fruiting bodies were larger in size. Moonmoon *et al (*2010) cultivated *Pleurotus ostreatus* on different substrates such as rice straw, rice straw + wheat straw, rice straw+paper, sugarcane bagasse and sawdust and all the substrates except rice straw were supplemented with 10% rice bran. The substrate without supplement was considered as control. The effects of various substrates on mycelial growth, colonization time, primordial appearance time, mushroom yield, biological efficiency (BE), and size of the mushroom and chemical composition were analyzed. Among all aspects, rice straw(control) was found as a best substrate with yield (381.85 gm) and BE (95.46%) followed by rice plus wheat straw, rice straw plus paper waste for the production of mushroom (Sharma *et al* 2013). Ashraf *et al* (2013) compared the effect of different agricultural wastes on growth and yield of mushroom production, three species of *Pleurotus* viz. *P. sajor-caju* (V1), *P. ostreatus*, and *P. djamor* were grown on three different substrates cotton waste (T1), wheat straw and paddy straw (T3). The fastest spawn running, primordial initiation, harvesting stage, maximum number of fruiting bodies and maximum yield was observed in T1 took minimum number of days T3 showed maximum yield in 1st flush showing no significant differences with treatment T1 whereas T1 took maximum yield in 2nd flush and 3rd flush. Islam *et al* (2009)

revealed that the use of different sawdust of different plant also affects the production of oyster mushroom when cultivated on seven different types of saw dust source for growing mushroom. Seven different type of substrates like Mango, Jackfruit, Coconut, Jam, Kadom, Mahogony, Shiris sawdust supplemented with wheat bran and $CaCO_3$ were evaluated which revealed that the maximum biological yield per packet was obtained with Mango sawdust followed by Mahogony, Shiris, Jackfruit and Coconut sawdust. Bhatti (1987) also suggested that the variation of biological efficiency and incubation period of oyster Mushroom on different substrates may be due to their different composition. The cultivation of edible fungi is a controlled bioconservation of agro industrial lingo-cellulosic waste and residues. Mushroom cultivation fits in very well with sustainable farming and has several advantages. It uses agricultural waste products. A high production per surface area can be obtained, after picking the spent substrate is still a good soil conditioner. The Mushrooms are good cash crop. The development of oyster mushroom (Grey and pink) production methodologies on agricultural waste like Paddy straw and wheat straw gives very high yield as proposed by Randiv (2012).In an another study, Siddhant *et al* (2013) reported that among various component of wheat straw, pieces of stem (1.0 and 1.7cm) were proved best with 341 gm, 68.2% and 336 gm, 67.2% yield and biological efficiency, respectively than wheat straw as a whole. Nallathambi and Marimuthu (1993)cultivated *Pleurotus* species on different agro wastes like paddy straw, wheat straw etc. and they reported maximum yield with paddy straw. Dinesh Babu (2010) revealed that paddy straw was the most suitable substrate for the cultivation of *P. platypus* and *P. eous.* Sharma *et al* (2013) cultivated of *Pleurotus ostreatus* on different substrates such as rice straw, wheat straw and sawdust and all the substrates except rice straw were supplemented with 10% rice bran. The results revealed that different substrates affected mycelial growth, colonization time, primordial appearance time, mushroom yield as well as biological efficiency (BE). They found that among all, rice straw was found as a best substrate with yield (381.85 gm) and BE (95.46%) %) followed by rice plus wheat straw, rice straw plus paper waste for the production of mushroom which significantly similar. Moreover, Yildiz *et al*. (2002) explained that the woods are natural substrates which contains very small amount of nitrogen and they are very much efficient in producing the fruiting body of different species of oyster mushroom. *Pleurotus sajor-caju* was also cultivated using different substrates and it was observed that the paddy straw supplemented with saw dust and wheat straw was very much efficient in mycelial

run as well as in production and biological efficiency was high and Pokhrel *et al* (2013) also reported that the biological efficiency was about 78-84% when cultivated in paddy straw supplemented with maize stalk .Chakraborty *et al* (2015) also reported that the effect of paddy straw in combine with wheat straw increases the production of *P. ostreatus*. Baysal *et al.,* (2003) also reported that the supplementation of 20% rice husk initiate the fastest mycelial growth, pin head formation and fruit body formation which proves that the supplementation is an advantage in the production of oyster mushroom. Pala *et al* (2013) also reported that the growth of *Pleurotus sajor-caju* was significantly rapid in case of paddy straw followed by wheat straw and the production was higher in paddy straw than that of wheat straw. Zhng *et al* (2002) also reported that the yield of *P. sajor-caju* was increased at least 10% more when cultivated in paddy straw. Ingale and Ramteke (2010) also stated that the cultivation of *P. ostreatus, P. sajor-caju* and *P. djamor* was worldwide practiced industrially and it was observed that the production was high using the different agro wastes like paddy straw, wheat straw and saw dust. *Pleurotus djamor* is a new introduction in North Bengal has been reported by Roy *et al* (2015) which showed significant growth and yield in plastic bag as well as in bottles cultivated in paddy straw. In the present investigation, the results revealed that the cultivation of *P. djamor* grown in different substrates gives higher yield during the winter season in compare to summer season. It was also observed that during the fruiting initiation, *P. djamor* requires very less amount of water. The results also revealed that the amount of production increases in wheat straw and combination of wheat straw and paddy straw while it was less in saw dust.

Mushrooms are rich in proteins, vitamins, and minerals and popularly called as the vegetarian's meat. Mushroom proteins are considered to be intermediate between that of animals and vegetables. Moisture content of the cultivated *Pleurotus* species were also evaluated in this present investigation and results revealed that fruiting body possess high amount of moisture content. It was also observed that the pinhead stage contains lower moisture content than the mature stage. Among the *Pleurotus* species, *P. djamor* contains lower amount of moisture content while *P sajor-caju* and *P ostreatus* possess high moisture content. Ahmed *et al* (2009) explained that the maximum moisture (92.45 %) of fruiting bodies was recorded on paddy straw cultivation. The high moisture content of fruiting bodies of *P. djamor* is agreeable to earlier reports worked on different species (Manzi *et al.,* 1999; Alam *et al.,* 2008). The combination of

wheat straw and paddy straw showed significantly highest lipid content, protein content as well as sugar content. The carbohydrate content found in our study was 50.4 %; the results are in conformity with the values that were stated by Patil and Telang, (2010); Garcha *et al.*, (1993), Regula and Siwulski, (2007). Paddy straw, wheat straw was used as substrates for growing the four different species of oyster mushroom i.e. *P. ostreatus, P. sajor-caju, P djamor* and *P florida*. Growth was observed and it was found that the effect of wheat straw was higher in different species than that of the other species. It was also found that the substrate variation differs in various biochemical constituents like protein, reducing sugar, total sugar and lipid content of selected species. Sinha and Mehta (2014) used wheat straw, banana leaves cotton waste, and paddy straw as substrates and compared the biochemical parameters of the fruiting body and results revealed that the fruiting body of wheat straw showed higher biochemical constituents in compare to other substrates. Ashraf *et al* (2013) also reported that *P. djamor* showed the highest percentage of dry matter and moisture content was found high in *P. sajor-caju*. *Pleurotus djamor, P. ostreatus* and *P. sajor-caju* showed the maximum protein and fiber contents. The ash contents were found maximum *P. sajor-caju*. The highest fat and carbohydrate contents were found in *Pleurotus sajor-caju* and *P. ostreatus*. Yang *et al* (2001) reported that the fibre content in *P. djamor* was much higher than those in white and yellow winter mushrooms (*Flammulina velutipes*). Dundar (2008) found that the carbohydrate values of *P. sajor-caju*, *P. ostreatus* and *P. eryngii* more or less similar in all the species. Total protein content of all mushroom species was investigated. In the present investigation, different stages of cultivated species were taken for the study of protein content. Results revealed that all the mushroom species contains a very high amount of protein content. Study of protein during its growth were also investigated which revealed that the pinhead stage as well as the mature stage possess high amount of total protein content. SDS-PAGE of all *Pleurotus* species showed a good amount of protein bands and band pattern analysis clearly indicated that all *Pleurotus* species possess a good amount of high as well as low molecular weight proteins. Alam *et al* (2008) referred that *Pleurotus florida, P. sajor-caju, P. ostreatus* and *Calocybe indica* were rich in proteins and fibres and contained a lower amount of lipid. In this investigation, the total sugar and educing sugar content was estimated and it was observed that *P. ostreatus* and *P florida* contains higher total sugar and reducing sugar content in compare to other two species. The total lipid content of *P. florida* was grown on wheat and paddy straw being the highest followed by paddy straw alone. The

content of protein and fat content were similar (Patil *et al.*, 2008; and Patil and Dakore, 2007). Lipid content of all four species was estimated in the present investigation and it was also observed that the mushroom fruiting body possess very low amount of lipid content. Lipid content of different stages also revealed that at pinhead and young stage, the lipid content found to very low in compare to mature stages. Shin *et al.* (2007) also explained that the lipid content ranges between 4.3-4.9 g per 100 g in dry matter of cultivated *Pleurotus* species. Dietary fibre of mushroom powder was also estimated in this present study and the results revealed that *P. djamor* consists about 46.5% dietary fibre while *P. ostreatus, P. sajor-caju* and *P. florida* possess lower amount of dietary fibre. The results also revealed that *Pleurotus* sp. consists 34.8% dietary fibre which was significantly similar as suggested by Justo *et al.* (1999). They also reported that the pileus and gills were protein and lipid rich and stripe was carbohydrate and fibre-rich.

Natural anti-oxidants are the good source for neutralizing free radicals generated in the body after oxidative stress. The present study was aimed at *in vitro* evaluation of anti-oxidant properties of edible mushrooms such as *Pleurotus ostreatus, P. djamor, P. sajor-caju* and *P florida* widely consumed in North Bengal region. Ethanolic extracts of *Pleurotus* sp. were investigated for the antioxidant activity. Different concentrations such as 5mg/ml, 10mg/ml and 20mg/ml were estimated and it was found that *P djamor* and *P ostreatus* showed higher DPPH scavenging activity in compare to other two species. Results also indicated that DPPH scavenging activity increases directly proportional to the concentration. The present investigation also includes the ferric reducing antioxidant power and the results revealed that *P. djamor* and *P florida* showed higher FRAP activity and *P djamor* showed highest activity in 20mg/ml. concentration. Adebayo *et al* (2012) explained that the antioxidant activity of evaluated mushroom extracts gave positive results with free radical scavenging activity found to be higher in all used in vitro methods and also shown the potential of mushroom extract as a potent therapeutic agent and a food supplement. The anti-oxidant studies included DPPH radical scavenging activities, free radical antioxidant power activity total flavonoid activity as well as carotenoid activity. Chaturvedi *et al* (2011) stated that oyster mushrooms are a potential source of antioxidant compounds and the antioxidant activity were concentration dependent. Dubost *et al*., (2007) explained that the methanol extract of fruiting bodies of *P. ostreatus* showed reducing power and high antioxidant properties. Menaga *et al* (2013) reported that the methanolic extract of

P. florida showed the most potent radical-scavenging activity at a maximum concentration of 100 µg/ml and the scavenging effects on DPPH radicals. Md. Rahman *et al* (2013) also reported that the ethanol extract of *P. florida* possesses appreciable antioxidant activity, as indicated by the polyphenol contents, DPPH scavenging activity, reducing power effect. The extract manifested significant reducing power which exceeded even that of ascorbic acid at a concentration of 500 µg/ml. The radical scavenging activity of *P. ostreatus* mushroom is reported to be higher (6 mg/ml) than those of other mushrooms like *Agaricus bisporus, Volvariella volvaceae, Calocybe indica* and *Hybsizus ulmarius* reported by Ramkumar *et al* (2010). When compared to *P. ostreatus* mushroom the methanolic extract of *P. florida* has higher chelating activity against ferrous ion was also reported by Md. Imran *et al* (2011). Finimundy *et al.* (2013) reported that IC_{50} value of DPPH scavenging ability of aqueous extract of *P. sajor-caju* showed 9.01 % and the EC_{50} values of *P. abalones* in DPPH radicals scavenging ability and reducing power were 8.68 and 4.68mg/ml respectively as suggested by Wang *et al* (2012). Deshmukh and Shinde (2014) compared the cold water and hot water extracts of *Pleurotus florida* and *P. sajor-caju* and found that the cold water extract of both the species showed higher antioxidant activity. The IC_{50} value of hot water extract of *P. squarrosulus* was found to be 340 µg/ml as resulted by Pal *et al* (2010). Total flavonoid content of *Pleurotus* species were also investigated and it was observed that *P djamor* and *P florida* possess high amount of total flavonoid activity and it was also observed that the activity increase depending upon the concentration. Rao *et al* (2013) also reported that the Ethanolic extracts of the button mushrooms, showed higher antioxidant activity such as DPPH free radical scavenging, carotenoid activity, total phenolic compounds and total flavonoid concentration revealed antioxidant activity in *Agaricus bisporus*. Sathyaprabha *et al* (2011) also reported that total flavonoid compound was higher in *Pleurotus platypus* which was cultivated in Teak leaves in compared to other substrates and *Pleurotus eous* shows highest amount in paddy straw. Khan *et al* (2011) also proved the antioxidant activity of *P florida* and *P sajor-caju* using the hypercholesteraemic rats and confirmed their activity in animal system.

In vivo antidiabetic activity of selected *Pleurotus* species were done to obtain the antidiabetic activity of oyster mushroom using Streptozotocin induced albino rats. Effect of Streptozotocin in albino rats was observed and it was found that stz helps in

enhancing the blood sugar level in compare to the normal control sets. In the present investigation, the results clearly showed that the extracts of *P. djamor, P ostreatus, P. florida* and *P. sajor-caju* exert significant anti-hyperglycaemic effects in Streptozotocin induced diabetic rats in compare to normal control, positive control and negative control. The results also revealed that the powder of *Pleurotus* sp. helps in regaining the body weight of the experimental rats which was significantly similar as positive control. *Pleurotus djamor* and *P. ostreatus* showed better results in case of blood glucose as well as body weight. Andrade and Wiedenfeld (2001) showed that Streptozotocin helps in lowering the blood glucose level. The results also revealed that the body weight of the treated rats decreased due to induction of blood sugar. Furuse *et al* (1993) also reported that the body weight of the sugar induced rats decreased and it was subjected to recover with proper treatment. Non-insulin dependent diabetes mellitus (NIDDM) condition, which is common amongst diabetic subjects, is characterized by reduced circulating concentration of insulin, poor insulin sensitivity or insulin resistant, poor glucose tolerance resulting in high sugar in plasma. Hyperglycaemia condition per se impairs insulin secretion (Davis and Granner, 1996). Ravi *et al* (2013) studied on the antidiabetic activity of *P. ostreatus* using alloxan-induced diabetic mice. He explained that *P. ostreatus* showed a significant hypoglycemic effect on diabetic mice which was capable of improving hyperlipidemia and also helps in improving the normal kidney functions. Sultana *et al* (2014) also applied extracts of *Pleurotus florida* on the alloxan induced mice along with metformin and reported that it helps in lowering the blood glucose level which was also found in case of our study. Kang *et al* (2001) also reported that the mycelial powder of *P. eryngii* helps in lowering the plasma glucose level and also effective in regaining the body weight of the Streptozotocin induced albino rats. Polysaccharides of *Pleurotus* species helps in lowering the plasma glucose level and also helps in regaining the body weight of the rats. Rushita *et al* (2013) also explained that the methanolic extract of *Pleurotus citrinopileatus* significantly helps in lowering the blood glucose level in alloxan induced albino rats. Kiho *et al* (2001) reported that the molecular mass of the polysaccharide of mushrooms was high and thus it showed higher antidiabetic activity. Along with the blood glucose level, other blood parameters such as urea, creatinine, triglyceride, cholesterol and liver enzymes like serum glutamic pyruvate transaminase (SGPT) and serum glutamic oxaloacetate transaminase were also investigated in the present study. The results clearly revealed that the *Pleurotus* mushroom powder had positive effect on controlling the other blood parameters.

Diabetic induced rats suffers from different disorders which caused by different blood parameters. High urea and creatinine indicates the impurity in blood which results in various kidney disorders. Results revealed that suspension feeding helps in lowering the urea and creatinine level in compare to control set. It was also observed that the application of Streptozotocin drastically increased in negative control but in case of positive control, it helps in lowering the urea, creatinine, triglyceride as well as serum glutamic pyruvate transaminase and serum glutamic oxaloacetic transaminase activity. In case of treatment of *P. ostreatus, P sajor-caju, P. djamor* and *P. florida* powder, they also helps in lowering the other blood parameters in compare to the control sets. Yamamoto *et al,* (1981) suggested that alloxan and beta cytotoxin, destroys beta cells of islets of Langerhans of pancreas and reducing the endogenous insulin secretion and paves ways for the decreased utilization of glucose by body. Johny and Okon (2013) also reported that ethanolic extract of *Pleurotus ostreatus* significantly lowers the plasma glucose level in alloxan induced albino mice and also compared with the standard drug metformin. Dhanabal *et al* (2007) also reported that the increased rate of plasma glucose decreases the protein content of the cell and rapidly increasing the plasma cholesterol, creatinine urea as well as plasma triglyceride level.

Mushroom industries generate discharges a bi-product called spent mushroom substrate (SMS). This is the unutilised substrate and the mushroom mycelium left after harvesting of mushrooms. As the mushroom industry is steadily growing, the volume of SMS generated annually is increasing. Spent mushroom substrates were applied in the field for the crop improvement and results revealed that the effect of spent substrates helps in the growth and development of the *Capsicum chinense, C. annumm, Solanum lycopersicum* and *Amaranthus* sp. It was also observed that the yield was increased in case of treated pants in compare to untreated plants. Results in this present investigation also revealed that the soluble phosphate content of soil increases and also leaf and root phosphate content which clearly indicates that application of spent mushroom substrate acts as soil conditioner which helps in phosphate solubilisation and also mobilization of phosphate from soil to leaf through root which helps in plant growth promotion. Application of the spent mushroom substrates as biofertilizer for crop improvement is the only way out of the problem (Phan and Sabaratnam; 2012). Royse *et al.* 2004 explained that approximately 600 ton of SMS is produced in South Korea annually, of which 58 % is from *Pleurotus ostreatus* cultivation. These spent mushroom substrates

were helps in growth and yield of the crop plants. The results revealed that spent mushroom substrates showed higher phosphatase activity in soil; root as well as in leaves. It was also reported that after harvesting of fruiting body, spent mushroom substrates possess some amount of extracellular enzymes secreted by the mushroom species and thus it helps in plant growth. Of all the enzymes, laccase is the most reserved and common in SMS from *A. bisporus* (Mayolo- Deloisa *et al.* 2009), *Pleurotus sajor-caju* (Singh *et al*. 2003), *P. ostreatus, L. edodes, and Hericium erinaceum* (Ko *et al*. 2005).

Processing is an important step for mushroom cultivation. Shelf-life of oyster mushroom is very limited and it as very difficult to keep it for very long time fresh. So processing technique was adopted for long term preservation of the oyster mushroom. Drying is an important step for processing of mushroom. Fruiting body of the *P. ostreatus, P sajor-caju, P djamor* and *P florida* was dried in various way like direct sundry, indirect sundry and freeze dry. Drying of oyster mushroom results in reducing the water content form fruiting body which results in long term preservation of the fruiting body. The cultivation of mushroom has a great potential for the production of protein rich quality food and for recycling of cellulose agro-residues and other wastes. The moisture content of freshly harvested mushroom is 70-90% based upon the variety. In view of their highly perishable nature and commercial value, the fresh mushrooms can be processed to extend their shelf life such as canning, drying, pickling, etc. Drying preserves mushrooms for very long periods of time with little or no deterioration in flavour or quality. Drying methods vary from sun/air drying to machine drying (dehydrators) to microwave drying as resulted by Balan and Mahendran (2014). Mushroom biscuits were prepared using the dried mushroom powder in the laboratory and it was tasted for its different quality such as taste, texture, its softness and it was fond that the biscuits were very good for health and it can be stored for long time. Desayi *et al* (2012) also prepared biscuits by adding mushroom powder to the biscuit recipe at 5, 10and 15 per cent concentrations along with addition of strawberry and vanilla flavours at each level, whereas biscuits prepared only with bakery recipe were kept as control. Among different treatments, 10 per cent mushroom powder along with 0.2 per cent vanilla flavour recorded highest scores for organoleptic parameters like colour and appearance, flavour, crispness, taste and overall acceptability even up to 30 days of storage. Mahamud *et al* (2012) the composition of mushroom powder and bread

prepared incorporating various levels of mushroom powder were analyzed to determine the effects of various levels of mushroom powder in nutritional constituents and consumers' acceptability. The mushroom powder showed significantly better result for texture and overall acceptability variables of consumer acceptability. Nutritional composition, of 5% mushroom powder consists content 10.07% protein, 9.20% fat, 1.82% ash and carbohydrate 62.87%) was better and good for human health. Rosli *et al* (2012) reposted that the application of powder of *P sajor-caju* in preparation of mushroom biscuits was rich in nutritional constituents like reducing sugar, protein as well as dietary fibre and lower lipid content in compare to the wheat flour made biscuits.

Cultivation of *Pleurotus* species practiced throughout the world and India is one of the large producer as well as transporter of *Pleurotus* species. Several species cultivated in India and in North Bengal about four species cultivated throughout the year namely *P. ostreatus, P sajor-caju, P djamor* and *P florida*. Cultivation of *Pleurotus* species facing some problems of contaminants which results in decreasing in the production and sometimes it turns into an epidemic that rapidly spread the entire cultivation unit and gradually contaminates all bags. Several bacterial, fungal contaminants affected the growth of *Pleurotus* sp. Fungus like *Trichoderma, Fusarium, Coprinus, Cladobotryum dendroides;* affects the mushroom substrates and grows before the mycelial run of *Pleurotus* species over the substrates. Some bacterial contaminants were also affected the mushroom substrates which resulted in limiting the spawn rung over the substrates and also reduction the rate of fruiting body initiation. Singh *et al* (2014) studied on the green mould disease of *P ostreatus* and *P florida* caused by *Trichoderma harzianum* which results in rapid decrease in spawn run rate on the substrates and lowering the yield substantially. Carbandazium was used against the green mould and it helps in lowering the spread of *T. harzianum* on the substrate was also supported by Singh *et al* (2014). *Pleurotus* mushroom is subject to many vagaries of nature like pests and diseases that adversely affect its production and productivity. Among the various moulds and competitors of *Pleurotus* spp. green moulds are reported to be devastating disease in the crop production of this mushroom. The main fungal species causing green mould have been identified as *Trichoderma viride* and *Trichoderma harzianum* (Sharma and Bahukhandi, 2003). Oh *et al.,* (2003) reported that *Trichoderma* spp. is most common antagonistic and mycoparasitic pathogen of *Pleurotus* crop causing green

mould disease. Park *et al.*, (2005) also supported that the pathogen inhibits the growth of mushrooms and in severe outbreaks; the fruiting bodies are not produced from contaminated beds. Shah *et al.*, (2013) also supported the use of carbendazim and it was found to be best fungicide, against the infection of green mould disease of mushrooms.

Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving ones productivity in an organization or enterprise. It plays an important role for imparting knowledge and updating skills of the farmers. To make training meaningful and effective, it is very much important to identify the training needs of the farmers based on which a suitable training module can be designed. It is essential to organize an appropriate training to the right people, in the right form, at the right time. Singh *et al* (2014) undertaken to know the relationship of selected personnel, socio-economic and psychological characteristics of the respondents with their training needs in relation to commercial mushroom cultivation. Mishra (2012) reported that the most important promoting factor for mushroom enterprise is simple technology, which farmwomen can handle very easily. The impact assessment of mushroom enterprise on growers indicates the improvement in their occupation followed by 'standard of living', 'saving, employment generation and 'knowledge and attitude'. The farmwomen faced much constraint in 'non-availability of spawn in locality' and least problem in 'mushroom treated as non-veg item'. Sixty percent of the respondents stated that "supply of quality spawn", 'thorough coverage of marketing aspects' and 'insurance' are the three major constraints for successful mushroom entrepreneurship. Sud *et al* (2013) reported about the training programme on cultivation and value addition of oyster mushroom to the growers which includes of 50 percent theory and 50 percent practical helped in improving the cultivation practice in Himachal Pradesh. Growers of North Bengal are very efficient in producing the *Pleurotus* species. Formerly there were only two species namely *P. ostreatus* and *P sajor-caju* largely cultivated in North Bengal but after proper training of mushroom cultivation and knowing about the seasonal productivity, growers are now efficiently producing all the four species of *Pleurotus* according to their season and a good amount is now produced by them. Post-harvest processing was also a very big issue for the growers in this region. Growers who have trained are now adopting various drying techniques, mushroom powder and mushroom biscuits for long term processing of *Pleurotus* species. Sud *et al* (2013) explained that the training programmes which involve both

theoretical and practical aspects of production and value addition proved to be effective as indicated by feedback of the trainees. Shirur *et al*., (2011) organization of such training programmes is beneficial in many ways as it promotes popularization of mushroom production and value addition among farming community in the region and acts as a mean to expose farmers with mushroom based industries such as instrumentation, mushroom processing and other units.