J. Mycopathol. Res. ***58 (1&2)*** *: 1-14, 2020;* (ISSN 0971-3719)

REVIEW

Potential of Macrofungi in Waste Management, Human Health and Societal Upliftment: A review

M.P.THAKUR AND H.K. SINGH*

Directorate of Instruction,Indira Gandhi Krishi Vishwavidyalaya
*Raipur 492 012 (Chhattisgarh) *Department of Plant Pathology, College of Agriculture, Raipur*

Received : 24.03.2020 Accepted : 10.04.2020 Published : 27.07.2020

Millions of microbes including fungi, bacteria, viruses, phytoplasma, nematodes etc. exists in nature of which fungi is considered to be the most predominant microorganisms on this earth. It has been estimated that 1.5 million species of fungi exists in nature but only 5% of the fungi are known to the mankind. Many of these fungi are reported to cause several diseases but some of these fungi are beneficial too. Mushrooms are such fungi whose approximately 10,000 species are macroscopic and blessed with varieties of enzymes which can easily degrade the highly complicated compounds present in most of the plant wastes, industrial wastes and forests wastes. In India, a large volume of plant agro wastes (620 million tons) is generated every year as a result of agricultural activity which is roughly 15% of the total biomass produced. Similarly, industries produce different kind of industrial wastes. In forest areas, lot of deciduous trees, perennial trees shed their leaves, felling of wood logs gets accumulated and degraded by mushroom fungi. These mushroom fungi play a key role in degradation of wastes and giving rise to the most nutritious fruit bodies of the wild fungi called edible mushrooms. Mushrooms have enormous medicinal value due to the presence of several biologically active compounds including polysaccharide, tri-terpenoids, lentinan, adenosine, ling zhi 8, polysaccharide Krestine (PSK), Polysaccharide Peptide (PSP), Eritadenine butyric acid.These compounds exert medicinal influences on their users. Mushroom farming has now become one of the most proven income generating enterprise in different parts of the country to double or triple the farmers income within a year. It is the important source of food, nutrition, income and employment security in rural sector of the society particularly in Chhattisgarh state which is pre-dominated by tribal community.

Key words : Fungi, mushrooms, waste management, societal development

INTRODUCTION

Microbes play a very important role in disease causation and recycling of wastes. There are 1.5 million species of fungi, 1,30,000 species of viruses, 60,000 species of algae and 30,000 species of bacteria (Hawksworth, 1991) in nature and perform various functions. Out of 1.5 million species of fungi, there are 10,000 species of fungi which are macroscopic and called edible mushrooms. Mushroom fungi besides its edibility have enormous role in recycling of plant wastes. In India, a large volume of plant agro wastes (620 million tons) is generated every year as a result of agricultural activity. It is roughly 15% of the total biomass produced in grassland as well as cultivated land. It is produced by the plants as a result of photosynthesis activity. Industries also produce different kind of industrial wastes. In forest areas, lot of deciduous trees, perennial trees shed their leaves, felling of wood logs gets accumulated and degraded by mushroom fungi. It has been estimated that about 2/3rd of the biomass production occurs in forests areas (65%). Net productivity of plant dry biomass is reported to be 155.2 billion tons in a year (Bassham,1975).Around 200 billion tons of organic matter are generated annually through photosynthesis (Zhang, 2008) and agro-industries posing a severe threat to environment (Koopmans and Koppejan, 1997) because it is either burnt or lying unused and rotten during monsoon season in bulk quantity leading to further environmental deterioration. Innovative technologies developed can effectively utilise these ligno-cellulosic materials into more profitable items using solid state fermentation technology (Chang, 2006; Zervakis and Philippoussis, 2000). Mushroom farming is one such technology in India having potential to process the waste plant materials/crop residues

Corresponding author- mp_thakur@yahoo.com

(620 million tons) into best valuable food items with good protein conversion efficiency and productivity per unit area and time.

Mushrooms have enormous nutritional and medicinal value (Thakur *et al*., 2013, Barman et al, 2018). Mushrooms have long been celebrated as a source of powerful nutrients with many of the nutritional attributes of produce, as well as attributes more commonly found in meat, beans or grains. It has medicinal properties like hypotensive and rental effects (Yip et al., 1987), immunomodulatory and antitumour activities from mycelial cultures (Liu et al., 1996; Wang et al., 1995, 1996), immunomodulatory and antitumour activities of lectins from edible mushrooms (Wang et al., 1996, 1997) and medicinal effects of *Ganoderma lucidum* (Chang and Buswell 1999, Chang and Miles, 2004). This medicinal value in mushroom is due to the different nutrients present and different bio-active compounds primarily Polysaccharide (50 types have been isolated), Triterpenoids (more than 100 types), Lentinan, Adenosine, Ling Zhi 8, Polysaccharide Krestine (PSK), Polysaccharide Peptide (PSP), Eritadenine butyric acid. Mushrooms are believed to help fight against cancer. They are an excellent source of selenium, an antioxidant that works with vitamin E to protect cells from the damaging effects of free radicals. Button mushrooms can reduce the risk of breast cancer and prostate cancer. Vitamin B_3 in oyster mushrooms is 5-10 times higher as compared to any other vegetable. Good source of Vitamin $B_{12.}$ Calcium, phosphorous and iron content in oyster mushrooms is approximately double the amount available in beef, pork and chicken meat.

Mushroom growing can transform rural economy by promoting equitable economic growth in society. They are a unique group of macro fungi through which a non-green revolution in India may be brought out. They demonstrate great potential for generating a great socio-economic impact for the mankind, at local, national and regional levels. In view of this, the present article emphasizes on the role of microbes particularly macro fungi in waste management, health and societal development.

Generation of Plant Waste

Mushroom species have been tried to be cultured on a large spectrum of plant waste. Bassham (1975) has estimated the net productivity of dry biomass due to photosynthesis by plants on the earth to be 155.2 billion tons per year. About 2/3rd of the biomass production occurs on land and remaining in the ocean. Most terrestrial plant material occurs in forests (65%), with a bit more than 15% generated in grass lands and cultivated land. McHale (1970) has calculated that about three quarters of the approximate 24 million tons of biomass generated on the cultivated lands and grasslands is waste or residue. The production of cultivated crop plant wastes in the World and India are presented in table 1.

Table 1: Production of wastes of cultivated crops plants (X 1000 mt)

Plant wastes	World	India
Cereals	7,802,400	849,928
Pulses plants	175,941	43,608
Oil crops	354,185	35,527
Plantation crops	1,370,065	221,580
Total	9,702,591	1150,643

Source : FAO Production Year Book (1994)

Mushroom as a potential source for waste management

The Spent Mushroom Substrate (SMS) left after final crop harvest is a matter of concern for all of us as it creates various environmental problems including ground water contamination and nuisance (Beyer, 1996). The SMS has been found to be a good nutrient source for agriculture mainly because of its rich nutrient status, high cation exchange capacity (CEC) and slow mineralization rate which retain its quality as an organic matter. SMS contains 45% water though bulky, is light in weight (Dann, 1996). The traits and composition of SMS vary in different mushrooms because of difference in types of substrate used and their subsequent utilization by mushrooms (Ahlawat, 2011). SMS normally contains 1.9-0.4-2.4% (N-P-K) before weathering and 1.9-0.6-1.0 (N-P-K) after decomposition for 8-16 months. It contains much less heavy metals than sewerage sludge, which precludes its classification as a hazardous substance. SMS can be used for different purposes as under:

1. Organic fertilizer (Vermicompost) for crop production
2. Re-growing of oyster mushroom
3. Use as cattle feed

Spent mushroom substrate is still nutrient-rich and contains about 80% of the total nitrogen in bound form with high molecular weight fractions of lignin and humic substances (Grabbe, 1982). Spent substrate of oyster mushroom (*Pleurotus florida*) was therefore used along with other plant wastes comprising of mainly paddy straw in half of the quantity to convert it into vermicompost. It was found that the addition of spent mushroom compost in half of the quantity reduced the period of vermi compost formation by almost 45 days as against 80-90 days without addition of vermi compost. It helps a lot in reduction of the period for vermi compost formation by the mushroom growers. It has now become a very common practice by the mushroom growers in Chhattisgarh State. They are making use of this compost in cultivation of organic vegetables with good yield and quality of the produce. The research work carried out at NRCM, Solan on effective use of SMS had shown very encouraging results on plant growth, fruit yield and quality along with diseases management abilities (Ahlawat et al., 2004b, 2005a, 2005b, 2006a, 2007a, 2007b; Dev Raj et al., 2005) in many vegetables (tomato, lettuce, chilli, cauliflower etc.) and flowers (marigold). Applications of SMS of *Pleurotus ostreatus* have a direct effect on the growth and yield of *T. occidentialis* (Orluchukwu *et al*. 2016). SMS also had effect on nutritional constituents of vegetables and fruits (Priadi *et al.* 2016). The use of SMS in growing leafy vegetables has also been recognised as a possible means of enhancing sustainable production of food crops by Okokon *et al.* 2009. SMS of *Calocybe indica* has direct effect on growth parameters of leafy vegetables (Barman *et al.* 2017). Similarly, Jonathan *et al.* (2011) used SMS of *Pleurotus pulmonarius* as possible organic fertilizer for the improvement of growth of vegetables in Nigeria. Jonathan *et al.* (2012) considered SMC (Spent Mushroom Compost) as remnant substrate for biodegradation of agricultural wastes (rice straw and sorghum stalk) into substrates of utilizable products. Tuhy *et al.* (2015) obtained healthy effect on tomato plants. SMS also contributed significantly to the number of branch, number of leaves in the vegetables depending on the rate of application (Saalu *et al.* 2010; Roy *et al.* 2015).

Production of second crop of mushroom from the spent substrate can prove more efficient utilization of the substrate ingredients and can also ameliorate the problem of solid waste disposal in the mushroom industry (Fahy and Wuest, 1984). In view of this, SMS obtained from oyster mushroom beds was used in our mushroom laboratory along with the fresh paddy straw and wheat straw substrates for cultivation of oyster mushroom in 3:1 (paddy straw: Spent mushroom substrate & wheat straw: spent mushroom substrate) or 1:1 ratio (paddy straw: spent mushroom substrate & wheat straw: spent mushroom substrate). It was found that the incorporation of spent mushroom substrate in the ratio of 1:1 worked excellently well compared to 3:1 ratio. Both the substrates had almost similar effect on mycelial growth and yield. In one of the study conducted by Royse (1993), higher yield of *P.sajor-caju* (79% Biological Efficiency) was obtained by supplementing the spent shiitake basal medium with 12% soybean and 1.0% CaCO3. Similarly, Jonathan *et al.* (2012) also considered SMS as remnant substrate of mushroom cultivation.

Oyster mushroom cultivation was practiced by several urban ladies in Raipur city and they had a problem in disposing off the spent mushroom substrate. When, they approached to our laboratory, they were advocated to supply it to the nearby local dairy unit. They didn't accept first but later, the dairy unit people contacted the mushroom growers and asked to supply the spent mushroom substrate even wet than dry. Thereafter, the urban women started charging @ Rs. 3.00 per kg dry straw because it enhanced the milk yield by giving the nutritious diet to their cattle. It may be perhaps due to the cellulose made available after *Pleurotus* spp. (Oyster mushroom) cultivation which can act as energy source for animals as they have sufficient quantity of enzymes/ microbes in rumen, which can degrade it further. Besides availablity of cellulose, oyster mushroom cultivation also improves protein value and digestibility of the substrate (Ahlawat, 2011). The paddy straw mushroom spent substrate has pH in the range of 8.82 to 9.16; while oyster mushroom spent substrate has pH between 6.51 to 7.69. The values of electrical conductivity, total dissolved solids and nitrogen content are lower in paddy straw mushroom spent substrate than oyster mushroom spent substrate. The oyster mushroom SMS contains higher nitrogen (1.82%) as compared to paddy straw mushroom (1.06% to 1.46%). The oyster mushroom SMS can

substitute about 30% of the total feed without affecting the growth of animals.

Effect of Mushroom on Health

Different species of oyster mushroom (*Pleurotus florida, P. sajor caju, P. flabellatus, P. eous, platypus*, *P. membranaceus* are very commonly cultivated in state of Chhattisgarh as it is advocated by mushroom scientists from AICRP on Mushroom, Raipur. It has lot of nutritional and medicinal values (Thakur 2014 and Barman et al., 2018). In view of the rich nutritional and also medicinal value of *Pleurotus florida* and *P. sajor caju*, it was sent to Indian Institute of Nutrition, Hyderabad (A.P.) for the detailed analysis of nutritional value and was found to be highly rich in almost all major and trace elements. They furnish good quality proteins (Table 2), but the crude protein content of *Pleurotus florida* and *P. sajor caju* varied greatly.

Table 2: Quality of protein in mushroom compared to other food items

Food items	Quality of protein (Biological value)
Milk	100
Meat/fish	80-85
Mushroom	82
Cereal	40-45
Legume	50-55

Having known the good quality of protein and other nutrients (Acharya *et al.* 2017, Zhang *et al.* 2016), it was thought to explore the medicinal value of this mushroom. The fruiting bodies of *Pleurotus sajor caju* (Fig 1) and stalk of *P. florida* (Fig 2) were oven dried, powdered (Fig 3) and advocated directly to use either orally 5-10g at a time followed by a glass of water or with a glass of milk. But, the respondent did not like to consume the powder as we advised. It was then put it in a gelatin capsule @ 500mg per capsule (Fig 4&5) and advocated to be used by the patients suffering from diabetes, joint pain, anemia, gout, blood pressure, paralysis etc. Three to six capsules in a day were recommended for the patients suffering from various disorders/illnesses. It was found that 90% of the patients suffering from above disorders reported relief in their health. Sugar went down by 25-30 point before and after medication by royal oyster capsule. It was thereafter only we designated these capsules as **Royal Oyster** (Thakur, 2018). It is a unique natural herbal product found it very effective against various disorders/ailments may be due to the presence of varieties of bio active compounds present mainly polysaccharides, lectins, lactones, terpenoids, and alkaloids (Rahi and Malik, 2016; Toledo et al. 2016 and Nagy et al.,2017) imparting various health benefits. It has been tested against 480 patients suffering from Various illnesses as mentioned above

Fig. 1 : Dehydrated Oyster Mushroom

in close coordination with the two Ayurvedic practioners. One of the SHG named “Satguru Kabir Biotech ATMA Samuh” located at Kapadah in Pandariya tah. of Kabirdham distt. is involved in the preparation and sale of this product to the individuals or in the local markets. Keeping in view of the beneficial effects of this Royal Oyster, it is in the process to patent the product with National Research Development Council, New Delhi.

Fig. 2 : Stalk of Oyster

Table 3: Evaluation of three species of *Pleurotus* for their growth and yield potential under farmer's conditions

Name of Farmers	*P. florida*			*P. sajor-caju*			*P. flabellatus*			Average		
	SR	Yield (g)	BE (%)	SR	Yield (g)	BE (%)	SR	Yield (g)	BE (%)	SR	Yield (g)	BE (%)
Shri Tulsi Ram	20	290	34.80	19	568	68.20	20	500	60.00	19.66	452.66	54.33
Shri Kaushal Verma	25	365	43.80	24	300	36.00	23	190	22.80	24.00	285.00	34.20
Shri Bhuvan lal Verma	20	582	69.80	18	545	65.40	17	600	72.00	18.33	575.66	69.06
Smt. Vimla Verma	18	312	37.40	16	345	41.40	19	217	26.00	17.66	291.33	34.93
Ku. Lata Verma	19	260	31.20	18	153	18.40	17	275	33.00	18.00	229.33	27.53
Smt. Parmeshawri Verma	17	632	75.80	19	473	56.80	18	462	55.40	18.00	311.66	62.66
Shri Ramanand Verma	23	320	38.40	24	160	19.20	25	235	28.20	24.00	238.33	28.60
Shri Tilak Ram Verma	16	510	61.20	17	497	59.60	15	393	47.20	16.00	466.66	56.00
Shri Arwind Verma	16	370	44.00	18	482	57.80	15	453	54.40	16.33	435.00	52.06
Smt. Kamla Verma	18	583	70.00	17	468	56.20	18	612	73.40	17.66	554.33	66.53
Shri Alakh Ram Verma	16	498	59.80	17	340	40.80	16	450	54.00	16.33	429.33	51.53
Ku. Mongra Verma	32	153	18.40	30	155	18.60	27	233	28.00	29.66	180.33	21.66
Ku. Meena Verma	18	230	27.60	17	230	27.60	18	185	22.22	17.66	215.00	25.80
Dr. KhemKaran Verma	17	348	41.80	19	222	26.60	17	435	52.20	17.66	335.00	40.20
Shri Jawahar Lal Verma	16	437	52.40	18	318	38.20	16	505	60.60	16.66	420.00	50.40
Shri Janak Lal Verma	-	-	-	-	-	-	-	-	-	-	-	-
Shri Hari Shankar Verma	17	507	60.80	19	345	42.20	17	355	42.60	17.66	402.33	48.53
Ku. Vimla Sahu	24	247	29.60	22	213	25.60	20	185	22.20	22.00	215.00	25.80
Shri Ram Khilawan Verma	21	197	23.60	21	173	20.80	20	240	28.80	20.66	203.33	24.40
Dr. RatiRam	18	357	42.80	20	402	48.20	17	392	47.00	18.33	383.66	46.00
Shri Suhar Verma	-	-	-	-	-	-	-	-	-	-	-	-
Shri R.N. Baghel	-	-	-	-	-	-	-	-	-	-	-	-
Shri Khorbehra	-	-	-	-	-	-	-	-	-	-	-	-
Average	19.52	378.84	45.43	19.63	336.26	40.40	18.68	364.05	43.68	-	-	-

Table 4 : Efficacy of different straw substrates for their effect on yield of *Pleurotus florida*

Name of Farmers	Paddy Straw			Wheat Straw			Soybean Straw			Average		
	SR*	Yield (g)	BE (%)	SR	Yield (g)	BE (%)	SR	Yield (g)	BE (%)	SR	Yield (g)	BE (%)
Shri Alakh Ram	27	207	24.80	25	147	17.6	-	-	-	26.0	177	14.13
Shri Bhagwat Prasad Verma	-	-	-	-	-	-	-	-	-	-	-	-
Smt. Kanto Verma	25	303	36.40	24	353	42.4	-	-	-	24.5	328	39.40
Shri Ram Narayan Verma	15	127	15.20	19	153	18.3	-	-	-	14	140	16.75
Shri Jai Prakash	16	150	18.00	18	315	37.8	15	100	12.00	16.33	188.33	22.60
Smt. Kachra Bai	21	242	29.00	19	530	63.6	17	400	48.00	19	390.66	48.86
Smt. Parmeshwari Verma	19	293	35.20	19	325	39.0	-	-	-	19	309	37.10
Smt. Vimla Verma	33	197	23.60	29	253	30.4	-	-	-	31	225	27.00
Shri Devi Prasad Verma	22	413	49.60	20	170	20.4	14	278	33.40	18.66	287	34.46
Smt. Chitralekha Verma	-	-	-	-	-	-	-	-	-	-	-	-
Ku. Mongra Verma	20	247	29.6	-	-	-	-	-	-	20	247	29.6
Shri Vimal Sahu	22	407	48.8	-	-	-	-	-	-	22	407	48.8
Dr. Khem Karan Verma	21	430	51.6	-	-	-	-	-	-	21	430	51.6
Dr. Rati Ram Verma	21	530	63.6	-	-	-	-	-	-	21	530	63.6
Shri Arwind Verma	-	-	-	-	-	-	-	-	-	-	-	-
Shri Bhuvan Lal Verma	17	267	32.0	-	-	-	-	-	-	17	267	32.0
Smt. Kamla Verma	-	-	-	16	318	38.2	-	-	-	16	318	38.2
Ku. Lata Verma	-	-	-	-	-	-	-	-	-	-	-	-
Shri Tilak Ram	20	418	36.5	-	-	-	-	-	-	20	418	36.5
Shri Jawahar Lal	-	-	-	-	-	-	-	-	-	-	-	-
Average	21.35	302.21	35.27	20.33	284.88	34.18	15.33	259.33	31.13	-	-	-

Mushroom in Societal Development

Mushroom is the important source of food, nutrition, income and employment security in rural sector of the society particularly in Chhattisgarh state which is pre-dominated by tribal community. Mushroom farming has become one of the most

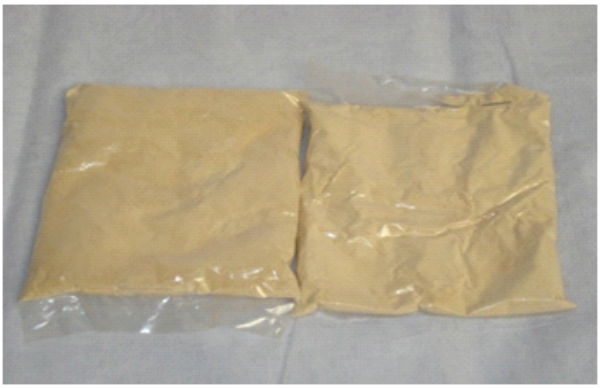

Fig. 3: Mushroom powder

Fig. 4: Oyster Mushroom Capsule

Fig. 5 : Oyster Mushroom Capsule in PP bags

proven income generating enterprise in different parts of the country to double or triple the farmers income within a period of 2-3 months. In view of

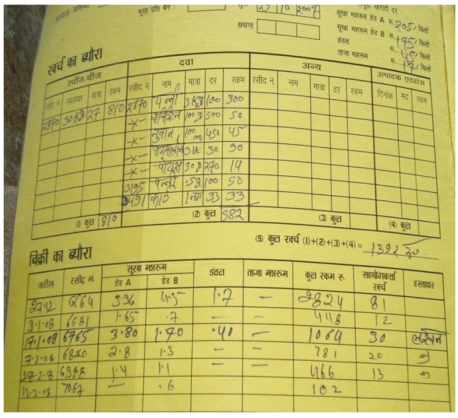

Fig. 6: Details of costs and benfits of oyster mushroom

Fig. 7 : An Innovative technology for popularisation of oyster mushroom in urban and rural areas

Table 5: Mushroom spawn production in Chhattisgarh State

Name of the firm	Districts	Quantity (quintals per annum)
Mushroom spawn lab, IGAU,	Raipur	60-70
Mushroom spawn lab, IGAU,	Jagdalpur	8-10
Mushroom spawn lab, IGAU,	Kawardha	5-7
Chhattisgarh mushroom , Tendua, Abhanpur owned by Mrs. Namrata Yadu)	Atal Nagar, New Raipur	70-80
Osheen Mushroom Spawn Lab	Rajnandgaon	5-6
Osheen Mushroom Spawn Lab	Bhairamgarh (Beejapur)	4-5
Osheen Mushroom Spawn Lab	Beejapur	4-5
Satguru Kabir Biotek ATMA Samuh	Kapadah (Kabirdham)	4-5
Dewangan Spawn Lab, Dhamtari Road	Dhamtari	8-10
Chhattisgarh Mushroom Swayatt Sahkarita Mary adit, Gudihari	Raipur	25-30
Sraddha Suman Mahila Samuh (Tarra)	Raipur	8-10
Bose Mushroom Lab	Raipur	8-10
Roverent Mushroom	Durg	8-10
Chhattisgarh Resource Organization	Durg	20-25
Querishi Mushroom Farm	Durg	8-10
Deshmukh Spawn Lab	Durg	8-10
Om Mushroom Farm	Rajnandgaon	12-15
Biotech Lab, Govt. of Chhattisgarh	Ambikapur	10-12
Pradeep Shah Mushroom Lab	Ambikapur	10-12
Basant Gupta Mushroom Lab	Bilaspur	12-15
Raghav Mushroom Lab	Bilaspur	15-20
Precious Mushroom Spawn Lab	Bilaspur	22-25
Rupak Mushroom Lab	Korba	40-50
Annapurna Mushroom Farm	Korba	8-10
Chakrabarty Mushroom Lab (Mrs. Chakraborty)	Durg	8-10
Tamrakar Mushroom Lab	Durg	5-7
Biotech Lab	Ambikapur	6-8
Mushroom Spawn Lab	Mudhipar, Pithora , (Mahasamund)	8-10
Krishi Vigyan Kendra	Kanker	5-6
Kanha Korea Mushroom	Korea	12-15
Kiran Agro Park	Jamul, Bhilai	6-7
Krishi Vigyan Kendra	Bhatapara-Baloda	4-5
Krishi Vigyan Kendra	Janjgir-Chapa	4-5
Krishi Vigyan Kendra	Korea	4-5
Krishi Vigyan Kendra	Ambikapur	4-5
Krishi Vigyan Kendra	Bilaspur	4-5
Krishi Vigyan Kendra	Mahasamund	4-5
Krishi Vigyan Kendra,	Beejapur	4-5
Krishi Vigyan Kendra,	Gariaband	4-5
Krishi Vigyan Kendra,	Bastar	5-6
	Total	474-586

this, three species of *Pleurotus* performing well in our laboratory were evaluated for their growth and yield under farmer's conditions at Tarra and Chatoud villages of Raipur district following poly

Table 6: Commercial units of oyster mushroom production and marketing in Chhattisgarh

Name of Firm	Place	Proprietors	Targets
Chhattisgarh Mushroom	Tendua (Abhanpur) Raipur	Mrs. Namrata Yadu	95 Kg/day production
Kiran Agro Park	Sheopur, Bhilai	Mr. Devesh Mogre	100kg /day production
Anndata Bahuuddeshiya Society (Paddy straw/Oyster)	Behradih of Janjgir distt.	Registered Society	Sale of fresh, dry mushroom and processed product
Button Mushroom unit	Siltara Industrial Area, (Raipur)	M/ S Kakkar Commercials Pvt. Ltd.	10 qtls/day of fresh button mushroom and products
Rajendra Mushroom	Pithora	Shri Rajendra Sahu	50 Kg/day production
Chandrakar Mushroom	Kurud (Dhamtari)	Shri Chandrakar	30 Kg/day production
Mushroom Production and Training Centre	Jagdalpur	Smt. Dadsena	Production and training on Mushroom Technology
Mushroom Corner (Sale counter)	Sastri Market, Raipur	Ms. Namrata Yadu	Sale of fresh, dry mushroom and processed product
Om mushroom	Dongargarh, Rajnandgaon	Shri D. K. Shukla	90 Kg/day production
Purohit Mushroom	Kishanpur, Pithora Mahasamund	Shri Prashant Kumar Purohit	30 kg /day and Sale of fresh, dry mushroom and processed product
Annapurna mushroom	Korba	Shri Ajay Vishwakarma	70 Kg/day production
Roverent mushroom (Sale counter)	Durg	Shri Rahul Gupta	Sale of fresh, dry mushroom and processed product
Sraddha Suman Mahlia Samuh	Raipur (Tarra)	Self Help Group	Sale of fresh, dry mushroom and processed product
UKS Mushroom	Jangalpur, Gandai (Durg)	Mr. Saurabh Janghel (Fig. 8)	60 kg/day sale of fresh, dry mushroom, processed and value added product

Fig. 8 : UKS Oyster Mushroom Unit at Jangalpur, Gandai (Durg)

Mushroom farmer honoured with National Award

■ Staff Reporter

RAIPUR, Sept 12

CHHATTISGARH'S innovative Mushroom farmer Rajendra Kumar Sahu has been bestowed with the National Award for innovation in mushroom production and best utilisation of the available resources.

A resident of village Patiyapali of Basna Block in Mahasamund District, Rajendra Kumar Sahu was awarded by the Directorate of Mushroom Research, Solan (Himachal Pradesh) with the 'Progressive Mushroom Producer' accolade. Sahu developed a new technique of mushroom production in haystack lying open under the mango trees in his fields.

Sahu is growing and marketing mushrooms under the guidance of Indira Gandhi Agriculture University's scientists for past 12 years. Every day, he is yielding 3 to 5 kilograms of hay mushrooms, which is being sold for Rs 200 to Rs 300 per kilogram from his farm.

Scientists of Directorate along with the Scientists of the University had visited the farms of Rajendra Sahu and admired the technique used by him. In this technique, Rajendra is growing hay mushrooms in iron pipes under the shade of mango trees. On the direction of University of Vice-Chancellor Dr S K Patil, he has been provided with training and equipment to prepare mushroom spawn. Sahu also manufactures and sells earthworm manures. He also sells earthworms to the farmers as a source of extra income.

Farmer Rajendra Kumar Sahu receiving the National Award for innovation in mushroom production.

Fig. 9 : Raj Mushroom Kisan Nidan Club Training and Research Centre, Pathiapali (Mahasamund) growing paddy straw mushroom and awarded at the National Level

bag method of cultivation using hot water substrate treatment in a 833 g/dry straw/bag with all the

Table 7 : Organization of State Level/sponsored/other on campus/ off campus training programmes conducted by me as Course Director between 2005-2006 to 2013-14.

Training	From	To	Sponsoring agency	Trainees from	No. of participants
Mushroom processing technology	14.6. 2005	16.6. 2005	DBT	Dondekhurd	20 women
Mushroom processing technology	20.6. 2005	22.6. 2005	DBT	Tarra	23 women
Mushroom spawn production technology	18.7. 2005	21.7. 2005	DBT	Tarra and Dondekhurd	14 women
Training on Mushroom Production technology	1.8.2005	11.8.2005	Self	Government Science College, Raipur	7 students
Mushroom Production technology	19.9. 2005	21.9. 2005	DBT	Tarra	40 women
Mushroom Production technology	23.11.2005	25.11. 2005	DBT	Dondekhurd	20 women
Training on Mushroom Production technology	6.12.2005	15.12. 2005	Self	Government Science College, Raipur	7 students
Mushroom processing technology	8.5.06	10.5.06	DBT	Dondekhurd	20 women
Mushroom processing technology	22.5.06	24.5.06	DBT	Tarra	21women
Mushroom spawn production technology	12.7.06	14.7.06	DBT	Tarra and Dondekhurd	13 women
Mushroom Production technology	2.8.06	4.8.06	DBT	Tarra	20 women
Mushroom Production technology	17.8.06	19.8.06	DBT	Dondekhurd	20 women
Training on Mushroom Production technology	2.8.06	30.8.06	Self	Government Science College, Raipur	2 students
Mushroom processing technology	6.8.06	8.8.06	Deptt. of HorticultureKabeerdham	Pandaria Block (Mohtara)	25 (11+14 women+men)
Mushroom Spawn Production technology	19.9.06	25.9.06	Deptt. of Horticulture,Raipur	Raipur distt.	29 (24+5 women+men)
Mushroom processing technology	5.10.06	7.10.06	Deptt. of Horticulture Kabeerdham	Kawardha Block (Beejabairagi)	26 (25+01 women+men)
Mushroom Spawn Production technology	5.12.06	11.12.06	Deptt. of Horticulture, Raipur	Raipur distt.	29 (5+24 women+men)
Training on Mushroom Production technology	27.12.06	30.12.06	CCOST, Raipur	Matia and Dondekala,	60 (30 Women from Matia and 30 from Dondekala
Mushroom Spawn Production technology	2.1.07	8.1.07	Deptt. of Horticulture Kabeerdham	Kawardha Block	28 (04+24 women + men)
Mushroom Spawn Production technology	24.1.07	30.1.07	Deptt. of Horticulture Kabeerdham	Pandaria Block (Jamgarh, Kodwagodan)	25 (23+02 women + men)
Training on Mushroom Production technology	16.2.2008	19.2.2008	CCOST	Sirri village	60 participants
Mushroom Production technology	27.7.2008	30.7.2008	CCOST	Thathapur Bhata Mohbatta	60 women
Mushroom Processing technology	21.5.2008	23.5.2008	Jila Panchayat, Kabirdham	Kapadah village in Pandaraiya Tah.	35 Women
Mushroom Processing technology	9.6.2008	11.6.2008	Jila Panchayat, Kabirdham	Chhirpani village in Pandaraiya Tah.	45 Women
Mushroom Production technology	10.7.2008	14.7.2008	Jila Panchayat, Kabirdham	Kusumghata village in Bodla Tah.	75 Women
Mushroom Production technology	28.7.2008 18.8.2008	30.7.2008 19.8.2008	Jila Panchayat, Kabirdham	Rajanavagaon In Kawardha Tah.	75 Women
Mushroom Production technology	22.8.2008	26.8.2008	Jila Panchayat, Kabirdham	Ghuturkundi village in Pandaraiya Tah.	75 Women

Mushroom Spawn Production	5.9.2008	9.9.2008	Jila Panchayat, Kabirdham	Kawardha Tah.	20 Women
Mushroom Production technology	15.12.2008	17.12.2008	Jila Panchayat, Kabirdham	Makke in Kawardha tah.	75 Women
Mushroom Production technology	5.1.2009	7.1.2008	Jila Panchayat, Kabirdham	Chharbhata Khurd in Pandariya Tah.	75 Women
Mushroom Processing technology	21.1.2009	23.1.2009	Jila Panchayat, Kabirdham	Vicharpur in Sahaspur Lohara Tah.	75 Women
Mushroom Processing Technology	27.1.2009	29.1.2009	Jila Panchayat, Kabirdham	Silhati in Sahaspur Lohara Tah.	75 Women
Mushroom Processing Technology	5.2.2009	7.2.2009	Jila Panchayat, Kabirdham	Dania Khurd in Sahaspur Lohara Tah.	75 Women
Mushroom Production technology	12.1.2009	12.1.2009	KVK, Rajanadgaon	Suragi Farm, Rajanadgaon	80 women
Demonstration on Mushroom Production technology	14.2.2008	14.2.2009	CCOST	Musturi, Bilaspur	60 women
Mushroom Crop Production Technology	21.12.2009	24.12.2009	DBT	Parsada village in Raipur Distt.	65 women
Mushroom Crop Production Technology	22.2.2010	25.2.2010	DBT	Uperwara village in Raipur Distt.	60 women
Mushroom Crop Production Technology	30.7.2010	2.8.2010	DBT	Bhatagaon village in Raipur Distt.	50 women
Mushroom Crop Production Technology	4.8.2010	-	COA, Kawardha and Osheen Vigyan Suchna Pradaugiki, Prashikshan & Anusandhan Sansthan, Rajnandgaon	Women from self help groups of Kawardha and nearby villages were present.	70 Women
Live demonstration of oyster mushroom	20.9.2010	-	DBT, New Delhi	Women from Parsada village	35 women
Mushroom Spawn Production Technology	22.11.10	26.11.10	Self finance	Beejapur and Rajnandgaon distt.	2 women and one man
Mushroom Spawn Production Technology	3.5.2010	7.5.2010	Self finance	Korea distt.	One women and two man
Mushroom Production technology	15.1.2011	18.1.2011	DBT, New Delhi	Parsada Village	50 women
Demonstration on Oyster Mushroom Production Technology	20.09.2010 & 28.9.2010	-	DBT, New Delhi	Parsada village in Raipur Distt.	33 women
Mushroom Crop Production Technology	9.3.2011	10.3.2011	DDA, Kabirdham	Sahaspur Lohara and Bodla blocks of Kabirdham Distt.	35 women
Mushroom Crop Production Technology	24.3.2011	26.3.2011	DDA, Rajnandgaon	Mahoba village of Rajnandgaon Distt.	23 women
Mushroom Crop Production technology	12.7.2011	15.7.2011	DBT, New Delhi	Uperwara Village	50 women
Mushroom Spawn Production technology	27.7.2011	30.7.2011	DBT, New Delhi	Parsada Village	10 women
Mushroom Crop Production technology	20.7.2011	23.7.2011	DBT, New Delhi	Bhatagaon Village	50 women
Mushroom Crop Production technology	18.12.2011	21.12.2012	DBT DBT, New Delhi	Parsada village	51 women
Mushroom Crop Production technology	28.1.2012	31.1.2012	NHM, Raipur	Samnapur Village	55 women
Mushroom Crop Production technology	19.2.2012	22.2.2012	DBT, New Delhi	Uperwara village	55 women
Mushroom Crop Production Technology	3.3.2012	6.3.2012	NHM, Raipur	Dharampura village of Kabirdham Distt.	50 women
Mushroom Spawn Production Technology	11.3.2012	14.3.2012	NHM, Raipur	SKCARS, Kawardha	20 women
Mushroom Crop Processing Technology	16.3.2012	19.3.2012	NHM, Raipur	Majgaon village in Kawardha block	60 women

Mushroom Spawn Production Technology	20.3.2012	23.3.2012	NHM, Raipur	SKCARS, Kawardha	22 women
Mushroom Crop Production technology	9.7.2012	12.7.2012	DBT DBT, New Delhi	Bhatagaon Village	50 women
Mushroom Spawn Production technology	13.7.2012	16.7.2012	DBT DBT, New Delhi	Bhatagaon Village	10 women
Mushroom Crop Production technology	17.7.2012	30.7.2012	DBT DBT, New Delhi	Parsada/Uperwar a Village	20 women
Training on Mushroom Production Technology	23.3.2013	23.3.2013	National Horticulture Mission, Distt. Rajnandgaon	Khairagarh, Gandai Tah. of Rajnandgaon District	53 farmers
Training on Mushroom Production Technology	24.3.2013	24.3.2013	National Horticulture Mission, Distt. Rajnandgaon	Dongargarh, Dongargaon, Manpur-Mohla Tah. of Rajnandgaon District	52 farmers

standard package of practices under Institutional Village Linkage Programme (Table 3). In four farm families, no spawn run was observed due to excessive moisture and insect infestation. In others, there was no much difference on spawn run by different species of *Pleurotus. Pleurotus flabellatus* on an average took least time of 18.68 days compared to 19.52 in *P. florida* and 19.63 in *P. sajor-caju* for spawn run. The average yield in different farm families was highest (378.84 g) in *P. florida* followed by *P. flabellatus* (364.05 g) and *P. sajor-caju* (336.26 g). The similar trend was noticed in biological efficiency as well. The average period required for spawn run in three species of *Pleurotus* remarkedly varied with respect to different farm families. It varied from 16.33 to 29.66 days. Similarly, there was huge difference in average yield of *Pleurotus* spp. among different farm families. It differed from 180.33 to 575.66 g on yield basis while 21.66 to 69.06 per cent on efficiency wise. Similarly, three straw substrates commonly available in the village area were evaluated for their performance on yield of *P. florida* at Tarra village under IVLP (Table 4). No spawn run was observed in the household of six farm families. The average period required for spawn run by *P. florida* in rest of the farm families was least (15.33 days) on soybean straw followed by wheat straw (20.33 days) and paddy straw (21.35 days) substrates. On the other hand, the average yield was almost same on paddy and wheat straw substrate. However, it was least (31.13%) on soybean straw substrate. The average period required for spawn run by *P. florida* irrespective of the substrate varied from 16.33 to 26.00 days in different farm families. Similarly, the average yield and BE of *P. florida* differed from 140.00 to 530 g/hag and 22.60 to 63.60 per cent BE in different farm families respectively.

PRADAN is an NGO working in Sukhtawa area of Hoshangabad district in M.P. for the last 30 years where 250 women of scheduled caste are cultivating oyster mushroom for their income generation under my technical guidance. They provide all the expenses required for the oyster mushroom cultivation to the rural women including oyster mushroom spawn, PP bags, nylon strings, wheat straw, chemicals etc. and they had buy back system of buying sundried oyster mushroom from the rural women and paid the balance to the women when they brought sundried oyster mushroom. They regularly train the rural women in their headquarter, provide hand holding and maintain the yellow cards of the individual women in their computer. From the yellow cards issued by them (Fig. 6), it is very clear that the total expenses towards inputs given to a women for oyster mushroom cultivation was Rs. 1392/- and the amount paid towards purchase of different grades of sundried oyster mushroom was Rs. 5685/- thus a net benefit of Rs. 4293/- was earned by a women within 2.5-3 months period which almost three times more than the cost involved.

Mushroom spawn production, crop production, mushroom processing and marketing can be the independent activity for employment generation in a small, medium or large scale. Mushroom cultivation in Chhattisgarh has been promoted by ICAR-AICRP on Mushroom at IGKV, Raipur, 19 Krishi Vigyan Kendras (KVKs) and constituents Colleges of the university by establishing 40 Mushroom Spawn Laboratory (Table 5) and Mushroom Crop Production units in 14 KVKs (Bastar, Dantewada, Bijapur, Kanker, Dhamtari, Mahasamund, Rajnandgaon, Kawardha, Janjgir, Korba, Korea, Ambikapur, Raigarh, Bilaspur) and

14 small to medium crop production units in private sector (Table 6). KVK, Gariaband under my supervision promoted an innovative oyster mushroom scheme "*Ghar Ghar Mushroom*" with the financial support from Chhattisgarh State Skill Development Authority, Raipur. This activity was demonstrated at National Mushroom Mela at Solan in H.P. where it got Best Stall Award (Fig 7). Besides this, there are three colleges of our university namely SKS College of Agriculture and Research Station, Rajnandgaon, KL College of Horticulture, Rajnandgaon and SK College of Agriculture and Research Station, Kawardha which have established mushroom spawn and crop production units under my supervision as State Nodal Officer and promoting mushrooms in a big way by preparing student entrepreneurs, women SHGs and unemployed youths.

Oyster mushroom is one which is most pre dominantly cultivated in Chhattisgarh State by the tribals almost round the year due to ease of cultivation technology, availability of spawn, less time required for cultivation, low technical know how required and cheap availability of agro waste (>130 lakh tonnes of agrowaste in CG) mainly paddy straw, wheat raw substrates, mustard straw, sugarcane baggase, chickpea straw etc. Oyster mushroom is practiced by >1000 individual women /Women SHGs, >250 entrepreneurs in Dhamtari distt. are promoted by Sri Rajeev Lochan Agro Invention Producer Co. Ltd., Megha (Dhamtari distt.) whose members are involved in mushroom spawn production, oyster mushroom crop production, processing and marketing, >200 farmers in Rajnandagoan distt. by SHGs are practicing oyster mushroom production and processing. Similarly, paddy straw mushroom is demonstrated by our KVK, Janjgir and gradually picking up well in Janjgir-Chapa, Dhamtari, Mahasamund and Raigarh districts which are well connected by road to Odisha State. The farmers in these areas are growing paddy straw by procuring the spawn from our KVKs as well as Cuttack areas by regular bus services. At Janjgir distt., >500 farmers have made the Mushroom Federation called "Anndata Bahuuddeshiya Society" at Behradih of Janjgir distt. in which 50 farmers groups are working and compelled Distt. Collector to provide the outlet in Heart Place of the Janjgir town for sale of their mushroom and mushroom based products.This mushroom federation is registered under Deptt of Cooperative and growing paddy straw mushroom in a big way. The farmers are very well supported by the District Collector. Similarly, Raj Mushroom Kisan Nidan Club Training and Research Centre, Pathiapali owned by Mr Rajendra Sahu is supporting paddy straw cultivation by >250 farmers of Mahasamund distt. and based on his innovative idea of growing paddy straw mushroom in Mahasamund distt., he was honoured with National Award by ICAR-Directorate of Mushroom Reserach, Solan (H.P.) during national Mushroom Mela in 2019 (Fig. 9). In the same way, the Department of Forest, Pithora (Mahasamund) under our technical guidance is involved in training and cultivation of oyster and paddy straw mushroom to >300 farmers at Pithora Nursery of the Forest Department. They have established a big Mushroom Spawn Production Unit in their nursery under my guidance and supervision.

CG State Rural Livelihood Mission (SRLM) i.e. LIFE-MGNREGA Project, we trained 6308 farmers who have given their consent to follow mushroom as an income generating activity. Under this project, the farmers/labourers who have continuously served for 100 days in MGNREGA project without break were considered to be one who is the poorest and most needy person in the society and required to be supported by the government on top priority. The family members who showed their interest in mushroom cultivation were identified by the officials from SRLM and these farmers were imparted residential training of six days by 12 KVKs of Chhattisgarh during 2016-2017 & 2017-2018 under my guidance and close supervision as Director, Extension Services, IGKV, Raipur. Under this project, 432 farmers/ labourers were trained by us by organising 6-day residential training programmes by 12 KVKs (Surguja, Bijapur, Dhamtari, Bastar, Raigarh, Korba, Rajnandgaon, Gariaband, Janjgir-Chapa, Kanker, Narayanpur and Bilaspur). Many of the farmers trained by us are now growing mushrooms in their household in a small scale. Similarly, Chhattisgarh State Skill Development Authority has identified Mushroom Production as an important income generating activity as a result we have been given the target to impart training on Mushroom Production Technology to the school dropouts who passed 8th class/rural youths/ farmers who are interested in mushroom growing. In the present paper, attempt has been made to

recycle the wastes easily available in bulk quantity using strength of the mushroom fungi, promoted its health benefits to the mankind and tried to train/ demonstrate mushroom cultivation technology in a small, medium or large scale for the livelihood up gradation in all classes of the society.

Besides above, 61 training programmes on mushroom spawn production technology, mushroom crop production technology, training on oyster mushroom production technology, demonstration of mushroom technology on farmers field and mushroom processing technology were conducted from 2005-2006 to 2013-2014 to train women, men, youths, students from different districts of Chhattisgarh (Table 7). The training programmes were supported by Department of Biotechnology, Govt. of India, New Delhi, National Horticulture Mission, Directorate of Horticulture and Farm Forestry, Raipur, Rajnandgaon, Department of Horticulture Kabirdham, Chhattisgarh Council of Science and Technology, Raipur, Jila Panchayat, Kabirdham. Many of these trainees including some students adopted mushroom production as a source of their livelihood in Kabirdham, Durg, Bilaspur, Korea, Dantewada, Bijapur, Jagdalpur districts and involved in mushroom spawn production, oyster, paddy straw mushroom production, mushroom processing and mushroom marketing.

REFERENCES

Acharya K, Das K, Paloi S, Dutta AK, Hembrom ME, Khatua S and Parihar A. 2017. Exploring a novel edible mushroom *Ramaria subalpina*: Chemical characterization and Antioxidant activity. *Pharmacogn J.***9:** 30-34.

Ahlawat, O.P., Sharma, Vibhuti, Indurani C. and Vijay, B. 2004b. Physico-chemical changes in button mushroom spent substrate recomposted by different methods. In: International Workshop on "Recent Trends in Environmental Science" from 24-26th April, 2004 at National Environmental Science Academy, New Delhi.

Ahlawat, O.P., Indurani C.and Sagar, M.P. 2005a. Spent mushroom substrateproperties and recycling for beneficial purposes. In: Frontiers in Mushroom Biotechnology (R.D. Rai, R.C. Upadhyay and S.R. Sharma, Eds.). pp. 314-334. National Research Centre for Mushroom (HP), India.

Ahlawat, O.P., Sagar, M.P., Dev Raj, Indurani C., Gupta, Pardeep and Vijay, B. 2005b. Effect of spent mushroom substrate of different age and recomposted by different methods on growth, yield and quality of *Capsicum annuum*. Indian J. Horticulture (communicated).

Ahlawat, O.P., Dev Raj, Sagar, M.P., Gupta Pardeep and Vijay, B. 2006a. Effect of recomposted spent mushroom substrate on yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*). Mushroom Research **15**: 149-152.

Ahlawat , O.P., Dev Raj, Sagar M.P., Gupta Pardeep and Vijay, B. 2007a. Effect of recomposted button mushroom spent substrate on growth, yield and quality of Ginger (*Zingiber officinale*). Indian Journal of Mushrooms (accepted).

Ahlawat, O.P., Sagar, M.P., Dev Raj, Gupta Pardeep and Vijay B. 2007b. Effect of recomposted button mushroom spent substrate on growth and yield attributes of Wheat (*Triticum aestivum* L.). Mushroom Research (accepted).

Ahlawat, O.P. 2011. Recycling of spent mushroom substrate. In : Mushrooms Cultivation, Marketing and Consumption, (eds. Manjit Singh, Bhuvnesh Vijay, Shwet Kamal and G.C. Wakchaure), Directorate of Mushroom Research (ICAR), Chambaghat, Solan –173213 (HP) pp. 189-196.

Barman S, Acharya A, Chakraborty U and Chakraborty BN. 2017. Evaluation of the Effect of Different Compost Formulations and Casing Materials on Button Mushroom Production. *International Journal of Science and Nature*, **8 :** 377-385.

Barman, Shibu, Chakraborty, B.N. and Chakraborty, Usha. 2018. Edible Mushroom: Boon to human health and nutrition. *J. Mycopathol. Res.* 56(3) : 179-188.

Bassham, J.A. 1975. Biotechnol Bioeng. Symp. No.2, 9.

Beyer, M. 1996. The impact of the mushroom Industry on the environment. Mushroom News 44(11): 6-13.

Chang, S.T. 2006. The world mushroom industry: Trends and technological development. *Int. J. Med. Mushrooms*, 8, 297–314.

Chang, S. T. and J. A. Buswell. 1999. *Ganoderma lucidum* (Curt.:Fr.) P. Karst. (Aphyllophoromycetidease): a mushrooming medicinal mushroom. *Int. J. Med. Mush.* **1**: 139-146.

Chang, S. T. and P. G. Miles. 2004. Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact (Second Edition).CRC Press.Boca Raton, 451pp.

Dann, M.S. 1996. The many uses of spent mushroom substrate. Mushroom News **44** : 24-27.

Dev Raj, Indurani C., Sagar, M.P., Gupta Pardeep, Ahlawat, O.P. and Vijay B. 2007. Effect of spent mushroom substrate recomposted by different methods and of different age on vegetative growth, yield and quality of tomato (*L. esculentum*).). The Indian Journal of Agricultural Sciences (communicated).

Fahy, H.K. and Wuest, P.J. 1984. Best practices for environmental protection in the mushroom farm company. Chester County Planning Commission West Chester, PA, p. 65.

Grabbe, K. 1982. Prinzipien des mikrobiellen Stoffumsatzes bie der Aufbereitung Flussiger and fester Reststoffe und ihre Bedeutung fur die Substratherstellung im C h a m p i g n o n a n b a u Wissenschaft and Umwelt **4**:210-218.

Hawksworth, D. 1991. The fungal dimension of biodiversity: magnitude, significance, and conservation. Mycol. Res. **95**:641-655.

Jonathan SG, Lawal MM and Oyetunji OJ. 2011.Effect of Spent Mushroom Compost of *Pleurotus pulmonarius* on Growth Performance of Four Nigerian Vegetables. *Mycobiology,* **39:** 164-169.

Jonathan SG, Okorie AN, Babayemi OJ, Oyelakin AO and Akinfem AO. 2012. Biodegradation of Agricultural wastes (rice straw and sorghum stalk) into substrates of utilizable products using white Rot fungus (*Pleurotus florida) Nat. and Sci.*, **10:** 131-137.

Koopmans, A. and Koppejan J. 1997. Agricultural and Forest Residues - Generation, Utilization and Availability, Regional Consultation on Modern Application of Biomass Energy, Kula Lumpur, Malaysia.

Liu, F., V. E. C. Ooi, W. K. Liu and S. T. Chang. 1996. Immunomodulatory and antitumour activities of polysaccharide-protein complex from the culture filtrates of a local edible mushroom, Tricholoma lobayense. Gen. Pharmac. **27**:621-624.

Liu, F., M. C. Fung, V. E. C. Ooi and S. T. Chang. 1996. Induction in the mouse Gene expression of immunomodulating cytokines by mushroom polysaccharide-protein complexes. Life Sciences **58:**1795-1803.

MaHale, M. (1970). Ecological context, Braziller, New York.

Nagy M, Sonia Socaci S, Tofana M, Biris-dorhoi ES, Dorin Tibulca D, Petrut G.2017. Chemical Composition and Bioactive Compounds of Some Wild Edible Mushrooms. Bulletin UASVM *Food Science and Technology,* **74:** 3-8.

Okokon JE, Ekpo AJ and Eseyin OA.2009. Evaluation of in vivo anti malarial activities of ethanolic leaf and seed extracts of *Telfairia occidentalis*. *J. Med food*; **12:** 649-653.

Orluchukwu JA, Mac-Aboh AR and Omovbude S.2016.Effect of different rates of spent mushroom substrate on the growth and yield of fluted pumpkin (*Telfairia occidentalis* HOOK. F) in South-South, Nigeria. *Nature and Science,* **14:** 12-15.

Priadi D, Arfani A, Saskiawan I and Mulyaningsih ES. 2016**.** Use of grass and spent mushroom compost as a growing medium of local tomato (*lycopersicon esculentum* miller) seedling in the nursery. *AGRIVITA Journal of Agricultural Science,* **38:**242-250.

Rahi DK and Malik D. 2016.Diversity of mushrooms and their metabolites of nutraceutical and therapeutic significance. Review Article, *Journal of Mycology*, 1-18.

Roy S, Barman S, Chakraborty U and Chakraborty B. 2015. Evaluation of Spent Mushroom Substrate as biofertilizer for growth improvement of *Capsicum annuum* L. *Journal of Applied Biology and Biotechnology,* **3:** 22-27.

Royse, D. J. 1993. Recycling of spent shiitake substrate for production of the oyster mushroom (*Pleurotus sajor-caju*). Mushroom News **41** : 14-18.

Saalu LC, Kpela T, Benebo AS, Oyewopo AO, Anifowope EO, Oguntola JA. 2010. Dose-Dependent Testiculoprotective and Testiculotoxic Potentials of *Telfairia occidentalis* Hook f. Leaves Extract in Rat Intern. *J. Appl. Res. Nat. Prod.*, **3:** 27-38.

Thakur, M.P. and Singh, H.K. 2013. Mushrooms, their bioactive compounds and medicinal uses: A review. *Medicinal Plants* 2013; **5**: 1-20.

Thakur, M.P. 2014. Present status and future prospects of tropical mushroom cultivation in India: A review. *Indian Phytopath*. **67**: 113-125.

Thakur, M.P. 2018. Advances in post harvest technology and value additions of edible mushrooms. Indian Phytopath, **71:**303–315.

Toledo CV, Barroetavena C, Fernandes A, Barros L and Ferreira ICFR. 2016. Chemical and antioxidant properties of wild edible mushrooms from Native Nothofagus spp. Forest Argentina. *Molecules*, **21:** 1201-1215.

Wang, H.K., Ng TB, Liu W.K. Ooi VEC and Chang ST. 2015.Using spent mushroom substrate as the base for organic- mineral micronutrient fertilizer- field test on maize. *Bioresources*, **10:** 5709-5719.

Wang, H.K., Ng TB, Liu W.K. Ooi VEC and Chang ST. 1996. A polysaccharidepeptide complex from cultured mycelia of the mushroom Tricholoma mongolicum with immunoenhancing and antitumour activities. *Biochem*. and *Cell Bio*. **74**: 95-100.

Wang, H. X., T. B. Ng, V. E. C. Ooi, W. K. Liu and S. T. Chang 1997. Actions of lectins from the mushroom Tricholoma mongolicum on macrophages, splenocytes and life-span in sarcombearing mice. *Anticancer Res.* **17** : 419-424.

Yip K. P., K. P. Fung, S. T. Chang and S. C. Tam. 1987. Purification and mechanism of the hypotensive action of an extract from edible mushroom *Pleurotus sajor-caju*. Neuroscience Letters supplement 28:S59.

Zervakis, G. and Philippoussis, A. 2000. Management of agro-industrial wastes through cultivation of edible mushrooms, In: Proc. IV European waste forum 'Innovation in waste management ', C.I.P.A., Milan.

Zhang, Y.H.P. 2008. Reviving the carbohydrate economy via multi-product lignocelluloses bioefineries, *J. Ind. Microbiol. Biotechnol.*, 367-375.

Zhang JJ, Li Y, Zhou T, Ping XD, Zhang P, Sha Li and Hua-Bin L. 2016. Bioactivities and Health Benefits of Mushrooms Mainly from China Molecules, **21:** 938-944**.**