

Medicinal mushrooms of Kerala - a brief overview

K.B.Vrinda

Formerly, Mushroom Research Lab, Jawaharlal Nehru Tropical Botanic Garden & Research Institute, Palode, Thiruvananthapuram 695 562, Kerala, India.

Corresponding author Email: drvrindakb@hotmail.com

(Submitted on January 29, 2022; Accepted on May 04, 2022)

ABSTRACT

Kerala is rich in its fungal biota. Mushrooms indigenous to Kerala have enormous potential as sources of bioactive agents for biopharmaceutical exploitation. A study which aimed to bring out a comprehensive account of the wide variety of medicinal mushrooms available in Kerala, revealed the presence of 34 species of medicinal mushrooms. Ecological survey, molecular identification and assessment of the medicinal potentials of these mushrooms are good research domain. This will ensure the full and sustainable exploitation of these mushrooms

Keywords: Kerala, Medicinal properties, Mushrooms

INTRODUCTION

Historically, mushrooms have long been thought to hold medicinal value. In the Orient, several thousand years ago, there was the recognition that many edible and certain non-edible mushrooms could have valuable health benefits (Bensky and Gamble, 1993; Hobbs, 1995). A large variety of mushrooms have been utilized traditionally in many different cultures for the maintenance of health, as well as in the prevention and treatment of diseases through their immunomodulatory and antineoplastic properties. In the last decade, the interest for pharmaceutical potential of mushrooms had increased rapidly, and it was suggested that many mushrooms were like mini-pharmaceutical factories producing compounds with miraculous biological properties (Patel and Goyal, 2012).

There are approximately 700 species of higher *Basidiomycetes* that have been found to possess significant pharmacological activities (Ajith and Janardhanan, 2007). The Chinese and other cultures have used mushrooms as medicine traditionally for thousands of years. Although the general medicinal benefit of mushrooms is immunity enhancing, varying mushrooms have varying degrees of specific benefits. Some species of mushrooms have been used as medicine for thousands of years, particularly in China and Japan. They have been studied in modern medical research since the 1960s, where most studies use extracts, rather than whole mushrooms. It appears that combining several types of mushrooms in a formula, creates a synergistic immune response. So often it is beneficial to use formulas containing several varieties.

There are a wide variety of medicinal mushrooms available. Different species of mushrooms have been found to contain various chemical constituents, micro and macronutrients as well as secondary metabolites and are commonly used for their nutritive and medicinal values. Medicinal mushrooms have been more widely used as traditional medicinal ingredients for the treatment of various diseases and related health problems largely due to the increased ability to produce the mushrooms by artificial methods.

A number of bioactive molecules, including antitumor substances, have been identified in many mushroom species. Terpenoids are the primary class of bioactive compounds isolated from mushrooms. Polysaccharides are the best known and most potent mushroom-derived substances with antitumor and immune modulating properties. Numerous reports were published describing the isolation and study of substances with medicinal properties from a large number of mushroom species (Mizuno *et al.*, 1995).

In the last few years, *Basidiomycetes* have received great attention due to their medicinal values, easy availability, and lower side effects and toxicity on non-target organisms. This paper discusses briefly some of the common medicinal mushrooms of Kerala and its medicinal properties.

METHODS

Survey and collection of wild mushrooms from different parts of Kerala was conducted during the period from 2015 to 2018. Fresh fruiting bodies were collected from different forest areas of Kerala. All collections were identified following standard morpho-taxonomic protocols (Singer, 1986). Information on medicinal properties was gathered solely from authentic published sources. All studied materials were deposited in the mushroom herbarium of JNTBGRI (TBGT-M).

RESULTS AND DISCUSSIONS

The checklist contains information on 34 species of medicinal mushrooms (**Table 1**) with details on collection locality, season, medicinal properties and references. Morpho-taxonomic descriptions of the species are excluded as most species are well known which can be fetched from earlier literature.

CONCLUSION

Mushrooms are still far from being thoroughly studied and even the inventory of species is incomplete, with only 10% known so far. The number of mushrooms screened for pharmacological potential is still much lower. Kerala, floristically one of the richest states with diverse habitats may hold many potential medicinal species. In order to get a clear

Taxa	Locality	Season	Medicinal properties	References
<i>Agaricus bisporus</i> (J.E.Lange) Imbach	Idukki Dt., Munnar	February	Anti-inflammatory, anticancer, anti-candidal	Zhang <i>et al.</i> , 2009; Grove, 1981; Hong <i>et al.</i> , 2004
<i>Agaricus campestris</i> L.	Idukki Dt., Munnar	May	Antihyperglycaemic, antidiabetic	Gray and Flatt 1998
<i>Agaricus sylvaticus</i> Schaeff.	Thiruvananthapuram Dt., TBGRI campus; Wayanad Dt., Ponkuzhi	April-December	Antibacterial, antiviral, anticancer, antioxidant, immunostimulant.	Munkhgerel <i>et al.</i> , 2011; Fortes <i>et al.</i> , 2008
<i>Amanita muscaria</i> (L.) Lam.	Idukki Dt., Munnar	July-August	Neurological disorders, female menopause, subduing over-excitability, bladder and intestinal cramps.	Hobbs, 1995
<i>Amanita pantherina</i> (DC) Krombh.	Thiruvananthapuram Dt., Kallar	July-August	psychoactive compound muscimol, but is used as an entheogen	Michelot and Howell, 2003
<i>Auricularia nigricans</i> (SW.) Birkebak, Looney & Sanchez - Garcia	Kollam Dt., Thennala; Thiruvananthapuram Dt., TBGRI campus	June	Cholesterol lowering, hypoglycaemic, anticoagulant, uterine bleeding, abdominal and tooth pain.	Hanssen and Schadler, 1982
<i>Calocybe indica</i> Purkay. & A. Chandra	Thiruvananthapuram Dt., TBGRI campus	November	Anticancer, antidiabetic, antioxidant, antidiabetic, antimicrobial, antihyperglycaemic and anti-lipid peroxidation activity	Ghosh, 2015; Nisha and Kumuthakalavalli, 2016; Alfala <i>et al.</i> , 2017; Krishnamoorthy, 2003
<i>Cantharellus cibarius</i> Fr.	Thiruvananthapuram Dt., TBGRI campus; Kallar; Wayanad Dt., Muthanga, Ponkuzhi.	January, May-September, November - December	Antioxidant, antimicrobial, antioxidant, cytotoxic, antihypertensive and antibacterial properties	Aina <i>et al.</i> , 2012; Kozarski <i>et al.</i> , 2015
<i>Coprinus comatus</i> (O.F. Mull.) Pers.	Wayanad Dt., Muthanga	February, August	Anti-diabetic, anti-inflammatory, anti-cancer, immunomodulatory and anti-antitumor	Li <i>et al.</i> , 2010; Cui <i>et al.</i> , 2002; Xing <i>et al.</i> , 2003; Gu and Ju, 1996
<i>Ganoderma lucidum</i> (Curtis) Karst.	Thiruvananthapuram Dt., TBGRI campus, Kallar	July	Analgesic, anti-allergenic, anti-inflammatory, antibacterial, antioxidant, antitumor, antiviral, hypotensive, cardio tonic, expectorant and antitussive, anti-HIV, hepatoprotective, immune-modulating.	Hobbs, 1995
<i>Hygrocybe coccinea</i> (Schaeff.) P. Kumm.	Kollam Dt., Achenkovil	June	Antioxidant, anti-tumour	Zusman <i>et al.</i> , 1997
<i>Hygrocybe parvula</i> (Peck) Murrill	Thiruvananthapuram Dt., TBGRI campus; Wayanad Dt., Muthanga; Kollam Dt., Kulathupuzha, Thennala, Aryankavu.	June-November	Anthelmintic, antibacterial, antifungal	Chittaragi and Kodyalath, 2014; Mather and Gonzalez, 1982

<i>Hymenopellis colensoi</i> (Dörfelt) R.H. Petersen	Thiruvananthapuram Dt., TBGRI campus; Kollam Dt., Thenmala, Palakkad Dt., Nelliyanampathy; Idukki Dt., Munnar, Rajamala; Wayanad Dt., Meppady	June-November	Antifungal, antioxidant, hepatoprotective	Cerna and Musilek, 1968; Volc <i>et al.</i> , 1978; Liu <i>et al.</i> , 2017
<i>Lentinus sajor-caju</i> (Fr.) Fr.	Thiruvananthapuram Dt., TBGRI campus; Kollam Dt., Aryankavu, Cheenikala	April, June; August - December	Antioxidant, anticancer, anti-inflammatory, antidiabetic, antitumor	Kanagasabapathy <i>et al.</i> , 2013; Boonsong <i>et al.</i> , 2016; Finimundy <i>et al.</i> , 2013; Silveira <i>et al.</i> , 2015; Zhuang <i>et al.</i> , 1993
<i>Lentinus squarrosulus</i> Mont.	Thiruvananthapuram Dt., TBGRI campus, Perayam, Kallar, Kollam Dt., Thenmala, Cheenikala; Ernakulam Dt., Iringole; Alappuzha Dt., Kuttanad; Wayanad Dt., Ponkuzhi	January- December	Antioxidant, antitumor	Ahmad <i>et al.</i> , 2014; Hussein <i>et al.</i> , 2015;
<i>Lepista sordida</i> (Schumacher) Singer	Thiruvananthapuram Dt., TBGRI campus; CPCRI campus, Palode, Varkala; Kollam Dt., Thenmala, Kulathupuzha	January-December	Anticancer, antioxidant, anti-ageing	Mazur <i>et al.</i> , 1996; Zhong <i>et al.</i> , 2013
<i>Macrocybe gigantea</i> (Masse) Pegler & Lodge	Thiruvananthapuram Dt., TBGRI campus	January-March; May - November	Antimicrobial, hepatoprotection, antioxidant	Roy <i>et al.</i> , 2017; Acharya <i>et al.</i> , 2012
<i>Macrolepiota dolichaula</i> (Berk. & Broome) Pegler & R.W. Rayner	Thiruvananthapuram Dt., TBGRI campus, Bharathanoor, Peringamala, Palode, Kulathupuzha; Kollam Dt., Madathara, Kadakkal.	January - March; May - November	Antioxidant, anticancer, antioxidant, immunostimulating.	Samanta <i>et al.</i> , 2015.
<i>Macrolepiota mastoidea</i> (Fr.) Singer	Kollam Dt., Kulathupuzha, Thenmala	September	Antimicrobial, antiviral, antitumor, anti - Allergic, immunomodulating, anti - inflammatory, antiatherogenic, hypoglycemic, hepatoprotective	Barros <i>et al.</i> , 2007, 2008; Lindequist <i>et al.</i> , 2005
<i>Macrolepiota procera</i> (Scop.) Singer	Palakkad Dt., Chembotty	December	Antioxidant, anti-tumor and anti-bacterial	Popescu <i>et al.</i> , 2016; Didukh <i>et al.</i> , 2003
<i>Omphalotus illudens</i> (Schwein.) Bresinsky & Besl.	Thiruvananthapuram Dt., TBGRI campus: Wayanad Dt., Muthanga	March, June - July, September - December	Antibacterial, antioxidant, antitumor	Kalyoncu <i>et al.</i> , 2010; McMorris <i>et al.</i> , 2010; Schobert <i>et al.</i> , 2011; Wiltshire <i>et al.</i> , 2007
<i>Oudemansia canarii</i> (Jung.) Hohn.	Thiruvananthapuram Dt.: TBGRI campus, Kallar; Kollam Dt.: Thenmala, Achankovil; Ernakulam Dt.: Bhuthankettu, Edayar, Idukki Dt.: Munnar; Wayanad Dt.: Nadavayal	January, April - November.	Anti-hypertensive, immune stimulating, anticancer, antimicrobial, antifungal	Rosa <i>et al.</i> , 2003, 2005; Anke, 1997.
<i>Pleurotus cystidiosus</i> O.K. Miller	Thiruvananthapuram Dt., TBGRI campus	August	Antioxidant, anticancer, body ache, immune boosting.	Lau <i>et al.</i> , 2013; Kudahewa <i>et al.</i> , 2008; Menikpurage <i>et al.</i> , 2012

<i>Pleurotus flabellatus</i> Sacc.	Thiruvananthapuram Dt., TBGRI campus; Kollam Dt., Cheenikkala, Thenmala, Rosemala; Ernakulam Dt., Iringole; Palakkad Dt., Nenmara	February, June - December	Immunomodulatory, antiproliferative, antitumour, antioxidant, antimicrobial, immune-enhancing, anticancer	Jagdish <i>et al.</i> , 2008; Jedinak <i>et al.</i> , 2011
<i>Psilocybe subcubensis</i> Guzman	Wayanad Dt., Nadavayal; Thiruvananthapuram Dt., TBGRI campus, Kollam Dt., Sankhili,	May-July, December.	Cluster headaches, obsessive-compulsive disorder, addiction, fear and anxiety	Delgado and Moreno, 1998
<i>Russula cyanoxantha</i> (Schaeff.) Fr.	Thiruvananthapuram Dt., TBGRI campus; Kollam Dt., Sankhili	June-July, November	Antitumour, antifungal, antidiabetic	Gao <i>et al.</i> , 2000; Güler <i>et al.</i> , 2012;
<i>Russula nigricans</i> Fr.	Thiruvananthapuram Dt., TBGRI campus	June, November	Antitumor, antidiabetic	Mao, 1998; Ohuchi and Aoyagi, 2010
<i>Schizophyllum commune</i> Fr.	Thiruvananthapuram Dt., TBGRI campus, CPCRI campus, Venjaramoodu, Vizhinjam	February, April, July, August, November	Anticancer, antimicrobial, anti-HIV	Mantovani <i>et al.</i> , 1997; Mirfat <i>et al.</i> , 2014; Ito and Sugawara, 1990
<i>Termitomyces clypeatus</i> R. Heim	Thiruvananthapuram Dt., TBGRI campus, Kallar; Kollam Dt., Thenmala, Achenkovil; Wayanad Dt., Muthanga	May-October	Antioxidant, antitumour, antimicrobial	Giri <i>et al.</i> , 2012;
<i>Termitomyces heimii</i> Natarajan	Thiruvananthapuram Dt., TBGRI campus, Kallar; Kollam Dt., Achenkovil, Kulathupuzha	March, May, June - September, December	Antioxidant, regulation of blood pressure, blood lipid, immune response, inflammation, apoptosis, anti-inflammatory, anti-anxiety	Mau <i>et al.</i> , 2004; Yukui <i>et al.</i> , 2009; Jaconello, 1992; Niren, 2006
<i>Termitomyces microcarpus</i> (Berk. & Broome) R. Heim	Thiruvananthapuram Dt., TBGRI campus, Kallar.	Jan.-April; June - November	Antioxidant, antimicrobial	Rajoriya and Gupta, 2015; Giri <i>et al.</i> , 2012
<i>Volvariella volvacea</i> (Bull.) Singer	Thiruvananthapuram Dt., TBGRI campus; CPCRI campus; Kollam Dt., Cheenikkala, Sankhili; Wayanad Dt., Muthanga	January- April, June - July, September - October	Antitumor, antioxidant, anti-inflammatory	Joseph <i>et al.</i> , 1999; Sudha <i>et al.</i> , 2008

picture of these wild mushroom resources, a more detailed survey has to be carried out and phytopharmacological screening is essential for better knowledge and utilization. The present work which aimed to bring out a comprehensive account of the wide variety of medicinal mushrooms available in Kerala is far from complete due to time constraints.

Conclusively, mushrooms indigenous to Kerala have enormous potential as sources of bioactive agents for biopharmaceutical exploitation. Ecological survey, molecular identification and assessment of the medicinal potentials of these mushrooms are good research domain. This will ensure the full and sustainable exploitation of these mushrooms.

ACKNOWLEDGEMENTS

The author is thankful to the Director, JNTBGRI for the facilities and to WGP, Planning & Economic Affairs Department, Govt. of Kerala for financial assistance.

REFERENCES

- Acharya, K., Chatterjee, S., Biswas, G., Chatterjee, A. and Saha, G.K. 2012. Hepatoprotective effect of a wild edible mushroom on carbon tetrachloride-induced hepatoprotective in mice. *Int. J. Pharm. Pharm. Sci.* **4**: 285-288.
- Ahmad, R., Muniandy, S., Shukri, N.I.A., Alias, S.M.U., Hamid, A.A., Wan Yusoff, W.M., Senafi, S. and Daud, F. 2014. Antioxidant properties and glucan compositions of various crude extract from *Lentinus squarrosulus* mycelial culture. *Advances in Bioscience and Biotechnology* **5**: 805-814.
- Aina, D.A., Jonathan, S.G., Olawuyi, O.J., Ojelabi, D.O. and

Durowoju, B.M. 2012. Antioxidant, antimicrobial and phytochemical properties of alcoholic extracts of *Cantharellus cibarius* a Nigerian mushroom. *N.Y. Sci. J.* **5**(10): 114-120.

- Ajith, T.A. and Janardhanan, K.K. 2007. Indian medicinal mushrooms as a source of antioxidant and antitumor agents. *J. Clin. Biochem. Nutr.* **40**: 157-162.
- Alfala., Alexandar, S. and Jaykar, B. 2017. Isolation and Characterization and antimicrobial activity of *Calocybe indica* APK-2. *Sch. Acad. J. Pharm.* **6** (4): 120-125.
- Anke, T. 1997. Strobilurins. In: *Fungal Biotechnology* (Ed.: Anke T.), Chapman & Hall Weinheim, London.
- Barros, L., Baptista, P., Correia, D.M., Casal, S., Oliveira, B. and Ferreira, I.C.F.R. 2007. Fatty acid and sugar compositions and nutritional value of five wild edible mushrooms from Northeast Portugal. *Food Chemistry* **105** (1): 140-145.
- Barros, L., Falcão, S., Baptista, P., Freire, C. and Vilas-Boas, M. 2008. Antioxidant activity of *Agaricus* sp. mushrooms by chemical, biochemical and electrochemical assays. *Food Chemistry* **3**: 61-66.
- Bensky, D. and Gamble, A. 1993. *Chinese Herbal Medicine: Materia Medica, Chinese Herbal Medicine Materia Medica*. Eastland Press Inc, Seattle.
- Boonsong, S., Klaypradit, W. and Wilaipun, P. 2016. Antioxidant activities of extracts from five edible mushrooms using different extracts. *Agric. Nat. Resour.* **50**: 89-97.
- Cerna, J. and Musilek, V. 1968. 2NADH₂ dehydrogenases in

- the basidiomycete *Oudemansiella mucida*. *Experientia* **24**: 22-23.
- Chittaragi, A. and Kodiyalmath, J. 2014. Anthelmintic screening of crude extracts of *Hygrocybe parvula*. *Journal Club for Applied Science* **1**: 21-27.
- Cui, M., Zhang, H. and An, L. 2002. Tumor growth inhibition by polysaccharide from *Coprinus comatus*. *World Chin. J. Digestol.* **10**: 287-290.
- Deepalakshmi, K. and Mirunalini, S. 2014. *Pleurotus ostreatus*: an oyster mushroom with nutritional and medicinal properties. *J. Biochem. Tech.* **5 (2)**: 718-726.
- Delgado, P.L. and Moreno, F.A. 1998. Hallucinogens, serotonin, and obsessive-compulsive disorder. *J. Psychoactive Drugs* **30**: 359-66.
- Didukh, M.Y., Wasser, S.P. and Nevo, E. 2003. Medicinal value of species of the family *Agaricaceae* Cohn (higher *Basidiomycetes*): current stage of knowledge and future perspectives. *International Journal of Medicinal Mushrooms* **5**: 133-152.
- Finimundy, T.C., Gambato, G., Fontana, R., Camassola, M., Salvador, M., Moura, S., Hess, J., Henriques, J.A.P., Dillon, A.J.P. and Roesch-Ely, M. 2013. Aqueous extracts of *Lentinula edodes* and *Pleurotus sajor-caju* exhibit high antioxidant capability and promising in vitro antitumor activity. *Nutr. Res* **33**: 76-84.
- Fortes, R.C., Recôva, V.L, Melo, A.L. and Novaes, M.R.C.G. 2008. Effects of dietary supplementation with medicinal fungus in fasting glycaemia levels of patients with colorectal cancer: A randomized, double-blind, placebo-controlled clinical study. *Nutr. Hosp.* **23**: 591-598.
- Gao, J.M., Dong, Z.J. and Liu, J.K. 2000. The constituents of the basidiomycete *Russula cyanoxantha*. *Acta Bot. Yunnan* **22**: 85-89.
- Giri S., Biswas, G., Pradhan, P., Manda, S.C. and Acharya, K. 2012. Antimicrobial activities of basidiocarps of wild edible mushrooms of West Bengal, India. *International Journal of Pharm. Tech. Research* **4 (4)**: 1554-1560.
- Gray, A.M. and Flatt, P.R. 1998. Insulin-releasing and insulin-like activity of *Agaricus campestris* (mushroom). *Journal of Endocrinology* **157**: 259-266.
- Grove, J.F. 1981. Volatile compounds from the mycelium of the mushroom *Agaricus bisporus*. *Phytochemistry* **14**: 2021-2022.
- Gu, Y. and Ju, Y. 1996. Food and officinal mushroom-*Coprinus comatus*. *Vegetable* **13**: 10-12.
- Güler, P., Khatun, S., Cakilcioglu, U. and Chatterjee, N.C. 2012. Antifungal Effects of *Russula cyanoxantha* Against the Plant Pathogen *Fusarium moniliforme* and *Fusarium culmorum*. *The 3rd International Biotechnology and Biodiversity Conference & Exhibition (BIOJOHOR 2012)*, Johor Bahru, Johor, Malaysia.
- Gunde-Cimerman, N. 1999. Medicinal value of the genus *Pleurotus* (Fr.) P. Karst. (*Agaricales* s.l., *Basidiomycetes*). *International Journal of Medicinal Mushrooms* **1 (1)**: 69-80.
- Hanssen, V.H.P. and Schadler, M. 1982. Pilze als volksmittel in der chinesischen medicine. *Deutsche Apoth.-Zeit* **122**: 1844-1848.
- Hobbs, C.H. 1995. *Medicinal Mushrooms: An Exploration of Tradition, Healing and Culture*. Botanica Press, Summertown, Tennessee.
- Hong, F., Yan, J., Baran, J.T., Allendorf, D.J., Hansen, L.D., Ostroff, D.F. *et al.*, 2004. Mechanism by which orally administered β -1, 3-glucans enhance the tumoricidal activity of antitumor monoclonal antibodies in murine tumor models. *J. Immunol.* **173**: 797-803.
- Hotson, J.W. and Lewis, E. 1934. *Amanita pantherina* of Western Washington. *Mycologia* **26(5)**: 384-391.
- Hussein, J.M., Tibuhwa, D.D., Mshandete, A.M. and Kivaisi, A.K. 2015. Antioxidant properties of seven wild edible mushrooms from Tanzania. *African Journal of Food Science* **9(9)**: 471-479.
- Ito, W. and Sugawara, I. 1990. Immunopharmacological study of sulfated schizophyllan (SPG). 1. Its action as a mitogen and anti-HIV agent. *International Journal of Immunopharmacology* **12**: 225-233.
- Jaconello, P. 1992. Niacin versus niacinamide. *Canadian Medical Association Journal* **147 (7)**: 9-90.
- Jagadish, L.K., Shenbhagaraman, R., Venkatakrisnan., V and Kaviyaran, V. 2008. Studies on the phytochemical, antioxidant and antimicrobial properties of three indigenous *Pleurotus* species. *Journal of Molecular Biology and Biotechnology* **1**: 20-29.
- Jedinak, A., Dudhgaonkar, S., Wu, Q.L., Simon, J. and Sliva, D. 2011. Anti-inflammatory activity of edible oyster mushroom is mediated through the inhibition of NF- κ B and AP-1 signaling. *Nutrition Journal* **10**: 52.
- Joseph, J.A., Shukit-Hale, B. and Denisova, N.A. 1999. Reversal of age related declines in neuronal signal transduction, cognitive and motor behavioral deficits with blue berry, spinach or strawberry dietary supplementation. *Journal of Neuroscience* **19**: 8114-

- 8812.
- Kalyoncua, F., Oskaya, M. and Kayalarb, H. 2010. Antioxidant activity of the mycelium of 21 wild mushroom species. *Mycology* **1** (3): 195-199.
- Kanagasabapathy, G., Malek, S.N.A., Mahmood, A.A., Chua, K.H., Vikineswary, S. and Kuppusamy, U.R. 2013. Beta-glucan-rich extract from *Pleurotus sajor-caju* (Fr.) Singer prevents obesity and oxidative stress in C57BL/6J mice fed on a high-fat diet. *Evid. Based Complement. Alternat. Med.* 1-10.
- Kozarski, M., Klaus, A., Jakovljevic, D., Todorovic, N., Vunduk, J., Petrovic, P., Niksic, M., Vrvic, M.M. and van Griensven, L. 2015. Antioxidants of edible mushrooms. *Molecules* **20**: 19489-19525.
- Krishnamoorthy, A.S. 2003. *Current Vistas in Mushroom Biology and Production* (Eds.: Upadhyay, R.C., Singh, S.K. and Rai, R.D.) *Mushroom Society of India*, 131-135.
- Kudahewa, D.D., Abeytunga, D.T.U. and Ratnasooriya, W.D. 2008. Antinociceptive activity of *Pleurotus cystidiosus*, an edible mushroom, in rats. *Pharmacognosy Magazine* **4**: 37-41.
- Lau, C.C., Abdullah, N. and Shui, A.S. 2013. Novel angiotensin I-converting enzyme inhibitory peptides derived from an edible mushroom, *Pleurotus cystidiosus* O.K. Miller identified by LC-MS/MS. *BMC Complementary and Alternative Medicine* **13**: 313-323.
- Li, B., Lu, F., Suo, X. and Nan, H. 2010. Antioxidant properties of cap and stipe from *Coprinus comatus*. *Molecules* **15**: 1473-1486.
- Lindequist, U., Niedermeyer, T.H.J. and Julich, W.G. 2005. The pharmacological potential of mushrooms. *Annals of Oncology* **2**: 285-299.
- Liu, Q., Zhu, M., Geng, X., Wang, H. and Ng, T.B. 2017. Characterization of polysaccharides with antioxidant and hepatoprotective activities from the edible mushroom *Oudemansiella radicata*. *Molecules* **22** (2): 234.
- Mantovani, G., Bianchi, A., Curreli, L., Ghiani, M., Astara, G., Lampis, B. *et al.* 1997. Clinical and immunological evaluation of schizophyllan (SPG) in combination with standard chemotherapy in patients with head and neck squamous cell carcinoma. *Int. J. Oncol.* **10** (1): 21321.
- Mao, X.L. 1998. *Economic Fungi of China*, 1st Edn. Sciences Press, Beijing, p. 376.
- Mather, S.B. and Gonzalel, L. 1982. Identification of terpenoids from leaves of *Piptocarpha peritoria* and their biological activities. *Journal of Natural Products* **45**: 495-496.
- Mau, J.L., Chang, C.N., Huang, S.J. and Chen, C.C. 2004. Antioxidant properties of methanolic extract from *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosus* mycelia. *Food Chemistry* **87**: 111-118.
- Mazur, X., Becker, U., Anke, T. and Sterner, O. 1996. Two new bioactive diterpenes from *Lepista sordida*. *Phytochemistry* **43**(2): 405-407.
- McMorris, T.C., Chimmani, R., Alisala, K., Staake, M.D., Banda, G. and Kelner, M.J. 2010. Structure-activity studies of urea, carbamate, and sulfonamide derivatives of acylfulvene. *J. Med. Chem.* **53**(3): 1109-16.
- Menikpurage, I.P., Soysa, SSSBDP. and Abeytunga, D.T.U. 2012. Antioxidant activity and cytotoxicity of the edible mushroom, *Pleurotus cystidiosus* against Hep-2 carcinoma cells. *J. Natn. Sci. Foundation Sri Lanka* **40**(2): 107-114.
- Michelot, D. and Melendez-Howell, L.M. 2003. *Amanita muscaria*: chemistry, biology, toxicology, and ethnomycology. *Mycological Research* **107** (2): 131-146
- Mirfat, A.H.S., Noorlidah, A. and Vikineswary, S. 2014. Antimicrobial activities of split gill mushroom *Schizophyllum commune* Fr. *American Journal of Research Communication* **2** (7): 113-124.
- Mizuno, T., Saito, H., Nishitoba, T. and Kawagishi, H. 1995. Antitumour-active substances from mushrooms. *Food Reviews International* **11**: 23-61.
- Munkhgerel, L., Erdenechimeg, N., Dumaa1, M., Zhang, G., Odonmajig, P. and Regdel D 2011. Chemical and biological investigation of the *Agaricus sylvaticus* Schaeff ex. Seer. *Mongolian Journal of Chemistry* **12**(38): 92-97.
- Niren, N.M. 2006. Pharmacologic doses of nicotinamide in the treatment of inflammatory skin conditions: A review. *Cutis* **77**: 11-16.
- Nisha, A.P. and Kumuthakalavalli, R. 2016. Anticancer activity of milky mushroom (*Calocybe indica* var. APK2) against A549 human lung cancer cell line studies. *Int. J. Pharm. Bio. Sci.* **7**(3): 73-80.
- Ohuchi, K. and Aoyagi, Y. 2010. Inhibitory effect of mushroom extracts on α -amylase and aglucosidase. *Nippon Shokuhin Kagaku Kaishi* **57**: 532-538.
- Patel, S. and Goyal, A. 2012. Recent developments in mushrooms as anticancer therapeutics: a review, *Biotech* **2** (1): 1-15

- Phan, C., Wong, W., David, P., Naidu, M. and Sabaratnam, V. 2012. *Pleurotus giganteus* (Berk.) Karunarathna & K.D. Hyde: nutritional value and *in vitro* neurite outgrowth activity in rat pheochromocytoma cells. *BMC Complem. Altern. M.* **12**: 102.
- Popescu, M., Costea, T., Nencu, I., Duțu, L.E. and Gîrd, C.E. 2016. Polyphenols contents and antioxidant activity of some Romanian wild edible mushrooms. *Farmacia* **64** (2): 231-236.
- Rajoriya, A. and Gupta, N. 2015. Proximate and antioxidant activity of mycelia of *Termitomyces microcarpus* and *Amanita loosii*. *Agri. Res. Tech. J.* **1**(1): ARTOAJ.MS.ID.55554
- Rosa, L.H., Machado, K.M.G., Jacob, C.C., Capelari, M., Rosa, C.A. and Zani, C.L. 2003. Screening of Brazilian Basidiomycetes for antimicrobial activity. *Memo'rias do Instituto Oswaldo Cruz* **98**: 967-974.
- Roy Das, A., Saha, A.K. and Das, P. 2017. Proximate composition and antimicrobial activity of three wild edible mushrooms consumed by ethnic inhabitants of Tripura in northeast India. *Studies in Fungi* **2** (1): 17-25.
- Samanta, S., Nandi, A.K., Sen, I.K., Maity, P., Pattanayak, M., Devi, K.S.P., Khatua, S., Maiti, T.K., Acharya, K. and Islam, S.S. 2015. Studies on antioxidative and immunostimulating fucogalactan of the edible mushroom *Macrolepiota dolichaula*. *Carbohydr. Res.* **413**: 22-29.
- Schobert, R., Knauer, S., Seibt, S. and Biersack, B. 2011. Anticancer active illudins: recent developments of a potent alkylating compound class. *Curr. Med. Chem.* **18**: 790-807.
- Silveira, M.L.L., Smiderle, F.R., Agostinia, F., Pereira, E.M., Bonatti-Chavesa, M., Wisbecka, E., Ruthes, A.C., Sasaki, G.L., Cipriani, T.R., Furlan, S.A. and Iacomini M (2015). Exopolysaccharide produced by *Pleurotus sajor-caju*: Its chemical structure and anti-inflammatory activity. *Int. J. Biol. Macromolec.* **75**: 90-96.
- Singer, R. 1986. *The Agaricales in Modern Taxonomy*. Koeltz Scientific Books, Koenigstein, ed. 4, pp. 981.
- Ghosh, S.K. 2015. Study of anticancer effect of *Calocybe indica* mushroom on breast cancer cell line and human Ewings sarcoma cancer cell lines. *Sci. J.* **8**(5): 10-15.
- Sudha, A., Lakshmanan, P. and Kalaiselvan, B, 2008. Antioxidant properties of paddy straw mushroom *Volvarella volvacea* (Bull. ex Fr.) Sing. *International Journal of Applied Agricultural Research* **3**(1): 9-16.
- Wiltshire, T., Senft, J., Wang, Y., Konat, G.W., Wenger, S.L., Reed, E. and Wang, W. 2007. BRCA1 contributes to cell cycle arrest and chemoresistance in response to the anticancer agent irifolven. *Mol. Pharmacol.* **71**: 1051-1060.
- Xing, F., Wang, H., Han, C. and Wang, Y. 2003. Study on the immunocompetence of polysaccharides from the *Coprinus comatus*. *J. Food Sci.* **24**: 139-141.
- Yukui, R., Wenya, W., Rashid, F. and Qing, L. 2009. Fatty acids composition of apple and pear seed oil. *International Journal of Food Properties* **12** (4): 774-779.
- Zhang, M., Huang, J., Xie, X. and Holman, C.D.J. 2009. Dietary intakes of mushrooms and green tea combine to reduce the risk of breast cancer in Chinese women. *Int. J. Cancer* **124**: 1404-1408.
- Zhong, W., Liu, N., Xie, Y., Zhao, Y., Song, X. and Zhong, W. 2013. Antioxidant and anti-aging activities of mycelial polysaccharides from *Lepista*. *Int. J. Biol. Macromol.* **60**: 355-359.
- Zhuang, C., Mizuno, T., Shimada, A., Ito, H., Suzuki, C., Mayuzumi, Y., Okamoto, H., Ma, Y. and Li, J. 1993. Antitumor protein-containing polysaccharides from a Chinese mushroom Fengweigu or Houbitake, *Pleurotus sajor-caju* (Fr.) Sing. *Biosci. Biotechnol. Biochem.* **57**(6): 901-906.
- Zusman, I., Reifen, R., Livni, O., Smirnov, P., Gurevich, P., Sandler, B., Nyska, A. and Gal, R. 1997. Role of apoptosis, proliferating cell nuclear antigen and p53 protein in chemically induced colon cancer in rats fed corn cob fibre treated with the fungus *Pleurotus ostreatus*. *Anticancer Research* **17** (3): 210-513.