National Symposium on Mushrooms

Trends and Innovations in Mushroom Science

(27-28 April, 2017)

Abstracts

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MESSAGE

I am happy to know that ICAR-Directorate of Mushroom Research, Solan is orgaizing a National Symposium on Mushrooms: Trends and Innovations in Mushroom Science during 27-28 April 2017 at Solan, Himachal Pradesh.

While the country has achieved food security for the billion plus population, it is high time that focus is now given to address the issue of malnutrition. In this regard, provisioning alternative protein sources becomes vital and important. Mushrooms form a significant form of food as it is rich in protein and anti-oxidants, and has been recorded for their therapeutic effects across the globe. In India, mushrooms have formed inroads into the fooding pattern. In the process, we have been able to use the 700 million tons of agrowastes that are generated through our farming practices and make them useful habitats for cultivation of mushrooms. Once recycled, they become the source of organic matter that could viably be incorporated into the soil as well enabling productivity of the soil per se. Further, the process of mushroom cultivation has been a cottage industry providing employment opportunities. This bgecomes furthermore important when we discuss about processes and practices to double farmers' income. While we dwell upon varieties of mushrooms that can fetch good yield, it is also essential that we have holistic package of practice and innovations thereof to boost this sector not only as a production sector, but also as a social sector enabling food and nutritional security.

I hope the symposium will delibetare on various issues of mushrooms and their cultivation vis-à-vis market and provide a road map for the development of this sector inclusively.

I wish the Symposium, a grand success.

Dated the 12th April, 2017
New Delhi

(T. MOHAPATRA)

Mk- v'kkd dekj fl ag
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MESSAGE

In the backdrop of diverse agricultural scenario in India, mushroom cultivation is still considered as an ancillary activity. However, with suitable technological interventions and proper policy backup, mushroom cultivation can prove to be a substantial avocation in helping the farmers to double their income.

Use of mushrooms as food and neutraceuticals is known for generations. Their description and use can be seen in many ancient treatises including the Vedas and the Bible. The early civilizations like Greeks, Egyptians, Romans, Chinese and Mexicans alike have appreciated the mushrooms as delicacy and therapeutic agents and were used in the religious ceremonies considering them divine. Where Greeks regarded them as strength food for warriors, Romans considered them as food of gods, Chinese called them as "Elixir of Life".

Although the first artificial cultivation of mushrooms started in China somewhere around 600 AD, their commercial cultivation started only with the cultivation of white button mushroom in 1600 AD in France. Scientific cultivation started in the beginning of 20thand more than 100 mushroom species had been cultivated, off which 20 are being cultivated world over on different commercial scale. Though India can be termed as late starter in mushroom cultivation, the prospects for mushroom cultivation in the country are quite heartening. The ICAR-Directorate of Mushroom Research, Solan has been at the forefront in serving the mushroom science in the country.

The organization of the National symposium on mushrooms with the joint efforts of ICAR-DMR, Solan and Mushroom Society of India deserves special praise for focusing on trends and innovations in mushroom science. The deliberations emerging out the symposium may serve as the basis for future action plan with respect to research and policy formulations. I wish the symposium to succeed in meeting its set objectives.

Dated : 12.04.2017

(AK Singh)

Preface

This National Symposium on Mushrooms: Trends and innovation in Mushroom Science is a continuum of the conferences organized by Mushroom Society of India since 1994. Till now 5 conferences have been organized on various themes. Considering the changes taking place all over the globe and impetus towards growth of mushroom research and development in India, this was an apt topic and the interactions during the event will help all of us to promote the research in various aspects of mushroom science. We thank our colleagues from all parts of the India for their overwhelming response to the symposium being organized by ICAR-Directorate of Mushroom Research, Solan (ICAR-DMR) and Mushroom Society of India (MSI) during 27-28 April 2017. In this compilation of abstracts, there are more than 120 contributions including keynote, oral and poster presentations on various facets of mushroom science in addition to two theme lectures by Dr. VP Sharma and Dr. Manjit Singh. The contributions have been grouped into 7 sessions that are: (i) Germplasm, (ii) Biochemistry/ Biomolecules, (iii) Genetics and breeding, (iv) Post harvest and extension studies, (v) Mushroom Production & Protection, (vi) Medicinal & Mycorrhizal Mushrooms, and (vii) Yadavindra Young Scientist Award.

The main purpose of the symposium is to provide a platform for interactions on latest trends in mushroom research and development in the country. In addition to the scientific deliberations, the conference will provide an opportunity for mushroom growers/entrepreneurs to interact with mushroom scientists and a venue to different stakeholders to showcase their products, services and technologies related to mushroom farming, processing and marketing.

I would like to thank all members of Scientific Advisory Committee and Organizing Committee for their help and support. We thank Dr. T Mohapatra, Secretary, DARE & DG-ICAR and Dr. A.K. Singh, DDG (HS), ICAR for their guidance. I particularly thank my colleagues at ICAR-DMR who have been working for this symposium since the inception of the concept to organize the symposium.

(VP Sharma)
Director ICAR-DMR & President, MSI

PROGRAMME FOR THE NATIONAL SYMPOSIUM ON MUSHROOMS: "Trends and Innovations in Mushroom Science" from 27-28 April 2017 at ICAR-Directorate of Mushroom Research, Solan

27.04.2017 Abstract No

8.30-9.30	**Registration**			
9.30-11.00	**Inauguration**			
9.30-9.35		Welcome	VP Sharma	
9.35-10.00	Theme Lecture- I	Recent trends and innovations in mushroom diversification in India	VP Sharma	
10.00-10.25	Theme Lecture-II	Changing global scenario in mushroom industry	Manjit Singh	
10.25-10.55		Address by Chief Guest	PL Gautam	
10.55-11.00		Vote of Thanks	Satish Kumar	
11.00-11.30	**Tea**			
11.30-1.00	**Session-I: Germplasm**			
11.30-11.50	Keynote-I	Future prospects of mushroom bioiversity in India	TN Lakhanpal	I-K-1
11.50-12.10	Lead Lecture-I	Mushroom diversity of eastern ghats (Kolli hills) from southern India	M Kumar and V Kaviyarasan	I-L-1
12.10-12.20	Oral-I	Diversity and ethnomycology of genus *Volvariella* speg. in north west India	Munruchi Kaur	I-O-1
12.20-12.30	Oral-II	Wild edible mushrooms from Nagaland State of India	AO Toshinungla and Chitta Ranjan Deb	I-O-2
12.30-12.40	Oral-III	First report of *Pleurotus cystidiosus* O.K. Mill from Kerala, its spawn production and bed studies	PJ Krishnapriya *et al*.	I-O-3
12.40-12.50	Oral-IV	Indian mushroom diversity collection at ICAR-DMR culture bank, Solan	Anupam Barh *et al*.	I-O-4
12.50-13.00	Oral-V	Mushrooms biodiversity of Jammu and Kashmir, India	Sanjeev Kumar and Yash Pal Sharma	I-O-5
13.00-13.10	Oral-VI	Geographical mapping of mushroom wealth in Maharashtra	VK Bhalerao *et al*.	I-O-6
13.10-13.20	Oral-VII	Diversity of ectomycorrhizal genus *Russula* Pers. from sal forest of North West India	Jitender Kumar and NS Atri	I-O-7
13.20-13.30	Oral-VIII	Macrofungal assemblages in moist deciduous forests of Western Ghats, India	M Krishnappa	I-O-8

Simultaneous Poster session will be held for Session-I. Posters may be displayed at 11.00 in the DMR museum of TOT building

13.20-14.00 Lunch

14.00-15.20 Session-II: Biochemistry/ Biomolecules

14.00-14.20	Keynote-I	Medicinal mushrooms – issues for consideration and action	RD Rai	II-K-1
14.20-14.30	Oral-I	Biochemical comparison of commonly cultivated mushroom varieties of Kerala	RM Zacharia *et al*.	II-O-1
14.30-14.40	Oral-II	Isolation, screening and characterization of amylase producing bacteria from white button mushroom compost	Neerja Rana *et al*.	II-O-2
14.40-14.50	**Poster Session Break**			
14.50-15.00	Oral-IV	Textile dye decolourization by a thermostable immobilized laccase isolated from *in vitro* cultured *Ganoderma lucidum*	Aarti Tuli *et al*.	II-O-3
15.00-15.10	Oral-V	Study of antioxidant activity in *Lentinula edodes* (shiitake) using different extracts	Navreet Kaur *et al*.	II-O-4
15.10-15.20	Oral-VI	*Pleurotus ostreatus* polysaccharides with antioxidant and antimicrobial properties	Gagandeep Kaur *et al*.	II-O-5
15.20-15.30	Oral-VII	Developing eco-friendly green products from mushrooms - An initiative towards developing mushroom bio-factories	Perumal Karuppan *et al*.	II-O-6

Simultaneous Poster session will be held for Session-II. Posters may be displayed at 14.00.

15.30-16.00 Tea and Poster session

15.45-17.05 Session-III: Genetics & Breeding

16.00-16.20	Keynote	Development of hybrids in button mushroom in India	Manjit Singh	III-K-1
16.20-16.35	Lead Lecture-I	Genetic improvement of *Pleurotus* species	Harpreet S Sodhi	III-L-1
16.35-16.50	Lead Lecture-II	DNA barcoding of mushrooms - Prospects and problems	MC Yadav	III-L-2
16.50-17.00	Lead Lecture-III	Characterization of WRKY transcription factor in *Agaricus bisporus* and its possible role	Shwet Kamal	III-L-3
17.00-17.10	Oral-I	Assessment of diverse strains of oyster mushroom for their cultural, morphological and yield attributes under foothill condition of Pasighat, Arunachal Pradesh	RC Shakywar	III-O-1
17.10-17.20	Oral-II	Evaluation of different *Pleurotus* spp. under mid hill conditions at Meghalaya	Baiswar P *et al*.	III-O-2

17.20-17.30 Tea

17.30-19.10 Session-IV: Post harvest and extension studies

17.30-17.50	Keynote-I	Mushroom cultivation: a sustainable avocation for rural tribal population of Chhattisgarh State	MP Thakur and Deepti Jha	IV-K-1
17.50-18.05	Lead Lecture-I	Mushroom technology as a social enterprise – The way forward	Meera Pandey & G Senthil Kumaran	IV-L-1
18.05-18.20	Lead Lecture-II	Innovative approaches for popularization of mushroom among youth and women in Southern India	Reeny Mary Zacharia	IV-L-2
18.20-18.30	Oral-I	Post Harvest studies on *Macrocybe gigantea* (Giant Mushroom) for increasing shelf life	Geeta Sharma and Megha Suman	IV-O-1
18.30-18.40	Oral-II	Marketable value added products of oyster mushroom	Sujata Makkar *et al*.	IV-O-2
18.40-18.50	Oral-III	Mushroom standards for fresh and dried mushrooms and their products	BL Attri	IV-O-3
18.50-19.00	Oral-IV	A study on mushroom consumer behaviour: Implications for mushroom farming, marketing and public health policy	Mahantesh Shirur *et al*.	IV-O-4
19.00-19.10	Oral-V	Mushroom information dissemination through internet technologies	Y Gautam	IV-O-5

Simultaneous poster session for Session III and IV

19.10-19.45 General Body meeting of members of MSI.

Fellowship of Rs 25000/ to attend the international symposium
Dr. HS Garcha Award.
Financial report of MSI.
Change of constitution of MSI regarding election of President.
All the Indian authors should be member of MSI.
Rate of proceeding of all conference to be fixed and proforma invoice to be sent to all the libraries.

19.45-21.30 Dinner

28.04.2017

9.30-11.20 Session-V: Mushroom Production & Protection

9.30-9.45	Lead Lecture-I	Modern farm design in button mushroom	BL Dhar	V-L-1
9.45-10.00	Lead Lecture-II	Recent trends in compost production technology in India	B Vijay	V-L-2
10.00-10.15	Lead Lecture-III	Pest status of mushrooms and their bio-management	Anju Sudhakar Khanna	V-L-3
10.15-10.30	Lead Lecture-IV	Culture stability, commercial scale cultivation and shelf life studies on the silver-silk straw mushroom, *Volvariella bombycina*	OP Ahlawat *et al*.	V-L-4

10.30-10.45	Lead Lecture-V	Holistic approaches for management of pest and diseases in mushrooms	Satish Kumar *et al*.	V-L-5
10.45-10.55	Oral-I	Evaluation of bacterial antagonists against *Mycogone perniciosa* causing wet bubble disease of white button mushroom (*Agaricus bisporus*) in Kashmir	Shaheen Kounsar *et al*.	V-O-1
10.55-11.05	Oral-II	Evaluation of locally available agricultural wastes for growth and yield potential of *Pleurotus* species	MK Yadav *et al*.	V-O-2
11.05-11.20	Oral-III	Utilization of nitrogen rich supplements for quality and quantity improvement of *Lentinula edodes* and *Calocybe indica* and its propagation in villages of Haryana	Satyawati Sharma *et al*.	V-O-3
11.20-12.00	**Tea and poster session**			
12.00-12.10	Oral-IV	Effect of substrate moisture on the production of straw mushroom, *Volvariella volvacea*	BK Pani *et al*.	V-O-4
12.10-12.20	Oral-V	Studies on design of non-conventional energy based mushroom growing sheds for hilly regions	PK Bhargava	V-O-5
12.20-12.30	Oral-VI	Influence of substrates, spawning and post-spawning practices on yield and yield attributing parameters of Indian oyster mushroom, *Pleurotus pulmonarius*	P Hemalatha *et al*.	V-O-6
12.30-12.40	Oral-VII	Designing and construction of aerated bunkers with spigot floor	Naveen Patwal	V-O-7
12.40-12.50	Oral-VIII	Cultivation and yield evaluation of wild *Pleurotus* spp. from Western Ghats of Maharashtra	AC Jadhav *et al*.	V-O-8
12.50-13.00	Oral-IX	Opportunities of diversification of mushroom cultivation in India with special reference to straw mushroom	KB Mohapatra *et al*.	V-O-9
13.00-13.10	Oral-X	Engineering Interventions In Indian Mushroom Industry	G Senthil Kumaran and Meera Pandey	V-O-10
13.10-13.20	Oral-XI	Popularization of pipe method of button mushroom compost production in Bihar	Dayaram	V-O-11
13.20-13.30	Oral-XII	Button mushroom compost making by using the spent substrate of the previous button mushroom crop	OP Ahlawat *et al*.	V-O-12
13.30-14.00	**Lunch**			
14.00-15.40	**Session-VI: Medicinal & Mycorrhizal Mushrooms**			
14.00-14.20	Keynote-I	Therapeutic potential of reishi - *Ganoderma lucidum* for prevention and treatment of cancer	KK Janardhanan	VI-K-1

14.20-14.35	Keynote-II	Cultivation aspect of *Morchella* spp.	TN Lakhanpal (Retired)	VI-K-2
14.35-14.50	Lead Lecture-I	Status of *Ophiocordyceps sinensis* (syn. *Cordyceps sinensis*) in India	RP Singh	VI-L-1
14.50-15.00	Lead Lecture-II	Effect of ectomycorrhizal application on the survival and growth of *Shorearobusta* under nursery conditions	Jitender Kumar and NS Atri	VI-L-1
15.00-15.10	Oral-I	Molecular identification and optimization of conditions for *in vitro* culture of *Cordyceps sinensis*	Vikas Kaushik *et al*.	VI-O-1
15.10-15.20	Oral-II	Morels: an elusive and sumptuous mushroom	Monika Thakur	VI-O-2
15.20-15.30	Oral-III	Kashmir morels: a review on distribution, diversity and ethnobotanical studies	Rukhsaar Sayeed *et al*.	VI-O-3
15.30-15.40	Oral-IV	Antibacterial effects of different extracts of *Lentinula edodes* strains	Navreet Kaur *et al*.	VI-O-4
15.40-15.50	Oral-V	*Ganoderma lucidum* and its potential against HSV	Krishna Kondragunta *et al*.	VI-O-5
15.50-16.00	Oral-VI	Selective estrogen receptor modulation (serm) and apoptosis induction of ergosterol peroxide from mangrove habitat mushroom *Fulvifomes* sp	M Kalaiselvam and G Mano	VI-O-6
16.00-16.15	**Tea and simultaneous poster session will be organized along with sessions**			
16.15-17.15	**Session-VII: Yadavindra Young Scientist Award**			
16.15-16.30	Oral-I	Genetics and hybrid breeding of *Pleurotus* spp. for biotic and abiotic stresses	VK Bhalerao	VII-O-1
16.30-16.45	Oral-II	*In silico* investigation of 35 different species of genus *Pleurotus* and their inter-relationship amongst compatible mating groups	Anupam Barh	VII-O-2
16.45-17.00	Oral-II	Study of mycelial growth rate and extracellular enzyme activities as a combined tool to select the shiitake strains for cultivation on wheat straw	Sudheer Kumar Annepu	VII-O-3
17.00-17.15	Oral-IV	Taxonomy and Enzyme assay of *Trametes versicolor* Fr. from district Solan of Himachal Pradesh	Neha Thakur	VII-O-4
17.15-17.30	Oral-V	Production, characterization of dyes from *Pycnoporus sanguineus* and application of dye in textile fabrics	S. Chandra Sekarenthiran and K. Perumal	VII-O-5
17.30-18.15	**Plenary Session**			
17.30-17.45		Presentation of report of all the sessions by respective chair of the session		
17.45-18.15		Compilation of recommendations of Symposium		

About Keynote and Lead speakers

Dr VP Sharma

Dr. VP Sharma obtained his B.Sc (Agri) from Himachal Pradesh Krshi Visva Vidyalaya, Palampur, in 1984 and M.Sc (Plant Path.) from Dr Y.S Parmar University of horticulture and Forestry, Solan, in 1986. He received his Ph.D. (Plant Pathology) in 1989 from Dr Y.S Parmar University of horticulture and Forestry. He Joined as Asstt. Mycologist in the Deptt. of Mycology and Plant Pathology, UHF, Nauni, Solan in May, 1990. From 1999 May to Feb, 2004 he served the university as Mycologist and in Feb, 2004 joined DMR Chambaghat, as senior scientist. He has received Yadvindra Young Scientist Award two times in 1994 and 1997. He was Principal Scientist from Feb. 2007 to October, 2015. Presently he is the Director of ICAR-DMR since October 2015.

Dr Manjit Singh

Dr. Manjit Singh obtained his M.Sc. and Ph.D. degree from Punjab Agricultural University Ludhiana. In 1976 he started his scientific career as Scientist in the first batch of Agricultural Research Service of ICAR. After serving Central Potato Research Institute from 1976 to 1983, he joined NCMRT (now DMR), Solan on 6th March, 1984 and worked at the Centre till 6th Jan, 1988. During his short stay at this centre he developed three varieties of white button mushroom (including one hybrid). Thereafter he joined CAZRI, Jodhpur where he served as Head, Division of Plant Sciences and Biotechnology from May 1997 to December 2008. He received M.S. Randhawa Medal from PAU, Ludhiana in 1975 and ICAR Team Award in 1993. He joined as Director DMR on 01.01.2009. ICAR had renewed the appointment tenure of Dr. Manjit Singh as Director of Directorate of Mushroom Research, Solan upto 31.03.2015. He superannuated on 31.03.2015 (A.N.). He has joined as *Mushroom Advisor*, Government of Punjab, India in February 2016. Dr. Manjit Singh is presently General Secretary, World Society of Mushroom Biology and Mushroom Products (WSMBMP).

Dr RD Rai

Dr. R.D. Rai obtained his M Sc (Biochemistry) with gold medal from the University of Allahabad and Ph D (Biochemistry) from Central Drug Research Institute (CDRI) Lucknow. He joined the Indian Council of Agricultural Research (ICAR) in the first batch of the Agricultural Research Service (ARS) on 1st September 1976, at the then Central Staff College for Agriculture (now NAARM) at Hyderabad. He was recipient of the National Merit Scholarship during M Sc and CSIR JRF during Ph D. His PhD thesis was on biochemical studies on amoebic meningo-encephalitis caused by Acanthamoeba culbertsoni in albino-mice. After training at Hyderabad, he joined Central Potato Research Institute (CPRI) and was posted at its regional station at

Patna from 1976 to 1983. Dr Rai joined the National research Centre for Mushroom, Solan in March 1984, where he served as Senior Scientist till 1998 and then as Principal Scientist (Biochemistry) till July, 2009. He worked on Fungal degradation of ligno-celluloses by mushrooms, Morphogenesis in mushrooms, Post harvest biochemistry of Mushrooms and Medicinal mushrooms. He has served as Head, Division of Bio-chemistry, New Delhi from 2010-16. He has served the Centre in many areas of scientific and administrative endeavor. He was founder Chief Editor, Mushroom Research: an international journal of mushroom research and development from 1991-2004.

Dr Harpreet Singh Sodhi

Dr Harpreet Singh Sodhi is Senior Mycologist (Professor) in the Department of Microbiology, Punjab Agricultural University, Ludhiana. He has been a Scientist engaged with the mushroom research since October, 1984. He did his M. Sc. from PAU and PhD from University of London, London (UK). He has guided 12 M. Sc students and 5 PhD students. He has worked on all facets of the mushrooms including production technology, post harvest care, shelf life improvement, medicinal components, nutritional status, genetic improvement of mushroom strains etc.. He worked as a team member of the mushroom group at PAU to give technology of cultivating five mushroom varieties namely, *Agaricus bisporus, Calocybe indica, Lentinus edodes, Pleurotus* spp. and *Volvariella* spp. round the year under natural climatic conditions of Punjab. His major interest in mushroom research is to develop novel strains through genetic manipulation besides developing low cost technology. He has published about 50 research papers and various articles in extension bulletins.

Dr Mahesh C Yadav

Dr Mahesh C Yadav is a Geneticist working since last 21 years on different agri-horticultural crops especially mushrooms. He was born on 19.12.1967 at Ram Nagar in Firozabad District of Uttar Pradesh. Dr. Yadav has a brilliant academic career. He was Silver Medallist during B. Sc. (Ag & AH) from CSAUAT, Kanpur in 1989 and obtained both his M. Sc. (Genetics) in 1992 and Ph. D. (Genetics) in 1998 degrees from Post-Graduate School of IARI, New Delhi. He joined ICAR's Agricultural Research Service (ARS) as Scientist (Genetics) at NRCM (now ICAR-DMR), Solan in 1996. Dr. Yadav is credited to establish first Biotechnology/Molecular Genetics Lab at NRCM, Solan during 2000-01. He was deputed for foreign training under World Bank funded NATP project and worked under the guidance of renowned mushroom geneticists Dr. T.J. Elliott and Dr. M.P. Challen on ITS Sequencing and phylogenetics of button mushroom at HRI, Wellesbourne, UK in 2002. Besides his foreign deputation, he had also undergone advanced trainings in the world renowned Labs in Biotechnology like CCMB and CDFD, Hyderabad in 1999, ICGEB, New Delhi in 1999, and NRCPB, New Delhi in 2002. Dr. Yadav was awarded prestigious Yadavindra Young Scientist award in 2002 for his contribution in molecular breeding in button mushrooms. Dr. Yadav joined NBPGR, New Delhi on promotion as Principal Scientist in Sept. 2009 and his group is currently working on DNA bar-coding system in agri-horticultural crops, assessment of molecular diversity in plant genetic resources of rice and maize, and terminal heat tolerance in wheat. He is currently leading a mega project of National Innovations in Climate

Resilient Agriculture (NICRA) on "Focused collection of germplasm from climatic hotspots in wheat & rice and characterization and evaluation for heat and drought tolerance" funded by ICAR w.e.f Feb. 2015.

Dr Shwet Kamal

Dr. Shwet Kamal has obtained his Ph.D degree in mushroom from National Research Centre for mushroom with Registered with LN Mithila University, Darbhanga in the year 2001. He worked as Research Associate at IHBT (CSIR), Palampur and NRC for Mushroom, Solan till 2006. Then he has joined Amity University as lecturer. Dr. Shwet Kamal has been selected for MIUR fellowship, Italy and worked as guest researcher at Dipartimento de Biologia Vegetale, Universita de Torino, Italy for a period of one year. During the period he has also been nominated as a member of World Tuber Genome Consortium, INRA, France. Dr. Shwet Kamal has joined DMR as Senior Scientist on 16th March 2010.

Dr MP Thakur

Borne on 24th June, 1961 at Niwari (Mandla, M.P.), graduated (1982), post graduated (1984) and Doctorate (1988) from JNKVV, Jabalpur. Started my professional career in 1986 as Research Associate at Cotton Research Station, Khandwa (M.P.), as Junior Scientist in Indo-German project, Harda (M.P.) and Asstt. Prof. at COA, Khandwa in 1988 at JNKVV, Jabalpur (M.P.). Then, I joined, IGKV, Raipur on 14th Sept., 1988 as Asstt. Professor, selected as Associate Professor in 1995 and was transferred to AICRP on Mushroom on 11th June, 1996 as Scheme Incharge and continued till March, 2007, became Principal Scientist in 2003 and **HOD** (Plant Pathology) for about a year in 2006. Nominated as **Nodal Officer** for establishment of a new College of Agriculture at Kawardha (C.G.) on 19th April, 2007 and **Dean** (Officiating) since 11th Dec., 2007 to 11th July, 2012. Joined as **Professor and Head** (PP) on 12th July, 2012 and continuing till date. During my educational & professional career, awarded ICAR Junior & Senior Research Fellowships, Merit Scholarships, Certificate of Honours at UG and PG degrees. Nominated as **Zonal President**, Central Zone (Madhya Pradesh, Rajasthan, Andhra Pradesh and Chhattisgarh states) of Indian Phytopathological Society, New Delhi for 2013, nominated by DG, ICAR as **MEMBER** for Research Advisory Committee of DMR, Solan for three years from 2013-2016, nominated as Zonal Councilor, West Zone (Madhya Pradesh, C.G. Rajasthan, Gujarat) of ISMPP, Udaipur in 2001. Visited China, Mexico, Thailand, U.K., Nepal for educational purposes. Awarded Fellowship for Training to the In Service Young Scientist by Madhya Pradesh Council of Science and Technology, Bhopal in 1992, awarded Best Worker by IGAU, Raipur in 2001, awarded Best Poster Paper in 2005,2008, "Krishi Shree" Award for outstanding contribution by Minister of Education, Govt. of Chhattisgarh in 2007. Have been the **FELLOW** of Indian Society of Mycology and Plant Pathology, Udaipur since 2010 and Indian Society of Pulses Research and Development, Kanpur since 1995. Working as "**Editor**" of *Mushroom Research*, since 2006 published by MSI, Solan (H.P.), *Journal of Mycology and Plant Pathology* published by ISMPP, Udaipur from 2002-2011, *Indian Phytopathology* published by Indian Phytopathological Society, New Delhi since 2011, as "Editor in Chief" of *Journal of Agricultural Issues* published by IGKV, Raipur since March, 2012. Worked as Editor, *Journal of Agricultural Issues* published by IGKV, Raipur from 1994-2004. Organized FIVE

National Conference/Seminars/Workshop, ICAR Short Course, 126 training programmes of National and state levels. Written 3 books, 3 practical manuals, 10 technical bulletins, 23 Extension bulletins, 10 multicolored folders, 6 compendium of lectures. Published 70 research papers, 9 chapters in books, 2 review articles, 69 popular articles, presented 38 keynote address/guest lectures/invited talks in International and National Conferences. Chaired, co chaired dozens of technical sessions of in International and National Conferences. Have been the **Judge** in dozens of Competition Awards by being organized by the different Academic Societies and Councils.

Dr Meera Pandey

Developed technologies for the lignocellulosic waste management through the production of edible and medicinal mushrooms. Developed strategies for efficient input resources in mushroom cultivation. Developed strategies for the utilization of mushrooms for nutrition management. Developed strategies to make mushroom production a zero waste system. Documentation and conservation of mycological wealth and ethnomycological knowledge for posterity. Developed strategies for mechanization of Indian mushroom industry. Developed strategies for ut ilization of spent mushroom substrate for betterment of soil health. Upgraded the skills and technical empowerment of human resource for economic upliftment through mushroom technology. Conceptualized the concept of ornamental mushroom as conservation strategy for non edible mushrooms.

Dr Behari Lal Dhar

Dr. B. L. Dhar is a renowned mushroom scientist and has done his masters and doctoral degree on mushrooms. He has 30 years of reasearch experience in the field of mushrooms. He has served 24 years in the Directorate of Mushroom Research in different capacities. He has worked on cultivation of specialty/ lignicolous mushrooms for five years with a Japanese team and also released of 2 high yielding varieties NCB-6 and NCB-13 of summer white button mushroom *Agaricus bitorquis* for commercial cultivation in India. He has developed technology for cultivation of summer white button mushroom *Agaricus bitorquis*-for the first time in the world.He has also worked on post composting supplementation of compost with N-rich organic materials for yield increase, in *A.bisporus* and *A. bitorquis*. Dr. Dhar has standardized suitable casing materials for Indian conditions, recommendation of Mushroom Spent Compost, Coir Peat and Farm Yard Manure for cultivation of button mushrooms with comparable mushroom yields. Developed Mushroom Farm Design appropriate to Indian growing conditions, with modern infrastructure and climate controls. Dr. Dhar is honoured by the International Society for Mushroom Science (UK) by selecting him as 'Mushroom Personality', American Mushroom Institute by publication of his contributions to Mushroom Science under the column Researchers Around the World in their issue of Mushroom News. Dr. Dhar has visited and given lectures at various cuntries like Ireland, Hong kong, Malasiya, China and France.

Dr B Vijay

Bhuvnesh Vijay obtained his M.Sc. Botany (specilization in Plant Pathology) from Vikram University Ujjain (M.P.) in 1974. He served as Assistant Professor (Pl. Pathology) at Agriulture Research Station, Durgapura, Jaipur from 1974 to 1977. After that he joined the Agricultural Research Service of ICAR and was working at Directorate of Mushroom Research, Solan (HP) since October, 1983 till retirement. He completed his doctoral research on "Investigations on compost mycoflora and crop improvement in *Agaricus bisporus* (Lange) Sing from HP University Shimla (HP) in 1996. Main focus of Dr. B. Vijay's earlier research was on refinement in cultivation technologies of oyster and white button mushroom and also on the role of mycoflora in compost production for white button mushroom (*Agaricus bisporus*).

Dr Anju Sudhakar Khanna

Worked on nematode pests associated with mushrooms, vegetable crops, ornamentals and medicinal and aromatic plants and their management and insect pests of mushrooms and their management. Presently concentrating on nematode pests of vegetable crops and ornamentals in field and under protected cultivation and their management. Developed under graduate course on ' Nematode pests of Horticultural crops and their management' for teaching at National level as per the guidelines of ICAR.

Dr OP Ahlawat

Dr. Om Parkash Ahlawat obtained his M.Sc. and Ph.D. in Microbiology from Ch. Charan Singh Haryana Agricultural University, Hisar in the year 1989 and 1993, respectively. Dr. Ahlawat joined Agricultural Research Services of ICAR in Sept 1993 and after one year of foundation training, he joined NCMRT, Solan in Sept 1994 and worked till Dec 1999. He rejoined National Research Centre for Mushroom in August, 2000 as Senior Scientist, Biotechnology. Presently he is serving as Principal Scientist (Biotechnology). He has received KU Patel Award in the year 2000 from All India Food Preserver's Association, New Delhi, Scientist of the Year Award, (2004) from NESA, New Delhi and Kejriwal Award 2007 from AIFPA, New Delhi. He has worked in microbiological and biochemical aspects of button mushroom compost and casing soil. The other areas, where he has made significant contributions are the indoor cultivation technology of paddy straw mushroom, cultivation technology of *Volvariella bombycina*, improved strains of *Volvariella volvacea* and spent mushroom substrate recycling. He has also worked at INRA, Bordeaux, France.

Dr Satish Kumar

Satish Kumar obtained his PhD (Agricultural Entomology) form Himachal Pradesh Krishi Vishva Vidyalaya, Palmapur in the year 1996. In the same year he joined the Agricultural Research Services of Indian Council of Agricultural Research. He joined NRCM, Solan in 1996. For his significant contribution in mushroom research, he was awarded the Fellowship of Mushroom Society of India.

Dr KK Janardhanan

Did his B.Sc from University of Kerala, M.Sc. from University of Rajasthan and Ph.D from University of Rajasthan. He worked as Deputy Director, CIMAP, Lucknow (1994) now working as Professor, Amala Cancer Research Centre, Trichur (1998). His research area are Microbiology, Fungal metabolites, Medicinal mushrooms. He has been awarded by Dr. Agnihotrudu Memorial Oration Award, Fellow of Czechoslovak Academy of Sciences, National Society of Ethnopharmacology

Prof TN Lakhanpal

T.N. Lakhapal was born on October 1st, 1944, Hamirpur ,Himachal Pradesh. He received his B.Sc. Hons and M.Sc. Hons degrees in Botany from Punjab University Chandigarh in 1965 and 1967 securing 2nd and First Position respectively in the University and his Ph.D. Degree from the University of Delhi in 1975 .. He joined the department of Bio-sciences, H.P. University Shimla in 1976, and served the university in various capacities as Chairman of the Department , Dean Faculty of Life Sciences, Director, Institute of Integrated Himalayan Studies and after retirement as Professor Emeritus of UGC for two years. He also served briefly as Visiting Professor in the department of Forest Science, Oregon State University, USA and Mizoram University, Mizoram. And is honourary Professor in the department of Bio-sciences, Sri Sathya Sai University, Prasanthi Nilayam (AP).

Dr. Lakhanpal has been a pioneer in research on Cellular Slime Moulds, Acellular Slime Moulds, Mushrooms and Mycorrhiza. He has extensively explored the bio-diversity of various groups of fungi from N.W. Himalaya: and has published monographs on the Taxonomy of Indian Myxomycetes, The Family Amanitaceae in India, The Family Boletaceae in India and the Biology of Indian Morels Technology was also developed by his group for the cultivation of Shiitake (*Lentinus edodes*) and Milky mushroom (*Calocybe indica*).

Dr. Lakhanpal has served as President of Plant Sciences Section of ISCA, President of Mycological Society of India, and Indian Mushroom Growers Association. He was conferred Life time achievement award at Banaras Hindu University and Fellowship by Indian Mycological Society (Calcutta). He served as a member of QRT on mushrooms, Biodiversity Authority of India, Biodiversity Board of Himachal Pradesh, DST, DBT, DoE&F, GBPIHED, NRCM, UGC and HFRI. He was also Chairman RAC, Directorate of Mushrooms, Solan. He was Chief Editor of the Indian J. of Mushrooms and was also on the editorial board of Indian Phytopathology, Indian Journal of Mycology & Plant Pathology, J. of Tree Sciences, India J. of Microbiology, and Hill J. of Botany .Dr. Lakhanpal is Fellow of Indian Phytopathological society and Society for Mycology and Plant Pathology.

He was honored with Best Teacher Award by H.P. University, Shimla and Sarswati Award of Delhi University and the Best Citizen award by the International Publishing House and Rashtrya Gaurav Award by Friendship Society of India. He has completed 10 major projects sponsored by different granting agencies: DST, DBT, DOE&F, ICAR, GBPIHED & UGC.

Dr. Lakhanpal has to his credit over 175 research papers, and ten books. He has trained a large number of M.Sc. & M.Phil students and 30 students have received Ph.D. under his supervision

Dr RP Singh

Dr. R.P. Singh has been involved with Mushroom Research and Development since last 38 years (Assistant Professor to Professor and Head Plant Pathology, Director CAS and Emeritus Scientist from Nov. 1972 to June, 2010). He has initiated and established Mushroom Research and Training Centre at the G.B. Pant University of Agriculture and Technology, Pantnagar Uttrakhand, India. He has formulated and implemented five research projects on different aspects of mushrooms apart his leadership to All India Coordinated Mushroom Improvement Project since 1984. His achievements on medicinal mushroom includes development of technology for the production of *Ganoderma lucidum, Lentinula edodes, and Cordyceps sinensis*. He has led a team of researcher's on Cody*ceps sinensis* highly priced medicinal mushrooms. He attended and presented papers in 25 National and 6 International conferences including latest an International conference on *Cordyceps sinensis* conference at Xining, China in June,2o10. He has guided 06 Ph.D. and 8 M.Sc.(Ag.) students and published more than 150 research papers / articles. He has authored two books and twelve book chapters. He has been member International Society of Mushroom Science, Life Member Mushroom Growers Association,Life member of Mushroom Society of India, Vice-President Indian Society of Mycology and Plant Pathology and President, Mushroom Society of India. He has been member R AC, Directorate of Mushroom Research, Solan and member QRT formed by ICAR to review the work done from 2005-2010 at DMR, Solan and AIC Research Project on Mushroom. He was awarded P.R. Verma award of Indian Society of Mycology and Plant Pathology (2000 & 2006), best paper award from Indian Phytopathological Society and M.J. Narsimhan academic award of Indian Phytopathlogical Society . He was member of Board of Management of Rajasthan Agriculture University, Bikaner for the year 2005-06 and member expert comittee, National Biodiversity Authority, Govt. of India for the year 2008-09.

Prof NS Atri

Prof. N. S. Atri (b. 1st Sept., 1955): M. Sc. (Punjabi Univ., 1978), M. Phil. (Punjabi Univ., 1981), Ph.D. (Punjabi Univ., 1985); Date of joining this Department: 7th September 1987;Field of Specialization: Mushroom Mycology and Plant Pathology; Research Activities: Published 85 papers, guided 5 Ph.D. and 8 M. Phil. and 10 M. Sc. students, completed three research projects on mushrooms; Vice-President, Mycological Society of India (2012-2013),Membership: Councillor MSI (2011-2012), Life Member Indian Botanical Society; Mushroom Society of India, Mushroom Growers Association, Indian Phytopathological Society, Society of Mycology & Plant Pathology, Punjab Academy of Sciences, Mycological Society of India and Indian Science Congress Association, Kolkata. Edited 4 books entitled “Fungi - Diversity and Conservation in India, Germplasm Diversity and Evaluation: Angiosperms; Germplasm Diversity and Evaluation: Algae, Fungi and Lichens, Biodiversity Evaluation-Botanical Prespective, Member Editorial Board Mushroom Research-An International Journal of Mushrooms; NELUMBO, Bulletin of Botanical Survey of India, KAVAKA-Journal of Mycological Society of India, Coordinator examination (2003-2005), Co-coordinator SLET(Computers-2006), Coordinator SLET (B. Ed.-2007), Controller Examination (2009-2010), Convenor Advisory Committee (Examination Reforms), Member Advisory Committee. Academic Staff College, Punjabi University, Patiala, Deputy coordinator DRS-SAP-III of UGCand Head, Department of Botany and Coordinator FIST Programme of DST.

Theme Lecture-I

T-1. Recent trends and innovations in mushroom diversification in India

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Mushrooms have been consumed since ancient times for their nutritional value. They are considered as a potential substitute of muscle protein on account of their (i) high digestibility (Digestibility coefficient around 89%), (ii) good amino acid content and (iii) about 1000 times higher production of protein per unit area. They have low fat content, high fibre and all essential amino acids and contain all important minerals too. On exposure to UV-light, mushrooms also produce large amounts of vitamin D, which is normally difficult to obtain from a regular diet intake. Among the possible direct medicinal value of mushrooms, the most important ones are anti-cancer, hypolipidemic, hypocholesterolemic, and anti-hypertensive. There is tremendous potential and appeal for growing a highly nutritious food with excellent taste from substrates that are plentiful and not very expensive. Also, it is very environmental friendly, capable of converting the lignocellulosic waste materials into food, feed and fertilizers.

The button mushroom *Agaricus bisporus* is one of the most widely cultivated edible mushroom species in the world and its commercial cultivation is over three centuries old. The world production level for 2009 is estimated at ca. 4 million tons with an economic value of ca. 4.7 $ billion. Till date the share of button mushroom in world mushroom production is the maximum amounting to almost 30% while the share of button mushroom in India is more than 85%. Today, commercially grown mushroom species are button and oyster mushrooms, followed by other tropical mushrooms like paddy straw mushroom, milky mushroom, shiitake, etc. But all the other mushroom species contributes a total of 15% in Indian mushroom Production. India is predominantly a tropical/subtropical country but it is ironical that the mushroom production in India is mainly restricted around temperate button mushroom requiring high energy inputs.

Diversification is essential for sustainability of any farming system. Mushroom component in a farming system augurs well to impart the diversification as it makes use of agro residues of the farm and also recycle the spent mushroom compost after harvesting the mushrooms. Continuous efforts to cultivate/ domesticate many wild mushrooms are underway at the Directorate of Mushroom Research, Solan (HP). Much progress has been achieved in standardizing the technologies by using different agro-residues to cultivate different mushrooms such as *Flammulina velutipes*, *Auricularia polytricha*, *Auricularia rosea*, *Hericium coralloides*, *Lentinus sajor-caju*, *Lentinus squarrosulus*, *Macroletpiota procera*, *Pleurotus eryngii* (King Oyster mushroom), *Volvariella bombycina*, *Macrocybe gigantea*, etc.

Cultivation technology of a new mushroom *Macrocybe gigantea* has been standardized. This new tropical edible mushroom is rich in protein, Vit-D, Potassium, Iron and Zinc. The mushroom resembles white button mushroom and milky mushroom, which makes its marketing easy. Further, the pungency associated with milky mushroom is not found in this mushroom and its suitability for tropical climate can be a helpful for growing in most part of India.

Paddy straw mushroom is one of the most cultivated mushrooms in Indian coastal areas of Odisha, Andra Pradesh, etc. The temperature required for the mushroom is normally 35-40 °C with high humidity. The problem with this mushroom is its highly perishable nature. ICAR-DMR has selected a new variety of this mushroom *Volvariella bombycina*, which can grow at a lower temperature and the keeping qualities are very good. Cultivation technology of this new variety is standardized for commercial production.

Shiitake is world second most cultivated mushrooms and has high nutritive and medicinal attributes. Traditionally shiitake mushroom has been grown on natural logs of various trees species with yields up to 33%, which takes 8-18 months in fructification. Further, shiitake cultivation technology on synthetic log system was used where the substrate was sawdust. This method takes around 80-90 days time with biological efficiency is 75 to 100%. Recently a new strain DMRO-Shiitake-338S has been developed, which along with some modified package of practice, can fruit within a period of 42-45 days with an average biological efficiency of 125-130 per cent in a total cropping period of four months.

Flammulina velutipes, commonly referred as winter mushroom, is popular in East Asian countries and is known for its nutritional and medicinal value. It can be cultivated on saw dust of broad leaves supplemented with 10% wheat bran. This is a temperate mushroom fruiting in the temperature range of 10-14 °C. The complete technology for its cultivation has been standardized at the Directorate.

This mushroom (*Auricularia* spp.) is fourth most popular mushroom in the world. Unfortunately not a single farm has been noticed growing this mushroom in India even though cultivation technology for this mushroom was standardized at this Directorate. At present, this mushroom is collected and consumed in many North East states of our country and thus demand is already there. There is tremendous scope for its cultivation in temperature range of 20-32osC.

India has tremendous potential for mushroom production and all commercial edible and medicinal mushrooms can be grown. There is increasing demand for quality products at competitive rate both in domestic and export market. Though growth of mushroom will depend on increasing and widening domestic market in coming years, export market will be equally attractive. To be successful in both domestic and export market it is essential to produce quality fresh mushrooms and processed products devoid of pesticide residues and at competitive rate. It is also important to commercially utilize the compost left after cultivation for making manure, vermin compost, briquettes, etc. for additional income and total recycling of agro wastes.

Theme Lecture-II

T-2. Changing global scenario in mushroom industry

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Mushrooms have been collected and consumed since times immemorial. Cultivation of mushrooms like *Auricularia, Flammulina, Lentinula* were attempted hundred years ago in China. Button mushroom cultivation started in caves in France in 1650. Scientific cultivation, however, started only at the beginning of the 20th century when pure cultures of mushroom were prepared from spore and tissue. Cultivation in the beginning of the 20th century was focused on button mushroom and was slow. The production was mainly in USA and Europe. The white button mushroom, so popular today, was selected from brown buttons in 1926 in USA. In first half of the 20th century the focus was on cultivation of button mushroom in West and to a lesser extent on Shiitake in East. In second half of 20th century there were rapid changes in rate of growth of mushroom production and number of species under commercial cultivation. By end of 20th century the share of button mushroom in total world production was less than 40 per cent which in next ten years became around 30 per cent. By 2010 button mushroom still had maximum share in global mushroom production. 21st Century, particularly last ten years, have witnessed sudden rapid rise in cultivation of mushrooms other than button. Net result is an exponential growth in world mushroom production. Due to almost unimaginable growth in production of shiitake, oyster mushrooms, wood ear mushroom and *Flamullina*, the contribution of these mushrooms to total world mushroom production has increased tremendously as compared to button mushroom which is no more the number one mushroom in terms of share in global mushroom production. Major contributor in mushroom production is China where button is considered an exotic mushroom. There is always mismatch between data by USDA and Chinese Academy. According to FAOstat Code 0449 mushroom means *Agaricus*, *Morchella*, Tuber and *Boletus*.

The contribution of medicinal mushrooms in world trade has increased over last few decades. The research focusing on validation of medicinal benefits and number of trials on use of novel chemicals derived from mushrooms in cancer research has attracted attention of industry. Increase in awareness about health benefits has promoted use of mushrooms as neutriceuticals. Some mushrooms like *Cordyceps, Phellorina* and various others are still collected from the forest. There are efforts to cultivated mycorhhizal and other unique mushrooms as there are indications that increased collections along with rapid change in forest cover, urbanisation, increasing demand of mushrooms etc are likely to affect the biodiversity and natural availability of such mushrooms.

Session-I: Germplasm

Keynote Presentation

I-K-1. Future prospects of mushroom biodiversity in India

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Tth the recent spurt in nutraceutical significance of mushrooms and their usefulness in health care, the socio economic status of mushrooms has scaled significant heights the world over. With the thrust in nutritional and nutraceutical potential, it has become imperative not only to strengthen and evaluate the existing germplasm but also to explore hitherto unexplored areas and places not yet reached. The compilation of mushrooms biodiversity by DMR, Solan consolidates the available biodiversity into a handy book and also necessitate the need for more explorations looking at the vastness of the number of species recorded so far which appear to be not fully representative of the phanerogamic diversity, total forested area and topography of India. State wise analysis reveals that certain area in the N. W. Himalayas, Western Ghats and some states like Jammu and Kashmir, Punjab, Himachal Pradesh, Kerala, Maharashtra, Rajasthan and some states in N.E. Himalayas ranges seem to have been fairly explored but still the explorations do not seem to be commensurate with the vegetation diversity, ecological variables and many area have been still beyond approach. The coordinating centers of DMR are fairly well placed to rise to the occasion and conduct explorations in their respective areas of operation with the help of experts so that authentic specimens become repository of the germ plasm of mushrooms in the country. It has to be a concerted effort coordinated by the Directorate of Mushrooms Research with the full support of the Ministry on priority basis.

Lead Lecture

I-L-1. Mushroom diversity of Eastern Ghats (Kolli Hills) from southern India

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Tropics are considered as rich repositories of mushroom diversity and most of the new mushrooms reported in recent years are from tropics, especially those species forming ectomycorrhizas with native trees. India is one such tropical country with diverse ecological characteristics for species richness. In India, a total number of 1,160 species are only described in 2 orders viz., Agaricales and Boletales till 2005. Studies on mushrooms have been exponentially increasing in the last two decades especially for search of active components. Attempts have been made in many parts of the world to explore the use of mushrooms and their metabolites for the treatment of a variety of human ailments. The biodiversity of mushroom of Eastern Ghats was taken up in order to fill up the few lacunas in the South Indian mushroom diversity. During study many mushrooms like *Gymopilus dilepis*, *Gymnopilus palmata*, *Lentinus tuberregium*, *Calocybe Indica*, *Pleurotus ostreatus*, *L. squarrosulus*, *L. cladopus*, *Mycena pura*, *Macrolepiota rhacodes*, *Termitomyces microcarpa*, *Termitomyces eurrhizus*, *Auricularia polytricha, Agaricus bisporus* and many others were recorded including ethno botanical details. Of these some were well documented for their medicinal properties.

Oral Presentations

I-O-1. Diversity and ethnomycology of genus *Volvariella* Speg. in north west India

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The present paper presents in detail the diversity of genus *Volvariella* falling under family *Pluteaceae* of order *Agaricales* from North West India. *Volvariella* is represented by 50 species all over the world, in which India represents 28 taxa while 91 taxa are registered till date in Mycobank. *Volvariella* is characterized by possessing exannulate stipe with a sac like lobed volva at the base, free pink to brown lamellae and smooth, double walled inamyloid basidiospores with open pore type hilum and bilateral convergent hymenophoral trama. North West India being rich in biodiversity has various vegetational zones and represents altitudinal variations. Of the 45 collections made, the ethnomycological data and identification to species and variety level were carried out. Economically, the genus *Volvariella* is quite significant for its food value and it is interesting to note that none of its species are reported to be poisonous. Some of the species like *V. volvacea* (Bull.) Singer, *V. bombycina* (Schaeff.) Singer, *V. diplasia* (Berk. & Br.) Singer, are commercially exploited. The most common amongst these is *V. volvacea*, also known as 'paddy straw mushroom' reported to contain specific proteins which has been reported to inhibit the growth of tumour cells, *V. bombycina* is another important edible mushroom which is appreciated for its chemical and nutritional characteristics as it possesses antioxidant, antitumour and hypercholesterolemic effects. In present study two species viz. *Volvariella albida* and *V. bumelia* and four varieties viz. *V. bombycina* var. *parva*, *V. bombycina* var. *terricola*, *V. terastia* var. *magnacystidiata, V. volvacea* var. *lignicola* are new additions to genus *Volvariella* while seven taxa viz. *Volvariella bakeri*, *V. jamaicensis*, *V. peckii*, *V. lepiotospora*, *V. volvacea* var. *masseei*, *V. nullicystidiata*, *V. volvacea* var. *nigricans* are first time reported from India. Of the identified taxa based on the ethnomycological deleberations and literature committed, six species viz. *V. bombycina, V. diplasia*, *V. bakeri, V. terastia, V. taylorii* and *V. cubensis* are edible in which three species viz. *V. bombycina, V. terestia* and *V. diplasia* are the commonly harvested agarics from the wild for human consumption. These wild edible species have possibilities of introduction into cultivated commercial strains through breeding experiments.

I-O-2. Wild edible mushrooms from Nagaland state of India

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Edible mushrooms are traditionally collected from the forests but now days cultivated varieties have become popular. Wild edible mushrooms (WEM) are known for their medicinal and nutritional value across the globe. WEM are among the non-wood forest products which have been looked upon as a source of income especially for rural areas and as health food. North-eastern region of India is one of the

biodiversity hotspots. Nagaland is one of the North-eastern states of India which is agro-climatically very rich and supports the growth of many wild mushrooms. WEM are consumed by the tribes of Nagaland as part of their ethnic cuisine and have been a delicacy since time immemorial. WEM have become one of the most prized after food because of its many health benefits. The present study throws light on the rich diversity of WEM of Nagaland and its potential as a valuable food resource. A total of 36 WEM were collected and identified on the basis of present study. Antioxidant properties and nutritional qualities in some highly popular edible varieties of the state have been evaluated during the present study. The proximate analysis show that all the mushrooms vary in their nutritional compositions. The methanolic extracts of the WEM shows significant antioxidant activity and hence, are source of rich antioxidants. WEM are healthy food supplements and can play a key role in the socio-economic upliftment of the people exploration.

I-O-3. First report of *Pleurotus cystidiosus* O.K. Mill from Kerala, its spawn production and bed studies

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Present work is the first report of *Pleurotus cystidiosus* O.K.Mill (abalonus/brown oyster mushroom), from Kerala, and the particular variety was isolated from *Saracaasoca* (Roxb.) tree. Its identity was confirmed as *P. cystidiosus sub* sp. *abalones* by ITS sequencing and registered in Genbank database (accession no: KY214254). It is unique among the oyster mushrooms, owing to its bigger size, thick, fleshy, buff coloured, less spore forming sporocarps with the longest shelf life and life cycle among the oyster species. The culture is also characteristic, due to the occurrence of black coremial structures, indicating its anamorph stage (*Antromycopsis broussonetiae*). The coremia comprised of elliptical (16.31x7.48µm) and round conidia (8.06x8.49µm), as recorded from the microscopic studies. Physiological studies recorded dark condition, 30 °C temperature and pH 8 as favourable for the growth of mycelia. Spawn studies were conducted, using three different substrates viz., paddy grain, sorghum and rubber sawdust. Among the substrates, sorghum was identified as the best substrate in terms of number of days taken for complete spawn run (19 days) and the thick white nature of mycelium. Addition of different amendments has positive effect on spawn production. In this context, a trial was conducted, by adding three different amendments viz., thiamine (25, 50 and 75 ppm), yeast (0.5, 0.75 and 1%) and iron (0.25, 0.5 and 0.75 %) with sorghum as the basal substrate. Among the different treatments tried, yeast 1% was found to be the best in terms of time taken for complete spawn run (15.10 days), thick white fluffy mycelium, least contamination and was recorded as the best amendment, followed by yeast 0.75 % (17.3 days) and 0.5 % (19 days). Addition of yeast resulted in the maximum occurrence of coremia. Treatments viz., iron 0.5% (29.00 days) and 0.75 % (30.3 days) took the maximum number of days for spawn run and recorded a thin, sparse mycelium growth. Cultivation trials were undertaken using paddy straw as bed substrate, which produced buff coloured, large fruiting bodies in 36-42 days, with a biological efficiency of 74 %.

I-O-4. Indian mushroom diversity collection at ICAR-DMR culture bank, Solan

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ICAR- Directorate of Mushroom Research (ICAR-DMR) culture bank is the largest mushroom culture bank in India and includes edible, non-edible, poisonous, medicinal and mycorhizal mushrooms. The collection of mushroom specimens was started by ICAR-DMR during 1983 and continued the explorations to conserve the mushroom biodiversity. The aim of ICAR-DMR culture bank is to conserve and catalogue the mushroom diversity of India and utilise it for commercialization. The ICAR-DMR culture bank comprises of 3057 cultures of approximately 166 different identified genera of mushrooms (up to 31 Dec 2016). The ICAR-DMR culture bank catalogues the mushroom cultures through six different coding pattern viz. DMR- *Agaricus* sp as DMRA, DMR- *Agaricus bitoquis* as DMRAB, DMR- *Pleurotus* sp. as DMRP, DMR-Other edible culture as DMRO, DMR- Wild Cultures as DMRX and DMR- Moulds and Pathogen as DMRM. The culture bank also plays a significant role in domestication of strains. The strains domesticated by utilzing the cultures of culture banks are DMRX-1049 (*Auricularia polytricha*), DMRO- 106 (*Auricularia rosea)* etc. On the basis of the previous identification by the mushroom researchers and taxonomists, the culture bank consists of around 401 *Pleurotus* sp, 273 *Agaricus* sp., 158 *Lentinus* sp., 116 *Calocybe* sp., 108 *Volvariella* sp., 102 *Ganoderma* sp., 60 *Polypore* sp., and 57 *Morchella* sp., etc. The culture bank also consists of approx 602 unknown strains which are under identification process. The collection in culture bank represents around 94.3 percent of the indigenous collection and 5.6 percent of exotic collections. The percentage of the wild collection is highest, which is recorded at 53.6 percent, followed by other edible culture i.e. 28.8 percent. The majority of cultures deposited in the culture bank is mainly obtained through exploration work, done by ICAR-DMR, contribution from AICRPM centres, Research institutes, collaboration with different organizations and private mushroom farms. Presently, the correct identification of mushroom cultures through taxonomic characters and DNA barcodes is in progress and will deliver a firm base of mushroom culture utilisation for the future.

I-O-5. Mushrooms biodiversity of Jammu and Kashmir, India

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Mushrooms are good source of delicious food with high nutritional and medicinal attributes and are referred to as low calorie neutraceuticals. Numerous species of wild growing mushrooms are recognized and widely consumed as a delicacy across various regions of India. They are fleshy, subfleshy, or sometimes leathery, umbrella like sporophores that bear their fertile surface either on lamellae or lining the tubes, opening out by means of pores. They are attracted attention of naturalists before the microscope was invented and micro fungi discovered. The adaptation of mushrooms to the environment is nutrition based. They live as saprophytes, parasites, symbionts and are served by the environment in return sharing and caring. People are attracted by mushrooms but the categories vary- some like, some dislike and

others are indifferent in attitudes and are called Mycophilic, Mycophobic and Mycoindifferent. More recently mushrooms have come to occupy a prime place as medicinally important food items because they contain low calories, fats and sugars and therefore good for fat people and sugar patients. The studies on them are also incomplete and extreme from complete. Many traditional recipes and modern recipes available but both intensive and extensive studies are needed on them. Overall analysis of mushroomology presents a very wide field of research and development. Some efforts undertaken in this regard on Jammu and Kashmir wild mushrooms have been discussed in the present communication.

I-O-6. Geographical mapping of mushroom wealth in Maharashtra

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Maharashtra is the third largest state (in area) in India. The Western Ghats region of Maharashtra is one of the globally recognized heritage site of biodiversity hotspot that has an unestimated wealth of biodiversity including mushrooms. The Maharashtra is blessed with nine diverse agroclimatic zones that harbour a treasure of fungal diversity. Though the occurrence of mushrooms is of diverse nature in Maharashtra as documented by different research workers in past, but the documentations are not concisely presented. The work of taxonomic survey of mushrooms in Maharashtra, seems to have been started as late as 1975 and since then about 274 species of wild mushrooms, mostly belonging to the order Agaricales were recorded. The scientists of AICRP on Mushroom, Pune Centre, College of Agriculture, Pune studied the diversity of edible, non edible and medicinal mushrooms from all the forest areas of Maharashtra. The present study, envisages to consolidate the previous records of this important group of fungi, the mushrooms, from various regions of Maharashtra made by various earlier workers and also to add a note on the observations made by the workers at this centre. In all more than 274 species classified under 140 genera belonging to 23 families and five orders (*Agaricales*, *Boletales*, *Cantharellales*, *Polyporales* and *Russulales*) have been reported from Maharashtra. The species of *Panaeolus* and *Volvariella* are placed in *incerte sedis* and the later genus has been placed outside the pluteoid clade in a study. The most represented genera are *Agaricus* (18 spp.) followed by *Marasmius* (13 spp.), *Mycena* (8 spp.), *Lepiota* (7 spp.), *Pleurotus*, *Termitomyces* (6 spp. each), and *Amanita* and *Inocybe* (5 spp. each). Most of the genera are represented by one or two species.

The districts belonging to Konkan costal climatic zone *viz.,* Ratnagiri, Raighad and Thane with very high rainfall and laterite soils were rich in wild mushroom diversity. The maximum mushroom species were reported in Thane district (55) followed by Raigad (39) and Ratnagiri (24) which were grouped in one cluster with *Agaricus, Pleurotus, Termitomyces, Hygrocybe* and *Marasmius* which are commonly observed genera. Whereas, the districts Sindhudurg and Kolhapur were grouped in one cluster with commonly reported genera *viz; Agaricus, Pleurotus; Termitomyces* and *Hygrocybe* . The maximum number of genera were reported in the part of Western Ghats belonging to Pune district which has average 3000 to 6000 mm rainfall with *'Warkas'* i.e. light laterite and reddish brown soil. The *Pleurotus*, *Tricholoma*, *Cantharellus* and *Ganoderma* as common genera were found in the Sub Montane Zone and Western Maharashtra Plain Zone areas of the districts Satara, Sangli, Ahmednagar, Nashik and Dhule having annual rainfall of

700-2500 mm and reddish brown to black tending to lateritic soil. Very rare mushroom flora were reported from scarcity zone and Central Maharashtra Plateau Zone having major districts of Marathwada region with annual rainfall less than 750 mm and rare forests. The high rainfall Eastern Vidharbha region also reported rich mushroom flora with commonly observed genera *viz., Agaricus, Pleurotus*, *Amanita Cantharellus, Leucoagaricus*, *Termitomyces* and *Boletus* which are grouped in two different clusters. The trend of distribution of mushroom flora revealed the occurrence of maximum number of genera in agro climatic zones with high rainfall areas, which becomes a common hotspot of yearly occurrence of *Termitomyces* which are consumed by local peoples seasonally. The Sub Montane Zone and some parts of Ghat zone, particularly Kolhapur, Pune, Nahsik and Lgarpuri were the hotspot for *Pleurotus*. The intensive survey of mushrooms indicated that the environment of Maharashtra is congenial for natural growth of diversified genera of mushrooms especially *Pleurotus*, *Termitomyces, Cantharellus* and *Boletus.* However, more efforts are needed to explore the hidden mushroom flora of Maharashtra. An attempt in this direction will not only enable to explore edible species but also help to screen and select potential species for commercial cultivation. Considering the above facts, attempts were made for mapping of wild mushroom flora of Maharashtra as a guide for mushroom researchers.

I-O-7. Diversity of ectomycorrhizal genus *Russula* Pers. from sal forest of north west India

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The genus *Russula* Pers. is among the most common and dominant ectomycorrhizal mushroom genera. They form symbiotic associations with a variety of plants and play vital role in forest ecosystem. Species in this genus are widely distributed throughout the world, from the tropics to temperate regions. Intensive studies on this genus have been carried out in temperate forests of north west India. However, there are very few studies from tropical forests of India, which is largely dominated by economically important ectomycorrhizal tree species *Shorea robusta* Gaertn. (Sal). In the view of above fungal forays have been undertaken during year 2013-2016 to different localities of tropical sal forest of north west India and *Russula* was found to be the dominant ectomycorrhizal genus. Sporocarps and their ectomycorrhizae were collected by tracing the hyphal connections between sal tree and sporocarps. The macroscopic and microscopic details of each investigated taxon were worked out as per standard methodology. In this paper the morphoanatomical details of sporocarps and mycorrhizal roots associated with some *Russula* sp., are investigated. Ectomycorrhizae are mainly distinguished by differences in the size and colour of mycorrhizal system, surface texture, extraradical mycelium, mantle, size of hyphal cells, shape of cystidia and cell shape of Hartig net.

I-O-8. Macrofungal assemblages in moist deciduous forests of Western Ghats, India

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Moist deciduous forests of Western Ghats supports rich and diverse macro-fruit bodies with a total of 102 macro fungal species (69 genera; 37 families) found fruiting on soil, fallen plant material and on wood. In total, 11 morpho-groups were identified. The macro fungal assembelages were examined based on sporoma inventories over 5 years. The sporoma encountered were collected and analyzed for their identity. In this survey, macro fungi were identified by the presence-absence for sporoma colour. The field expeditions were carried out from January 2011 to December 2015 in a 50 x 20 m transect. Sampling of 10 plots revealed 15,994 sporomas of macro fungi. Of these, more than 20% of the sporoma (3,906 individuals) were found during 2010 and considered as highest during the study period. The time line for the fruiting was narrower than that for species on wood and soil, with maximum fruiting recorded during June to August. The family Agaricaceae, Psathyrellaceae and Polyporaceae dominated the macromycete communities during 2011 having the greatest number of species. The species belonged predominantly to the genera *Agaricus, Ganoderma* and *Xylaria*. The remainder appeared to emerge inconsistently over the survey. *Ganoderma lucidum* and *Ascobolus stercorarius* were most frequently recorded species. Macro fungal incidence was found to be significantly higher during 2011 compared to other. The study provides benchmark knowledge on relationship between macrofungal community richness and amount of rainfall in moist deciduous forests and briefly connected in the possibility of macrofungal families, genera and species. This will serve as a base information in native forests for further studies and in similar forests elsewhere in order to enrich the information on diversity of macro-mycobiota in India. This may also help identify possible novel species being extrapolated in the future for the betterment of mankind.

Poster Presentations

I-P-1. New species of genus *Agaricus* L.: Fr. - to India from Kerala

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The mushroom production in India is going up especially the white button mushroom. However, the white button mushroom *Agaricus bisporus* cannot be grown in Kerala due to its low temperature requirement. But there is immense scope for the exploitation of the natural flora. In this context a study was conducted in the twenty agroclimatic zones of Kerala in order to exploit the natural flora of *Agaricus* sp. suitable for cultivation. Forty two *Agaricus* species were collected, identified and recorded from different localities of the zones. *A. bingensis* was the most commonly occurring species and collected from eight zones *viz*., semidry red loam, semi dry laterite, semidry alluvium, sub-humid laterite, humid laterite, humid grayish Onattukara, humid forest loam and wet laterite. Its identity was confirmed by ITS sequencing and registered at Genbank database (accession number: KY704348). This species is widely distributed/ reported from Africa and used for food, particularly by the Acholi tribe from Uganda. Relative humidity and atmospheric temperature of the locality on the day of collections were observed. The average maximum temperature recorded on the day of collection of the species was 30.1°C and the average minimum temperature was 23.5°C. The relative humidity recorded on the day of collection was up to 96 per cent. Mycelial growth of the local isolate of *A. bingensis* was studied in liquid media *viz*., malt extract media, oats media, Czapek's Dox media and complete media. The growth was maximum on complete media and malt extract media. Effect of temperature on the mycelial growth was observed by growing them in complete media at temperature *viz*., 10, 15, 20, 25, 30 and 35°C and was found that it grow best at 25 and 30°C. Maximum mycelial growth was obtained in pH 6. The growth was more when glucose and sucrose were used as carbon source.

I-P-2. Study of wild mushroom from the district of Amritsar and Gurdaspur (Punjab- India) and some biological aspects

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Fungal forays were conducted to explore the mushrooms from the districts Amritsar and Gurdaspur of Punjab during rainy season. Six mushrooms (three from each district) were collected. On the basis of their characters, they were identified as *Schizophyllum commune* (DMRO-580), *Ganoderma lucidum (a)* (DMRO-581), *Collybia* sp. (DMRO-585) from Amritsar and *Lentinus sajor-caju* (DMRO-582), *Ganoderma lucidum* (b) (DMRO-583) and *Psathyrella candolleana* (DMRO-584) from Gurdaspur. The tissue cultures prepared on potato dextrose agar were deposited at Directorate of Mushroom Research, Chambaghat, Solan (HP), India and accessioned as DMRO-580, DMRO-581, DMRO-582, DMRO-583, DMRO-584 and

DMRO-585, respectively. It was identified that *Lentinus sajor-caju* is an edible species but *Psathyrella candolleana and Collybia* sp. could be edible. *Schizophyllum commune* and both *Ganoderma lucidum* have medicinal importance. *Ganoderma lucidum* DMR 583 showed maximum linear growth rate as 15 mm/d on both PDA and CYM media. In biomass study, *Collybia* sp. showed maximum biomass on both 5th and 10th day as 1.6 g/L and 3.1 g/L, respectively. The exoglucanase, endoglucanase and xylanase activities were found maximum for DMRO-583 which was 0.765 U/mg proteins, 0.853 U/mg protein, 0.366 U/mg protein, respectively. Laccase activity was maximum for the culture DMRO-582 as 7.5 U/mg proteins. During spawn production, growth rate on 8th day and 16th day was maximum for the culture DMRO-580 as 11.2 mm/d and DMRO-584 as 11.0 mm/d, respectively, while on 24th day the growth rate was maximum for the cultures DMRO-580. Substrate selection showed wheat straw as the best substrate for DMRO-580 and paddy straw for DMRO-583 and compost was better substrate for DMRO-580 and DMRO-583.

I-P-3. Survey and studies on morphological characters of black ear mushroom (*Auricularia* spp.) from prominent places of Kerala

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Survey was conducted in ten different locations of Thiruvananthapuram and Kollam districts of Kerala for collecting *Auricularia spp*. The collected mushrooms were gregarious and lignicolous in habit. Mushrooms collected from all the locations were gregarious in habit and lignicolous in habitat. Wood logs of Mango, fallen Coconut wood logs, Bottle brush tree stumps, copper pod tree stumps, Swarna gopuram (*Tecoma stans*), *Casuarina equisetifolia, Acasia spp.* Cashew, *Macaranga indica* and Drumstick were found to be the host substrate for mushrooms collected from Vellayani. Coconut and Drumstick were the hosts for Venganoor collections. Rubber and Coconut saw mills were found to be hot spot for collections from Vanchiyoor, Nedumangad, Palode, Arippa and Kulathupuzha. From Neyyatinkara and Vanchiyoor mushrooms obtained from Coconut, Tamarind and *Casuarina*. Kattakada collections were obtained from Teak wood and Rubber. Coconut and Drumstick were common hosts for Ponmudi collections. Pileus characters of *Auricularia spp.* ranged from brown to dark brown colour, diameter of 2.6 – 3.8 cm, with varied texture. The stipe was absent in all collections and if present, it was very small, 0.4 to 1.0 cm in length and 0.4 to 0.9 cm diameter. Volva and annulus were also absent in all the collected mushrooms.

I-P-4. Survey of mushroom flora of Western Ghats of Kerala (India)

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Western Ghats, a reservoir of abundant mushroom flora, was selected for collection, identification and isolation new strains. Survey was done during south-west and north-east monsoon seasons of 2006-2014. The survey resulted in the collection of 326 species of mushrooms among which 92

mushrooms were identified based on the macroscopic and microscopic characters. The collections were wet preserved and maintained. The collection includes edible mushrooms *viz*., *Agaricus* sp*., Volvariella volvaceae, Tremella fuciformis, Macrolepiota procera, Calocybe indica, C. gambosa, Termitomyces robustus, T. microcarpus, Auricularia polytricha, Cantherellus* sp*., Calvatia* sp*., Coprinus comatus, Pleurotus cystidiosus, P. eous, P. opuntiae, P. squarrosulus, P. tuber-regium, P. djamor, Tricholoma* sp*.* and *Boletus* sp*.,* poisonous mushrooms *viz., Agaricus xanthodermus, Amanita solitaria, Lepiota cristata, Clitocybe* sp*., Entoloma sinuatum, Chlorophyllum* sp*., Daldinia concentrica* and *Russula emetica*. Hallucinogenic mushrooms *viz., Panaeolus companulatus, Psilocybe squamosa* and inedible mushrooms *viz., Trametes versicolor, Lenzites* sp., *Pycnoporus cinnabarius, Hydnum* sp*., Polyporus* sp. and medicinal mushrooms *viz., Ganoderma lucidum, G. applanatum* and *Schizophyllum commune* were also collected. *Daldinia concentrica, G. applanatum, Phellinus punctatus* and *Trametes* sp. were seen throughout the year. The collected mushrooms were categorised and classified to family level. Among these, twelve mushrooms were isolated and brought in to pure culture *viz*., *A. polytricha, Calvatia* sp*., C. indica, C. gambosa, Coprinus comatus, G. lucidum, P. cystidiosus, P.djamor, P. eous, P. opuntiae, P. squarrosulus, P. tuber-regium, P. djamor* and *Volvariella volvacea.* Tissue culture, mother spawn, spawn production and cultivation were successfully done in *P. eous, P. tuber-regium, P. opuntia, P.djamor, Calocybe indica, C. gambosa, Ganoderma lucidum, V.volvacea* and *Auricularia polytricha.* The collections included rare mushrooms *Sphaerobolus* sp*., Geastrum* sp*., Russula* sp. and *Amanita* sp.

I-P-5. Ethnomycological studies of some wild mushrooms from Kashmir Himalayas

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Mushrooms are a heterogeneous group of macrofungi, known for their nutritional and medicinal importance from ancient times throughout the world. The use of mushrooms as valuable tonic, food and ethnomedicines has also been reported from different parts of the world. Scanty information is however available on the use of mushrooms as ethnomedicines in Kashmir Valley. An ethnomycological survey was carried out in different remote areas of Kupwara district of Kashmir Valley to document the indigenous use of various mushrooms growing in the area by the local tribal people and local herbalists. Mushroom hunters, local hakims, herbalists and aged people from tribal communities and nomads were consulted, interviewed and taken as guides to collect various mushroom species of the surveyed area. It was found that mushrooms were used commercially, as a source of food and medicines for different ailments. Many species were collected from the area, out of which about 33 species belonging to Ascomycetes and Basidiomycetes, were used for their nutritional and medicinal values. The study revealed that mushrooms were used by the local hakims against various ailments ranging from respiratory, blood and heart ailments, arthritis, nervous and urinogenital diseases either singly or in association with some herbal medicines.

I-P-6. Edible mushroom diversity from Odisha State of India

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Mushrooms are consumed worldwide because of their nutritional, medicinal value as well as pleasant taste and flavor. These are source of livelihood for poor and landless people as they can be cultivated and collected from wild. However, many people are not aware about the edibility of wild mushrooms which are generally confined to the tribal areas. The present study was undertaken for collection, identification and preservation of wild edible mushrooms of the state of Odisha, India. Odisha has a greater diversity in respect to soil and flora. During the study eighteen edible mushroom species belonging to ten genera *Amanita, Auricularia, Boletus, Calocybe, Lentinus, Pleurotus, Russula, Tuber, Termitomyces* and *Volvariella* were obtained from thirty districts. Among the collected, species of *Termitomyces* and *Volvariella* were found most predominant in the coastal and central part of the state and are widely consumed by the people. Similarly, species of *Russula, Termitomyces* and *Tuber* were more frequently found in some of the western districts associated with Sal and Palasa.

I-P-7. Diversity of *Lentinus* species from Western Ghats of Karnataka (India)

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Western Ghats of Karnataka (India) are among the hot spots of biodiversity in India. The humid climate of the region due to ever green forests is ideal habitat for growth of variety of mushroom flora during rainy season, which includes edible, poisonous and medicinal species. In present study, six mushroom species were collected during rainy season (July-September) of the years 2014 and 2015 at different places of the Western Ghats. While collecting the mushrooms, necessary field information were recorded. These mushrooms were identified based on the Internal Transcribed Spacer (ITS) region sequence. The genomic DNA was extracted and amplified by PCR using ITS-1 and ITS-4 primers. The amplified product was got sequenced from Sci Genome Pvt. Ltd., Kerala (India). The sequences thus obtained were BLAST searched at National Centre for Biotechnological Information (NCBI) Gen Bank. The sequences showed varied homology (97% to 100%) for individual species. Based on the sequence homology the mushrooms were identified as *Lentinus sajor-caju* (98%), *L. polychrous* (100%) , *L. strigosus (*97%), *L. tigrinus* (99%), *L. tuber-regium* (100%) and *L. velutinus* (99%). Further, these sequences were submitted to NCBI database and obtained accession numbers. Pure culture from the *L. sajor-caju* tissue was isolated and successfully cultivated on saw dust. The study revealed the occurrence of different *Lentinus* species in the Western Ghats of Karnataka which can be explored for commercial cultivation.

I-P-8. Some new records of *Agaricus* from north Kashmir of India

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The paper presents the study of systematic survey for the exploration of *Agaricus* from North Kashmir. The area exhibits varied climatic and topographic conditions and provides an environment for the lavish growth of *Agaricus*. Information on the wild agarics from the state of Kashmir being limited, systematic study of wild *Agaricus* from north Kashmir was undertaken and numbers of collections were made. Presently the taxonomy of four species of genus G*ymnopilus* P. Karst., belonging to family *Strophariaceae* Singer & Smith and one species of genus *Melanoleuca* Pat. of family *Tricholomataceae* Roze. are discussed. Four species of genus *Gymnopilus* (*G. decipiens* (Sacc.) P.D. Orton, *G.crocias* (Berk. & Broome) Singer, *G. junonius* (Fr.) P.D. Orton and *G. fuscosquamulosus* Hesler), and one species of genus *Melanoleuca* (*M. subalpina* (Britzelm.) Bresinsky & Stang) are taxonomically described. All of these are reported for the first time from India.

I-P-9. New and noteworthy taxa of genus *Tricholoma* (Fr.) Staude from India

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Present paper deals with five species of genus *Tricholoma* of family Tricholomataceae under order Agaricales. *Tricholoma* is represented by a large number of fairly fleshy white-spored gilled fungi in mycorrhizal associations with different conifers. This genus is characterized by robust carpophores with campanulate or hemispherical to obtusely flattened cap with a thin involute margin while young. Although, it lacks a universal veil but a partial veil might be present, if so it is fibrillose or floccose which disappears towards maturity. The stipe is furfuraceous, scaly, or has longitudinal striations. A number of collections of *Tricholoma* were made along with their ECM roots while fungal forays from Kashmir Himalayas. These collections were analyzed taxonomically as per standard methodology. As an outcome of this study *T. vaccinum* var. *macrospora* is proposed as var. nov. while *T. atrosquamosum*, *T. myomyces*, *T. pardinum* and *T. sciodes* are new records to the Indian diversity of agarics. The mycorrhizal association studies of *T. vaccinum* var. *macrospora*, *T. atrosquamosum* and *T. pardinum* were done, which were found in association with *Pinus wallichiana.*

I-P-10. Wild edible and medicinal mushroom species of West Bengal

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Edible mushrooms are the fleshy and edible fruit bodies of several species of macrofungi. They can appear either below ground (hypogeous) or above ground (epigeous) where they may be picked by hand. Mushrooms are the most vital and indispensable functional food in the present scenario. Wild edible mushrooms are known for their medicinal and nutritional value across the globe and extension workers are exploiting its potential as an income generator for the tribal people in West Bengal. Scientists across the globe are harnessing the mushrooms for their wide palatability and medicinal properties among masses. In the eastern region of India, some common wild edible species are *Auricularia polytricha*, *Aleuria aurantia*, *Auricularia judae, Cantharellus cibarius*, *Coprinus comatus*, *Dacryopinax spathularia, Laetiporus sulphurous*, *Lactarius volemus, Laccaria tortilis, Lactarius piperatus, Lentinula edodes, Lycoperdon perlatum, Macrolepiota albuminosa, Pleurotus citrinopileatus, Pleurotus pulmonarius, Schizophyllum commune, Termitomyces eurrhizus, Termitomyces heimi, Tremella fuciformis, Tricholoma imbricatum,* etc. Some mushrooms found in these areas have medicinal properties too. There are a few primary mechanisms that these mushrooms undergo making them anti-cancerous. Firstly, they enhance the body's immune system which is first line of defense against cancer. When this system is weak or has failed, the mechanism for cancer has a better opportunity to manifest. Some anti-cancer mushrooms exhibit direct antiviral and tumour shrinking abilities. Additionally, these medicinal mushroom have very mild side effects. Extracts of medicinal mushroom are used worldwide to fight cancer and enhance and modulate immune response. *Lentinula edodes* (shiitake), *Grifola frondosa* (maitake), *Ganoderma lucidum* (mannentake), and *Cordyceps* have medicinal use in parts of Asia as well as in West Bengal.

I-P-11. Morphological and cultural variability of wild *Pleurotus* spp. reported from Western Ghats and Sub Montane Zone of Maharashtra (India)

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The Western Ghat and Sub Montane Zone of Maharashtra comprise of dense forest is harbouring very rich natural mushroom flora. The total of 26 morphologically different samples of oyster mushroom were collected during monsoon months of 2014 from Western Ghat and Sub Montane Zone of Maharashtra. The wide variability in morphological characters of wild species was observed. Most of the samples were found in dense forest area and at high latitudes and among the samples the variability in habitat were observed. The samples were seen on the different substrates like tree trunk, wooden stumps, leaf litter and compost. The morphological characters of wild edible oyster mushroom *viz.,* cap colour, cap shape, cap diameter, stipe attachment, stipe length and gill attachment were recorded. In all 15 pure cultures of *Pleurotus* sp were obtained from 26 samples of oyster mushroom collected during survey work. The significant variability in mycelial growth rate of 15 wild oyster mushroom isolates in comparison with *P.*

sajor-caju on malt extract agar medium and potato dextrose agar medium at 26°C was observed. The pH between 6.5 to 7.9 was found to be most congenial for most of the wild isolates of oyster mushroom. The maximum dry matter was recorded at neutral pH of 7.5 in a wild isolate.

I-P-12. Precious wild edible and medicinal fleshy mushrooms from Rajasthan

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During rainy season of 2016 fungal forays were conducted and interesting mushrooms were collected. Many of them are popular among villagers and tribals. These mushrooms are on the top rank in terms of liking and people eat them even in dried form. These are *Podaxis pistillaris* and *Phellorinia inquinans*. The marketing is being done by popular vendors and even export potential has been found because of their demand in Middle East countries. Some other important medicinal mushrooms that were collected and can be domesticated and can be marketed at large scale include *Ganoderma lucidum, Auricularia auriculae judae, Schizophyllum commune, Coriolus versicolor* and *Colotricia perrenis*.

I-P-13. Diversity of species of the genus *Psathyrella* (Psathyrellaceae, Agaricales) from Punjab, India

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A detailed investigation of species of *Psathyrella* was carried out in Punjab State of India, during the years 2008-2012. In this paper, 17 collections belonging to 14 species of genus *Psathyrella* has been worked out for their external and internal details and key to identification for these species has been given. These species include *P. patialensis* sp. nov., *P. aurantiacoumbonata* sp. nov., *P. plicatilis* sp. nov., *P. incerta, P. moshiana, P. singeri, P. dichroma, P. barrowsii, P. murrillii, P. candolleana* var. *solitaria*, *P. araguana, P. candolleana, P. longistriata* and *P. floccosa.* Out of these, three species proposed as new species *viz*. *P. patialensis* sp. nov., *P. aurantiacoumbonata* sp. nov.*,* and *P. plicatilis* sp. nov. For all these species, detailed descriptions of all the macroscopic and microscopic characters and line drawings with the help of camera lucida are given.

I-P-14. Patterns of macromycetes diversity, composition and distributional patterns in Western Ghats: A case study of Shimoga district

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The forest sampling locations situated in the Shimoga district, belongs to the Western Ghats of Karnataka and is a model example that allows for the examination of the relationship between macrofungi and diversity as present in conservation. In this area, there are 11 morpho-groups representing both ascomycetes and basidiomycetes. The geodiversity of the area is well-documented, while data on its mushroom diversity and its status are rudimentary. Attaining a supplement was the one of the main aim of this study. In Western Ghats part of Shimoga district, besides the famous waterfalls, three types of forests (evergreen, semi-evergreen and moist deciduous) were found, which contained 156 species of macrofungi representing 91 genera and 43 families. Mushroom surveys were conducted fortnightly in 10 experimental plots from January 2012 to December 2016 in a 50 x 20 m transect in each surveyed area/year. Sampling of 10 plots revealed a total of 19,564 sporocarps. Species richness was higher in terrestrial habitats. Of these, more than 20% of the sporocarps (4,674 individuals) were found during 2012 and considered as highest during the study period. Linear regression analysis showed that the mushroom species richness and sampling plots were statistically significant (R^2 = 47.3%; P = 0.001). The study provides benchmark knowledge on relationship between mushroom diversity, species richness and rainfall in central Western Ghats and briefly connected in the possibility of mushroom families, genera and species. It will serve as a good basis in native forest types for further studies in order to enrich the information on diversity of mushrooms in India corresponding to unexplored and threatened taxa.

I-P-15. Lignicolous Xylariaceae members in Hosanagar taluk of Karnataka, India

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Xylariaceae is an old family of order Xylariales, it is large and relatively well-known family which is representative of ascomycetes distributed all over the world. Most of the Xylariaceae members are saprobic or weekly pathogens, some are endophytes in woody plants. Xylariaceae members are known to degrade lignin and cellulose in wood logs, in fallen branches, seed coat and litter. Regular field survey have been conducted to explore Xylariaceae members in Hosanagar taluk of Karnataka. This taluk is characterized by dry deciduous and evergreen forest regions which favours luxuriant growth of Xylariaceae members, the specimens were collected and screened by standard methods and each specimen was examined on the basis of morphological and microscopical characters. The collected sporocarps were generally erect greatly varies in morphology measures from 0.5 cm to 15cm in length , brown to black in colour, the internal structures well developed with cylindrical asci, ascospores are usually dark brown in

colour The species, *Xylaria hypoxylon, X. polymarpha, X. carpophylla, X. minuta, X. Tentaculata, X. grammica* and *Daldinia concentrica* were documented. Further study is in progress.

I-P-16. Diversity of wild mushrooms in Sirsi taluk, Karnataka

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Sirsi taluk is located in Uttara Kannada district of Karnataka state which is having 11.2 km² area and the elevation is 610m. Average annual rainfall in Sirsi taluk is 2500mm which helps in the abundant growth of wild mushrooms. Mushrooms unveil pattern of diversity that are related largely to substratum and host availability. Temperature and rainfall interact with the habitat of the fungus either stimulate or retard fruiting. The macrofungal species were examined based on sporocarp inventories over study period. The field expeditions were carried out during January 2016 to December 2016 in 50 x 20 m transect. Sampling of 5 plots were made for identification of macrofungi. The macrofungi were collected and characterized with a systematic methodology, photographed, allotted accession number and preserved. Density, abundance, frequency and diversity indices like Shannon and Simpson were calculated annually using standard protocols. A total of 30 species of macrofungi belonging to 13 families were identified. The study revealed the ecological productivity and biodiversity has been altered by climatic factors, with many threatened taxa and an increased risk of extinction of some species.

Session-II: Biochemistry/Biomolecules

Keynote Presentation

II-K-1. Medicinal Mushrooms – issues for consideration and action

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World has witnessed, of late, a paradigm shift favouring the so-called "alternative systems" of machine, owing mainly to the increased realization of the deleterious effects of the man-made medicines, and the information freely available about the unscrupulous practices pharma-conglomerates resort to, for commercial considerations. Botanicals or herbals predominate many ancient "alternative systems" of medicine, though animal-products have also been used in many East-Asian countries. Mushrooms, the fungi, fall somewhere in between the true plants and animals –and have been mentioned, reported and researched- upon to possess unique and potent pharmacological properties; many such claims have also been validated. These are being produced and traded in significant quantities – the annual trade in the medicinal mushrooms and their products is roughly estimated around $5 bn. China is the undisputed leader in the field. Though more than twenty species of the medicinal mushrooms are currently being produced and commercially traded, but the value-wise most important ones are the species of: *Ganoderma Grifola, Cordyceps, Lentinula, Hericium, Schizophyllum,* of which *Ganoderma* is the unquestioned "king of medicinal mushrooms". Today's-talk is not to praise the unique, potent and important pharmacological properties of the medicinal mushrooms, which, indeed, would be repetition of my own earlier presentations here and else-where, but some very important issues related with the field:

- Most important issue is the "over-claim" about beneficial effects, obviously for commercial considerations; few mushrooms are presented as panacea.
- Claims should be subjected to rigorous scientific scrutiny for validation/repudiation of the claims of beneficial effects.
- Quality-control, from cultivation to marketing – standard production, storage and processing practices
- The products should be made available as "over-the-counter" medicine, as health-supplements which are now permitted in many countries including USA (since 1994); but most of the trade is still in form of "direct-selling" or "multi-level-marketing" (MLN) – patient becomes the practitioner.
- In *Ganoderma*, mention the species, or combination of species; besides, not 10% or 30 % polysaccharides, but specific content of the active β-1,3 – 1,6 polysaccharides, or Ganoderic acid A (PCA).

Oral Presentations

II-O-1. Biochemical comparison of commonly cultivated mushroom varieties of Kerala

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The present study was conducted with a view to assess the commonly cultivated mushroom varieties of Kerala based on nutrient composition. Results of studies using five varieties grown on chemically sterilized paddy straw revealed that pink mushroom (*Pleurotus eous*) was nutritionally high as it contained lowest carbohydrate (2.59 g), higher protein (2.72 g) and dietary fibre (2.9 g) per 100 g fresh mushrooms as compared to all other varieties. It also contained higher quantity of all the essential amino acids except valine than *P. florida*. But for minerals, *P. sajor-caju* was superior as it contained the highest quantity of sodium (100 ppm), potassium (3300 ppm), calcium (11.8 ppm), magnesium (191 ppm), iron (75.26 ppm) and zinc (29.27 ppm) in fresh mushroom. The antioxidant selenium (0.87 ppm) was present only in this variety. An experiment was conducted using three varieties in order to determine whether the nutrients varied with substrates. Mushrooms from rubber wood sawdust beds showed an increased value of carbohydrates, protein and fat. Fibre content was less in mushrooms from sawdust for *P. eous* and *Hypsizygus* sp. In the studies using different modes of sterilization for substrates, mushrooms from steam sterilized paddy straw beds recorded higher quantity of carbohydrates, fibre and pH. Increased content of calcium, magnesium and zinc were noted in *P. florida* and *P. eous*. In another study analysis of *P. eous* harvested at different stages of maturity showed increased quantity of carbohydrates (6.39 g%), fat (0.4 g%) and minerals like sodium (82 ppm), potassium (3320 ppm), calcium (84 ppm) and iron (30 ppm) at first day after pinhead formation. Calcium showed a drastic reduction in the third day after pinhead formation. Results showed that proximate minerals and amino acids varied with mushroom varieties, substrates, type of sterilization and days for maturity.

II-O-2. Isolation, screening and characterization of amylase producing bacteria from white button mushroom compost

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Amylases are one of the most industrially important enzymes and hold the maximum market share of enzyme sales. They have potential application in a wide number of industrial processes such as food, fermentation, textile, paper, detergent, and pharmaceutical industries. Microbial amylase is preferred over other kinds of amylase obtained from plants and animals due to its biochemical versatility, higher production rate, stability, and easy availability of huge number of microbial strains. In the present investigation, a total of 8 bacterial isolates were isolated from white button mushroom compost of Nauni

and screened for their ability to produce amylase. Out of all three isolates *viz*. M13, M31 and M51 were found to be amylase producers. However, isolate M13 gave highest zone size of 10.00 mm with enzyme index of 37.00. On the basis of morphological and biochemical characterization, M13 isolate was found to be gram positive, non spore forming bacteria having circular form, raised elevation with entire margin and translucent colonies. Isolate M13 was positive for oxidase, MR test, glucose test, sucrose test, lactose test, urease test and H_2S test positive. Whereas it was negative for catalase, simmon citrate, indole test and VP test. Physiological characterization revealed that temperature of 45°C, pH 9 and incubation period of 72 hrs was optimum for the production of amylase by M13 isolate. The phylogenetic analysis showed distinct clustering of the isolate M13 with *Bacillus* sp. (NR112686). Among different substrate sources, highest amylase activity of 61.35 IU was obtained in apple pomace as a low cost substrate. One per cent starch and yeast extract was found to be the best carbon and nitrogen sources with amylase activity of 65.68 IU and 78.88 IU, respectively. Thus, isolate M13 was found to be the potential source for amylase production.

II-O-3. Textile dye decolourization by a thermostable immobilized laccase isolated from *in vitro* cultured *Ganoderma lucidum*

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Ganoderma lucidum, the white rot fungus was collected from different hosts in four different agroclimatic zones of Haryana state in the months of August/September 2015 and 2016. The fungus was authenticated by molecular technique of ITS sequencing approach. Production of laccase from *in vitro* established cultures was carried out by submerged fermentation in 2L fermenter. The extracellularly produced crude enzyme was partially purified using ammonium sulphate precipitation. PAGE of crude enzyme confirmed the presence of laccase as major enzyme. It was further purified by DEAE-cellulose chromatography. The enzyme was covalently attached to PVA(poly vinyl alcohol) membrane with 68.25% retention of enzyme activity in the temperature range of 45-55° C in pH range of 4 - 5.5. Textile reactive dye effluents were collected from Textile Industrial Township, Panipat (Haryana) and the immobilized enzyme was used to decolourize the synthetic dyes. Effective and stable decolourization of synthetic reactive dyes with laccase showed its potential for industrial applications.

II-O-4. Study of antioxidant activity in *Lentinula edodes* (shiitake) using different extracts

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Lentinula edodes (shiitake) is considered as first medicinal mushroom to enter the realm of modern biotechnology and recognized as second most popular edible mushroom in the world. It possess

many health beneficial properties such as antitumor, antiviral, antimicrobial, anti-inflammatory and antioxidant properties that contributes about 25% of total yearly production of mushrooms. In this study, three strains of *L.edodes* (Le-S, Le-C, Le-I) were evaluated by using alcoholic, aqueous and crude extracts in order to study the antioxidant potential of shiitake. Three different methods (Hydroxyl radical scavenging potential, antioxidant activity in linoleic acid emulsion and improved ABTS radical decolourization assay) were used to assess the antioxidant property of shiitake. The maximum hydroxyl radical scavenging activity was obtained from alcoholic (84.1%) and aqueous (57.1%) extracts of fruit body of Le-S. In linoleic acid emulsion, maximum antioxidant activity was observed in alcoholic extracts of fruit body of Le-S (40.1%) after 1 hour of incubation. This percent inhibition value increased to 51.1% after 2 hours of incubation but decreased to 20.9% and 18.6% after 3 and 4 hours of incubation respectively. The results of ABTC radical scavenging capacity showed maximum percent inhibition in alcoholic extracts of biomass of Le-S (96.3%). In this case, fruit body of Le-S depicted maximum activity in aqueous extracts (93.2%) and alcoholic extracts (91%). Therefore, the maximum antioxidant potential is expressed by alcoholic extracts of fruit body and biomass of Le-S strain of *L.edodes.* The determination of antioxidant potential in *L. edodes* extracts could be used as a natural source of antioxidants or possible constituents in food supplements and pharmaceuticals industry.

II-O-5. *Pleurotus ostreatus* polysaccharides with antioxidant and antimicrobial properties

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Mushrooms are nutritionally functional food and a source of physiologically beneficial and nontoxic medicines. Biologically active substances originating from Basidiomycetes have beneficial effect on human health. Among these compounds, polysaccharides (especially β-glucans) play an important role due to their anticancer and immunomodulating activities. In present study, polysaccharide fractions were obtained from edible mushroom *Pleurotus ostreatus*. Three polysaccharide fractions were obtained with ethanol precipitation from cold water, hot water and hot aqueous NaOH extracts. The fractions were subjected to Fourier Transform Infra-red Spectroscopy (FTIR) for structural analysis. Spectra of three fractions showed several intense overlapped IR bands in the region of 950-1200 cm^{-1} (mainly CC and CO stretching vibrations in pyranoid rings) indicating the presence of polysaccharides as the major component. All fractions also showed peaks near 1078 cm^{-1} indicating presence of β (1→3) glucans. Hot water fraction showed peak at 1374 cm^{-1} that further confirmed presence of β glucans. Cold and hot water fractions showed peak for stretching vibrations of C-H bond (2921 cm^{-1}). Cold water fraction also showed peak for hydroxyl group stretching vibration. The polysaccharide fractions were tested for their antibacterial potential using well diffusion technique. All fractions showed moderate activity against *Yersinia enterocolitica*, while cold water fraction also indicated antagonistic activity against *Salmonella typhi*. The antioxidant activity of *P. ostreatus* polysaccharide fractions was determined via the 2, 2-diphenylpicrylhydrazyl (DPPH) radical neutralization assay. Relative to DPPH, the NaOH soluble fraction showed maximum antioxidant activity (0.21) followed by cold (0.02) and hot water fractions (0.01), respectively.

II-O-6. Developing eco-friendly green products from mushrooms - An initiative towards developing mushroom bio factories

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Mushrooms are known to us as fleshy fungi, with attractive colours & designs, and widely distributed in different regions. The secondary metabolites from mushrooms proved to have promising antimicrobial, anticancer, antioxidant, anti-inflammatory, hepatoprotective, etc. which gain the special increasing attention among pharmacologists and medical practitioners. The presentation will focus on progress made so far by us in mushroom based process and product development especially on fungal dyes with additional functional properties, followed by utilizing mushroom secondary metabolite for nutraceutical products. The presentations will also emphasis on utilising the enzymes from mushrooms for waste water treatment. The presentation will concluded that the SMS was converted into value added products like eco-friendly paper, biogas, ethanol and plant growth promoters.

Poster Presentations

II-P-1. Decolourization of synthetic dyes using enzyme extract from spent *Pleurotus* spp. spent mushroom substrate

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The use of synthetic dyes is increasing at an alarming rate and their discharge as textile waste can cause substantial ecological damage. Biological decolourization of dyes using microorganisms is an environmentally friendly and cost- effective alternative to chemical methods. White rot fungi are known to act on highly recalcitrant environmental pollutants and they can be effectively used in paper and pulp industries, textile industries, xenobiotic degradation and bioremediation. Mushroom industry generates a virtually inexhaustible supply of a fungus-colonised-substrate left after cropping and is commonly called spent mushroom substrate (SMS). This SMS finds practical applications as a readily available and cheap source of enzymes for bioremediation, animal feed and energy feedstock. White rot fungi produce various isoforms of extracellular oxidases including laccase, Mn-peroxidise (MnP) and lignin peroxidase (LiP), which are involved in degradation of lignin in their natural lignocellulosic substrate. The present study investigates the dye decolourization potential of enzymes extracted from SMS generated from five different *Pleurotus* spp. (*P. florida, P. sajor-caju, P. ostreatus, P. sapidus* and *P. eryngii).* The SMS evaluated from different stages of growth of the *Pleurotus* spp. showed that the activity of the lignocellulolytic enzymes varied depending upon the growing stage of the mushroom. The SMS of *Pleurotus* spp. can be used for decolourization under optimized conditions. The findings of the study have the potential to be transformed into reliable and robust dye decolourization treatment process.

II-P-2. Decolourization of chemically different dyes by enzymes from spent compost of *Calocybe indica*

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The pollution of the environment with synthetic organic compounds has become a major problem worldwide. Wastewaters from textile industries are a complex mixture of many polluting substances such as organo chlorine-based pesticides, heavy metals, pigments and dyes. Colour removal especially from textile wastewaters has been a big challenge over last decades. Majority of edible fungi secrete extracellular lignocellulolytic enzymes like laccase, lignin peroxidase, manganese peroxidase, cellulase, etc. The ability of the white rot fungi to degrade dye can be directly correlated with its ability to degrade lignin; the dye molecules are degraded along with lignin. Consequently, an adequate disposal method is needed for the high quantities of spent mushroom substrate (SMS) generated in this agro-food industrial activity. In this study a total of three dyes from azo (amido black and Congo red) and polymeric/

heterocyclic(RBBR) dye group were decolourized by enzymes extracted from spent compost of *Calocybe indica* strains(C1,C3,C6,C7 and CBE1515). The activity of lignocellulolytic enzymes were assayed during crop growth stages. The results showed that the enzyme activity and decolourization percentage varied depending upon growing stages of mushroom. From the results of present study, it could be concluded that the enzymes extracted from spent compost of *Calocybe indica* can be a source of industrially important enzymes which have potential in the bioremediation of synthetic dyes.

II-P-3. Oyster mushrooms (*Pleurotus*): Cultivation and functional food aspects

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Mushrooms are popularly consumed all over the world due to their taste, flavour and high nutritional value and medicinal properties. *Pleurotus* is a genus of edible and medicinal mushrooms with wide geographical distribution. It has ligninolytic enzyme (laccase, Mn-oxidizing peroxidases and acryl oxidases) production system which enables its dwelling on lignin and cellulose rich substrate. The wide range of lignocellulosic waste such as wheat straw, rice straw, soybean straw, etc is considered highly suitable for its cultivation. Most of the species of this genus are rich in proteins with essential amino acids, physiologically important polysaccharides and essential fatty acids, dietary fibers, important minerals, and some vitamins. Owing to presence of bioactive ingredients like glucans, ergosterol, polyphenolics; *Pleurotus* mushrooms have been reported to have anticancer, antihypercholesterolemic, antihypertensive, antidiabetic, antiobesity, hepatoprotective, anti-aging, antimicrobial, antiallergic, and antioxidant activities. This paper summarizes the prospects of *Pleurotus* species with special emphasis on *Pleurotus eryngii* to sustainable agriculture and functional food potential. The work would also include the findings on the cultivation of *P. eryngii* on different substrate combinations to enhance the quality and quantity of the fruiting body of two mushrooms.

II-P-4. Influence of amendments on fruiting body production of *Auricularia polytricha* (Mont.) – wood ear mushroom and analysis of proximate constituents

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Auricularia polytricha, the black jelly or wood ear mushroom, has high medicinal and nutritional values. Addition of different supplements has positive effect on the mushroom production. In this context a trial was conducted by adding five different supplements *viz.,* wheat bran, rice bran, cotton seed hull, neem cake and groundnut cake @ 2 and 4% concentration with rubber sawdust as a basal substrate. Among the different amendments tried, wheat bran 2% was found to be the best in terms of time taken for complete spawn run (32.0 days) and time taken for pinhead formation (38.3 days) which was at par with

4% wheat bran (39.7 days). The early fruiting also occurred first (45 days) in beds amended with 2% wheat bran, which was at par with groundnut cake 2% (45.3 days). The average weight of sporocarp was also the highest in 2% wheat bran amended beds (4.16 g). However, the maximum number of sporocarps (33.3) was recorded in 2% rice bran amended beds followed by beds amended with 2% groundnut cake (29.7). The maximum biological efficiency of (56 %) was recorded from eight harvests in beds amended with 2% rice bran followed by rice bran 4% (51 %), wheat bran 2 % (49 %) and they were found to be best treatments. The lowest BE was obtained from two treatments of neem cake 4% (26 %) and neem cake 2% (28 %). Proximate constituents namely moisture, carbohydrates, protein, fat, fibre and β-carotene were analysed. The results indicated significantly high nutritional profile *viz.,* moisture (90.12 %), carbohydrates (11.7 %), protein (10.5 %), fat (0.76%), fibre (17.69 %) and β-carotene (0.178).

II-P-5. Enzymatic and antioxidant profiling of *Pleurotus* spp. and *Calocybe indica* cultivated in Jammu

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Mushrooms are fleshy edible fungi which are essentially a rich source of good quality protein having most of the essential amino acids, minerals and vitamins with low calorific value. In recent years, *Pleurotus* spp. and *Calocybe indica* have gained prominence as a type of edible mushrooms. The present study consolidates the enzymatic profiling and antioxidant potential through antioxidant assays such as DPPH free radical scavenging, metal chelating activity and reduction assay of fruit bodies of edible mushrooms of *Pleurotus sapidus*, *P. sajor-caju* and *Calocybe indica*. Cellulase activity and β 1,3-glucanase activity were recorded maximum in *P. sapidus* (1.34 U/mg protein and 0.09 U/mg protein) and lowest in *C. indica* (0.49 U/mg protein and 0.05 U/mg protein) whereas, xylanase activity was recorded maximum in *P. sajor-caju* (0.19 U/mg protein). DPPH free radical scavenging activity was maximum in *C. indica* with IC 50 6050.6 ìg/ml and lowest in *P. sajor-caju* with IC 50 362.93 μg/ml. Chelation power was found to be maximum in *P. sapidus* with IC 50 813.8 μg/ml. Reducing power was maximum in *P. sajor-caju* with EC 50 18.66 μg/ml. Maximum alkaloid content was found in *P. sajor-caju* (74.02 mg boldine/100g dry wt.) and least in *C. indica* (0.003 mg boldine/100g dry wt.). Highest saponin content was found in *C. indica* (0.08 g/ 100g dry wt.) and lowest in *P. sapidus* (0.053 g/100g dry wt.). Flavonoid content was highest in *P. sapidus* (0.392 mg/CA/100g dry wt.) and lowest in *Calocybe indica* (0.102 mg/CA/100g dry wt.). Thus the above study reveals that besides having high protein content, these mushrooms are good source of natural antioxidants.

II-P-6. Characterization of some nutraceutical components in three wild edible mushrooms of Haryana

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The present work deals with the biochemical analysis of three edible mushrooms for evaluation of some nutraceutically important components. The three mushrooms namely, *Calocybe gambosa* (Fr.) Donk, *Lentinus squarrosulus* Mont. and *Podaxis pistillaris* (L.) Fr. were collected from their natural habitat in Haryana during monsoon seasons of years 2013-2016 and were preserved by air-drying. Among these three mushrooms, *C. gambosa* and *P. pistillaris* are consumed commonly by the local inhabitants of the area while *L. squarrosulus* is preferred comparatively less. The study provides information regarding the amount of phenolic compounds, flavonoids, steroids, alkaloids, β- carotene and lycopene present in them which was done following standard protocols. All investigated mushrooms were also found to be good sources of proteins, crude fiber, and total carbohydrates with low fat contents and high energy value. *C. gambosa* was found to be having maximum amount of phenolic content (1.54 mg of gallic acid equivalents/g extract), while minimum quantity was found in *P. pistillaris i.e.*, 0.97 mg of gallic acid equivalents/g extract. Total alkaloid content was also present in maximum amount in *C. gambosa* (1.82 g/100 g dry weight of sample) as compared to the other two species evaluated. Flavonoid content (3.65 mg of quercitin equivalents/g extract), steroid content (1.80 mg of diosgenin equivalents/g extract), β- carotene (4.68 μg/g of dry weight) and lycopene (1.23 μg/g of dry weight) were found in maximum quantity in *L. squarrosulus*. All the components were present in minimum quantity in *P. pistillaris* among the three mushrooms studied. The presence of these bioactive components in mushrooms contributes to the pharmacological characteristics such as anti-oxidative, immunostimulatory and anti-microbial, etc.

II-P-7. Production of amylase by thermophilic bacteria from spent mushroom compost and its application in food industry

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Due to increasing demand for enzymes in various industries, there is enormous interest in research on enzymes suitable for commercial applications and their cost effective production techniques. Amylase constitutes a class of industrial enzymes representing approximately 30 per cent of world enzyme production. Amylase has found applications in utilization of waste biomass for valuable products, fermentation processes, juice processing and bakery industry. Amylase is generally extracted from plants but microorganisms serve as a potential source of amylase production. The present investigation was carried out to isolate the amylase producing bacteria from spent mushroom compost and to see its application in bun preparation and clarification of juices. Total 3 isolates were found to be amylase producers, among which M13 gave a highest zone size of 10 mm with enzyme index of 37. Based on biochemical and sequence analysis of 16S rRNA, M13 showed maximum identity of 99% to *Bacillus* sp. The highest

amylase activity was obtained in apple pomace as a substrate at 72 hours of incubation at pH 9.0 and 45°C temperature. Among different sources starch and yeast extract were found to be best carbon and nitrogen sources, with amylase activity of 65.68 IU and 78.88 IU, respectively. The bacterial isolate based amylase was used for preparation of buns and clarification of kiwi and apple juices. It was found that application of 1 per cent amylase yielded 60 per cent apple juice with incubation of 30 minutes with high sensory characteristics i.e. colour (8.00), taste (7.54) and flavour (7.32) on 9 Hedonic scale basis. Whereas in kiwi juice 0.75 per cent amylase yielded 56 per cent with incubation of 60 minutes with considerably improved taste (7.24), colour (8.00) and flavour (7.24). The maximum leaving activity of 2.15ml/h and loaf volume 177.43 cm^3 were observed for M13 at the amylase concentration of 1.25 % with overall acceptability of 8.0 on 9 Hedonic scale basis in terms of colour, taste and flavour. Hence the amylase yield, stability and low cost substrate production supported the hypothesis that microbial enzyme have potential in food industry.

II-P-8. Effect of amendments and chemical sprays on fruiting body production of *Pleurotus opuntiae* (Durieu and Lev.) Sacc. and analysis of proximate constituents

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Pleurotus opuntiae owing to its short duration, pure white nature and ability to utilise the locally available substrates makes it a promising oyster mushroom species, which can revolutionize the mushroom farming. The particular variety, isolated from arecanut tree (*Areca catechu* L.) logs was confirmed by ITS sequencing and registered at Genbank database (accession number: KY214255). Addition of different amendments has positive effect on the mushroom production. In this context a trial was conducted in Instructional Farm, College of Agriculture, Vellayani by adding three different amendments *viz.,*wheat bran, rice bran and neem cake @ 2 and 4% concentration and four sprays *viz.,* gibberellic acid (20 and 40 ppm), gypsum (1 and 2%), urea (0.5 and 1%) and 1M potassium dihydrogen phosphate (2 and 2.5%) at spawn run, first harvest and 15 days later, with rubber sawdust as a basal substrate. Among the different treatments tried, wheat bran 4% was found to be the best in terms of time taken for complete spawn run (10 days) and time taken for pinhead formation (11.1 days), which was at par with 2% wheat bran and 4% rice bran. The early flush also occurred in beds amended with 2% and 4% wheat bran (14 days), which was at par with rice bran 2% and 4% (14 days). However, the maximum number of sporocarps were recorded in 2.5% potassium dihydrogen phosphate (1185) sprayed beds, followed by beds sprayed with 2.0 % potassium dihydrogen phosphate (900). The least number of sporocarps were recorded in treatments *viz*., gibberellic acid 40 ppm (210) and 20 ppm (125). Gibberellic acid treatment resulted in immature, smaller sized sporocarps. The maximum biological efficiency was recorded from three harvests in beds amended with 4% wheat bran (80 %) which was on par with 1 M potassium dihydrogen phosphate 2.5 % (79.9%) and were found to be the best treatments. The least biological efficiency was obtained from treatments *viz*., neem cake 2 % (62.2 %), gypsum 2% (52.4 %), urea 0.5 % (41.4 %), gibberellic acid 40 ppm (25 %) and 20 ppm (19.5%). Proximate constituents namely moisture, carbohydrates, protein, fat, fibre, lipids and reducing sugars were analysed for *P. opuntiae.* The results indicated the presence of

significant nutritional quantities *viz.,* high amount of moisture (90.7%), carbohydrates (46.13%), protein (19.96%), fat (2.2%), fibre (9.68%), lipids (3.88%) and reducing sugars (6.31%).

II-P-9. Qualitative and quantitative methods for estimation of extracellular ligninolytic enzymes in edible mushrooms

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Most mushrooms degrade lignin, cellulose and hemicelluloses with the help of various ligninolytic enzymes. These ligninolytic enzymes help to utilize agro-industrial waste and help in the production of lignocellulosic bio fuel. For detection of extracellular enzymes such as laccase, general peroxidase, protease and cellulase, the synthetic substrates such as 2, 2'-azino-bis (3ethylbenzthiazoline)-6-sulphonate (ABTS), pyrogallol, gelatin and CMC (carboxy-methylcellulose) were used, respectively. The detection of these enzymes was done by the colour development around the colonies. The blue colour formation depicts presence of laccase, yellow colour for general peroxidase, clear zone for proteases and yellow opaque layer for presence of cellulases in mushroom cultures. Quantitative estimation of these enzymes in liquid broth media was done through the study of reaction kinetics using calorimetric methods. The synthetic substrates such as 2,2'-azino-bis(3ethylbenzthiazoline)-6-sulphonate (ABTS), veratryl alcohol, and reactive Black 5 was used for laccase, lignin peroxidase and versatile peroxidase**,** respectively while substrates 3-methnolamino benzoic acid and 3-methyl-2-benzothiazolinone hydrazone hydrochloride were utilized for manganese peroxidase (MnP). The quantitative study of cellulases was done by utilization of CMC and filter paper while xylan was used as the substrate for estimation of xylanase. The enzyme was prepared by lyophilisation and grinding of the mycelia. For the quantitative analysis of cellulase and xylanase, the powder of mycelia was diluted with the sodium citrate buffer, and calorimetric assay of glucose was done after the incubation. These qualitative and quantitative methods are currently well proven in *Flammulina* and *Lentinus* species of mushrooms and further need to be standardized for other mushrooms.

II-P-10. Qualitative and quantitative production of lignocellulolytic enzymes using different agrowastes for enhancing yield potential of *Pleurotus eryngii*

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Pleurotus eryngii is one of the most valued edible, medicinal white rot fungi which is commercially cultivated on various lignocellulosic agro-wastes. These fungi possess an extensive enzyme system to degrade insoluble lignocellulosic substrates which plays an important role for efficient conversion of plant residues for large number of biotechnological and environmental applications. Lignocellulolytic enzyme production from different cheap and locally available lignocellulosic agricultural wastes (wheat straw, paddy straw, maize stalks and soybean straw as carbon source) by three strains of *P. eryngii* (DMR-P-120, DMR-P-135, DMR-P-257) was investigated in this study for improving the yield potential of *P. eryngii*

by correlating the enzyme activity of these *Pleurotus* strains. The qualitative screening for lignocellulolytic potentials by three strains of *P. eryngii* under optimum growth conditions was tested by using different chromogenic indicators, viz. carboxymethyl cellulose (0.5 g/l) for cellulose, xylan (1 g/l) for xylanase and rice bran with 0.75 g/l guaiacol. All the three strains produced white and reddish brown colored zones around the fungal colonies that confirmed the lignocellulolytic potential of all the *P. eryngii* strains. In submerged fermentation, among the four agricultural wastes tested, maize stalks produced high amount of endoglucanase (2.44 U/mg of protein) and exoglucanase (1.28 U/mg of protein) for DMR-P-135 strain while wheat straw produced maximum amount of β-glucosidase (5.56 U/mg of protein), xylanase (5.72 U/mg of protein) and laccase (330.18 U/mg of protein) for DMR-P-120 strain. These results indicated that the selection of carbon source could be an important factor for the production of lignocellulolytic enzymes by *P. eryngii* and in this study the enzyme activities were up-regulated by maize stalks and wheat straw. Therefore, these enzyme expressions could be used as a marker for selecting the better locally available substrate for commercial cultivation under Punjab conditions.

II-P-11. Estimation of sugars, protein and phenol content in different strains of oyster mushroom

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Oyster mushroom is an edible white rot fungus and is classified into the genus *Pleurotus* that comprises about 40 species. Edible mushrooms could be a source of many different nutraceuticals such as essential amino acids, unsaturated fatty acids, phenolic compounds, tocopherols, ascorbic acids, soluble sugars and carotenoids. Keeping this in view the present study was conducted to determine the total soluble sugar (reducing and non-reducing sugar), protein and total phenol contents in the fruit bodies of different strains of oyster mushroom viz., PL-01, PL-03, PL-04 and PL-05 harvested from different substrates. It was observed that the total soluble sugar (TSS) content was maximum (16.9%) in the fruit bodies of strain PL-05 harvested from wheat straw + palm leaves (1:1). Whereas it was lowest (11.8%) when harvested from wheat straw alone. However, in the fruit bodies of strains PL-01 harvested from wheat straw + waste paper, maximum (16.9%) TSS was estimated followed by that in PL-04. The maximum protein content (29.3%) was estimated in the fruit bodies of PL-05 harvested from wheat straw + waste paper while protein content decreased on the other substrates and strains. Minimum (10.3%) protein content was estimated in strain PL-04 harvested from wheat straw alone but it increased in the fruit bodies harvested from wheat straw + waste paper. The total phenol content was recorded maximum (0.80%) in the fruit bodies of PL-05 harvested from wheat straw while it was maximum (0.77%) in PL-01 harvested from wheat straw+ waste paper. The minimum phenol was recorded in strain PL-03 when harvested from wheat straw+ palm leaves. These results suggest that the total soluble sugars, protein and total phenol contents varied in the strains and are influenced by the substrate used for cultivation.

II-P-12. Variation in enzymatic activities in different strains of *Agaricus bisporus* commonly used in India

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Mushroom cultivation is gaining popularity in India since last few decades. Amongst cultivated mushroom, white button mushroom (*Agaricus bisporus*) contributes more than 80% of the total mushroom production of India. Five most popular strains of *Agaricus bisporus* collected from various mushroom farms in Himachal Pradesh in India were studied for their growth patterns and lignocellulolytic enzyme profile to ascertain their substrate colonizing potential and browning sensitivities. For this purpose, enzyme profiles i.e. cellulases (C_1, C_X, Xylanase, Laminerases, β-glucosidase) and lignilase (Tyrosinase, Laccase, Polyphenol oxidase, Lignin peroxidase and total Peroxidase) were analyzed. The result indicated that ligninase activity grouped the test strains into two groups on the basis of Tyrosinase, Polyphenol oxidase and Manganese peroxidase activity. The strains M7215 and S465 showed significantly lower activities of the above enzymes showing browning resistance in the strains to some extent. The Laccase and LiP activity is almost at par in all test strains showing at par Lignin degrading activity of the strains. All the test strains showed almost at par activity of C_1, C_X and β-glucosidase activities. However in case of Xylanase activity the strains S465 showed the minimum activity, which indicates the poor potential of hemicellulose degradation by the strain.

II-P-13. Performance of few coloured oyster mushroom species in terms of their antioxidant properties

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A comparative study of four commonly grown oyster mushroom species revealed that the coloured species have higher antioxidant properties. All the species were compared for the radical scavenging activity, reducing power, chelating effect on ferrous ions, total phenolics and total flavonoid content. Among the four species *Pleurotus djamor* showed highest antioxidant activity followed by *P. ostreatus* and *P. sajor-caju*, respectively. The white species *P. sapidus* had the lowest antioxidant properties. The study showed a positive correlation between pigmentation and antioxidant properties.

II-P-14. Estimation of proteases from *Pleurotus florida* and *Volvariella volvacea*

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A protease is any enzyme that performs proteolysis of protein by hydrolysis of peptide bonds. *Pleurotus florida* and *Volvariella volvacea* were subjected to estimation of serine, cysteine and aspartic proteases. Serine proteases are enzymes that cleave peptide bonds in proteins in which serine serves as the nucleophillic amino acid at the active site. In Humans, they are responsible for coordinating various physiological functions, including digestion, immune response, blood coagulation and reproduction. cysteine proteases are also known as thiol proteins. These proteases share a common catalytic mechanism that involves a nucleophillic cysteine thiol in a catalytic triad or dyad. These are used as an ingredient in meat tenderizers. Aspartic proteases use an activated water molecule bound to one or more aspartate residues for catalysis of their peptide substrates. These proteases include pepsin, cathepsins and renins. *P. florida* and *V. volvacea* were grown in potato dextrose agar medium to estimate total intracellular protein content as 39.66 µg/ml and 50 µg/ml, respectively. The mushroom mycelia were subjected to quantification of serine, cysteine and aspartic proteases. In *P. florida* serine proteases were 158.4 µg/ml, cysteine proteases 23.8 µg/ml, and aspartic proteases 40 µg/ml whereas in *V. volvacea* these were 213.96 µg/ml, 34.71 µg/ml, and 32.8 µg/ml, respectively.

II-P-15. Photo irradiated biosynthesis of silver nanoparticles using edible mushroom *Pleurotus florida* and their antibacterial activity

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Mushroom cultivation helps to give nutritional values and also provides proper recycling of agro- wastes. It is also having good quality of protein devoid of cholesterol high fiber with vitamins and minerals. In present study, the photo irradiation extracellular synthesis of silver nanoparticles was carried out using the aqueous extract of oyster mushroom (*Pleurotus florida*) as reducing agent. The synthesized silver nano-particles initially confirmed using UV-spectroscopy followed by Fourier Transform Infrared Spectroscopy (FTIR) which showed the presence of possible functional groups which can be responsible for the efficient stabilization of the sample in the reduction of size and shape. The synthesized nano-particles were characterized by SEM with energy dispersive X-ray spectroscopy (EDX) analysis which indicated the crystalline size and the presence of silver particles followed by X-ray diffraction (XRD). Moreover, the antibacterial activity of synthesized AgNPs against *K. pneumonia, E. coli*, *P. putida*, *S. aurous, V. cholera* were also done which showed with efficient activity .

II-P-16. Fluorescent metabolites from luminous mushrooms and its applications

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Among all the wild and wonderful things to find in the wilderness, mushrooms are by far the weirdest. Bioluminescence is the process that emits visible light by a living system; in which its active metabolite is being widely exploited as marker systems for detection & tracking of cells in the environment and as biosensors for detection of pollutants. Metabolites from luminescent mushrooms are effectively bioactive as anti-moulds, anti-bacterial, anti-viral, anti-cancerous, and also very useful in areas of biology, biotechnology & medicine as luminescent markers. These markers are very helpful for developing luminescent based microanalysis methods. Fungal bioluminescence is a beautiful phenomenon to study for its variety of metabolites into medical applications as natural products, preliminary material for pharmaceuticals or as lead structures for the development of pharmaceutical products. There are more than 70 species of mushrooms having bioluminescence properties that exist on earth, and though some may be uninteresting during the daytime, all are exciting at night. Among the many fluorescent mushrooms available, *Armillaria* and *Omphalotus spp.* was investigated for its fluorescent properties.

II-P-17. Isolation of secondary metabolites from the medicinal mushroom, *Ganoderma* species

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Mushrooms are gaining importance as rich sources for the diverse secondary metabolites often with potent biological activities. These secondary metabolites are extremely important molecules in modern drug discovery for the development some potent therapeutic agents to combat dreaded and chronic diseases. Mushrooms classified into three major categories such as edible, medicinal and toxic. The medicinal mushrooms are particularly useful in developing potent drugs. Medicinal mushrooms including fungi found to exhibit highly potent anticancer, immunomodulatory, antioxidant, radical scavenging, cardiovascular, antihypercholesterolemia, antiviral, antibacterial, antiparasitic, antifungal, detoxification, hepatoprotective and antidiabetic activities. Phytotherapeutic efficiency of terpenes and polysaccharides from mushrooms has been proved. Several of the mushroom polysaccharide compounds have proceeded through Phase I, II, and III clinical trials and are used extensively and successfully in Asia to treat various cancers and other diseases. With this background in mind and very little chemical and biological studies reported from Indian mushrooms, we have collected the medicinal mushroom species, *Ganoderma*. The mushroom material was extracted after proper processing and drying using Soxhlet extractor with solvents of increasing polarity from n-hexane, ethyl acetate and methanol under hot condition. Three single and pure compounds were isolated by extensive chromatographic purifications using Si and alumina gels.

Structures of the isolated compounds were elucidated by advanced spectral analysis viz. ^{1}H & ^{13}C NMR, DEPT, HMBC, HSQC, COSY, NOESY, IR, LRMS and HRMS as ergosta-7,22-diene-3-one, (**1**, 0.0015%), ergosta-7,22-diene-3β-ol (**2**, 0.034%) and 5α,8α-epidioxyergosta-6,22-diene-3β-ol (**3**, 0.0034%). The isolated compounds are being evaluated for their biological potential. Various aspects of the programme will be discussed in detail.

II-P-18. Evaluation of antimicrobial activity of sporocarps and mycelia of *Entoloma speculum* (Fr.) Quél.

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Antimicrobial activity of mycelia and sporocarps has been adequately worked out but comparative studies of both has not done in detail. The present work is to compare the antimicrobial activity of mycelia and sporocarps of *Entoloma speculum*. It is asaprophytic, white fleshy fungi, belongs to Entolomataceae. The collected fruiting bodies were dried, powered extracted from methanol by Soxhlet method. Mycelia was cultured on potato dextrose broth (Shittu 2005) and was extracted by methanol. Both extracts were tested against pathogens, viz., *Xanthomona scampestris, Pseudomonas syringae*, *Agrobacterium tumefaciens*, *Klebsiella pneumonia*, *E. coli*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Candida albicans*, *Trichophyton rubrum*, *Chrysosporium keratinophilum, Fusarium solani*, *Penicillium chrysogenum*, *Aspergillus niger*. Mycelial extract inhibited *T. rubrum* maximum (36mm), Sporocarp inhibited *F. solani* at 28mm maximum, the mycelial extract inhibited pathogenic fungi and sporocarps extract inhibited bacterial pathogens.

II-P-19. Screening of *Lentinus squarrosulus* Mont. for its profound activities

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Bhadra wild life sanctuary is a protected area and tiger reserve located 38 km northwest of Chikkamagaluru district in Karnataka state, India. Bhadra sanctuary has a wide range of flora and fauna. The diversity of geographical and climatic conditions prevalent in this sanctuary makes the region a natural habitat for a number of medicinal and edible mushrooms. One such mushroom of importance is *Lentinus squarrosulus* Mont., an edible macrofungi commonly found in the wild belonging to the family Polyporaceae. It is characterized by xeromorphic tough carpophores having gills with serrated margins.However, it is relatively unknown to the communities in different parts of the world and remain underutilized so far. In view of this, the sporophore was collected from the decaying wood of *Mangifera indica* L. of Bhadra wild life sanctuary situated in the Western Ghats of Karnataka during the month of August in the year 2016.The material was brought to the laboratory and taxonomically investigated and identified. In the present study, the fruiting body was shade dried and subjected to Soxhlet extraction using various solvent systems like petroleum ether, chloroform, ethanol and water depending on their dielectric constants from non polar to polar system. The extractives thus obtained were then tested for their myco-

chemical analysis to ensure the presence of active constituents. The analysis revealed the presence of major metablites *viz*., alkaloids, terpenoids, steroids, proteins, phenols, fats and oils. Among all the extractives, aqueous extract showed more number of myco-constituents. These secondary metaboiltes are reported to have many biological and therapeutic properties. Hence, this species is expected to have many medicinal uses and further studies may unravel the discovery of more potent natural drug that may prove useful in the treatment of various infections caused by microorganisms.

II-P-20. Amino acid, vitamin and fatty acid composition of *Lentinus sajor-caju*

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In this paper amino acid, vitamin and fatty acid profile of *Lentinus sajor-caju*, a basidiomycetous edible mushroom has been presented. During evaluation of 15 amino acids, 4 vitamins and 37 fatty acids were quantified from the dried sample of *Lentinus sajor-caju* cultivated on mixed substrate (wheat straw + paddy straw + saw dust + wooden flakes – 1:1:1:1). The total amino acid content has been evaluated at 18.82%. The essential amino acid index (EAA = 44.64%), biological value (BV= 36.93%) and protein efficiency ratio (PER= 0.10%) has also been determined. Lysine, alanine, cysteine, phenylalanine, leucine and histidine were present in large amounts while isoleucine, tyrosine, glycine, valine and methionine were present in comparatively reduced amount. Glutamic acid, aspartic acid, threonine and serine were not detected during estimation. Amongst the evaluated amino acids, exogenous amino acid lysine (6.66%) was preponderantly present in comparison to all other amino acids. Non-essential amino acid alanine (3.40%) was found to be second and cysteine (1.89%) third most abundant amino acid. From amongst the vitamins present in the mushroom sporophores, vitamin C (156 mg/g) was present in substantial amount followed by vitamin B6 (12.77 mg/g) and vitamin B5 (9.37 mg/g). The fatty acid assessment revealed the presence of 65.06% Polyunsaturated fatty acids, 27.89% Saturated fatty acids and 5.42% Monounsaturated fatty acids. Amongst the estimated fatty acids, linoleic acid (60.62%) was present in high amount in comparison to all other fatty acids and palmitic acid (17.6%) was found to be the second most abundant fatty acid in this mushroom.

Session-III: Genetics & Breeding

Keynote Presentation

III-K-1. Development of hybrids in button mushroom in India

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History of improvement of any species is linked to its domestication, cultivation and commercialization. Initial gains can be made by developing good cultivation techniques and selecting strains from the existing variability. For enhancing productivity as well as quality and develop quality planting material it becomes necessary to combine characters from different sources. Scientific cultivation of button mushroom started in beginning of 20th century when pure cultures from spore and tissue were made that paved way for quality spawn production. Initial improvements were made through selection from existing variability. A major step has been the selection of white coloured mutant in 1926 by Lambert. Technology for grain spawn and pasteurization of compost was developed in first half of 20th century but hybridisation has to wait till 1981 when first hybrid U1 was released. The primary reason was lack of clarity in understanding the life cycle of the species. It is now established that *Agaricus bisporus* has a unifactorial mating system and its life cycle is secondary homothallic. Most of the spores germinate to produce heterokaryotic fertile mycelia. However, few tri and tetra sporic basidia produce spores having nuclei of only one mating type and such spores on germination give rise to non fertile homokaryotic mycelia.

The first step in a breeding programme is collection and understanding of natural variability. The variability can be utilized directly by selection of desirable types, or selection from single spore isolates. Combining of traits from two strains requires identification of parents with desirable traits like yield, fruit body quality, disease resistance, browning, etc; development of homokaryotic cultures from spore prints of identified parents and inter-mating of compatible homokaryons from two parents to develop hybrids. Further selections can be made from segregating population represented by single spore isolates of the hybrid.

The simplest method to identify non fertile homokaryotic culture is to go for fruiting trials of single spore isolates or directly pick up spores from tetrasporic basidia using micromanipulator. It has been reported that frequency of tetrasporic basidia increases in later flushes and a BSN gene has been identified that when present means high number of tetrasporic basida. Markers like downward linear growth on compost, and molecular markers (RAPD, ISSR) can also help to identify homokaryons. Fragmentation and development of cultures through protoplast culture can also be employed. But the final test of non-fertility is fruiting trials. Hybrids can be developed by inter-mating of homokarotic cultures in petriplates. The approaches like resistance or auxotroph markers were suggested but have not been found to be of any practical value. Other approaches to develop hybrids include protoplast fusion and di-mon mating.

Considering that homo and heterokaryotic mycelia are multinucleate and lack clamp connections, the only method to confirm hybridisation is through fruiting trial. During this stage fruit body traits can be studied and undesirable types can be rejected. As it is not possible to screen and evaluate large number of hybrids, a rejection method based on the downward linear growth in compost has been developed.

Approaches like Marker Aided Selection (MAS) can also be employed. The selected hybrids are evaluated for three generations and after each screening number of hybrids is reduced and number of bags/ replication is increased. Hybrids can also be identified using isoenzyme/molecular markers. For transfer of limited traits from one strain to another genetic manipulation techniques like electroporation, particle bombardment or other methods of transformation can be employed.

Hybridisation work in button mushroom in India was initiated at DMR (then NCMRT) Solan in 1984 and first hybrid by inter-mating SSIs of S-11 and TM7 was developed in 1987. Considering that browning in white button mushroom after harvest is a major limiting factor affecting the quality and marketability of mushrooms, recently two browning resistant hybrids have been developed at DMR. For this 361 hybrids were developed using non-fertile isolates from 11 strains and these were evaluated for their bruise resistance by applying mechanical injury using a fork. In majority of the cases, the browning started immediately after the injury whereas a few remained unchanged even after two hours. After preliminary yield evaluation, five of these were selected and each hybrid was evaluated for yield on 1000 kg compost in a commercial unit. Finally, two of them (NBS-1 and NBS-5) were selected on the basis of better quality and higher yield. Final trial of the two strains was done on 4500 bags of 10 kg compost each in three commercial units. The yield of the two strains ranged between 21-25 kg per 100 kg of compost in a total harvesting period of 15 days. These two strains out yielded the strains used by those commercial units. It can be concluded that conventional breeding approaches will remain relevant, though molecular methods to understand variability, identify homokaryons and hybrids, or transformation techniques can be used to circumvent some of the time consuming steps.

Lead Lectures

III-L-1. Genetic improvement of *Pleurotus* species

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Pleurotus is a widely cultivated mushroom throughout the world as it can grow on any lignocellulosic substrate in a subtropical region. *Pleurotus* is known for its nutritional, medicinal and environment pollution control properties. There are about 40 well recognized *Pleurotus* species with 11 discrete insterility groups as per the mating compatibility studies. A bifactorial sexual compatibility system or tetrapolar heterothallism is a characteristic feature of the genus *Pleurotus* which is controlled by two unlinked loci with multiple alleles. A fertile dikaryon is generated only when fusion involves haploids heterothallic at both the loci ($A_xB_xA_YB_Y$). Product of A factor controls nuclear pairing, clamp formation, coordinate cell division and clamp cell septation while factor B product leads to nuclear migration, septa dissolution and clamp cell fusion. Molecular markers genetically linked to mating factors need to be identified in order to speed up the time required for selection of compatible mates. Strain improvement in *Pleurotus* for desirable traits like yield, morphology, enzyme production, adaptability to wide temperature range, sporelessness, environmental bioremediation, bioactive molecules etc. can be achieved through conventional breeding, parasexual hybridization, mutagenesis, protoplast fusion technology etc. The major aim of hybridization is to combine desirable characteristics from different strains and create variability in the existing germ plasm. Existence of variability in morphological traits and growth rate of mycelium of homokaryotic single basidiospores can be exploited for the development of inter-strainal hybrids. Various hybrid *Pleurotus* dikaryons using intra and inter species crosses have been developed. Fruit bodies from the *Pleurotus florida* PAU-5 were allowed to shed their basidiospores on filter paper under aseptic conditions. Forty-nine monokaryons were isolated from three spore prints, namely Ja, Jb and K. Three hundred and fifty-six crosses were laid to result in five compatible reactions (PFJ4, PFJ9, PFJ11, PFJ13 and PFJ14). The fruit bodies of the hybrid dikaryon PFJ4 were found to show grey pigmentation. The hybrid dikaryons PFJ11 and PFJ14 grew faster in wheat straw substrate to take 39 and 41 days, respectively, for complete mycelial impregnation as compared to the parent, PAU-5 (48 days). The dikaryon PFJ11 out-yielded the parent by giving 34.2% biological efficiency compared to 29.8% for the parent. A genetic linkage map of *Pleurotus pulmonarius* based on AFLP markers had identified the locus associated with the sporulation-deficient (sporeless) mutation of *P. pulmonarius* using 150 progeny isolates derived from a cross between sporeless and wild-type isolates. Based on the segregation of 300 AFLP markers, two mating-type factors, and the sporeless trait, a linkage map has been generated consisting of 12 linkage groups. Isozyme analysis is another useful tool for genetic studies related to agronomical research. A method lying on isoelectrofocusing followed by a blotting onto nitrocellulose was used to increase the sensitivity and the reproducibility of the enzyme detection. Five *Pleurotus* hybrid dikaryons, developed through cross-breeding of *Pleurotus florida* PAU-5 (PF-5) and *Pleurotus sajor-caju* PAU-3 (PSC-3) were characterized with respect to textural properties, color, and enzymatic and genetic variability. Available phenotypic and genotypic data can further help in the selection of monosporous isolates for developing inter-strainal hybrids which can lead to better prospects for genetic improvement in different species of *Pleurotus*.

III-L-2. DNA barcoding in mushrooms – Prospects and problems

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DNA barcoding is an emerging genomic tool for rapid and accurate identification and delineation of species in both animals and plants including mushrooms. DNA barcoding is the use of a short DNA sequence or sequences from a standardized locus (or loci) as a species identification tool. An optimal DNA barcode region is a small DNA fragment presented in all species of a major taxonomic group, having invariable nucleotide sequence in all members of the same species, but with sufficient variation to discriminate among the species. The barcode should contain enough phylogenetic information to assign the species to a particular taxonomic group. The region should have highly conserved primer binding sites for the amplification and sequencing. The sequence should be short enough to amplify even from degraded DNA. The insertions, deletions and substitutions at nucleotide level of the barcodes are the characteristic of the evolutionary path which makes barcoding technique as a valuable tool to classify even cryptic species.

The overall components of the barcoding technology consists of sample to be barcoded, laboratory technique including the use of universal primers to amplify DNA barcodes from the sample and online databases that contains the sequences of standard barcodes. The success of barcoding depends on the construction of an online library that contains the standard sequences of barcodes of almost all species. The DNA barcode that is well established in animals is a sequence of a 655-base fragment of the 5' end of the mitochondrial cytochrome c oxidase 1 (CO1 or *cox*1) gene. However in plants, substitution rates in this gene are much lower and there is often no sequence variation among species within a genus, and therefore this gene is not suitable as a plant barcode. The Consortia for Barcode of life (CBOL) has recommended the use of *mat*K and *rbc*L as universal barcode loci for land plants.

Six DNA regions were evaluated as potential DNA barcodes for fungi, the second largest kingdom of eukaryotic life, which included three subunits from the nuclear ribosomal RNA cistron along with regions of three representative protein coding genes (largest subunit of RNA polymerase II, second largest subunit of RNA polymerase II, and minichromosome maintenance protein). Although the protein-coding gene regions often had a higher percent of correct identification compared with ribosomal markers, low PCR amplification and sequencing success eliminated them as candidates for a universal fungal barcode. Among the regions of the ribosomal cistron, the internal transcribed spacer (ITS) region has the highest probability of successful identification for the broadest range of fungi, with the most clearly defined barcode gap between inter- and intraspecific variation. The nuclear ribosomal large subunit, a popular phylogenetic marker in certain fungal groups, had superior species resolution in some taxonomic groups, such as the early diverging lineages and the ascomycete yeasts, but was otherwise slightly inferior to the ITS. The nuclear ribosomal small subunit has poor species-level resolution in fungi.

Various barcoding loci such as CO1, ITS, LSU, SSU, IGS and RPB were studied by various research groups for their suitability in DNA barcoding in fungi and mushrooms. The most of the work reported was on the fungi with little information on macro-fungi including mushrooms. The studies reviewed mainly

indicate that ITS is the most accepted locus for the DNA barcoding of the mushrooms followed by RPB, IGS, LSU, SSU and CO1. The robustness of ITS barcodes relied mainly on the discriminating power and PCR amplification success. The barcode gap and species discrimination power, although higher for RPB but the PCR success of ITS made this locus more acceptable. Various studies now show that the DNA barcode choice and its reliability varied in mushroom taxa. Thus, barcoding system made the researchers more confident and reliable for mushroom species identification and speeding up the mushroom exploration and collecting of new mushroom species.

The use of multiple DNA barcodes has been emphasized for the identification of plant and fungal species. Therefore, the nuclear phylogenetic marker ITS region along with more conserved region from mitochondrial genome may be used for DNA barcoding in mushrooms. Schoch *et al*. (2012) proposed ITS as the primary fungal barcode marker to the Consortium for the Barcode of Life, with the possibility that supplementary barcodes may be developed for particular narrowly circumscribed taxonomic groups. Potential uses of DNA barcoding in mushrooms are: i) identification and delineation of new species, ii) comparative genomics and molecular phylogenetics, iii) identification of different life stages, iv) verification of mushroom pharmaceuticals/ foodstuffs, and v) IPR protection and trade in prized mushroom species. Thus, DNA barcoding markers could be used to broaden our understanding of both phylogenetic signal and detection of population-level variation for efficient management and use of biodiversity in fungi especially in mushrooms.

III-L-3. Characterization of WRKY transcription factor in *Agaricus bisporus* and its possible role

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Plants can reprogram their transcriptome through transcription factors with the variable environmental conditions. WRKY transcription factors are a class of sequence-specific DNA binding transcription factors found almost exclusively in plants and are key regulators, both positive and negative, of both biotic and abiotic stresses, seed development, seed dormancy and germination, development, plant hormone signaling, secondary metabolism and senescence. The WRKY protein family contains a highly conserved motif spanning about 60 amino acids and within this domain, there is an almost invariable heptapeptide signature WRKYGQK at the N-terminus and a novel zinc finger-like structure at the C-terminus. The WRKYGQK is the most dominant form of the signature followed by WRKYGKK and WRKYGEK, however, there are at least 35 variants of this motif present in plant and non-plant species. The WRKY domain can be characterized as WRRY, WSKY, WKRY, WVKY, or WKKY. WRKY proteins preferably bind to the consensus sequence TTGACC/T, the so-called W-box, which is usually enriched in the promoter region of WRKY target genes such as stress responsive genes. So far, only two WRKY homologues have been identified from non-plant species, *Giardia lamblia* and *Dictyostelium discoideum*. Some WRKY proteins exist as chimeric proteins combining NBS-LRR (nucleotide binding site - leucine rich repeat) proteins and WRKY domains. During the study, WRKY domain was searched *in silico* in the genome sequence of *A. bisporus* and also the priming sites were determined. On the basis of in silico results, two WRKY and one Nucleotide Binding Site primers were tested for amplification of WRKY domains in white button mushroom. Surprisingly, *Agaricus* genome showed the presence of WRKY domain at multiple sites and also different type of WRKY domains could be identified in the genome. Also the Nucleotide Binding Site (associated with WRKY domain) primer for disease resistance gene amplified fragment in the mushroom showing the presence of disease resistance gene. A total 51 amplicons amplified by the WRKY primers pair A7G1F & A7G1R and NBS primer pair M13R1 & M1495R. Both the primer pairs successfully amplified WRKY transcription factor domains. It was observed that the primers amplified the domain at different locations of the genome. Furthermore, the amplicon size also varied between 500 to 2000 bp. The results clearly demonstrated the presence of the factors at more than one location and also the structure and composition of the domain varied from one another. The sequence was used for the protein modeling of the WRKY protein of *A. bisporus*.

Oral Presentations

III-O-1. Assessment of diverse strains of oyster mushroom for their cultural, morphological and yield attributes under foothill condition of Pasighat, Arunachal Pradesh

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Pleurotus spp. commonly known as Dhingri or oyster or in Arunachal Pradesh (Tapar) is the third most important edible mushroom in the world. Mushroom was one of man's earliest foods for vegetarian as well as non-vegetarian people. They can be grown anywhere as long as the conditions for their growth and cultivation are provided. Four strain of oyster mushroom (PL-1, PL-2, PL-4 and PL-6) were evaluated for their cultural, morphological and yield attributes. Average highest yield (57.4 kg) was recorded in the strain PL-06 and has taken 41 days to complete the crop cycle. The temperature was recorded with Max. 24.7 and Min. 20°C with maximum relative humidity (90.4%). The strain PL-1 have taken 34 days crop cycle where as PL-4 has taken 39 days. Second highest average yield (46.6 kg) was recorded in the strain PL-2 followed by (38.0 kg) in PL-4. Highest pileus radius was observed in PL-6 followed by PL-2. It was observed that the paddy straw was suitable for cultivation of oyster mushroom in NEH region of India.

III-O-2. Evaluation of different *Pleurotus* spp. under mid hill conditions at Meghalaya

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Mushrooms are considered as delicacy in north east India. Mainly button, oyster, shiitake and milky mushroom are cultivated in north east India. In Meghalaya, oyster and button are more popular. Under All India Coordinated Research project six different strains viz. PL-14-01 to 06 were evaluated. Substrate used was paddy straw. Paddy straw was pre-soaked for 2 hours and dried for 4 hours. Spawning rate (grain spawn) was 100 g/kg dry straw. Total 5 replicates with 6 bags per replicate were used for each strain. Average minimum temperature was 10.8 °C and max temperature was 17.7 °C, relative humidity (83.6%) (taken at 10:00 am daily) during the entire cropping period (spawn run and fruiting). The strain PL-14-02 was found to be best in terms of yield (106.7 kg/100 kg dry substrate) followed by PL-14-03, 04 and 05 which were statistically at par. The strains PL-14-01 and 06 recorded the lowest yield (41.8 kg/100 kg dry substrate). Average fruit body weight of the strain Pl-14-02 was 29.1 g. On-farm trials conducted at different villages were also found to be encouraging (110 kg/100 kg dry substrate) for the strain PL-14-02.

Poster Presentations

III-P-1. Development of hybrids and single spore isolates of *Volvariella volvacea* for fruit body yield, nutritional profile and shelf life

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Volvariella volvacea - a tropical mushroom is mainly grown in South-East Asian countries both as a seasonal crop under the shade of trees and year around under indoor conditions. It is also known for its unique aroma and texture. Until recent past, its life cycle was considered as primary homothallic and hence developing new strains through conventional breeding was not given due impetus, except of limited attempts in developing the high yielding single spore isolates. Subsequent to the efforts on this line by several Chinese researchers, the life cycle of this mushroom has been reported as secondary homothallic just like *Agaricus bisporus*. This finding has raised the scope of developing hybrids in this mushroom just like in case of *A. bisporus*. In present study the single spore isolates obtained from three morphologically distinct *V. volvacea* strains were used for selecting consistently high yielding single spore isolates, and developing high yielding hybrids from the slow growing SSIs. The SSIs and the hybrids such developed were evaluated for their fruit body yield, nutritional profile and the shelf life. The yield performance of hybrids and SSIs was evaluated through successive growing trials using chemically treated paddy straw bundles and the composted substrate of cotton ginning mill waste and paddy straw under indoor cultivation conditions. After successive cultivation trials, two SSIs from a whitish/grayish strain DMRO-484 of *V. volvacea* and three hybrids obtained after crossing between the SSIs of strain DMRO-185 (giving small sized brown coloured fruit body) and strain DMRO-247 (giving big sized brown coloured fruit body) as well as between strain DMRO-247 (giving big sized brown coloured fruit body) and strain DMRO-484 (giving big sized white coloured fruit body), were found to give higher fruit body yield compared to their parent strains. The fruit bodies from the high yielding hybrids were found richer in vitamin D and crude fibre content as well as in the potassium: sodium ratio compared with parent strains. The fruit bodies from the high yielding SSIs and the hybrids did not differ much in shelf life of the fruiting bodies from the parent strains mainly with respect to loss in weight, veil opening, change in colour and the TSS values on storage for 24-48 hours. The study proves the possibility of developing high yielding and nutritionally superior hybrids in *V. volvacea* just as in case of *A. bisporus*.

Session-IV: Post Harvest and Extension Studies

Keynote Presentation

IV-K-1. Mushroom cultivation: a sustainable avocation for rural tribal population of Chhattisgarh State

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Mushroom cultivation is one of the most important source of food, nutritional, income and employment security in Chhattisgarh. There are four types of mushroom which are mostly grown in the existing agro-climatic conditions of Chhattisgarh. Spawn being the most important input in mushroom cultivation has been well taken care of by the Krishi Vigyan Kendras (KVKs) apart from ICAR-AICRP on Mushroom at IGKV, Raipur by establishing Mushroom Spawn Laboratory and Mushroom Crop Production unit. These KVKs located in different parts of the state are operating under the leadership of Directorate of Extension Services at the university level. KVKs of IGKV has made tremendous efforts to establish Mushroom Spawn Laboratory and Mushroom Crop Production unit in 14 KVKs (Bastar, Dantewada, Bijapur, Kanker, Dhamtari, Mahasamund, Rajnandgaon, Kawardha, Janjgir, Korba, Korea, Ambikapur, Raigarh, Bilaspur) of IGKV out of 20 KVKs and one KVK of Chhattisgarh Kamdhenu University (CGKV) i.e. KVK, Durg. 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 are technically supported by me as State Nodal Officer in establishment of Mushroom Spawn Lab and as Member of State Level Executive Committee of State Department of Horticulture and Farm Forestry, Govt. of Chhattisgarh under National Horticulture Mission.

Oyster mushroom is one which is most pre dominantly cultivated 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 mainly paddy straw and wheat straw substrates. It is very much liked by the tribal community followed by paddy straw mushroom, milky mushroom and button mushroom. Paddy straw is gradually picking up well in Janjgir-Chapa, 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. 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.

In view of the growing interest of the tribal farmers and extension personal in Mushroom cultivation, we signed a tri partite agreement with Director , Extension Services, IGKV, Raipur and Managing Director of State Rural Livelihood Mission under LIFE-MGNREGA Project to train 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 100 days in MGNREGA project without break has been considered to be one who should be supported 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. 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. As State Nodal Officer, I was asked to organise training programmes on Mushroom Production Technology through different KVKs/Colleges of IGKV, Raipur. Under this scheme, 132 farmers were provided 90 hrs. training on Mushroom Production Technology and they were trained at KVK, Janjgir-Chapa, Surguja, Jashpur, Bhatapara, Jagdalpur, Dhamtari and Dantewada during 2016-17. KVK, Janjgir-Chapa and Korba have also conducted on farm trials (OFT) on paddy straw and oyster mushroom to demonstrate the technology to the rural farmers. The technology has also been demonstrated under the developmental project entitled "Developing Livelihood Opportunities for Reducing Poverty through Community Irrigation and Integrated Farming Systems" at Gotatola and Surgi villages of Rajnandgaon under SRLM.

Similarly, the training programme on Mushroom Production Technology was imparted to 40 farmers (Men/women) for 90 hrs. under a Ad-hoc project "Transfer of technology to develop human resources in alleviating nutritional and stress problems" sponsored by Chhattisgarh Council of Science and Technology, Raipur to Dr.M.P.Thakur as Principal Investigator. This was the off campus training programme and organised at Technology village Sirri and the farmers involved in the training were from Sirri, Chivri, Dhendha, Karana, Hatband, Karga, Kotgaon and Alekhuta villages based on their interest in this area. These farmers were from different categories *viz*., OBC, SC, ST and varying in qualification from class V to graduation. The farmers during training in general were explained about the latest technology package of cultivating oyster, paddy straw, milky and button mushroom with more emphasis on practicals. They were also prepared for writing of Detailed Project Report to get the financial assistance from the funding agencies. The present paper dealt with the details of mushroom spawn units established, training programmes conducted under different schemes, on farm trials and FLDs conducted by KVKs on Mushroom Production Technology with reference to Chhattisgarh State.

Lead Lectures

IV-L-1. Mushroom technology as a social enterprise – The way forward

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Mushroom cultivation began in India in 1952. Since then this industry has been oscillating between the myths of earning millions overnight and the ground realities of growing a non-conventional crop. The concept, which branched off as a lesser-known shoot of mycology, has taken unusually long to establish itself in India. Although, mushroom science has the inherent subjective capability of a great impact on nutrition, agricultural waste management and environment cleansing; yet has been immensely underexploited in India. Social entrepreneurship is a novel movement gaining momentum around the world. It is a novel concept of modern business model which can find sustainable solutions to social, economic and environmental issues. It is a concept which believes in engaging in profitable commercial activities for mutual social and community gain. It works on the principle "Together we win", hence community takes precedence over individuals. Social enterprises have a strong character of creating jobs and making a socially just and inclusive business model. This is the ultimate objective of any scientific organization or scientific technology more so of public institutions like ICAR. *M*ushroom technology has the potential to become a social enterprise by integrating profitable agricultural waste management, nutrition management, creation of employment in rural unskilled sector, empowering women and linking with the government community programmes resulting in overall socio-economic upliftment. Mushroom technology can be a very successful social enterprise in the Indian context where agricultural crop residues to the tune of 100 million tons/annum is burnt, where millions of youth are unemployed, where there is rampant undernourishment and ever increasing threat of climate change. A majority (53%) of social enterprises in India are focussed on skill development, followed by 30% on education, 28% in agriculture-related activities, 26% in financial and clean energy, 22% in healthcare, 17% on farm livelihood, 16% food & nutrition and 14% sanitation & water. There is a need to evolve a road map in partnership with public institutions to establish mushroom technology as a social enterprise by entrepreneurs who have the managerial skills to link the individual mushroom activities into a profitable enterprise.

IV-L-2. Innovative approaches for popularization of mushroom among youth and women in southern India

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The first advanced estimate released by the central statistics office stated that the Indian economy is established to register a gross domestic product (GDP) growth rate of 7.1 per cent in 2016-17.The growth rate of agriculture and allied sector is at 4 per cent. During 2014-15 the population of India was 1267 million. In the rural area 25.7 per cent are below poverty line. Average marginal holding size is 0.39 ha. Per cent share of agriculture to the GDP for 2014-15 was 18 per cent. The decreasing size of land holdings with increasing population; declining soil fertility due to over exploitation of nutrients; increasing cost of cultivation over inputs; pitiable economic conditions; unemployment among rural youth and women; rising prices etc.are some of the grave issues which remain unsolved in the Indian agricultural scenario. Therefore, an integrated farming system including mushroom cultivation as the key activity for rural farmers has the potential to solve many problems now they are facing. India produces about 600 million tonnes of agricultural waste per annum which can be effectively used to produce protein rich mushroom. But now only 0.03 per cent of the wastes are used for mushroom cultivation. FAO has recommended mushroom as a high value crop to mitigate malnutrition out of protein deficiency in developing countries.According to 2015-16 estimate by the Ministry of Agriculture and Farmer Welfare, Government of India mushroom production was 76000MT. Among the South Indian states, Tamilnadu was the leading producer with an annual production of 6500T in 2010. Per capita consumption of mushroom is only 90 g for India;, while it is 1.49 kg for U.S.A and 11.62 kg for Netherlands. So, popularization of mushroom with special emphasis on health benefits to increase the demand is the need of the hour to solve various problemsof rural youthand women as mentioned earlier. Advantage of taking mushroom as an enterprise is covered in the paper. Several issues in the spread of this enterprise are also dealt with. Traditional approaches for technology transfer among rural youth and women like trainings, demonstrations, exhibitions that are being implemented in various South Indian states will be covered in the paper. Use of current agriculture approaches like Agriculture Technology Management Agency (ATMA) and the use of information and communication technology (ICTs) and participatory technology development (PTD) will be discussed. Role of master farmers, self help groups (SHGs) and farmers societies in the dissemination of knowledge on mushroom will also be mentioned as case studies.

Oral Presentations

IV-O-1. Post harvest studies on *Macrocybe gigantea* (giant mushroom) for increasing shelf life

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Macrocybe gigantium, commonly known as giant mushroom, belongs to the family Tricholomataceae of the order Agaricales. This is an edible mushroom having white sporophore, large sized fruit bodies (unique texture, taste) attractive colour and sustainable yield. The temperature requirement for the cultivation of this mushroom is 25-35°C. The shelf life of mushrooms must be enhanced for increasing their acceptability among the consumers. Considering this, post harvest studies on *Macrocybe* and *Calocybe* mushroom were carried out in the present investigation. The sporophores of *M. gigantea* (with and without blanching, WB and WOB, respectively), were steeped in solution of different chemicals like salt, sugar, citric acid (CA), ascorbic acid (AA) and potassium meta-bi-sulphite (KMS) for better shelf life. The results revealed that the fruit bodies preserved in chemical solutions of T1 (2% salt + 2% sugar + 0.3% citric acid + 0.1% KMS + 1% ascorbic acid without blanching) retained good colour and appearance of the sporophores of giant mushroom (MA-3) till 90 days. Thereafter it became slightly dull (scale 2) but it was acceptable up to 180 days after treatment. The texture of sporophores preserved in steeping solutions of treatments of T2 (2% salt, 2% sugar, 0.3% CA, 0.1% KMS and 1%AA-WOB), T4 (5% salt, 0.2% CA, 0.1% KMS (WOB) and T6 (0.1% AA, 0.1% CA, 0.1% KMS (WOB) were found almost fresh up to 90 days. The sporophores of strain MA-3 retained good colour, texture, appearance and acceptability till 9 days under freezing conditions of storage while in deep freezing conditions, the colour was retained up to 17 days.

IV-O-2. Marketable value added products of oyster mushroom

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Oyster mushroom (*Pleurotus florida*) is third most common edible mushroom grown in the different parts of the world. It has high nutrient contents (energy 357 kcal, protein 21.18 g, and carbohydrate 62.1 g/100 g) but this mushroom has shorter shell life. To overcome this limitation, present study was undertaken to develop various value added food products from dried mushroom powder i.e. mushroom biscuits, mushroom papad, mushroom soup powder, mushroom namakpara, mushroom savaiya and mushroom soya-nuggets. The nutrient composition and shelf-life of all above value added products were analyzed. It was observed that protein content was highest in mushroom soya-nuggets (37.7g/100g), whereas, it was least in mushroom biscuits (7.24g/100g). The overall protein content in mushroom soya-nuggets was found more than mushroom protein content due to addition of soybean flour into the recipe.

Carbohydrate content was found variable between 31.4g/100g in mushroom soya nuggets to 64.5g/100g in soup powder on dry weight basis. The fat content was least in savaiya (0.83g/100g) and maximum in namakpara (32.8g/100g). For shelf life, it was observed that products were found safe and good for use for one year when they were stored at ambient conditions i.e. 20°C. It is concluded that by way of value addition, shelf life and nutrient value of all products can be preserved effectively.

IV-O-3. Mushroom standards for fresh and dried mushrooms and their products

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A number of horticultural crops including mushrooms are being cultivated in India because of prevailing congenial climatic conditions and awareness among the masses to use the nutritionally rich produce in their daily diet. To have an impact of any produce in the market in general and consumers in particular, the producers are required to maintain certain minimum standards. Recently, Food Safety and Standards Authority of India (FSSAI) have adopted the European Regional codex standards for mushrooms being grown in India. These codex standards include fresh white button mushroom (*Agaricus bisporus*), paddy straw mushroom (*Volvariella volvacea*) and oyster mushroom (*Pleurotus* sp.) as well as value added products from various mushrooms. The scope, description, essential quality factors, hygiene, packaging and presentation and labelling have been included in the fresh and dried fungus whereas scope, description, essential composition and quality factors, food additives, hygiene, weights and measures, packing, storage and transportation and labelling, etc. have been included in the fungus products. A number of defects as damaged fungi, crushed fungi, spoiled fungi, maggot damaged fungi, seriously maggot damaged fungi, organic impurities of vegetable origin and mineral impurities have also been included. The essential quality factors include freshness of the mushroom, diameter of fruiting body, size and tolerance of defects. In the hygiene, the recommended practices as per the codex Alimentarius Commission are required to be followed with good manufacturing practices (GMP) free from micro-organisms and parasites. There must be uniformity, proper packaging like baskets, wooden boxes or cartons and name of the packed product must be shown in packaging and presentation. In the fungus products, the standards include for all edible fungi whether fresh or processed except canned button mushroom. The fungus products include dried, pickled, salted, fermented and frozen, etc. In the fungus products, the defects included are like that of fresh fungus. The general requirements for fungus products include raw material, permitted ingredients, styles and composition. The acetic acid, lactic acid, citric acid and ascorbic acid have been included as food additives. While filling, the container should not be less than 90% of its filling capacity and the minimum drained weight should be 50-53%. As these standards have been accepted directly, certain changes will be made after using in Indian conditions. FSSAI will monitor these codex standards regularly and after suggestions from various quarters, necessary modifications will be made.

IV-O-4. A study on mushroom consumer behaviour: Implications for mushroom farming, marketing and public health policy

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The demand for mushrooms is increasing world over because of their rich nutritional status and medicinal properties. Compared to the rise in the production and consumption of mushrooms in large part of the world, India witnesses a far below picture on the same. The mushroom consumer behaviour though has overarching implications for producers, marketing agencies and consumers; yet it is scarcely studied in India. Further, the multiplicity of factors influencing the mushroom consumption and the demand arising thereof for mushrooms decide the policy strategies to be embraced at macro level. Hence, the present study was undertaken to assess the mushroom consumption behaviour and the factors influencing the mushroom consumption. The study was conducted in Karnataka from 2012 to 2015 among 150 randomly selected respondents who came to purchase fresh mushrooms from 15 pre-decided different points of sale. To measure the mushroom consumer behaviour, scale developed by first author was used. The profile of the purchasers was studied for six variables; age, education, gender, family size, income and food habit. On food consumption habit, the respondents were classified as vegetarian, non-vegetarian and egg-vegetarian. The data was analysed using descriptive statistics, regression and stepwise regression. For the regression analysis, ordinal values were used for age, education, income and family size. The gender and food habit were analysed with one and two dummy variables, respectively. Since, the scale was developed to measure the mushroom consumer behaviour, the range scores were used as the basis for classifying the respondents based on mushroom consumer behaviour. The results suggest that, more than half of the respondents were falling in the medium category on the scale value followed by nearly 40 per cent respondents falling under low and about 10 per cent respondents in the high category of mushroom consumer behaviour. This trend needs to be altered to improve the consumption level of mushrooms in the interest of both consumers and the mushroom entrepreneurs. It serves dual role of improving the physical health of the former and the financial health of the later. The effect of six independent variables such as age, education, gender, income, family size and food habit on mushroom consumer behaviour was analysed through linear multiple regression. Education and income were significantly contributing towards mushroom consumer behaviour at 1 per cent level of significance. Age and size of the family were found to be non-significant. The preference for mushroom of individual was independent of his/her age and their family size. The R^2 of 32.4 in the linear regression model indicated the contribution of these six variables on the consumer behaviour. Large extent of variability (67.30 %) in the consumer behaviour remains unexplained by the unidentified variables.

IV-O-5. Mushroom information dissemination through internet technologies

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Internet technologies have stormed almost all spheres of life and agriculture is also not far behind in using them to disseminate mushroom related information among stakeholders in the mushroom industry. Internet is a global storehouse of information. ICAR-DMR is also on the way to harness the potential of the WWW (World Wide Web) to help in research and development and to provide important information to the mushroom farmers at the right time. The website of ICAR-DMR, Solan (www.nrcmushroom.org) provides a variety of information related to mushroom growing and advisory services to the farmers in English as well as Hindi. It contains information on all aspects of mushroom cultivation right from composting, spawning, cropping to post harvest processing and marketing. The information can be utilized by students, growers, consultants, marketers and other stake holders. An Expert System and a Decision Support System has been developed for mushrooms which gives information related to different aspects of mushroom cultivation as well as an interactive window for exchanging information among mushroom growers and experts. The facebook page of the Directorate is becoming popular day by day. DMR as well as users are posting important information related to mushroom growing regularly. Some videos have also been uploaded on you tube. In addition to this, a mushroom app has also been developed which has become very popular among the viewers. A mushroom group is being run on WhatsApp where growers and experts can have interaction. Growers send the photographs of crop/pest and diseases to experts and get a quick response for their problems related to growing. All these activities are making the delivering of information to mushroom growers easy and leading to instant solutions of many of their problems. With the booming mobile, wireless and internet usage, ICT has the ability to bring momentum to the mushroom industry. In coming days ICT is going to play a major role in providing online solutions to almost every problem of mushroom growers in addition to providing basic information on cultivation of different mushrooms.

Poster Presentations

IV-P-1. Effect of addition of button mushroom (*Agaricus bisporus*) powder on selected carbohydrate based products

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Mushrooms are highly nutritive, low-calorie food with good quality proteins, vitamins and minerals. Mushrooms are an important natural source of foods and bioactive components. Two selected carbohydrate based products namely rice and dal containing idli (RI), and chapatti (C) were formulated with dried button mushroom (*Agaricus bisporus*) powder (BMP). All the products were analysed for proximate analysis, sensory evaluation and textural properties. Results showed that the percentage of moisture, ash, fat and protein of RI and C increased in line with the levels of *A. bisporus* powder. The products in which 2%, 4% and 6% BMP was added, showed the percentage increase in nutrients as compared to control (0%). Mushroom based rice idli (RI) and chapati (C) had significantly higher acceptability compared to control. In conclusion, addition of BMP powder to partially replace rice and wheat flour in RI and C enhance essential nutritional components and acceptability by the consumers. Thus, BMP powder can be utilized in carbohydrate–based food products for enhancing nutrient composition without affecting its sensory acceptance.

IV-P-2. Empowering of unemployed youth through mushroom production technology

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Growing mushrooms on different agricultural residues not only provide protein rich foods to vegetarian population, but also minimize the uses of excessive chemical, pesticides and fertilizer from agricultural practices. The mushroom spent compost (compost left after mushroom harvesting) improve the soil fertility as farm yard manure and at the same time mushroom production technology generates employment to rural unemployed youth. The mushroom cultivation has attracted the attention of many unemployed youth and farmers of eastern Uttar Pradesh. Varanasi and Mirzapur were identified by Planning Commission as backward and poorest districts in Uttar Pradesh. At the same time, Varanasi and Mirzapur were blessed with varied agro-climatic conditions from temperate, tropical or subtropical. These regions are suitable for the production of three different types of mushrooms namely button, oyster and milky mushroom. There are plenty of raw materials available and the unemployed youths were trained to make use of this agrowastes for better economy and better living through mushroom farming. The target population were approached through village study, awareness and motivational camps followed by training and demonstration. Mushroom cultivation was found to directly improve livelihoods through economic empowerment and indirectly through nutritional and medicinal mushroom consumption.

IV-P-3. Knowledge of farmers in cultivation of oyster mushroom (*Pleurotus sajor-caju*) in Sriganganagar district of Rajasthan

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The study was conducted to assess the knowledge of farmers on cultivation of oyster mushroom (*Pleurotus sajor-caju*) in Sriganganagar district (Rajasthan). The sample consisted of randomly selected 100 farmers from village panchayat samities of Sriganganagar district. Personal interview technique was used for collecting data from the respondents. The outcome of the study revealed that the respondents had poor knowledge about the season of oyster mushroom cultivation, choice of species and variety of substrate. Further, respondents had poor knowledge about method of spawn inoculation. Majority of respondents had average knowledge about availability of spawn, prevailing price of spawn and shelf life. None of them had knowledge about post harvest processing and drying of oyster mushroom.

IV-P-4. Impact of pre drying and drying treatments on quality attributes of shiitake (*Lentinula edodes*) mushroom powder

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Shiitake (*L. edodes*) forms an excellent source of high quality proteins as well as biologically active compounds with potential additional medicinal value. Mushrooms, however, are highly perishable commodities and start deteriorating immediately after their harvest and have a short shelf-life of 1-2 days. Processing and preservation of mushroom is of vital importance to keep the wheels of this industry moving. Drying of untreated shiitake mushroom often results in product with unacceptable colour and flavour. At the same time, treatments may adversely affect the protein digestibility and antimicrobial properties thereby, forfeiting the nutritional and medicinal objectives. Present study reports impact of pre drying and drying treatments on crude protein, *in vitro* protein digestibility, antimicrobial activity and sensory attributes of shiitake (*L. edodus*) mushroom powder. Blanched and unblanched mushrooms were subjected to different chemical treatments including dip in KMS/ citric acid / hydrogen peroxide before solar/oven drying. All treatments were effective in producing organoleptically acceptable powders with significantly (Pd"0.05) improved *in vitro* protein digestibility. Also, the developed powders depicted antimicrobial activity towards *Staphylococcus aureus*, *E. coli, Bacillus subtilis* and *Salmonella typhi.*

IV-P-5. Effect of postharvest packing on shelf life of different mushrooms at ambient and low temperature

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Mushroom is nutritionally rich but highly perishable crop owing to its respiration rate and moisture content. Because of high respiration rate and moisture content, the mushrooms are spoiled very fast restricting their supply and availability at the distant places and markets. To make the Indian diet protein rich, mushrooms can play a very important and vital role because of its high protein content. The production of mushroom is increasing every year but to maintain the supply for a longer duration the postharvest spoilage is to be checked so that it reaches to maximum consumers at the places where it is not grown. The mushroom growers are reluctant to increase the production as the shelf life of their produce is very low forcing them to sell it at minimum prices. To restrict the postharvest spoilage and increasing the shelf life of mushroom an experiment was conducted at ambient (20-22°C) and low temperature (4-6°C) using button (*Agaricus bisporus*), paddy straw mushroom (*Volvariella volvacea*) and oyster mushroom (*Pleurotus* sp.). The mushrooms were packed in low density polyethylene and polypropylene bags (150 gauge) of different (200, 400, 600, 800 and 1000 g) capacities. The physico-chemical and bio-chemical parameters of all the treatments were recorded at different intervals. A significant difference among the physico-chemical characters of the mushrooms were recorded because of their shape and genetic make-up. There was a significant reduction in all the parameters like moisture, weight, size of the pileus, stipe length and diameter, sugars, polyphenol oxidase activity and total antioxidants with advancement of storage period both at ambient and low temperature but the changes were very fast at ambient conditions. Among the different mushrooms button has the highest storage shelf life of 18 days at low temperature which was only 3 days at ambient conditions. The paddy straw and oyster mushrooms were found to have shelf life of 6 and 6 days at low temperature and 1 and 2 days at ambient temperature respectively. Among the packing quantity 400 g of button mushroom in polyethylene and 200 g each of paddy straw and oyster mushroom were found optimum. In the packing material, polyethylene bags had an edge over the polypropylene bags.

IV-P-6. Fortification of pasta with white button mushroom: nutritional and rheological properties

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Macaroni popularly known as pasta is one of the extruded product. It is made from semolina flour derived from durum wheat and consumed in most of the countries worldwide. It is very popular due to its improved palatability and easy to cook ability. Macaroni provides significant quantity of complex carbohydrates, vitamin-B but is deficient in quality protein (less than 15%). Present study was conducted to prepare the mushroom supplemented macaroni (pasta) and study the effect of supplementation on

nutrients and antioxidant properties. The semolina was supplemented with white button mushroom (WBM) from 10% to 50% increments (T_1 to T_5). Moisture decreased within the treatment but ash, fibre, crude protein increased from 0.99% to2.66%, 0.79% to 5.79% and 11.39% to 22.50% respectively. The cooking weight decreased within the treatments while cooking loss decreased. The antioxidant activity increased in white button mushroom supplemented macaroni (pasta). In textural analysis the hardness increased and stickiness decreased with increase in the supplementation from 287.47 to 735.93 g and 0.023 to 0.002 g respectively. Based on the physico-chemical and rheological properties, semolina to mushroom ratio of 90:10 was recommended.

IV-P-7. Novel value added products of button and oyster mushroom

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Mushrooms are fungal fruit bodies which are used by human beings as food in form of culinary dishes, salads, sauces, pickles and processed dressings etc., but as most vegetables they are preferred as fresh. Whole mushrooms have very short shelf life because they lack cuticle to protect them from physical or microbial attack or water loss. Also, a very high respiration rate and water content make them prone to microbial spoilage, and they also exhibit enzymatic browning thus reducing their shelf life to less than 3 days in ambient conditions. Thus immediate marketing and sale of mushrooms becomes a necessity which is not yet organized in India. Processing of mushrooms (mainly drying) can extend the storage life up to a year. Fresh mushrooms can be processed in various forms to develop value added products with extended shelf life and minimal nutritional damage. Button and oyster mushrooms can be processed into many products such as pickles, papad, chips, mushroom fortified cakes, mushroom fortified noodles, mushroom cookies, mushroom candy, mushroom sauce and mushroom based sausages analogues etc. These value added products either ensures prolonged shelf life of mushrooms or develop nutritionally enriched shelf stable convenience food products.

Session-V: Mushroom Production & Protection

Lead Lectures

V-L-1. Modern farm design in button mushroom

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Button mushroom is the most popularly cultivated edible mushroom in the world today and holds very important position amongst the cultivated mushrooms world over. In India, button mushroom continues to be the main mushroom grown commercially both by seasonal and climate controlled mushroom growers. While seasonal grower grows in thatched mushroom growing huts with some modifications but without any climate controls, climate controlled mushroom growers grow mushrooms inside an insulated growing room with use of climate controls for growing mushrooms round the year for greater profits. Building modern mushroom growing houses have undergone total change in construction and climate control application in the world and India. The study focuses the construction, climate controlled application and technology used in raising a crop of button mushroom in shortest cropping period with economically viable mushroom yields.

Use of sandwich panels for building the insulated cropping rooms/ bulk pasteurization chambers have revolutionised the modern button mushroom farming in India with cost effective results and quick turn over. Modern climate controls are developed for precise application of temperature, RH, CO_2 concentration inside the crop rooms for obtaining maximum mushroom yields over a shortest cropping period.

V-L-2. Recent trends in compost production technology in India

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Compost production is the most important aspect of button mushroom cultivation. Of late there has been a visible change in its production technology, infrastructure development and machinery involved. Talking about the raw materials, soybean straw and sugarcane bagasse have almost completely replaced wheat straw in Maharashtra and Karnataka. Besides cheap both these materials are reported to give around 20% conversions at most of the farms. Further, mustard straw is fast replacing traditional wheat straw wherever it is available. Himalaya International, Gujarat unit is solely preparing compost using this material and is reporting about 22% average production. Saw dust based poultry manure is usually preferred over the pure droppings as later makes the compost greasy and does not mix properly with the base material. Lagoon has replaced the pre wetting area with maximum depth of 1.5 ft. with minimum of 5ft ramp for operational convenience. Compost production is totally shifted to indoor method and bunkers are utilized for the purpose. They are usually 14 ft. in width and are 1.25 to 1.5 times bigger than phase- II tunnels. Ventilation through pipes is preferred over the pressurized system. Spigots based pipes with 3" dia. and 6" manifold is generally used. A FD fan with 2800 RPM motor is preferred and few farms have installed frequency drive with the motor. Phase-. II tunnels with 14 ft. height and 12 ft. in width are preferred for operational convenience. Gratings are the things of past and have been replaced by 6-7" thick RCC perforated floor. Finished discarded cardboard spindle cones are used for making the holes. Total surface openings are only 8-10 % but it works. Plenum is 1.0 -1.5ft deep at the distant end of the blower. Blower is kept on the roof with ventilation duct inside the tunnel. Frequency drive is a must in this case. Full width doors with 12ft height should be kept for the operational convenience. Bunkers and tunnels are usually filled with the help of Bobcat or JCB. Few farms have installed local made filling lines and bag filling machines. At one farm in Hyderabad we have followed bunker system of ventilation in phase - II tunnel through pipes with excellent results and to cut down the power cost only 3HP motor was utilized for 20 tons compost production. Total Indoor Compost Technology (TICT) escaping phase –I altogether utilizing thermophilic fungi is being tested commercially at this farm.

V-L-3. Pest status of mushrooms and their bio-management

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Indian agriculture essentially needs to continually evolve so that it remains ever responsive to meet the growing and diversified needs of different stakeholders in the entire production to consumption chains. Mushroom production represents one of the most significant commercial steps towards diversification of agriculture based on microbial technology for large-scale recycling of agro-wares and their transformation into edible biomass, accepted as highly nutritive food with royal flavor and palatability. It relieves the pressure on arable land as its cultivation is indoors, and is more suitable for the women folk. Despite numerous appropriate reasons for this industry to rise in India like varied agro climate, large quantities of agro-wastes and sizeable population of the small and marginal farmers interested to grow mushroom as an additional source of income, the pace of growth is relatively slow. Reason behind is the unhygienic conditions in improvised mushroom farms which prove to be the hot beds for multiplication of various pests ad pathogens. Pests belonging to different phyla, orders and classes pose a constant threat to the successful commercial production of mushrooms.

Most significant among the arthropod pests are the insects belonging to Order Diptera and Coleoptera.

1. **Dipteran pests**: Dipteran flies are the most abundant and menacing among the arthropod pests throughout the world. These small to medium size delicate flies often bear resemblance to gnats and midges. These files are exceedingly numerous in individuals and species with a wide geographical range and extremely low economic threshold levels. More than 13 genera belonging to six families of these flies have been found to be the major pests of mushrooms in various regions of the globe. Of these *Bradysia* spp. *, Lycoriella* spp. *, Sciara* spp. (all belonging to family sciaridae) and *Magaselia* spp. (family phoridae) and some cecid flies (family cecidomyiidae) are highly destructive under Indian conditions.

Sciarida are small to medium sized delicat files of smaller and medium size with elongated abdomen, long legs and wings and are the major pests of mushrooms globally. These are attracted to the fermentation odors being emitted during cool down of peak heated compost. An adult female fly lays about 100-170 round to oval eggs singly or in the clusters in the spawned compost and casing material of mushroom beds. Larvae feed on mycelium, mushroom sporophores and decaying organic matter, and once full fed, they stop feeding and crawl into the casing surface by moving its abdominal tip and enter in to pupal phase. During summers flies breed in damp cool places. Though, known to mate in air, copulation under captivity has been recorded for the first time in *Sciara* sp. under laboratory conditions. Phorids are small hump backed black or light to dark brown flies which move rapidly with jerky movements. Adult cecids of *Mycophila* sp. are less than one mm in size and their larvae reproduced paedogenetically i.e. new generation is produced within the body of a mother larva without sexual reproduction.

Damage: Maggots of flies feed voraciously on mycelium, pinheads and emerging sporophores. In the process of feeding on the mycelium, they severe the mycelia attachments resulting in to cessation of

hyphal multiplication thus resulting into its depletion. The infected pinheads turn brown and dry prematurely without developing into the fruiting bodies. The maggots enter the sporophore/ sporocarps from the base of stipe, tunnel through the stipe to pileus where they feed voraciously on gills and render them unfit for consumption. Yield losses to the tune of 53.1 and 63.1 per cent in white button and oyster mushrooms have been recorded at inoculums level of 200 maggots at spawning time.

2. **Coleopteran pests:** Number of beetles belonging to different families *viz*., *Cis bilamellatus, Cyllodes bipligiatus, C. bifacies, C. whiteii, C.ater, C. literatus, Hadraule blaisdelli, Lasioderma serriccorne, Mycotretus apicalis, Pleurotobia tristigmata, Scaphisoma tetrastictum Sulcacis curtulus, Staphylinus* sp. etc. have been reported from mushrooms.Recent studies conducted in mushroom farms of the state revealed the presence of four genera of beetles viz., *Cyllodes indicus, Scaphisoma nigrofasciatum, Staphylinus* sp., and *Spondotriplax .pallidipes* in mushroom farms of H.P. Of these, detailed studies on morphology, biology, damage potential and management of most prevalent beetle *Cyllodes indicus* only has been done in the country. Commonly regarded as 'Sap Beetles', the adults of *C. indicus* are 4-5 mm in size with broadly oval body with three segmented, clubbed antennae and shining black elytra cut off squarely at the apex exposing one or two apical abdominal segments and an orange coloured spot on each elytra

Damage: The beetles infest the cropping bags of oyster mushroom. Both adults and grubs feed on the mycelium as well as sporocarps. They prefer to feed upon the soft tissue of stipe, gills and pileus. The grubs and adults fed on the mushroom mycelium until the fruiting bodies start to emerge and once the pin heads emerge, they become the preferred sites. The adults make irregular holes in the stipes of sporocarps of oyster mushrooms resulting in to their deformity.

3. **Collembolan Fauna:** Springtails have been known to infest and cause serious damage to button, oyster, shiitake and milky mushrooms in India. Out of number of genera reported to be associated with mushrooms *Achorutes armatus* and *Lepidocyrtus cyaneus* are of common occurrence in mushroom farms of India.

Damage: These tiny pests feed upon mycelium, congregate at the base of stipe and break up the mycelia connections, causing drying of emerging pin heads. They damage sporocarps/gills/buttons of mushroom as well by causing pitting and browning of buttons at the point of feeding in button mushrooms and destroying the gill lining in oyster and shiitake mushrooms.

4. **Mites:** Mites are small arthropods belonging to the class Arachnida and are considered to be minor pests. Thus, knowledge of mites associated with mushroom is still fragmentary. Of more than fifty four species of mites belonging to seven families of Arachnida recorded from cultivated mushrooms, *Tyrophagus putrescentiae* is the most commonly occurring mite in mushroom beds. Another commonly occurring mite in mushroom houses is *Tarsonema myceliophagus.* This shiny light brown mite is too small to be seen with a naked eye.

Damage: The myceliophagus mites are voracious feeders forming holes/cavities on stalks and caps. The mites enter the stipe from the growing substratum, tunnel through the stipe and in case of severe infestation completely hollow the buttons. Some of them gnaw the bases of mushroom stipes which in turn become rounded and acquire a reddish brown tinge.

5. **Nematodes:** Two groups of nematodes *viz*., myceliophages and saprophages are harmfully associated with mushroom cultivation. While myceliophagous nematodes effect the crop yields by direct feeding with the help of a hypo-pharyngeal needle like protrusible stylet in their mouth through which they suck the mycelial sap and devitalize it, saprophages have an indirect influence due to their association with bacteria which effect the mushroom growing. In all, six myceliophagous genera, two belonging to order Tylenchida (*Ditylenchus myceliophagous* and *Pseudhalenchus* spp.) and four belonging to order Aphelenchida (*Aphelenchodes* spp., *Aphelenchus avenae, Paraphelenchus* spp. and *Seinura* spp.) have been so far reported to be associated with cultivated mushrooms. Among these the most destructive are *Ditylenchus myceliophagous* and *Aphelenchoides* with 20 species reported from mushroom farms located globally. The damage potential of species viz., *A. agarici, A. composticola, A. myceliophagus, A neocomposticola, A. sachhari* and *D. myceliophagous* has been well established under Indian conditions. Aphelenchids having a short life cycle of 7-12 days within the temperature range of 22 to 28° C multiply very fast and play havoc with the crop.

In all, some 20 genera of saprophagous nematodes have been recorded in mushroom compost / beds. Recent studies in India showed the prevalence of saprophages like *Panagrolaimus fuchsi, Acrobeloides beutschlii* and *Caenorhabditis elegans* in mushroom farms in HP. Recent studies conducted on the role of these nematodes have presented a complex relationship existing between button mushrooms, bacterial microflora prevailing in growing substrate and saprophagous nematodes.

Damage: Myceliophagous nematodes thrive in compost and/or casing and as the mycelia growth initiates, they penetrate and puncture the mycelial cells through needle like stylet and suck the mycelia sap. Myceliophagous nematodes incur economic losses to the mushrooms; the extent of damage depending upon the nematode species involved, its initial inoculums level and the stage of cropping when nematode found entry into the beds. Total crop failures are not uncommon when these forms infest the mushrooms at spawning time. Saprophagous nematodes cause considerable yield losses by spreading specific bacteria responsible for inhibiting the mycelial growth. Yet the losses incurred are low as compared to that caused by myceliophagous nematodes.

Management : Maintenance of proper hygiene in the farm is the key to avoid mushroom pests from entering the cropping yards. Integration of various compatible measures is the key to successful management of insect pests. Management techniques including exclusion, cultural, resistance and biological control. Some of the points to be kept in mind for management of these pests are as follow:

Accurate identification of the pest, its biology and behavior, factors influencing its entry and dissemination in the mushroom farm, multiplication rate, seasonal abundance are of prime importance before going for management against any pest.

Monitoring of insect pest population through traps and study of their economic threshold level is of utmost significance. Screening of doors and ventilators of mushroom house with 35 mesh wire screen or more does not permit the entry of flies through theses ingress points.

Since mushrooms are extremely delicate and are mostly consumed fresh, use of chemical insecticide should be avoided and in no case the fruiting bags should be sprayed with any chemical spray. However,

compost can be treated with lindane 20EC @ 200 ml diluted in water per ton of straw at last turning can be used. Similarly casing can be treated@ 15 ml lindane diluted in water to mix well in one quintal casing.

Biological control using parasites, predators, pheromones, repellents antifeedents etc. if exploited fully would be the most feasible and successful method of management against mushroom insect pests. Entomopathogenic nematodes like *Steinernema feltiae, S. carpocapsae and Heterorhabditis bacteriophora* are known to parasitize sciarids, phorids and cecids infecting mushrooms and are available in commercial formulations for use against dipteran pests of mushrooms. However, these have not been exploited at the level of mushroom growers in India.

The bacterium *Bacillus thuringiensis* strain *israelensis* is effective against a few sciarid and phorid flies. Springtails can be managed if compost is prepared on pucca floor and bags are placed at a height from floor. Disinfection of composting yard and empty cropping rooms with mild insecticide like Malathion @ 0.05% also helps in curtailing their infestation. Use of clean mite free ingredients of compost, clean casing material and screening of windows and doors of mushroom house to avoid the entry ofinsects are the key factors to avoid mites.

No chemical barring Thionazin @80 ppm during the spawn run has been found to be safe without any residue as well as effective against nematodes infesting mushroom. Some antinematode fungal formulations *viz*., *Arthrobotrys oligospora* and *A. supera, A. irregularis, Candelalrella musiformis etc* have been found to be effective against myceliophagous nematodes in India and abroad. *Arthrobotrys robusta* strain Antipolis has been commercially made available for the management of mushroom nematodes in France. Interestingly, various species of oyster mushrooms viz., *Pleurotus ostreatus, P. sajor caju, P. cornucopiae and P. citrinopileatus* have been found to have nematophagous preinciples.

Various plant products and cakes, when applied in compost have yielded promising results against nematodes. Dry neem leaf powder @ 2% on w/w basis when mixed in compost at spawning reduces the nematode population significantly, eventually leading to increase in sporophore production Karanj cake@ 2% and neem cake @ 4% have also found to be very effective. Mushrooms like *Agaricus edulis, Pleurotus* spp. and *Stropharia rugosa annulata* are resistant to myceliophagous nematodes.

Heat treatment is perhaps the most efficient way to get rid of the menacing nematode pests. Pre-spawning treatment of compost and casing medium at air and bed temperature of 60°C for two hours makes them nematode free. Cook out temperature of 70 °C for 5-6 hours or 80° C for one hour in the cropping rooms is effective. Implements can similarly be sterilized at 55-60°C air temperature for 1.5 hours. Though most effective, heat treatment is highly expensive and cumbersome and small growers do not afford it.

V-L-4. Culture stability, commercial scale cultivation and shelf life studies on the silver-silk straw mushroom, *Volvariella bombycina*

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The study covers stability of mycelial cultures and mycolytic enzymes activity in six strains of three different species of straw mushroom on storage at refrigerated conditions, yield optimization and nutritional analysis of silver-silk straw mushroom, *Volvariella bombycina* vis-à-vis Chinese straw mushroom *V. volvacea*, shelf life of *V. bombycina* fruit bodies under refrigerated conditions and acceptability of Indian style dishes prepared from it. *V. bombycina* exhibited highest stability of cultures (76 days), followed by a strain of *Volvopluteus earlei* (50 days) coincided with highest activity of protease and lowest of N-acetyl-ß-glucosaminidase. Highest yield was obtained from beds of 12 and 18 kg capacity prepared out of composted substrate of paddy straw + cotton ginning mill waste (1:1, w/w). *V. bombycina* exhibited excellent keeping quality up to 7 days of storage at 4 ± 2 °C with wt loss of 5.80% and slight changes (± 4.17 to 6.95 %) in nutritional attributes.

V-L-5. Holistic approaches for management of pest and diseases in mushrooms

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In spite of varied agro-climatic conditions and huge agri- and industrial wastes available in India, pace of growth of mushroom industry is slow as compared to other mushroom growing countries. Among the several factors, occurrence of pests and diseases significantly affect the production and also the interest of growers in this enterprise. Many growers cultivate mushroom under natural climatic conditions and many abandon mushroom growing after 2-3 crops because of pests and disease problems. Wet bubble and yellow mould take heavy toll of the crop every year. Moreover, mushroom growing is a kind of monocropping which provides an easy access to food for insect-pests and medium for disease development. Short duration of the crop, deleterious effect of pesticides and residue problems limit the scope of liberal pesticide application in mushrooms. Crop protection operations in field crops are many but cannot be adopted as such in mushroom production. To achieve effective control of pests and diseases, due attention must be given to some of the activities starting right from the composting phase. Composting should be carried out on cemented floor. Proper moisture should be maintained in compost and proper pasteurization i.e. 59^{o}C for 6 hours with ample aeration. Casing should be pasteurized at 65^{o}C with 65% moisture. Empty rooms must be treated with 2% formalin. Proper hygiene and sanitation must be maintained in and around mushroom house and foot dips must be used. 150 ppm bleaching powder should be sprayed for controlling bacterial diseases. Harvesting should be done from new rooms to older rooms. Light trap can be used for monitoring and controlling fungal gnats. Cook out (chemical/ steam) should be carried out after termination of the crop. Bags should be drenched with 2% formalin before disposing off or 70 ^{o}C temperature must be maintained inside rooms for 8-10 hours. Spent mushroom substrate should be disposed off in pits away from mushroom farm and covered with layer of soil. During compost filling and spawning, the personnel doing this work should not be allowed to enter a clean corridor or the warehouse, or contact personnel engaged in harvesting mushrooms. All other workers on the farm should not be allowed to be in the working corridor and the growing room where the work is being done. By strictly following above mentioned steps pests and diseases can be effectively controlled.

Oral Presentations

V-O-1. Evaluation of bacterial antagonists against *Mycogone perniciosa* causing wet bubble disease of white button mushroom (*Agaricus bisporus*) in Kashmir

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Wet bubble is a devastating disease affecting the crop production of white button mushroom. Wet bubble disease causes extensive damage by bringing soft rot or decay of whole fruiting body. If not controlled well in time, the pathogen causes havoc damaging the entire crop. It causes serious crop losses in mushroom farms in India. The aim of the present study was to evaluate the *in vitro* and *in vivo* efficacy of antagonists against wet bubble (*Mycogone perniciosa*) associated with the cultivation of *Agaricus bisporus*. Among bacterial antagonists evaluated in vitro, all the test antagonists, *P. flourescens, B. subtilis* and *Azotobacter* sp., exhibited stimulatory effect of varying degrees on *A. bisporus* mycelium. *Pseudomonas fluorescens*-103, *Bacillus subtilis*-116 and *Azotobacter* sp.-106 gave mycelial growth 100.0, 98.88 and 98.51 per cent inhibition of the mycelial growth of *Mycogone perniciosa*, respectively. The incorporation of bacterial antagonists such as *P. fluorescens, B. subtilis* or *Azotobacter* sp. at different concentrations in pathogen-infected casing also resulted in appreciable disease control with corresponding yield gains.

V-O-2. Evaluation of locally available agricultural wastes for growth and yield potential of *Pleurotus* species

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Mushroom cultivation is the most suitable technology for creating wealth and health out of wastes from plants, animals and industries which are abundantly available on earth. Huge quantities of agricultural wastes and other organic wastes are generated annually through the activities of agricultural, forest and food processing industries. These wastes can be utilised for mushroom production. Seven locally available agricultural wastes were evaluated for growth and yield potential of five (PL-1, PL-2, PL-3, Psc-1 and Psc-2) *Pleurotus* species. Wheat straw was found best substrate for all species of *Pleurotus* in the all parameters such as growth period (spawn run period, pin head initiation, first, second, third and fourth flush harvesting or total cropping period), yield potential (no. of fruiting body, average length and width of stalk, diameter of cap, total length of sporophore, maximum and minimum weight of fruiting body) and total yield. Whereas, *Saccharam* straw and *Parthenium* waste as such were not suitable substrates but when combined with wheat straw, gave good yield in both years. The *Ficus* leave when combined with

wheat straw was also found to give better performance for all five *Pleurotus* species. *Parthenium* waste is new substrate used for the cultivation of *Pleurotus* mushroom.

V-O-3. Utilization of nitrogen rich supplements for quality and quantity improvement of *Lentinula edodes* and *Calocybe indica* and its propagation in villages of Haryana

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Medicinal mushrooms are consumed for their nutritional and therapeutic attributes worldwide. Although medicinal mushrooms like *C. indica* and *L. edodes* are rich in β-glucan polysaccharides, triterpenoids, antioxidants and various other bioactive molecules, their consumption is quite limited in India. Our country has all types of lignocellulosic waste materials which can be efficiently utilized for the cultivation of both these mushrooms. It has been reported that the supplementation of substrate with nitrogen rich sources improves the quality and quantity of the mushrooms considerably. Keeping in view the above facts, supplementation of basal substrates with nitrogen rich sources like cotton and mustard seed cakes (2, 3, 5 and 10%) for *L. edodes* and leafy biomasses of *Syzygium cumini, Cassia fistula* and *Bauhinia variegata* for *C. indica* (25, 50 and 75%) was carried out. The results revealed that the addition of 2% of cotton seed and mustard seed cake showed maximum Biological Efficiency (BE) of shiitake i.e. 60.95 and 55.78% respectively. In case of *C. indica* the wheat straw supplemented with 25% of *B. variegate/ S. cumini/ C. fistula* leafy biomass gave 82.93, 73.56 and 73.67% BE respectively while in control the BE obtained was 72.6%. The fruit bodies harvested from different treatments were analyzed for nutraceutical composition. Subsequently, efforts were made to propagate the *C. indica* cultivation and consumption in some selected villages of Haryana, distt. Gurgaon. In the present study yield (BE), nutritional properties and medicinal properties of the fruit bodies of the *C. indica* along with its propagation in the selected villages in Haryana was carried out.

V-O-4. Effect of substrate moisture on the production of straw mushroom, *Volvariella volvacea*

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Straw mushroom (*Volvariella volvacea*) is extensively cultivated in Odisha as a profitable business enterprise. It is cultivated in cuboidal beds with layer spawning. Keeping in view the absence of very limited research on the optimum moisture requirement of the substrate, an experiment was conducted to determine the effect of substrate moisture on the production of straw mushroom, *Volvariella volvacea*. Varied moisture contents *viz.,* 0 (dry straw without soaking), 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 % were maintained in the substrate prior to spawning. It was observed that soaked paddy straw with 60 %

moisture sustained the highest mushroom yield (1214.7 g, 12.1 % BE) compared to other treatments. Dry straw (without any soaking) failed to produce any fruiting body. The increase in moisture content from 10 to 60 % was directly proportional to the increase in yield. However, there was a gradual decline in yield as the moisture level increased from 60 to 90 %. There was no fruiting in saturated moisture (100 %) condition. It has commonly been observed that the top layer of a straw bed, having the same moisture status as other layers, produces very sparse or no fruiting. This adversely affect the overall productivity of the bed. Therefore, another study was conducted, where in, the moisture content of the top/covering layer was allowed to have different moisture levels such as 0 (dry straw, without soaking), 10, 20, 30, 40, 50 and 60 % whereas the remaining three layers contained 60 % moisture. It was revealed that, 30 % moisture in the covering layer was optimum to support maximum fruiting (463.7 g) on the top surface leading to highest overall production in the bed (1416.4 g, 14.1 % BE).This was significantly higher than that of the normal practice (1140.7 g, 11.4 % BE) of having 60 % moisture uniformly in all the layers. The beds covered with dry straw produced only 10.4 g of fresh mushrooms leading to significantly lower total productivity (938.4 g, 9.3 % BE).Therefore, it was inferred from the study that moisture content of 30 % in the top layer and 60 % in all other layers in a bed were optimum for obtaining higher yield of straw mushroom.

V-O-5. Studies on design of non-conventional energy based mushroom growing sheds for hilly regions

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Mushrooms are fungi and an important source of protein food due to their nutritive values. They are being grown almost in every part of the country for more than three decades. India has large domestic market and enormous potential of export of fresh, dried and preserved mushrooms. In hilly regions mushroom growing has emerged as fast developing industry and their cultivation has been established as a cottage industry. Low temperatures, high humidity, good amount of air circulation are ideal environmental factors for healthy growth of mushroom. Most of the time in hilly region, these environmental conditions may be achieved naturally by appropriate design of mushroom growing houses based on non-conventional sources of energy. Hence, the need was felt to evolve energy efficient design of mushroom growing houses for marginal and big growers. Studies were carried out to design mushroom growing sheds utilizing solar and wind energy for creating indoor environment conducive to greater production of mushroom for marginal and small growers of rural hilly regions. Design of mushroom growing rooms with approximately 200 sq m cultivation area and external dimension of 18.00 x 6.00 x 3.80 meters for cropping under natural and controlled environment has been developed for hilly regions. The thermal performance of mushroom shed developed has been evaluated. The indoor environmental temperatures have been estimated for the different months using a computer program developed in CBRI which is based on admittance procedure. It has been found that the evolved design based on minimum consumption of conventional energy enables the growers to grow button mushrooms for about six months (October-March) and for oyster and other varieties of mushrooms for 8 months (September – April).

V-O-6. Influence of substrates, spawning and post-spawning practices on yield and yield attributing parameters of Indian oyster mushroom, *Pleurotus pulmonarius*

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Nine agro-wastes including the paddy straw were evaluated for their influence on yield and yield attributing parameters of *Pleurotus pulmonarius*. Varying performance was observed among the substrates in days to spawn run and fruit harvest, average weight of sporophores and biological efficiency. The conventionally used substrate, paddy straw, was found superior among the substrates in terms of fruit yield (99.3 %) followed by maize stalk (92.3 %), maize cob (91.9 %), green gram stick (88.3 %) and paddy husk (80.3 %). Sugarcane bagasse, coconut coir, rice bran and saw dust were proved to be the poor yielders with 61.1, 64.4, 70.2 and 77.4 % biological efficiency. Superiority of paddy straw was established in terms of days to spawn run (16.3), days to first harvest (21.3) and average weight of fruit bodies (10.7 g) among the substrates. Among the spawning methods followed, both layer spawning and through mixing ones were statistically at par yielding 97.7 and 96.9 % biological efficiency. However, the top spawning method was inferior in terms of yield (78.4 %). It was further observed that the yields obtained out of both uncovered bags (97.3 %) and the bags with 1.0 cm holes (96.5 %) were statistically at par with one another. Moreover, bags with smaller holes were comparatively poor yielders (91.7 %).

V-O-7. Designing and construction of aerated bunkers with spigot floor

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In cultivation of button mushroom there have been many changes in preparation of compost in last few decades. One of the recent change has been shift from pile system to bunker system for Phase-1 composting. The bunkers can have plenum (low pressure system) or pipes with the spigots (high pressure system) below the compost. The latter is more prevalent and design and construction of such aerated bunker is described here. The system has a fan, main header pipe, sub-pipes fitted with spigots that have small hole opening in a groove in the floor. For efficient system there is need to understand the quantity of air required, its speed at outlet, size of pipes, fan, etc. Some of the basic parameters are described here.

The air in Cubic Meter per Hour (CMH) required for phase-1 is 10-15 m^3/h/ton of input compost in phase-1. Input compost means the compost weight taken during the start of fermentation. The weight loss during phase-1 is about 30% and during phase-2 is also about 30%. So for making 50 ton of compost the material we start with is about 100 ton. The pressure required for centrifugal fan in phase-1 is in between 4500-6000 Pa. The filling weight in phase-1 is 1.8 ton compost/m^2 maximum which results in filling height of 3.6 m. This maximum value is used only if the filling is done by bunker filler which means

that the filling is done loosely. Otherwise the filling weight should be taken as 1 ton compost per m^2 of input weight which leads to filling height of 2 m maximum.

The size of PVC pipe used below the compost is usually of 110 mm or 160 mm diameter. Both pipe sizes have matching spigot sizes available in market. For small bunkers 110 mm pipe can be used and for large bunker 160 mm pipe may be used. The hole in each spigot is to be around 5-7 mm in Phase-1/ bunker floor design and the spacing between spigot to spigot would be around 400 mm and pipe to pipe would be around 400 mm. This will make a grid of 400 mm X 400 mm of air outlets. Each spigot roughly gives an output of 4-5 CMH of air which in turns gives velocity at outlet of hole of around 40 m/s when drilled with 5-7 mm hole.

All the pipes at the opposite end of fan should be connected with PVC pipe header by using PVC pipe fittings. Usually in India, people close each pipe with end cap from which in due course of time air start leaking. And it also requires to be opened every time when it get filled with water which itself is a complex process. If we join every pipe at the opposite side of fan with PVC fittings like tee it will collect the water and will send it to gudy pit/gull tank. In between we are required to make air lock system. The purpose of air lock to stop the air coming out and the water that can easily drain out through the same pipe by gravity. This is done by dipping the outlet PVC pipe to depth of 1 meter in the airlock tank, made of concrete or brick work. The outlet of airlock goes to gudy pit thereafter.

The fan used in phase-1 in almost all cases uses total fresh air and no return air. Few companies in western countries use some of the return air because of environmental issues. The easiest way for the phase-1 is on/off system as the design is not so complex like in VFD driven motors. The VFD driven motors runs on the output signal given by computer control which further takes input signal from compost like oxygen content in compost and temperature of compost at various locations. Oxygen sensors are very sensitive equipment to handle upon.

As the pressure required by the bunker fan is high, usually the fan selection comes out to be at higher RPM. For example most often it would be 2800 rpm in direct drive fan. During start of motor the current drawn by motor is very high due to high starting torque. And this happens every time when motor starts. This reduces the life of contactors and motor and gives unnecessary jerk load to DG set. The solution to this problem is that we need to reduce the starting torque in motor. This is only possible if we reduce the weight of impeller considerably. For this reason I always recommend high pressure fan in Aluminium impeller. This type of fans can sustain larger no. of on/off in motor.

We need to make cavity line over the spigot aligned parallel to PVC pipes through some trapezoidal wooden strip special made for the purpose. The cross sectional size of that trapezoidal wooden strip is 30 mm X 35 mm X 40 mm X 35 mm. This strip is taken out after pouring and curing of concrete. This will make a depth of cavity 35 mm high and from top side it would be 40 mm wide. The reduced width at bottom i.e. 30 mm makes the strip easier to come out because of taper in it. The purpose of making this cavity is to secure the spigot from breaking due to regular movement of heavy machines and loader.

The bunker floor finished with trimix flooring using floor hardener chemical will always give better result, as it would make floor abrasive resistant to wear and tear from loader's heavy movement. The

concrete grade of minimum M20 should be poured for the flooring of bunker. Also the reinforcement of steel should be used according to the movement of machines expected.

V-O-8. Cultivation and yield evaluation of wild *Pleurotus* spp. from Western Ghats of Maharashtra

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The total 15 wild isolates of oyster mushroom collected from Western Ghats region of Maharashtra and submiitted to DMR for accession numbers were selected for the artificial cultivation and yield evaluation studies. The three years pooled data of different wild edible *Pleurotus* spp. showed statistically significant differences for all the growth parameters *viz.,* days required for spawn run, pinheads formation, first, second and third harvest. Significantly lowest days were required for complete spawn run for strain PN-14-41 (16.08 days) followed by the check (17.42), PN-14-38 and PN-14-40 (18.08). Days required for pinhead formation were significantly lowest (3.67) in the strain PN-14-41. The significant early fruiting i.e. first harvest was recorded in the strains PN-14-41 (24 days), followed by the check *P. sajor-caju* (25.3 days). Whereas, early second harvest was noticed in stain PN-14-41 (35 days) which was statistically at par with check (36.08 days). The minimum number of days for third harvest were noticed in PN-14-41 (47.9 days) which was statistically at par with the check (50.4 days) followed by PN-14-38 (53.6 days) and PN-14-40 (52.8 days) as compared to other strains under study. However, the maximum number of days for first, second and third harvest were noticed in the strains PN-14-42 (33.4 days), PN-14-50 (43.3 days) and PN-14-42 (61.0 days).

The significant variation was observed in all the morphological characters *viz.,* stipe length, pileus diameter, average fruit body weight, colour and odour. The pileus diameter and stipe length of mushroom fruiting bodies varied from 4.36 to 6.50 and 0.91 to 2.38 cm, respectively. The highest pileus diameter of 6.50 cm was recorded in check strain *P. sajor-caju* which was statistically at par with PN-14-41 (6.25 cm), PN-14-25 (6.26 cm) and PN-14-46 (6.31 cm). The significantly highest stipe length (2.38 cm) was recorded by the check as compared to other strains under study. The significantly lowest pileus diameter (4.34 cm) was recorded in strain PN-14-48, whereas lowest stipe length (0.91 cm) was recorded in the strain PN-14-50. The average fruit weight varied from 6.48 to 3.97 g in different strains. The check strain *P. sajor-caju* recorded highest fruit body weight (6.48 g) which was found to be statistically at par with the strain PN-14-38 (6.28 g) followed by PN-14-41 (5.89 g) and PN-14-46 (5.66 g). The minimum average fruit body weight (3.97 g) was recorded in the strain PN-14-25. The vast variation in mushroom fruitbody colour and odour was also observed in different strains under study. The light pink to dark pink colour was recorded in strains PL-14-40, PL-14-41, PL-14-47, PL-14-48 and PL-14-50. The acceptable pleasant odour was observed in PN-14-40 and PN-14-47, whereas, mild anise odour in PN-14-41 and PN-14-50 was observed.

The pooled data for yield performance of different wild edible oyster strains revealed the significant differences in total yield on wheat straw substrate. The significantly highest yield of 977.42 g/kg dry substrate was recorded by the strain PN-14-41 followed by the check strain *P. sajor-caju* (896.25 g/kg dry substrate),

PN-14-46 (888.75 g/kg) and PN-14-48 (879.50 g/kg). However, the lowest yield (575.83 g/ kg) was recorded in the isolate PN-14-42. The wild edible pink coloured strain PN-14-41 of oyster mushroom, was found statistically superior among all the wild strains and standard check *P. sajor-caju* for growth and yield parameters.

V-O-9. Opportunities of diversification of mushroom cultivation in India with special reference to straw mushroom

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India is blessed with varied agro-climate, abundance of agricultural waste and man power making it most suitable for cultivation of all types of temperate, sub-tropical and tropical mushrooms. It is estimated that about 600 million tonnes of crop residues are generated annually, a large amount of which are burnt in the field after harvest of crop in order to clean the field for growing next crop. In this process, a large amount of potent source of organic carbon and nutrient is lost which could otherwise be recycled back to the field. Besides cereal straw, a large amount of vegetable and fruit wastes (8-9 tonnes), coir dust, husk, dried leaves, coffee husk, tea wastes etc. may be available for recycling. If only one per cent of it is utilized for mushroom cultivation, India will be a major mushroom producing country. Mushroom production represents one successful microbial technology for conversion of agro-wastes into nutritious food. Indoor cultivation of mushroom utilizes the vertical space more efficiently and the crop is regarded as the highest protein producer per unit area and time among the components of traditional agriculture and animal husbandry. This horticultural activity has a promising scope to address the issue of nutritional security without undue pressure on land. Therefore, mushroom growing could be well popularized as an ideal income generating activity for the rural and semi-urban youth of the country.

Mushroom production: The global and national scenario

Mushrooms occur seasonally in many parts of the world in various habitats ranging from sandy plains to tropical forests and green meadows to road sides. More commonly grown species with good export potential are *Agaricus bisporus* (white button mushroom), *Pleurotus* spp. (oyster mushroom) and *Volvariella volvacea* (straw mushroom). Mushroom farming today is being practiced in more than 100 countries and its production is increasing at an annual rate of 10 per cent. Present world production of mushrooms is around 3.5 million tonnes. China is an example of success through low cost community based technology and diversification of specialty mushrooms making it a leading mushroom producing country of the world. At present the mushroom production of India is estimated to be around 1,20,000 tonnes/annum. However, major share (75%) is contributed by button mushroom though specialty mushrooms have greater scope in the country.

Scope of specialty mushrooms

Varied agro-climatic conditions and availability of agricultural and industrial wastes offer great opportunities for cultivating specialty mushrooms more particularly straw mushroom in commercial scale.

An ever increasing public craze for new and different foods adding variety, flavour and appeal to the food besides being nutritious because of their protein, fibre, vitamin and mineral contents make straw mushroom an appropriate component of the mushroom portfolio of the sub-continent. The average temperature requirement for fruiting of straw mushroom indicates that it can be successfully cultivated under natural climatic conditions prevailing in most of the agro-climatic zones. Moreover, huge quantities of lingo-cellulosic and other organic wastes are generated through the activities of agricultural, forest and food processing industries which could otherwise be degraded by the enzyme complexes possessed by mushroom resulting in a highly valued food protein. However, button mushroom alone contributes about 75 per cent of the total mushroom production in the country followed by oyster and paddy straw mushrooms paradoxical to the prevailing climate. Fortunately, straw mushroom has made inroads into south-east Asian countries with India as an exception.

Mushroom production: The state scenario

Mushroom production has attained the status of a cottage industry in the coastal plains of the state. Now Odisha is a leading state in terms of mushroom production with an annual production of 15,986 tonnes contributing to 13 per cent of the total output of the country. Straw mushroom production has reached an all time high of 9,550 tonnes/annum accounting for 60 per cent of the total mushroom production of the state.

Cultivation of straw mushroom: The conventional approach

Straw mushroom is well suited for cultivation in tropics because of its requirement of higher production temperature (34-35^{o}C). In addition, the mushroom grows on non-pasteurized substrate more desirable for low input agricultural practices. It is cultivated outdoor as an intercrop in the shades of coconut, areca nut, mango, jackfruit, bamboo, cashew nut, casurina and banana plantations of the hot and humid climate of coastal agro-climatic zone during summer and rainy seasons. The average biological efficiency hovers at 10-15 per cent in spite of the incidence at competitor moulds, diseases and insect pests. However, outdoor farming is increasingly popular owing to low capital investment. It seems that there is no viable alternative to the constraint ridden outdoor cultivation of straw mushroom for the resource poor farmers.

Mushroom cultivation under protected condition: The need of the day

It is imperative to say that mushrooms cannot be grown year after year with full commercial access, unless proper growing conditions are provided and adequate facilities are available for the control of diseases and insect pests. Possibly, such conditions can be fulfilled in shelf growing, by the construction of properly insulated and ventilated mushroom houses accommodating store room, cropping room as well as packing and preservation room. In Odisha, raising of simplified and low cost thatched mushroom houses are being encouraged for round the year cultivation of mushrooms with greater precision. Various modifications of the thatched houses are being designed now-a-days in order to make it more permanent and mushroom friendly. Shade net houses and houses having asbestos roof are therefore, viable alternatives to the thatched sheds. In view of the higher sale price of the produce, off-season or winter cultivation of straw mushroom is gaining popularity. Hence, poly house cultivation is being popularized during winter season wherever growers are interested.

Indoor cultivation using partially composted substrate

In door cultivation of straw mushroom with partially composted substrate can be a boon for the growers in view of its higher productivity (30-45 per cent). This system has successfully been initiated in Odisha and efforts are on to popularize it among the growers in spite of the fact that it is not farmers' friendly owing to its high capital investment.

Economics of straw mushroom cultivation

Straw mushroom cultivation is a profitable enterprise. The cost of raising one bed of straw mushroom of 18'' x 18'' x 18'' (L x B x H) size comes to Rs.60/- with production of one kilogram of mushroom at minimum within a crop cycle of 21 days. The net return is Rs.60/- per bed assuming the market rate at Rs.120/- per kilogram of produce. A model small production unit (300 sq.ft.) with the investment of Rs.25,000/- accommodating 1260 beds of straw mushroom in three tiers from February to November, gives an estimated net income of Rs.75,600/- (Rs.7,560/- per month).

The road ahead

In spite of the fact that specialty mushrooms including straw mushroom are for more popular than *A. bisporus* in East Asian countries including China, things are altogether different in India. Having given ideal climate, raw materials and man power, we have not been able to diversify the mushroom cultivation as per our requirement. Cultivation of straw mushroom can well be popularized among millions of resource poor farmers for their livelihood owing to its fast growing nature, easy and simple cultivation method and of course, greater acceptability. The authors would like to recommend low cost structures for the commercial cultivation of straw mushroom round the year which would pay rich dividends to the mushrooms growers in general and small and marginal farmers in particular.

V-O-10. Engineering interventions in Indian mushroom industry

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Mushroom is an indoor crop which requires well designed protected structures along with environmental control systems for maintaining temperature, relative humidity and required oxygen and carbon-di-oxide levels. A complete mushroom industry encompasses spawn production, cultivation and post harvest handling of the produce and value added products. All these activities require specific tools and machinery for creating an efficient production system. Although there are numerous mushroom production related machinery available globally, yet the Indian mushroom industry is largely manual till date. Engineering interventions for the Indian mushroom farming hold the key towards evolving it as an industrial crop. Hence, development of indigenous mushroom machinery is very essential to suit the skill of the rural operators and economical feasibility for its adoption. Keeping in view these factors, an initiation was made at ICAR-IIHR Bengaluru by developing indigenous spawn production machinery which have been adopted by many private and public spawn laboratories in India. Along with these machinery, the

commercially available equipments namely autoclave, laminar flow and incubator are enough to equip spawn industry. On the other hand for mushroom cultivation system requires machinery and tools for preparation of substrate, handling of substrate, filling and spawning of mushroom growing bags to enable efficient utilization of inputs and labour. Post harvest equipments for storage and packaging are also essential in the mushroom industry. Engineering interventions in conceptualizing and development of the growing structures, machinery and equipments are required keeping in view of the requirement for better quality cultivation practices and economical feasibility of its adoption by the Indian growers. These interventions should enhance the labour efficiency, reduce drudgery and better quality of operation in comparison to manual operation. It would save inputs in spawn production and mushroom production. Due to availability of various job opportunities in the growing Indian economy, the availability of farm labours is reduced in the rural areas. Mechanization helps to solve this problem too. Mushroom industry is energy intensive in using heat energy in boiling and sterilization/ pasteurization. The solar energy based water heating, steam generating and electric power generation systems can be suitably adopted to reduce the usage of electrical energy substantially. There are commercially available temperature and humidity maintaining systems which can be adopted at various level. The post harvest management in terms of cold storage, wrap film packaging and sealing are also available for adoption. Indian mushroom industry stands to gain enormously , if these engineering interventions are scientifically developed and integrated, which will enhance the quality production, save the input costs and there by increasing the profit of the growers in total.

V-O-11. Popularization of pipe method of button mushroom compost production in Bihar

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The pipe method of button mushroom compost production technology was evaluated at different locations in Bihar and it was compare with other existing methods i.e. long method of composting and pasteurized method of composting. The result of 10 locations i.e. of Bihar during 2014-15, 2015-16 and 2016-17 is presented in the present paper. The locations includes Pusa, Thahra Gopalpur and Kusaiya of Samastipur, Lolgan- Vaishali, Meenapur- Muzaffarpur. Tetaria -East Champaran, Chandi- Nalanda, Lahriasarai- Darbhanga, Pachwania- Madhubani, Runnisadipur- Sitamarathi. The compost ingredients includes: wheat straw- 1000 kg, mustard Cake-100kg , Gypsum-50, wheat bran- 100kg, urea 25 kg, MOP – 25 kg and SSP-50 kg, were used in all three methods. Log method and Pipe method compost were prepared at all locations but pasteurized tunnel compost was prepared at Pusa and supplied to all locations for comparison. Four hundred kg compost in each method was spawned @ 600 g spawn per 100 kg compost. Data in the form of Days for spawn run, Days for case run, days for pinhead initiation and yield per 100 kg compost was recorded. Besides daily temperature and humidity. The yield data was recorded up to 50 days after pinhead initiation. Out of three methods of compost production i.e pasteurization tunnel method, Pipe method and long method of composting, maximum yield was obtained by Pipe method i.e. 23-25 kg per 100 kg compost and at par to pasteurization tunnel method (25-27kg/ 100 kg compost) however yield ranges 14-18 kg per 100 kg compost in Long method of composting. Pipe method

of composting was superior to long method of composting in terms of yield, time and labour expenses. Result indicated that compost prepared by Pipe method was ready within 15 days for spawning as compared to long method of composting (prepared within one month). As regards expenses on wages, Pipe method needs only two turning whereas long method of composting need 8 to 10 turning within month. Pipe method is less expensive as compared to both method of composting. In North Indian Plaines Pipe method may be recommended for button mushroom seasonal growers.

V-O-12. Button mushroom compost making by using the spent substrate of the previous button mushroom crop

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Button mushroom grows on a well decomposed substrate called as compost. During its growth, it obtains nutrition and moisture from the compost leading to creation of an uncongenial growing environment and it ceases to give fruit bodies after a certain period. This left over substrate is called as spent mushroom substrate (SMS). On an average the production of 1 kg of button mushroom led to generation of 3-5 kg of the spent substrate. SMS is not finding many uses for mushroom growers and it creates nuisance and environmental pollution. Considering the nutritional composition of the button mushroom spent substrate, a series of experiments were carried out to use it as a basal ingredient in partial replacement of the wheat straw for button mushroom compost making. In present study, the fresh button mushroom spent substrate with around 55-60% moisture was used in three different proportions i.e. 20% w/w and balancing of nitrogen with poultry manure, 20% w/w without N balancing and 30% w/w without N balancing. Standard formulation comprised of wheat straw, poultry manure, wheat bran, urea and gypsum was kept as the control treatment. The experiment was repeated 5 times in successive years. In all trials, the compost output/unit wt. of wheat straw was higher in SMS substituted treatments compared with standard formulation. In two trials, the fruit body yield/q fresh compost was higher in all SMS substituted treatments, while in one trial it was significantly higher in 20% w/w SMS substituted treatment only and in rest it was at par with standard formulation. The compost prepared from different SMS substituted treatments was nutritional richer compared with standard formulation treatment. The total nitrogen, cellulose, lignin, total organic carbon, organic matter and potassium contents were higher in composts prepared with different SMS treatments. The nutritional profile of the fruit bodies harvested from the compost prepared with different proportions of button mushroom SMS is in the process of analysis. Compost production by substitution of wheat straw with SMS led to the saving of Rs. 600/ton of fresh compost. For a mushroom farm with 100 ton fresh mushroom production/year, the saving can go around INR 3.0 lakh (5,000 US$) and this figure can go up to INR 30.0 lakh (50,000 US$) for mushroom farm involved in 1000 ton fresh mushroom production/year. The present findings are important in terms of additional mushroom production, saving of revenue in compost making and saving of the environment.

Poster Presentations

V-P-1. Effect of supplements on the nutritional components of *Pleurotus sapidus*

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Oyster mushroom (*Pleurotus sapidus*) was cultivated on the paddy straw as basal substrate using various supplements *viz*. rice polish, wheat bran, rice bran and sawdust at different concentrations. Effect of these supplements on nutritional contents like carbohydrate, crude protein, crude fibers, crude fat, potassium, sodium, calcium, magnesium was studied. Each treatment was replicated four times. The results revealed that during the summer season, the highest yield was obtained in rice straw supplemented with 40% rice bran (w/w) followed by supplementation with 20% wheat bran and 30% rice bran respectively with a significant difference between each other. During winter season, the highest yield was found in rice straw + 10% rice polish followed by that in rice straw + 40% rice bran, rice straw +20% rice polish and rice straw + 20% wheat bran, respectively, with significant difference among them. Studies on nutritional components in various treatments in summer and winter showed that during both summer and winter season fruiting bodies produced on rice straw + 40% rice bran showed maximum carbohydrate, crude protein, and crude fibre contents. Also, lower fat content was found in the mushrooms produced with the same supplement.

V-P-2. *In vitro* interactions of *Trichoderma* species and *Pleurotus sajor-caju*

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Oyster mushroom (*Pleurotus sajor-caju*), having excellent flavour and taste, is found abundantly in Kashmir. *Pleurotus* spp. can be easily cultivated on different agrowastes, which do not need composting. This crop often suffers losses due to many fungal diseases. One of the fungal mycoparasite, *Trichoderma* spp, the cause of green mould, was observed in the samples collected from Mushroom Research Training Centre (M.R.T.C) in Kashmir valley. The pathogenicity demonstrated in accordance with the Koch's postulate both *in vitro* and *in vivo*. The symptoms included the browning of caps and curling of margins of pileus part of mushroom. The fruiting bodies often dry and shrink as well. Some fruiting bodies show symptoms of wateriness also. The *in vitro* interaction between *Trichoderma* spp. and *Pleurotus sajor-caju* on PDA and MEA was performed. Maximum inhibition of *P. sajor-caju* was expressed by *T. viride* followed by *T. harzianum* and then by *T. pseudokoninjii*. All the three species of *Trichoderma* overlap the *P. sajor-caju* mycelium. No zone of inhibition was produced by any of the *Trichoderma* spp. on both media. Amylase production test of *Trichoderma* spp., *Pleurotus sajor-caju* and *Pleurotus ostreatus*

was observed negative as no zone of clearance was observed on starch agar medium. Trybutyrin hydrolysis test of *Trichoderma* spp., *Pleurotus sajor-caju* and *Pleurotus ostreatus* was positive. A transparent zone of clearance was observed on Trybutyrin agar medium.

V-P-3. Comparative study on growth parameters of fruit body for five strains of milky mushroom (*Calocybe indica*)

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Mushroom production is the cost effective and economically beneficial source of subsidiary income. Among several cultivated mushrooms milky mushroom is an important mushroom grown in India. The growth parameters and yield attributes of five strains of *Calocybe indica* viz.,CI-4, CI-13, CI-14, CI-15, and CI-18 were studied. The results showed that CI-14 produced maximum number of fruit bodies (25) while CI-13 produced minimum. CI-4 produced fruit body with maximum average weight of 112.67 g but CI-13 produced fruit body of minimum average weight of 20 g. The CI-13 strain shown higher in average length of stalk (7.81 cm) followed by CI-14 (7.43 cm), CI-18 (6.13 cm), CI-4 (5.22 cm) and CI-15 (4.74 cm). The average width of stalk was maximum in strain CI-18 (3.17 cm) followed by CI-13 (3.03 cm), CI-14 (2.97 cm), CI-4 (2.50 cm) and CI-15 (2.39 cm). The strain CI-14 shown better performance for average diameter of cap (8.50 cm) followed by CI-4 (8.28 cm), CI-13 (7.78 cm), CI-18 (6.73 cm) and CI-15 (6.72 cm). Highest total length of fruit body was observed from strain CI-14 (10.41 cm) followed as CI-13 (10.32 cm), CI-18 (8.69 cm), CI-4 (7.36 cm) and CI-15 (6.90 cm).

V-P-4. Cultivation of Shiitake (*Lentinula edodes*) mushroom on several lignocellulosic agrowastes of Kerala

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Shiitake (*Lentinula edodes*) is one of the most important culinary and medicinal mushroom in the world reported to have anticancerous properties. Traditionally, shiitake has been cultivated on hard wood logs but recently there is a trend to cultivate it on sterilized or pasteurized substrates in order to increase yield and reduce the time of its production cycle. Mushroom cultivation has received little attention in most developing countries where millions of tons of lignocellulose rich wastes are unused. The present study will help to add one more edible medicinal mushroom to the edible mushroom flora of Kerala where agricultural by-products like sawdust, paddy straw and wood shavings of hardwood trees are available in plenty. Six different strains of *Lentinula edodes* (Le 1, Le 2, Le 3, Le 4, Le 5 and Le 6) were cultivated on various lignocellulosic wastes. Spawn run period and biological efficiency on different substrates when supplemented with rice bran and wheat bran were recorded.

For the substrate supplementation studies, the treatments used were Treatment 1: 80% sawdust and 20% wheat bran, Treatment 2 : 80% sawdust and 10% wheat bran, Treatment 3: 80% sawdust and 20% rice bran, Treatment 4: 80% sawdust and 10 % rice bran, Treatment 5: paddy straw and 20% wheat bran, Treatment 6: paddy straw and 20% rice bran, Treatment 7: paddy straw alone ,Treatment 8: 80% wood shavings of hardwood tree pincoda and 20% rice and wheat bran. The moisture of each substrate mixture was adjusted to 60% by proper mixing and filled in polypropylene bags @ 500 g substrate per bag and sterilized in autoclave for 2 hours at 121 °C and 15 lbs pressure. After cooling the substrate was inoculated @ 300 gram spawn per bag under hygienic condition and kept for incubation. The conditions provided for mycelial run was room temperature at 80% relative humidity and the bags were allowed to turn brown. Opening of bags was done after complete browning and bump formation had taken place in bags. At that time the temperature should be around 20°C with 85-90 % relative humidity. Cold water treatment was given by dipping the bags in chilled water (4-5°C) and kept for incubation at 18-20°C and 85-95% relative humidity till the pinheads appear as star like cracks. Results showed that the colonization of different substrates was achieved at durations varying from 60- 90 days after inoculation. First harvest was obtained 100 days after inoculation. Maximum number of fruiting bodies was obtained in teakwood sawdust followed by wood shavings of pincoda. Teakwood sawdust produced maximum biological efficiency in strain Le 1 (70 %) followed by Le 2 (58 %). Twenty percent supplementation of wheat bran was the best among the supplements used. Highest weight of fruiting bodies were observed in Le 1 strain (75 g). In paddy straw substrate, the mycelium colonized the substrate after a much longer time but produced no primordia even under favourable conditions. Le 6 was the least productive with a maximum biological efficiency of 28%.

V-P-5. Studies on spoilage of spawn of *Agaricus bisporus* in Himachal Pradesh, India

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Spawn is a potent source of contamination to cultivated mushroom. A number of spawn producing organizations have witnessed spawn failures due to high degree of contamination in their bottles or bags, which affected their commercial spawn quality and quantity. Although, grain spawn is currently prepared by inoculating sterilized grains with complete sterile precautions, but contaminations do occur. Various microorganisms e.g. bacteria, actinomycetes, yeast and fungi affect spawn making, sometimes leading to total spawn failure. In India 15-20 per cent losses due to spawn spoilage have been reported. Therefore the present investigation was undertaken with the objectives to isolate and identify the contaminants of spawn. Periodic survey of different spawn laboratories of Solan district of Himachal Pradesh for two consecutive years 2014 and 2015 revealed that the per cent contamination of spawn in different spawn laboratories ranged from 5-20 per cent. Fungal contaminants were isolated from spawn bags and spawn laboratory environment and were identified by National Centre of Fungal Taxonomy, New Delhi. Different fungal contaminants isolated were *Fusarium chlamydosporum, Phoma exigua, Aspergillus niger, Penicillium chrysogenu, Aspergillus fumigatus,* and *Fusarium pallidoroseum*. Among bacterial contaminants, only one species of *Bacillus* was isolated from the spawn bag whereas one species of

Straphylococcus was isolated from spawn laboratory environment. Studies on occurrence of different microorganisms in different months revealed that maximum contamination was observed during the month of August (18.33%) followed by the month of September (17.67%) and minimum was observed in the month of January (8.67%).

V-P-6. Effect of culture media on the mycelial growth of mushrooms

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Growth pattern of mushroom mycelia greatly varies with culture media. Even a slight variation of the components of culture media can influence the mycelial development. Faster production of pure culture of edible mushrooms are highly essential for its further utilization and studies. In this context an experiment was performed to assess the suitability of different media on mycelial development of five different mushrooms in College of Agriculture, Vellayani, Kerala. The media used were potato dextrose agar (PDA), carrot dextrose agar (CDA), yeast extract malt agar (YMA), malt extract agar (MEA) and potato dextrose peptone agar (PDPA) and study was conducted using *Pleurotus florida, Hypsizygous ulmerius, Calocybe indica, Agaricus bitorquis, Volvariella volvaceae*. 2% peptone supplemented potato dextrose agar (PDPA) medium was found more effective in mushroom mycelial development in the present study. Among the different media used PDPA was found best in fastening the mycelial coverage of *P. florida* (9.0 cm on 6th day), *H. ulmerius* (8.97 cm) and *V. volvaceae* (8.93 cm) in 9 cm petriplates. Peptone supplementation of the PDA media have a pronounced influence on accelerating the mycelial spread of these mushrooms. While PDPA is found least effective in mycelial development of *C. indica* which shows its inhibitory effect. On par with PDPA, MEA also found effective in development of mycelia of *V. volvaceae* (8.7 cm). MEA turned out to be the best media for the growth of *A. bitorquis* (8.83 cm). PDA media is the most effective media for development of *C. indica* (8.63 cm).

V-P-7. Cultivation of *Pleurotus eryngii* (Kabul Dhingri) in India

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Pleurotus eryngii has recently become the most commonly cultivated mushroom in east Asia. Other names used to refer to this mushroom include French Horn and King Trumpet Royale. It is commercially grown in China, Japan, South Korea, Italy, Australia, South Africa and the US. It ranks 3rd in amounts of total mushroom produced in the world. The *Pleurotus eryngii* mushroom has antioxidants. The antioxidant in this mushroom comes in the form of an amino acid known as ergothioneine. This mushroom also carries statins, which are disease fighting compounds. The particular compound found in the mushroom, *Pleurotus eryngii*, is called lovastatin. It is a compound that helps to lower cholesterol. This mushroom is also an excellent energy booster. It has antibacterial properties. For cultivation of *Pleurotus eryngii* saw dust supplemented with organic nitrogen materials was used as substrate. Substrate was wetted

thoroughly in water for 16-18 hours. After wetting 20% wheat bran was added in the substrate and mixed thoroughly. Two kg wet substrate was filled in each polypropylene bag (8X16"). The bags were plugged with non-absorbent cotton by inserting polypropylene ring at the mouth of bags. The filled bags were sterilized in autoclave for 1.5 hours at 1.55kg/cm^2 After the sterilization, the bags were cooled down to 20°C and they are inoculated with wheat grain based spawn @ 3% on dry weight basis. Inoculated bags were incubated at 22-25°C. Spawn run was complete in 15-20 days. After the completion of spawn run PP bag was removed from the substrate. Blocks were then placed in the cropping room at a temperature of 13±2 °C and relative humidity of 80-85% was maintained. Light (800-1000 lux) was provided for five hours daily for optimum development of fruiting bodies. Pin heads start developing after 5-7 days after removing the bags. Matured fruit bodies were harvested 3-4 days after pinning. BE of 30% was recorded.

V-P-8. Yield improvement of *Agaricus bisporus* using supplements

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Agaricus bisporus is among the most popular mushrooms with high economic, nutritional and pharmaceutical value. Adding nutritional supplements to the mushroom medium are known to have improved the yield and quality of fruiting body. Neem powder, groundnut cake and sunflower cake were used as supplements @1% fresh weight of compost. Maximum yield was observed from the compost supplemented with neem powder followed by sunflower cake and groundnut cake. The average weight of fruit body ranged from 12.5-17.5 grams. *Azotobacter* sp., *Bacillus circulans* and *Alcaligenes faecalis* were mixed with the casing soil @ 50 ml broth with 10^7- 10^8 cfu/ml population to 5 kg casing soil. Mushroom bags inoculated with *Azotobacter* gave yield of 15.3 kg/q of compost while *Alcaligenes faecalis* and *Bacillus circulans* gave less yield than control. The number of fruit bodies were more in control than in treated bags and the average weight of fruit body ranged between 12.5- 15.5 g. Three plant growth hormones (Gibberellic acid, Indole-3-acetic acid and Indole-3-butyric acid) were also sprayed three times during the crop, first during pin head appearance, after 1st flush and then after 2nd flush of mushrooms. Indole-3-butyric acid showed no significant increase in yield in comparison with the control. The number of fruit bodies was less in hormones sprayed bags in comparison to the control. The average weight of fruit body ranged between 12.5-15.8 g. The colour and texture analysis indicated that colour was milky white when groundnut cake and gibberellic acid were supplemented in comparison to creamy white mushrooms harvested from control bags. The surface of mushrooms was rough in control but smooth for neem powder, sunflower cake and *Bacillus circulans*, *Alcaligenes faecalis* and gibberellic acid treated bags.

V-P-9. Status and constraints of straw mushroom cultivation in Odisha

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The hot and humid coastal agro-ecological situation of Odisha with abundance of manpower and agricultural waste has made it most suitable for year-round cultivation of straw mushroom. It is often cultivated outdoor in the shade of coconut, arecanut, mango, jackfruit, cashew nut, bamboo, casuarina and banana plantations as an intercrop in the districts of Cuttack, Jagatsinghpur, Kendrapara, Khurda, Puri and Ganjam. However, it is largely an indoor crop in the remaining districts. As per the estimate, the straw mushroom production of the state was 9,550 tonnes during 2015-16, contributing to 60 % of the total mushroom production (15,986 tonnes) in the state of Odisha. The four leading districts namely, Puri, Ganjam, Khurda and Dhenkanal combinely shared 58 % of total straw mushroom production of the state. However, it was observed that all the thirty districts of Odisha are engaged in commercial straw mushroom cultivation employing the conventional procedure with outdoor production to the tune of 59 %. The above exercise established the fact that straw mushroom production has assumed the status of a cottage industry, being the livelihood option of a large section of society. Non-availability of quality spawn and bed contamination with competitor moulds were the major constraints encountered in all the four leading districts surveyed across the zones resulting in poor biological efficiency (10 %). *Coprinus* appeared to be the main competitor besides stray incidence of *Sclerotium, Rhizopus*, *Mucor, Trichoderma, Aspergillus* and *Penicillium*. Un-organized marketing of fresh mushroom was another problem faced by the growers.

V-P-10. The effect of some physical factors on the vegetative growth and cultivation of *Pleurotus sapidus* quell

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In the present investigation the basidiomycetous fungus *Pleurotus sapidus* was studied for its optimum vegetative growth by employing fourteen different solid and liquid media. The maximum growth was observed in Yeast Extract Agar (6.3 cm) in which the mycelium was found growing at the rate of 0.79 mm/day on an average. Colony characteristics including mat thickness, mat colour, uniformity of growth, etc. were also better in Yeast Extract Agar medium. Similarly fourteen different liquid media were evaluated, out of which maximum dry weight was recorded in Yeast Glucose Medium (6.66 mg/ml). *Pleurotus sapidus* was grown on the respective best solid and liquid media at variable temperature *viz*., 16°C, 19°C, 22°C, 25°C, 28°C, 31°C and 34°C. The maximum mycelial growth in Yeast Extract Agar (6.3 cm) and Yeast Glucose Medium (8.36 mg/ml) was recorded at 28±1°C.The effect of different pH levels ranging from 3.5 to 8.5 on vegetative growth was observed. The maximum mycelial growth was recorded at pH 6.5 in solid (6.30 cm) as well as liquid media (7.18 mg/ml). For determination of incubation period for maximum mycelial growth, the mycelium of mushroom was incubated in Yeast Glucose Medium at 28 ± 1°C maintained at pH 6.5. The mycelium of mushroom was harvested on daily basis continuously for 16 days.

The maximum mycelial growth of 6.3 mg/ml was recorded on the 12th day of incubation. For undertaking cultivation studies spawn was prepared on wheat grains. Five locally available different lignocellulosic substrates namely wheat straw, paddy straw, wooden flakes, sawdust and mixture of all these four were tried for *in vitro* cultivation of *P. sapidus*. On the overall basis, maximum fruit bodies were harvested from paddy straw in which 109 % biological efficiency (B.E) was achieved followed by mixture with 82% B.E, wheat straw with 71% B.E, wooden flakes with 46% B.E and sawdust with 20% B.E on fresh weight basis. Out of all the substrates used paddy straw proved to be the best for the cultivation of *Pleurotus sapidus*.

V-P-11. Effect of different casing soils on yield and biological efficiency of *Agaricus bisporus*

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The growth and development of *Agaricus bisporus* is not only related to genetic factors but also depends on environmental, chemical and microbiological conditions. Casing soil protects the compost against desiccation and supports mushroom sporophores development and provides gas exchange for development and growth. It also provides an environmental change in which the mushroom shifts from a vegetative stage to a reproductive one. The required physico-chemical properties of a good casing should be high porosity and water holding capacity (WHC), 7.2–8.2 pH, low content of soluble inorganic and organic nutrients. Many materials, alone or in combination, have been used as casing both commercially and experimentally, but only very few have shown to be of practical application. Keeping in view, different casing materials viz., Farm yard manure (FYM), spent compost (SC), sandy soil (SS), coir pith (CP) either alone or in different combinations were used as casing soil and their effect on yield and biological efficiency of button mushroom was analyzed. The findings indicated that the casing soil FYM + SC (2:1 w/w) resulted in maximum yield and biological efficiency (19.46 kg/q compost) followed by FYM alone (18.87 kg/q compost). The minimum yield was obtained from the sandy soil alone as casing soil (4.98 kg/q compost). The physico-chemical properties viz., pH and water holding capacity (1/3 and 15 bar) of FYM + SC (2:1 w/w) and FYM alone were in the range of 6.5-6.6, 66.3-67.4% and 42.7-44.7%, respectively, however, for sandy soil these were 9.1, 16.5% and 4.5%, respectively.

V-P-12. Mushroom growing in mineral water bottles – an innovative technology

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Mushroom growing is one of the fastest growing and most technologically sophisticated horticultural industries in the world. Unavailability of raw material and space limitation are the major hindrance to mushroom cultivation in Kerala. Simultaneously mineral water usage is increasing day by day .Used mineral water bottles are seen scattered inside trains, on the floors after conferences and heaped on the

road side. These bottles serve as breeding centres for mosquitoes which spread the dangerous Dengue fever prevalent in most states now. So if these plastic bottles can be reused for successful cultivation of mushrooms it is total wealth from partial waste.

Empty mineral water bottles of 2 litre capacity can be conveniently used for mushroom production. For this, first remove the wrapper from the sides of the bottle and clean it using hot water in which a few drops of dettol are added. Then the bottles are dried in hot sun to remove the moisture. Make holes all over the surface using a safety pin for air circulation and removal of exhaust gases. Cut the bottles into two halves around the middle and keep separately. Though many types of mushrooms are suited for bottle cultivation, research in Kerala Agricultural University has revealed that oyster mushroom, especially the pink variety (*Pleurotus eous*), is best suited for cultivation in bottles.

The next step in the cultivation is preparation of substrate. Any kind of agro waste is suited for mushroom cultivation. But paddy straw is the most common substrate widely used in different farms in Kerala which gives maximum yield. The substrates are often attacked by various fungi bacteria and pests and the yield is considerably reduced .To eliminate this and to ensure organic cultivation the substrate is soaked in boiled water for 30 minutes Drain off the water and dry in hot sun. ½ kg paddy straw is sufficient to fill four mineral water bottles of 2 litre capacity. The spawn or seed material of oyster mushroom is taken in a clean basin. Put some dried straw into the cut half of the bottle and press hard. Put a handful of the spawn on the sides. Again put some straw and another handful of spawn press tightly. This process is repeated till both the halves of the bottle are filled. The two halves filled with straw and spawn are joined using a cello tape Open the lid and sprinkle some straw on the top too. Now close the lid and keep the bottled mushroom in a dark room where there is no sunlight but enough air circulation. One packet of spawn weighs approximately 300 g and this can be used for filling 4 mineral water bottles.

In 8-9 days the entire bottle gets covered with white mycelium. Care should be taken to ward off pests and diseases if any spotted. After a week when small pinheads start emerging through the holes in the bottles they are transferred to another room where there is sufficient light and aeration. Water is sprinkled after opening the lid at the top of the bottle. Harvesting is done in another week's interval. Watering is done 3-4 times daily until harvesting of mushrooms is fully over. The yield is dependent on quality of spawn, nature of substrate, temperature, ventilation, moisture, etc. Around 300 grams of mushrooms are obtained from a single bottle. Since we are using sterilized bottles they are 100% free of contamination. Another advantage of bottle mushroom cultivation is that the bottles can be reused for cultivation after washing in lukewarm water and drying in sun. Thus this technology is excellent for reusing plastic mineral water bottles.

V-P-13. Influence of different substrates on cultivation of blue oyster mushroom (*Hypsizygus ulmarius* (Bull.:Fr.) Redhead)

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Hypsizygus ulmarius, commonly called as elm oyster or blue oyster is similar to other oyster mushrooms, but differs slightly in its morphology and biological efficiency. The study on evaluation of different substrates for the cultivation of blue oyster mushroom revealed its higher production in paddy straw followed by rubber sawdust. The maximum time for pinhead formation (60.8 days) and higher crop period (93 days) were recorded in rubber sawdust. The maximum yield was recorded on paddy straw (985 g kg^{-1}) which was statistically at par with rubber saw dust (905 g kg^{-1}). The least yield (255 g kg^{-1}) was recorded from beds prepared on sugarcane bagasse.

V-P-14. Comparison of growth behaviour and yield performance of *Pleurotus florida* and *Pleurotus sajor-caju*

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Comparison of growth behaviour and yield performance of two species of oyster mushroom such as *Pleurotus florida* and *Pleurotus sajor-caju* showed that, *Pleurotus florida* was better performing than *Pleurotus sajor-caju*. The spawn run period was fast (13 days) in *Pleurotus florida* than that in *Pleurotus sajor-caju* (15 days) whereas pin head appeared early (15 days) in *Pleurotus florida* while in *Pleurotus sajor-caju* pin heads appeared in 18 days. Maximum weight of *Pleurotus florida* fruiting body was observed to be 40 g whereas that of *Pleurotus sajor-caju* was observed to be 34 g. Minimum cropping period was observed in *Pleurotus florida* which was 43 days whereas *Pleurotus sajor-caju* showed longer cropping period of 49 days. *Pleurotus florida* gave maximum yield of 1363 g per bag with a biological efficiency of 136.3%. In comparison with *Pleurotus florida*, a lesser yield of 940 g per bag was shown by *Pleurotus sajor-caju* with a biological efficiency of 94.0%.

V-P-15. Comparison of rainy and winter season crop of *Pleurotus florida* for growth behaviour and yield potential

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The climatic conditions play a significant role in mushroom production. To compare rainy and winter season crop of *Pleurotus florida,* the criteria selected was growth behaviour and yield potential. The results have shown that the spawn run in winter season was rapid and substrate was colonized by

mushroom mycelium in 16 days only while time taken was more in rainy season i.e. 20.3 days. The pin head initiation, harvesting of first flush, second flush and third flush were also recorded early (22 days, 29.3 days, 42.7 days and 56.7 days) in winters as compared to rainy season (27 days, 34 days, 49.7 days and 64 days) respectively. Total yield of oyster mushroom grown in winter season (838.3 g) was higher than mushroom grown in rainy season (687.3 g). The yield of first harvest (360 g), second harvest (291.7 g) and third harvest (181.7 g) were also higher in winter season as compared to rainy season i.e. 305 g, 260 g and 122.3 g respectively. The maximum biological efficiency of yield potential was recorded from the mushroom beds in winter season where it was calculated as 83.8 percent. Present piece of work suggests that oyster mushroom *(Pleurotus florida)* can be cultivated in winter season for better yield performance.

V-P-16. Isolation of actinomycetes from mushroom compost

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The active component of compost mass mediating the bio-degradation and conversion process during composting is the residential microbial community, among which the actinomycetes play a very important role. Often the compost at conditioning stage becomes whitened. This whitening has been called “fire fang” and much of it is due to thermophilic actinomycetes. Actinomycetes belong to the phylum Actinobacteria, which represents one of the largest taxonomic units among the 18 major lineages currently recognized within the Domain Bacteria. Actinomycetes make the compost very selective to button mushroom by producing several nitrogen-lignin complex, lipid and protein compounds during phase second of composting. It is, therefore, necessary to isolate them from successive stages of the composting process. In addition, these individuals use many carbon sources, mainly ligno-cellulosic polymers and can survive even at high temperature and humidity for compost maturation.

The present investigation was carried out to isolate the population of actinomycetes from four samples drawn from turning I, II, III of phase first and phase second of composting from the M/S Tarai Food Corporation and MRTC, Pantnagar. The isolation of the actinomycetes was done from all four samples at 35°C, 45°C and 55°C using actinomycetes isolation agar (AIA media: sodium caseinate: 2g, L-Asparagine: 0.10g, sodium propionate: 4g, dipotassium phosphate: 0.50g, magnesium sulphate: 0.10g, ferrous sulphate: 0.001g, agar 15g, glycerol 5ml, distilled water: 1 litre, pH: 8.1±0.2) media at 10^{-5} dilution strength. Bacterial cfus were formed on AIA plates with significant differences in their physical appearance. Further, they were counted, selected and purified for further study. The samples of turning 1, 2, 3 of phase first and phase second resulted in less number of cfu of actinomycetes and high number of cfu of *Pseudomonas fluorescence* at the temperature 35°C and 45°C. However, at 55°C from all samples, colonies of only actinomycetes were found in the form of white, dry, wrinkled surface with irregular and circular shapes in AIA plates along with gram + reactions and reverse plate pigmentation.

V-P-17. Oyster mushroom cultivation in tribal areas of district Pithoragarh: role in rural development

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Pithoragarh district consists of five tehsils, eight blocks and 851 revenue villages. Among the Tribes, Bhotias and Vanrawats are present in the district. Bhotias are largely present in Dharchula and Munsiyari blocks of the district and Van Rawats are found in Kanalichina, Didihat and Dharchula blocks. Bhotias are predominantly migrating: in summers they move to higher altitude and in winters they come back to low altitude to avoid prevailing cold conditions. Van Rawats originally used to live in dense forest areas and their contact with general public was minimal. Their major activities include gathering of timber and food from forest. Bhotias are scattered mainly in two blocks viz. Munsiyari and Dharchula. Their main occupation is farming followed by livestock rearing. Bhotias and Van –rawats collect mushroom from forests in rainy season. Mushroom collected from wild areas could be poisonous and thus training and demonstration on mushroom cultivation were provided to them. Training and demonstrations on oyster mushroom cultivation were given using wheat straw and other locally available substrates. Mushrooms have the ability to transform nutritionally useless waste into highly acceptable nutritious food. They have the ability to degrade lignin along with cellulose and hemicellulose. In addition, the cultivation of mushrooms is labour intensive and provides opportunities to the landless labourers and weaker section of the society. The varied climatic conditions in different parts of the district help in growing mushroom under natural climate. Oyster mushroom (*Pleurotus sajor-caju*) was cultivated at different blocks of the district on the substrates prepared from wheat straw, finger millet straw, paddy straw and corn cobs. The yield obtained varied on different substrates. Maximum yield of 80 kg/q substrate was obtained on wheat straw and minimum of 55 kg/q on corn cobs substrate. The spent mushroom substrate was successfully used for vermiculture and vermi-composting. It was also used as substrate mixed with other organic wastes for culturing *Eisenia foetida.*

V-P-18. Species diversity of *Trichoderma* prevalent in oyster mushroom cultivation farms in western Maharashtra

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One of the most common contaminant of oyster mushroom is *Trichoderma*. Eighteen different diseased samples of green mould infections were collected from eleven different mushroom growing farms and spawn laboratories. A total of eight morphologically variable *Trichoderma* isolates were obtained. Cultural characteristics of eight *Trichoderma* isolates comprising growth rate, colour and colony appearance were examined which were regarded as taxonomically useful criteria. *Trichoderma* initially produces a dense pure white mycelium which resembles mushroom mycelium therefore they are very difficult to distinguish. Mycelial mat on the substrate gradually turns to a green colour because of the heavy sporulation of the causal agent producing a characteristic symptom of the disease.

The distinct variation in morphology among the eight different isolates of *Trichoderma* was not observed on Malt Extract Agar media. The *Trichoderma* isolates Tric-3 and Tric-8 on MEA media showed white, cottony mycelium with dense green conidiation near two concentric rings only. The concentric rings formed away from inoculum at margin with dense conidia. Whereas, conidia production was denser at centre than towards margin on PDA medium in Tric-3 and Tric-4 isolates. The Globose to Sub Globose shaped conidia (2.8 x 2.6 ìm) and flask shaped Phialide were observed in isolates Tric-3 and Tric-8.

The light green conidia were formed on whole plate, with more conidia towards margin and at inoculum in isolates Tric-1, Tric-2, Tric-4 Tric-5 Tric-6 and Tric-7 on MEA medium. Whereas, granular growth was observed on PDA medium in Tric-1, Tric-2 Tric-4 Tric-5 Tric-6 and Tric-7 isolates. The globose shaped conidia (2.8 to 3.0 x 2.7 to 2.8 ìm) and slender phialide were observed in six isolates. Based on cultural characters, growth rate, colour, colony appearance and micro-morphological characters, the isolate Tric-3 and Tric-7 were identified as *Trichoderma harzianum,* whereas, all other six isolates *viz.,* Tric-1, Tric-2, Tric-4, Tric-5, Tric-6 and Tric-7 were identified as *Trichoderma viride.*

Radial growth rate (mm/day) of different isolates of *Trichoderma* on Malt Extract Agar medium at 28^{o}C showed wide variation and it ranged from 13.17 to 17.50 mm/day. The isolate Tric-2 exhibited fastest growth (17.50 mm/day) and it was followed by isolates Tric-1 (16.25 mm/day) and Tric-4 (15.83 mm/day). The slowest growth rate of 13.17 mm/day was reported in Tric-8.

V-P-19. Effect of botanicals against the green mould pathogen *Trichoderma* in oyster mushroom crop

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Oyster mushrooms have gained popularity in most of the developing countries due to their simpler & low cost growing technique and wider adaptability due to availability of multiple edible species of Pleurotus. Recently, another kind of oyster mushroom, *viz. Hypsizygus ulmarius* has been added which is gaining fast popularity due to its better quality traits. However, due to the fact that oyster mushrooms are mostly cultivated on un-composted straws, its crop attracts various microbial pathogens and competitors, and hence, to- ward them off use of pesticides for the pre-treatment of their substrate is very common. However, recent reports of appearance of fungicidal resistance in some fungal pathogens of mushrooms have led to intensive search for bio-agents & botanicals for preventing the microbial invaders of mushroom crops. The authors while screening some botanicals selectively active against the Green Mould pathogen *Trichoderma,* have identified a formulation containing a mixture of amino-acids derived from the hydrolysates of soybean- protein and casein (commercial name Wellguard), showing potent anti-fungal activity. In the present communication, our findings on the efficacy of Wellguard for production of healthy grain spawn as well as for raising a better crop of *Hypsizygus ulmarius* without the use of any fungicide & germicide are being reported.

V-P-20. Evaluation of individual and combination of grain substrates in quality spawn production of mushroom

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In search of cost effective of mushroom spawn production, screened six grain substrates viz., Paddy (*Oryza sativa*), Wheat (*Tricticum aestivum*), Maize (*Zea mays*), Madua (*Eleusine coracana*), Bajra (*Pennisetum typhoides*), Jowar (*Sorghum bicolor*) and their combination (1:1, 1:3, 3:1) were selected in the experimentation. In the study, suitability of substrates with have supportive to mycelium proliferation and thickening, biological purity and vigor using cheap and easily available substrates in the locality was monitored to find out suitable spawn substrates. A total 45 different combinations were selected to. Among the individual and combination of grains, Wheat, Bajra, Bajra + Jowar (3:1), Rice + Madua (1:1), Wheat + Maize (3:1) and Maize + Jowar (3:1), were showed highly promising in mycelial proliferation and mycelial density over the grains in which the growth of the mycelium become very fast and covered entire substrates with 8-10 days as well as the density of the mushroom mycelium also very high. Individual and combination of substrates of mushroom spawn, Bajra, Maize and their combination (Rs.5315/qtl) were quite economical followed by Paddy (Rs. 5390/q), Wheat (Rs. 5425/q), Jowar (Rs.5640/q) and Madua (Rs.5640/q).

V-P-21. Evaluation of substrates and assessment of water requirement for commercial production of oyster mushroom in Jharkhand

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An experiment was conducted to assess substrates for maximum production of two commercially grown oyster mushrooms viz; *Pleurotus florida* and *Hypsyzygus ulmarius* on viz; paddy straw (*Oryza sativa*), ragi straw (*Elusine coracana*), maize (*Zea mays*) stalk and soybean (*Glycine max*) with minimum water requirement of during winter month of 2010 to 2012 . The foggers were used in cultivation room to maintain the relative humidity up to 80% . During cropping periods, the fogging time period was noted in minutes and the total period was converted in hour.The total water requirement was determined by following formula: Quantity of water(in litres) = 28x Number of fogger in room x total time taken in fogging (hours) to maintain humidity per day + quantity of water spray by hand spray, if any (Note : 28 litres water is discharged in one hour from one fogger).

The yield data was recorded on ten randomly selected samples (yield >500gper bag) from each substrates and statistically analyzed following completely randomized block design. The BE percentage was calculated using the substrate dry weights as follows:([weight of fresh mushrooms harvested/substrate dry matter content]× 100).The pooled data revealed that the *P.florida* resulted maximum biological efficiency on paddy straw (BE-118.1%) followed by ragi straw (60.15%), maize straw (56.7%) and minimum on soybean straw (51.85%). Whereas, soybean substrate was found the best substrate for blue oyster (*H.*

ulmarius) production resulted in BE 107.9% followed by that on Paddy straw (100.3 %).The water use efficiency of oyster species on different substrates were differed. The water requirement for per kg mushroom production differ with substrates. For *P. florida* per kg mushroom production, 19.1 litres water is required on Paddy straw, 21.9 litres on maize stalk, 22.9 litres on soybean straw and 34.5 litres on ragi straw. *H. ulmarius* per kg mushroom production 16.5 litres water is required on Soybean straw, 17.1 litres on paddy straw, 30.2 litres on maize stalk and 38.2 litres on ragi straw. Minimum water was required on paddy straw for *P. florida* per kg mushroom production whereas, in case of *H. ulmarius* minimum of 16.5 litres on soybean straw. Water requirement on ragi straw for both the oyster mushroom production has been recorded to be more than that in other cases mentioned above.

Session-VI: Medicinal and Mycorrhizal Mushrooms

Keynote Presentation

VI-K-1. Therapeutic potential of reishi - *Ganoderma lucidum* for prevention and treatment of cancer

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Cancer is the second largest cause of death among children and adults, claiming over eight million lives each year worldwide. *Ganoderma lucidum,* commonly known as Reishi or Lingzhi has been used in Traditional Chinese Medicine for more than 4000 years. In Chinese folklore, this mushroom is considered as a panacea for all type of diseases. Lingzhi and its extracts are known in Chinese medicine for the treatment of cancer.

Numerous pharmacological investigations demonstrated that hot water extract of *G.lucidium* inhibited tumor growth in animals. Extensive pre-clinical studies were carried out in our laboratory at Amala Cancer Research Centre to evaluate the anticancer activities of *G.lucidum.* The total extract of the fruiting bodies of the mushroom possessed 87% preventive and 72% curative antitumor activity. Two of the major chemical components of *G.lucidum* namely, polysaccharides and total triterpenes showed significant preventive and curative antitumor activity at a dose of 100mg/kg body weight of animals. Experimental studies in our laboratory showed that the total extract effectively inhibited 7,12-dimethyl benz(a) anthracene (DMBA) induced mammary adenocarcinoma in rats. The total extract also significantly inhibited skin tumors induced by topical application of DMBA and promoted by croton oil on mice. The mushroom extract showed profound effect on tumor induction, tumor latency period and tumor proliferation. These experimental results indicated that *G.lucidum* possessed profound anticancer activity.

Several clinical trials conducted in China and Japan and more recently in US showed that *G.lucidum* was highly beneficial to advanced cancer patients indicating the therapeutic use of Reishi for the treatment of cancer. Clinical studies also demonstrated that Reishi preparations exerted synergistic therapeutic effect when used in conjunction with radiation and chemotherapy and also reduced the side effects of these treatments. The most encouraging observation is the ability of the polysaccharides to reduce the side effects of chemotherapy with little evidence of toxicity. Cancer patients treated with Reishi showed death rate of patients in long-term treatment was significantly low. A continuous 2-3 months or more active treatment with a daily dose of 4-6g extract was proposed. *Ganoderma* polysaccharides under the trade name *, Ganopoly* is marketed as over the counter product in several countries.

Prostate cancer is the most common male malignant disease in several western countries and the third leading cause of death in men throughout the world. Reishi has been shown promising effect on prostate cancer in various pre-clinical and clinical studies. Based on available consolidated scientific and clinical evidence Reishi – *Ganoderma lucidum* impart profound benefits to cancer patients. Reishi improves the immune functions of the body and the anticancer effect is mainly due to its immune enhancing property of antitumor response.

VI-K-2. Cultivation aspect of *Morchella spp*

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Ever since the discovery of morels by Dillenius in 1719 and its acceptance as most delicious and nutritious mushroom and terming it as' Gourmet Delight' incessant attempts have been afoot to cultivate it like other cultivated mushrooms such as button or shitake. But cultivation technology has deluded till date although there are some reports of cultivating the morels and even of patenting the technology. Such successes are highlighted and blown out of proportion at times but then recede to the background and then follows a period of silence Such successful attempts are not accepted absolutely because no assured cropping is reported nor are answered the volley of questions and queries. A few months ago a Chinese news of cultivation of morels in the fields became viral and photographs of fruiting bodies appearing in the field were also shown vividly but eyes brows have been raised even on their veracity and authenticity. Right from 1883 onwards when first attempts were made on cultivation of *Morchella esculenta* in farm in 1883 periodically occasional claims have been made by different workers and transient success has also been reported/claimed. But perhaps a lot more needs to be understood about the biology of this enigmatic mushroom, although various aspects of its morphology, ecology, soil relationship, association with other plants and physiology have been thoroughly and intensely investigated.

Lead Lectures

VI-L-1. Status of *Ophiocordyceps sinensis* (syn. *Cordyceps sinensis*) in India

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Ophiocordyceps sinensis (syn. *Cordyceps sinensis*), commonly referred as Keera Ghas in India, is a high value medicinal fungus belongs to division Ascomycota, Class Sordariomycetes, order Hypocreales, family Ophiocordycipitacea, Genus-*Ophiocordyceps* and species *sinensis*. This entomopathogen has a limited distribution and its stromata have not been artificially cultivated so far while, another entomopathogenic fungus, *Cordyceps militaris* (an orange caterpillar fungus), has chemical capacities similar to those of *O .sinensis* and can be easily cultivated. The genus *Ophiocordyceps* has a worldwide distribution and most species have been described from Asia (notably China, Japan, Korea and Thailand). *Ophiocordyceps* species are particularly abundant and diverse in humid temperate and tropical forests. Some species are sources of important biochemical substances like cordycepin which has very high medicinal properties. The pharmacological and medicinal significance is mainly due to its bioactive ingredients. It contains a wide variety of potentially important constituents, including polysaccharides, ophiocordin (an antibiotic compound), cordycepin, cordypyridones, nucleosides, bioxanthracenes, sterols, alkenoic acids and exopolymers, etc. Cordycepin and cordycepic acid are regarded as the most important constituents of this fungus and owe high medicinal significance.

The hyphae of the fungus were aerial cottony white to creamish or yellowish, septate, branched, dense and 1-3µm wide. *Ophiocordyceps* showed the maximum growth on SDAY medium at 15°C and pH 6. It was observed that the wheat grains were colonized by the fungus in minimum period of 25 days. The fungus grew well and nutritional utilization of the fungus from wheat grains was higher. The hot water extract of fruiting bodies were found to contain both adenosine and cordycepin but in *O. sinensis* mycelia adenosine was detected and cordycepin was not detected. The ergosterol was present in the fruiting bodies and in the mycelia of *O. sinensis*. The *O. sinensis* extracts showed chelating activity on Fe^{2+} in a concentration dependent manner.

Reproduction of *O. sinensis* is highly host-specific. Native occurrence of this entomophagus fungus is mostly confined to the high Himalayan mountains in Tibet, Nepal and India, at an altitude ranging from 3000 to 5000 m. The most common occurrence of this fungus is between 3500 and 4500 m elevation in cold and arid environment. It is found in the high altitudes of Pithoragarh, Uttarakhand and other provinces at locations above 7000 feet. Local market and collection point for the Keera Ghas in the Valley is Munsyari. Dharchula town is a major storehouse for Trade. Traders have been coming from Nepal or Tibet to buy keera Ghas locally in the villages as Chipla, Ralam, Laspa, Burphu, Karshila, Lilam, Martoli, Milam, etc. of Pithoragarh district of Uttarakhand. During the month of May and June all the village folks camp in the mountains for collection of Keera Ghas. Men were busy in collection and women and girls remain busy in transportation to the collector's camps.

Market price, trade and channel of its collection are not transparent in the Indian subcontinent but a commercial trading exists. First of all field gatherers or local people collect the Keera ghas from the Alpine Habitat and then they give it to the Primary collectors. Primary collectors sell it to the agent or middlemen or sometimes the active field gatherers sell it directly to the middlemen or Agent in the Local Market, present in their respective regions only. Contractors / brokers collect the material from the various locations and sell it at higher prices at the regional level. And finally it reaches to the National and International Level. The cost of fungus at the final destination (brokers in the National and International markets) was much higher than the price paid to the field gatherers. Furthermore, dried specimens often fetch much higher prices in winter. Lack of cash and fluctuating prices deter most people from holding back their harvest and speculating on profits to be made by selling in winter. However, it is also used as a way of keeping savings at home. Sometimes the price is altered due to the cleanness and moisture content present. Prices usually change throughout the season on the basis of supply and demand.

VI-L-2. Effect of ectomycorrhizal application on the survival and growth of *Shorea robusta* under nursery conditions

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Shorea robusta is an economically important dipterocarp tree that can establish ectomycorrhizal symbiosis with a high diversity of fungi. Ectomycorrhizae have a helpful impact in seedlings survival and establishment by absorbing and transferring nutrients and water from the external environment. In the view of this some dominant ectomycorrhizal associates (*Russula* and *Lactifluus*) of *Shorea robusta* (Sal) organically attached to the host plant roots were collected, cultured, systematically investigated and identified. The mycelium of associated mushrooms was raised into pure culture for raising mass inoculums which was prepared using wheat grains. The colonised wheat grains were inoculated with the germinating Sal seeds for establishing the mycorrhizal association. In a year after every three months interval, the inoculated and control plants were observed for various growth parameters. Plant shoot and root samples were taken for nutrient content and mycorrhizal colonization analysis. It was concluded from the results that all measured growth parameters of seedlings grown in artificially inoculated soil treatments exhibited significantly higher values over the uninoculated control soil. All three ECM fungi (*Russula* sp. 1, *Russula* sp. 2, *Lactifluus* sp. 3) used during present investigations shows significant higher growth, but overall *Russula* sp. 1 (ECM 1) showed maximum growth in most of parameters as compared to *Russula* sp. 2 (ECM 2) and *Lactifluus* sp. (ECM 3). Maximum ECM association (70.05%) was observed with ECM1 followed by ECM2 (58.91 %). Nutrient analysis of Sal seedlings revealed increased uptake of both macro (P, K, Ca, Mg, S) and micro (Zn, Fe, Na, Cl, Cu, Mn etc.) nutrients in roots and shoots of artificially inoculated seedlings than natural inoculum (FS) and control (C). Plant inoculated with ECM has low concentration of heavy metals like Cr, Cu and Al in shoots as compared to control. So ECM is also protecting the plant from heavy metal toxicity. The survival rate has increased from 50% to 95% by mycorrhizal inoculation.

Oral Presentations

VI-O-1. Molecular identification and optimization of conditions for *in vitro* culture of *Cordyceps sinensis*

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Cordyceps sinensis, belonging to Ophiocordycipitaceae, is a well known entomogeneous and medicinal mushroom. It is found naturally at high altitudes of about 3000-5000 m on high Himalayan mountains in Asian continent. This study was aimed to establish optimal mycelial growth conditions for *C. sinensis*, such as growth media, pH and temperature. This mushroom was authenticated by using ITS (Internal Transcribed Spacer) sequencing approach by comparing ITS1-5.8S-ITS2 sequences. To investigate favourable growth media, four semi-synthetic media were used followed by culturing at different range of temperature and pH for the production of mycelium. It was observed that Sabouraud Dextrose Agar (SDA) is suitable medium for the mycelium growth followed by Potato Dextrose Agar (PDA) and least growth was observed in Malt Extract Agar. The growth of mycelium was evaluated at broad range of pH (acidic to alkaline) and temperature range (10°C-35°C) and best growth was observed at pH 6 and 20-25°C, respectively.

VI-O-2. Morels: an elusive and sumptuous mushroom

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Among wild edible species of mushrooms, morels rank first in choice and delicacy and have been the mushrooms of choice since ancient times in India and elsewhere. The morels comprise the genus *Morchella,* commonly called as 'Guchhi' in the Indian market. The ethnobotanical data gathered on these wild mushrooms reveals that these can be consumed directly in diet to promote health, as they have nutritional, medicinal and financial benefits also. All attempts made so far in various parts of the world to domesticate morels, have met only with an occasional success. This is probably because of the fact that the physiology of this mushroom is not yet fully understood. Although enough data has been available on the cultural characteristics, spore germination and physiology of morels, but, all this information does not yet seem enough to induce fructifications surely. The *Morchella* species have been analyzed for their nutritional and nutraceutical potential. Arising from the awareness of the relationship between diet and disease has evolved the concept of nutraceuticals. Although the nutritional facts and culinary uses of morels are well accepted all over the world, but the medicinal potential have yet to be explored and exploited. Studies were undertaken to record the ethnobotanical data on the morels of north–west Himalayas. All bioactive constituents like: polysaccharides, dietary fibers, oligosaccharides, peptides and proteins, and mineral elements (zinc, copper, iodine, selenium and iron), vitamins, amino-acids, etc. have been screened.

Morel extracts have very good concentrations of these bioactive components. They have been found to boost the immune system, and are reported to have various health benefits like anti-hypercholesterolemic, antitumour, immunomodulating, anti-oxidant potential, anti-cancerous, prebiotic activity and many more. Since, the nutritive and nutraceutical profile of morels is so lucrative, therefore, the morels have been a wonder myco-nutraceutical and their under-exploited potential needs to be fully explored and exploited.

VI-O-3. Kashmir morels: a review on distribution, diversity and ethnobotanical studies

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Morchella commonly referred to as “kann gitch” in Kashmir, is one of the costliest and the most sought after macro-fungi in the world. This study documents the ethnomycological data on the collection, appearances, consumption, myths associated, ethnic use in food and medicine, marketing and storage of morels found in Kashmir region. This indigenous technical knowledge of *Morchella* species was gathered by Participatory Rural Appraisal technique. The production and export of these morels have also been documented in the present study. The collection is done in the months of March-April. It is mainly relished as a delicacy due to its distinctive flavour and unique taste and is thus used in different recipes in high end weddings and five star hotels. Also it is highly valued for its use in treating various ailments like pneumonia, respiratory problems, fever, cough, cold, etc. This mushroom is exported to many countries for its excellent culinary properties but in recent years the export quantity has dramatically declined, reason being poor drying and storage conditions. It plays a crucial role in the economy of the state. The price of dried morels ranges from 20k to 40k per kilogram. This skyrocketing price is due to the fact that this mushroom is purely wild and its production has declined due to the unpredictable environment. Therefore, extensive attempts should be made to domesticate this valuable fungus on a large scale to exploit its nutritional and medicinal benefits.

VI-O-4. Antibacterial effects of different extracts of *Lentinula edodes strains*

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Lentinula edodes is one of the most widely cultivated and edible mushrooms in the world. Interest in shiitake is increasing due to its high medicinal and nutritional properties. Shiitake is known to have strong antimicrobial and antibacterial effects and may also reduce growth of cancerous tumours due to the presence of bioactive compounds such as lentinan, lentin, lenthionine, KS-2. In this study, six different bacterial cultures namely *Staphylococcus* sp., *Salmonella* sp., *Pseudomonas* sp., *Enterobacter* sp., *Klebsiella* sp. and *E.coli* were used for studying the antibacterial effects of three strains of *Lentinula edodes* (Le-I, Le-C and Le-S). On solid media, the antibacterial effects were studied by three methods namely streak plate method, spot plate method and filter paper disc method against six pathogenic bacterial

cultures. In streak plate method growth was observed of all bacterial cultures for aqueous extracts expect for the biomass of Le-C which inhibited the growth of *Salmonella* sp. The growth of all bacterial cultures was observed in case of alcoholic extracts of biomass of Le-I and Le-C but alcoholic extract of Le-S biomass inhibited growth of *Staphylococcus* sp*., Enterobacter* sp., *Klebsiella* sp. and *E.coli*. The alcoholic extract of fruit body of Le-S inhibited the growth of *Staphylococcus* sp., *Klebsiella* sp. Among the crude extracts growth was observed in all cases except for no growth of *Staphylococcus* sp. and *Salmonella* sp. in Le-I and Le-C and *Klebsiella* sp. in Le-C. Almost similar observations were recorded in spot plate method with few variations. The maximum inhibition zone was observed for the alcoholic extract of fruit body of Le-S(2.3 cm) followed by alcoholic extract of Le-C biomass(2.0 cm) and minimum was in crude extract of Le-C(0.65cm) in filter disc method for *Staphylococcus* sp. In aqueous extract, maximum inhibition zone was for *E.coli* in the fruit body of Le-S while minimum was for *Pseudomonas* sp. in the biomass of Le-S. Among crude extracts maximum inhibition was found in Le-C against *E.coli* and minimum was observed in Le-I. Thus it was observed that in solid media alcoholic extracts were most effective followed by crude extracts and aqueous extract. These results indicate that the extracts prepared from the three strains could be further purified and exploited for the development of nutraceuticals or dietary supplements.

VI-O-5. *Ganoderma lucidum* and its potential against HSV

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Ganoderma lucidum, an oriental fungus has a long history of use for promoting health and longevity in China, Japan, and other Asian countries. *G. lucidum* is rich in bio active compounds like Polysaccharides, Triterpinoids, and Ganoderic acid. *Ganoderma lucidum* mushroom does not have Cytotoxicity and has demonstrated to be safe as food supplement due to its' long history of oral administration not associated with toxicity. *Ganoderma lucidum* is very rich in antioxidants and other properties anti cancer activity. Apart from these *G. lucidum* has significant bio activity against the viruses like HIV, HSV and HPV. The present study focussed on anti herpetic activity against HSV of aqueous extract of *G. lucidum* and purification studies of bio active compounds of *G. lucidum*. Anti herpetic activity was recorded and there was no toxicity observed even in 2000 ìg/mL of aqueous extract of *G. lucidum*. Significance of *G. lucidum* on anti herpetic activity will unfold ways to new findings in pharmaceuticals.

VI-O-6. Selective estrogen receptor modulation (serm) and apoptosis induction of ergosterol peroxide from mangrove habitat mushroom *Fulvifomes* sp.

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Seventy percent of the breast cancer is caused by deregulation of Estrogens Receptors (ER's) which includes ERα and ERβ mediated estrogen signaling. ERα is characterized as a mediator of cell proliferation, while ERβ inhibits cell proliferation in breast cancer cells. Drug designed against estrogen sensitive breast cancer cell aggressive proliferation is targeted towards the down regulation of ERα and stimulation of ERβ. Selective estrogen receptor modulators from marine sources which is not been studied yet. With this molecular perspective the present investigation was carried out on the role of (SERM's) Selective Estrogen Receptor Modulating compound especially from mangrove habitat mushroom (*Fulvifomes* sp.), Commercially available SERM's gave good results but many of clinical studies showed resistant to cancer cells and it may cause some serious side effects, including fatigue, hot flashes, night sweats, vaginal discharge, mood swings, blood clots, stroke, and endometrial cancer. To overcome ERs resistant and side effects, the natural compound ergosterol peroxide was isolated and characterized using standard techniques. Further, detailed study on the *Fulvifomes* sp. derived EP (Ergosterol peroxide) towards induced apoptosis and increased expression of ERβ, decreased expression of ERα and aromatase gene CYP19 in hormone dependent breast cancer cell line MCF-7 also with *in silico* approaches. The present study revealed that EP could be a promising candidate for breast cancer therapy via modulating ERs.

Session-VII: Yadavindra Young Scientist Award

Oral Presentations

VII-O-1. Genetics and hybrid breeding of *Pleurotus* spp. for biotic and abiotic stresses

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Oyster mushroom is a basidiomycete and belongs to the genus *'Pleurotus'*. The oyster mushroom is one of the most suitable fungal organism for producing protein rich food from various agrowastes without composting. The productivity of oyster mushroom per unit space and time is very high as compared to all other cultivated mushrooms. *Pleurotus* mushroom is heterothallic and has a bi-factorial tetra-polar incompatibility mating systems which has two unlinked mating type factors.

The yield and quality of *Pleurotus* mushroom can be improved by developing temperature tolerant, *Trichoderma* molds tolerant and high yielding hybrid strains through intermating of monosporic cultures of different strains. The fluctuating temperature and *Trichoderma* contamination during cropping cycle reduces mushroom yield. Hybrid strains may not only give mushrooms that show resistance to diseases and pests but may also reduce the dependence and risks of environmental and cultural stresses. With this view, the genetic improvement in *Pleurotus*. sp through hybridization was undertaken to develop *Trichoderma* and temperature tolerant strains of *P. ostreatus.* The single spore isolates derived from both the parents in hybridization programme were monokaryotic in nature, which showed wide range of variation in morphological and cultural characteristics *viz.* colour, growth pattern, appearance and radial growth rate.

The average radial growth rate of different SSIs of *P. ostreatus* and *P. sajor-caju* also showed wide variation at 32°C and it ranged from 2.00 to 8.38 and 5.71 to 11.48 mm/day respectively. The SSIs of *P. sajor-caju* showed highest radial growth rate at 32 ^{O}C as compare to *P. ostreatus* and showed *in vitro* tolerance to high temperature as compared to SSIs of *P. ostreatus*.

An inter specific hybridization of 30 SSIs of *P. ostreatus* and 30 SSIs of *P. sajor-caju* was carried out by mono–mono crossing i.e. two point inoculation in all possible combinations. Out of 900 inter-specific crosses total, 206 compatible reactions were reported with true clamp connections owing to dikaryotic nuclear status. The mating combinations showed 24.77 % of compatibility.

The distinct variation in morphology among the 206 different hybrids (dikaryons) was observed. Different shades of white colour and mycelia pattern from thick to thin, fluffy to cottony, flat to rough and ringed to unringed were observed in dikaryons.

The average radial growth rate of different hybrids of *Pleurotus* sp. at 28°C, 30°C and 32°C varied from 4.52 to 12.86; 2.52 to 12.00 and 1.57 to 10.95 mm/day respectively. In all, 114 hybrid strains recorded significantly higher radial growth rate over the parent *P. ostreatus* (5.24 mm/day) at 32°C. Total 109 hybrids

showed temperature tolerance at 32°C. The high, moderate and less temperature tolerance levels were recorded by 77, 67 and 28 hybrid isolates, respectively at 32°C.

The *Trichoderma viride* was most prevalent green mould causing contaminant in spawn laboratories and wheat straw based oyster mushroom farms. The colonization and damage to hybrid strains by *Trichoderma viride* (Tric.-2) in dual culture was found to be in the range of 98.83 to 18.33 % and 70.77 to 4.54 % respectively. In all 47 hybrids showed high per cent resistance *to T. viride* with less damage and colonization by *T. viride* (Tric-2).

The *in vitro Trichoderma* resistance/ tolerance under high inoculum level on MEA medium showed varying degree of reaction from no growth to over running of mycelium of *Trichoderma* by hybrid isolates. While in grain spawn, different hybrid isolate showed 20 to 100 % contamination index. The minimum contamination (20%) was observed in H-1601, H-1816, H-2112, H-2306, H-2324, H-2709 and H-2812.

The variation was observed in days to spawn formation at different temperatures in selected temperature and mold tolerant hybrid isolates. Total forty three hybrid isolates including parental strain *P. sajor-caju* were significantly superior to parent P-1 i.e. *P. ostreatus* (DMRP-254) for complete spawn development at *32°C* .

The selected 47 temperature and *Trichoderma* tolerant hybrid strains showed biological efficiency from 12.33 to 83.73% in first cultivation cycle, while four strains failed to produce fruiting bodies. The highest biological efficiency was recorded in hybrid strain H-1601 (83.73%). The biological efficiency, more than 40.00% was recorded in eighteen different hybrid strains. The hybrid strains also showed wide variation in growth yield and morphological parameters in summer trial (CC-II).

The early spawn run and fruiting was observed in hybrid isolates H-1501, H-1910, H-2312, H-2810, H-2010 and H-1601 as compared to other hybrids. The highest biological efficiency was observed in hybrid strain, H-1601 (81.07%) which was at par with second parent *P. sajor-caju* (DMRP-112) (78.97%), hybrid isolates H-0124 (78.37%), H-2810 (75.20%), H-1501 (76.60%), H-1910 (73.37%) and H-2010 (72.67%), but all these hybrid strains were significantly superior over first parent i.e. *P. ostreatus* (DMRP-254). The acceptable faint colour, thin fruit bodies, smooth texture and mild fishy to pleasant odour was reported in hybrid isolates H-1501, H-1524, H-1601, H-1910 and H-2010

The significant variation was not observed in protein, carbohydrate and fat content (%) among the hybrid isolates. The protein, carbohydrate and fat content varied between 20.15 to 29.28; 56.12 to 64.16 and 1.90 to 2.66% respectively in all the hybrids under study. The highest protein content (29.28%) was recorded in strain H-2810, whereas the minimum crude fat content (1.90%) was noticed in isolate H-2212.

The maximum shelf life of 4.67 days was observed in strain H-1907 at room temperature. In all six hybrid strains recorded significantly higher shelf life over the parent P-2 at room temperature. The influence of *T. viride* on disease incidence and yield revealed that more disease incidence was observed in strain, H-2901 and minimum yield reduction in hybrid strain H-1907.

The correlation analysis showed positive and highly significant correlation between the radial growth at 32°C and biological efficiency. The positive correlation was further observed between per cent *Trichoderma* resistance and the growth and yield parameters of hybrid strains. The analysis of variance of the measured morphological traits, revealed the highly significant variation (p= 0.01) between crosses.

The genetic advance as a percent of mean was highest in most of the morphological and growth traits of mushroom hybrids. The higher level of heritability at broad sense was observed in all the measured traits of hybrid mushroom. The high heritability with high genetic advance indicates and confirms the additive gene effect in hybrids for expression of different characters and variability at phenotypic and genotypic levels. The 18 hybrids showed significant mid parent heterosis for most of the growth and morphological traits. The radial growth rate at 32°C and *Trichoderma* resistance showed significant highest mid parent heterosis in hybrid strains H-0124, H-1501, H-1524, H-1910, H-2010, H-2810 and H-2913. The biological efficiency showed higher mid parent heterosis in the strain No. H-0124, H-1501, H-1601, H-1910 and H-2010, while hybrid strain H-1601 showed high better parent heterosis.

Average polymorphism up to 87.71 per cent was reported in all 15 RAPD primers used. The dissimilarity coefficient value showed that the hybrid H-2913 and H-2916 were genetically more divergent from *P. sajor-caju*. While hybrid isolates, H-1907, H-1501, H-1601, H-1524 and H-1612 showed more dissimilarity than *P. ostreatus*.

It is concluded that morphologically and genetically diverse high yielding, temperature and *Trichoderma* tolerant inter-specific hybrid strains *viz*. H-0124, H-1501, H-1601, H-1910, H-2010 and H-2810 were superior in all growth, yield, morphological and quality parameters over the first parents i.e*. P. ostreatus.*

VII-O-2. *In silico* investigation of 35 different species of genus *Pleurotus* and their inter-relationship amongst compatible mating groups

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Thirty five ITS (Internal transcribed spacer) sequences of different *Pleurotus* spp. were accessed from BOLD (Barcode of Life Datasystems). The different accession was analyzed by bioinformatics tools to establish a molecular phylogenetic relationship with compatibility groups. Sequences of ITS of all species were Multiple sequence aligned by MAFFT (Multiple Alignment using Fast Fourier Transform) algorithm and quality of sequences were tested for confidence score using guidance server with 100 iterations. The aligned input sequence through GUIDANCE below 0.6 confidence score was removed. Therefore the remaining 32 sequence were used. The phylogenetic tree was created using the MEGA7. The phylogenetic tree created was divided into two main groups i.e. Group A and Group B. Group A and B accumulates 16 species each. The statistical result showed the significant differential evolutionary rates for selected 32 species of *Pleurotus* spp*.* A discrete Gamma distribution was used to ascertain the evolutionary rate differences among sites (5 categories, [+G]). Mean evolutionary rates in these categories were 0.04, 0.22, 0.56, 1.17, 3.01 substitutions per site. These rates are scaled, such that the average evolutionary rate across all sites is 1. This means that sites showing a rate < 1 are evolving slower than average and

those with a rate > 1 are evolving faster than average. Tajima's Neutrality Test showed that changes in nucleotide are not due to normal mutation rates but it is due to other evolutionary forces which are acted upon. The D value of Tajima's Neutrality Test depicted the low frequency of haplotypes and lower heterozygosity in *Pleurotus* spp. compared to number of segregating sites. This also indicates that rare alleles with higher frequencies may be present which ultimately leads to formation of linked genes for survival, created by natural selection. The inter-compatibility and inter-sterility groups identified from previous literature were compared with present molecular phylogenetic tree. Group A consists of six inter-sterility group (IG) while group B is having seven IG. The molecular time tree showed that group B is evolved relatively earlier than group A. The present investigation would be advantageous to understand a fine association between conserved molecular sequence and the taxonomic and biological concept of species.

VII-O-3. Study of mycelial growth rate and extracellular enzyme activities as a combined tool to select the shiitake strains for cultivation on wheat straw

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Shiitake, *Lentinula edodes* (Berk.) Pegler is the second most widely cultivated edible mushroom in the world. Being as white rot fungus, it grows naturally on fallen wood logs of broad leaved trees. But the commercial cultivation of shiitake gained momentum with an onset of synthetic log cultivation on sawdust based substrate. Steadily expanding market for shiitake at global level creates a huge scope for shiitake production from many new and unconventional areas. Even though, the cultivation technology of shiitake is standardized, still this valued mushroom has so far not been exploited at commercial scale in India. The prime constraint behind its poor adoption is less availability of good quality saw dust of desired species and scanty germplasm that can give fruiting on wide range of agro residues. Keeping these problems in view, a study was conducted to select the potential strains having ability to fruit on wheat straw.

A total no. of 35 strains of shiitake were obtained from the culture bank of the ICAR-Directorate of Mushroom Research, Solan. Preliminary screening was done to test the ability of the strains to produce sporophores on wheat straw based substrate at temperature of 20±2°C. Out of the 35 strains tested, nine strains which produced the fruit bodies on wheat straw were further selected to test their growth rates, profile of extracellular enzymes and yield potential. Extra cellular enzyme activities such as cellulose, xylanase, laccase, manganese peroxidise and versatile peroxidise were assayed to indicate the potentiality of strains to utilize the straw based substrate. The crop was raised on wheat straw based substrate prepared by mixing wheat straw and wheat bran in 80:20 ratio. The biological efficiency of different strains on wheat straw based substrate was recorded and correlated with the growth rates and enzyme activities to select the potential strains. The experiment was conducted in completely randomized block division (CRBD) with three replications and three blocks for each replication. Two consecutive trials were conducted to validate the yield data. An analysis of variance was conducted for all variables and a comparison of means was done according to Duncan's test using R-Studio software (version 1.0.136)

The radial and linear growth rates of different strains on WEA medium and on straw without supplementation was found non significant. However, linear growth rate of different strains varied significantly on supplemented wheat straw. The highest linear growth rate was recorded in strain no. DMRO-327 (0.59 cm/day) followed by DMRO-34 (0.56 cm/day) and DMRO-412 (0.54 cm/day). The correlations tested between the linear growth rate on enriched straw and BE of different strains was found significant with the r value of 0.752. The activity of oxidase enzymes such as laccase and MnP were found highest at initial days of spawning and later the enzyme activity declined. The activity of VP was increased till the complete colonization of substrate and reduced thereafter. Among the activity of carbohydrases, CMCase was found highest followed by FPase and Xylanse at the time of fruiting. In the present study, CMCase, FPase and xylanase activities of all the strains were followed two different peaks, one at the initial stages of spawn run and another peak at the time of primordial formation. This raise in enzyme activity at fruiting is an indication of ability of the strains to utilize the water soluble carbohydrates for fruit body formation. Based on the total biological yield, the strains were grouped into three categories by using the Duncan's comparison test. The strain no DMRO-327 was showed BE of 60.23% with the production rate of 0.67. The strains with medium yield potentiality expressed the average BE of 33.67% with the production rate of 0.37. The mean BE of strains grouped under low yield potential was 13.35% with a production rate of < 0.13. The thickness of the pileus which is the essential physical quality parameter for drying and fresh market was found highest in DMRO-327(16.33mm) followed by strain no DMRO-328 (15.33mm) and DMRO-51(14.33mm). Based on the thickness of pileus the strains were segregated into three grades such as G_1 > 15 mm thickness, G_2 – 10 to 15 mm and G_3 - <10 mm thickness.

The present investigation provided data useful for screening of available germplasm to grow on straw based substrate. The significant variations among the different genotypes in terms of enzyme activity and yield potential define the specific adaptability of strains towards the straw based substrate and validate the object of present study.

VII-O-4. Taxonomy and enzyme assay of *Trametes versicolor* Fr. from district Solan of Himachal Pradesh

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Genus *Trametes* Fr. is a member of class *Agaricomycetes* (Phylum –*Basidiomycota*, subphylum – *Agaricomycotina*) which have hymenomycetous basidiocarps, 2-8 spored basidia and perforate to imperforate parenthesomes. All species are characterized by annual to biennial, pileate, basidiocarps with trimitic hyphal system and ellipsoid to cylindrical to allantoid, thin-walled spores which are negative in Melzer's reagent. The present paper is based on the taxonomic and enzymatic studies on *Trametes versicolor*, collected from from Shilly forest in District Solan of Himachal Pradesh during 2014. The species was identified as *Trametes versicolor* on basis of macroscopic, microscopic and molecular studies. According to various workers, *Trametes versicolor* is full of a protein-bound molecule known as PSK, or polysaccharide K. Many polysaccharides (including PSK) have been shown to boost the immune system

to fight infection and many different types of cancers. The only efficient organisms capable of substantial lignin decay are white rot fungi in the Agaricomycetes, which also contains non-lignin-degrading brown rot and ectomycorrhizal species. Laccase and MnP are currently the focus of much attention because of their diverse applications, such as delignification, cross linking of polysaccharides, bioremediation applications, food technological uses, personal and medical care applications. Laccase plays a role in the morphogenesis and differentiation of sporulating and resting structures in basidiomycetes as well as lignin biodegradation of wood in white-rot fungi. In present study, the qualitative and quantitative estimation of extracellular ligninolytic enzymes; Laccase (EC 1.10.3.2) and (MnP) (EC 1.11.1.13) was done.

VII-O-5. Production, characterization of dyes from *Pycnoporus sanguineus* and application of dye in textile fabrics

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Textile industry in India is one of the oldest and third largest among all industries. During the textile dyeing process up to 40% of dyes may remain unfixed to the fiber and contaminates the industrial wastewater. They are very stable and difficult to degrade. These dyes are resistant to microbial attack and are hardly removed from effluents by conventional biological, physical or chemical treatments. As an alternate to synthetic dyes, dyes from different natural sources like plants, bacteria, micro fungi and macro fungi and actinomycetes are emerging. Several reports on production of metabolites are available and also various enzymes of industrial applications such as invertase, tyrosinase, á-amylase, xylanase, â-glucosidase and laccase were documented from *Pycnoporus* sp. *P. sanguineus* has long been used in popular medicine by indigenous tribes of the Americas and Africa for treatment of a number illness and also have potential medical applications. The presentation focuses on production, extraction and application of dyes from *P. sanguineus* for textile dyeing. The work was initiated with a native pure culture, followed by production and extraction of dyes from mycelial culture and fruit body of *Pycnoporus* sp. The extracted dyes were applied to the selected textile materials (cotton and silk yarns and fabrics). The presentations will also emphasis on utilising the locally available agri wastes for successful cultivation of *Pycnoporus*.