academicJournals

Vol. 13(4), pp. 523-545, 22 January, 2014
DOI: 10.5897/AJB2013.13446
ISSN 1684-5315 ©2014 Academic Journals
http://www.academicjournals.org/AJB

African Journal of Biotechnology

Review

Diversity, nutritional composition and medicinal potential of Indian mushrooms: A review

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Accepted 2 January, 2014

Mushrooms are the higher fungi which have long been used for food and medicinal purposes. They have rich nutritional value with high protein content (up to 44.93%), vitamins, minerals, fibers, trace elements and low calories and lack cholesterol. There are 14,000 known species of mushrooms of which 2,000 are safe for human consumption and about 650 of these possess medicinal properties. Among the total known mushrooms, approximately 850 species are recorded from India. Many of them have been used in food and folk medicine for thousands of years. Mushrooms are also sources of bioactive substances including antibacterial, antifungal, antiviral, antioxidant, antiinflammatory, anticancer, antitumour, anti-HIV and antidiabetic activities. Nutriceuticals and medicinal mushrooms have been used in human health development in India as food, medicine, minerals among others. The present review aims to update the current status of mushrooms diversity in India with their nutritional and medicinal potential as well as ethnomedicinal uses for different future prospects in pharmaceutical application.

Key words: Mushroom diversity, nutritional value, therapeutic potential, bioactive compound.

INTRODUCTION

Mushroom is a general term used mainly for the fruiting body of macrofungi (Ascomycota and Basidiomycota) and represents only a short reproductive stage in their life cycle (Das, 2010). Mushroom can be epigeous or hypogeous, large enough to be seen with the naked eyes and can be picked by hand (Chang and Miles, 1992). From the taxonomic point of view, mainly basidiomycetes but also some species of ascomycetes are mushroom forming fungi. Total mushrooms on the earth are estimated to be 140,000 species in which 10% (14,000 approximately) are known. Assuming that the proportion of useful mushrooms among the undiscovered and unexamined mushrooms will be only 5%, implies that there are 7,000 yet undiscovered species, which if discovered will be provided with the possible benefit to mankind (Hawksworth, 2001).

Mushrooms have a long association with humankind and provide profound biological and economical impact. From ancient times, wild mushrooms have been consumed by man with delicacy probably, for their taste and pleasing flavor (Das, 2010). They have rich nutritional value with high content of proteins, vitamins, minerals, fibers, trace elements and low/no calories and cholesterol (Agahar-Murugkar and Subbulakshmi, 2005; Wani et al., 2010).

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Abbreviations: NEH, North-eastern hills; **FRAP,** ferric reducing antioxidant power; **DPPH,** 2,2-diphenyl-1-picrylhydrazyl; **ABTS,** 2,2-azobis-3-ethylbenzthiazoline-6-sulphonilic acid; **RPA,** reducing power ability; **FRS,** free radical scavenging activity; **NOS,** nitric oxide synthase; **EAC,** Ehrlich's ascites carcinoma; **DLA,** Dalton's Lymphoma Ascites.

Many of them have been used in folk medicine for thousands of years. Some of them are nutraceuticals (natural food having potential value in maintaining good health and boosting immune system of the human body) while others can produce potent nutriceuticals (compounds that have medicinal and nutritional attributes and are consumed as medicines in the form of capsules or tablets but not as food) (Elmastas et al., 2007; Ribeiro et al., 2007). Mushrooms are known to be rich sources of various bioactive substances like antibacterial, antifungal, antiviral, antiparasitic, antioxidant, antiinflammatory, antiproliferative, anticancer, antitumour, cytotoxic, anti-HIV, hypocholesterolemic, antidiabetic, anticoagulant, hepatoprotective compounds, among others (Wasser and Weis, 1999; Lindequist et al., 2005; Ajith and Janardhanan, 2007). Out of approximately 14,000 known species, 2,000 are safe for human consumption and about 650 of these possess medicinal properties (Rai et al., 2005). In developing countries like India with rich biodiversity, mushrooms are a boon for progress in the field of food, medicine and unemployment because of several nutriceuticals and medicinal mushrooms that have been found to be useful towards human health development as food, medicine, minerals and drugs among others. (Rai et al., 2005; Sheena et al., 2005; Wani et al., 2010). The present review provides information on mushroom diversity in India and their nutritional and therapeutic importance of various Indian mushrooms towards human health and benefits such as food, medicine, minerals, drugs among others.

MUSHROOM DIVERSITY IN INDIA

In India the total recorded mushrooms are approximately 850 species (Deshmukh, 2004). There are references to the use of mushrooms as food and medicine in India in the ancient medical treatise, Charaka Samhita (3000±500 BC). However, the scientific study of mushrooms in India started with the identification and description of *Podaxis pistillaris* (L.: Pers.) by Linnaeus in the 18th century which was collected and sent by Koening from Tamil Nadu State. Later, Sir J.D. Hooker made extensive collection mostly from Assam, Darjeeling, Sikkim and Khasi hills which led to the publication of a series of papers by an English mycologist, Revd M.J. Berkeley between 1850 and 1882 (Natarajan, 1995).

Collection and scientific study of mushrooms in India really began during the 19^{th} century and continued till date (Kaul, 2002). The period can be divided into three phases. The first phase lasted from 1825 to 1899 and in addition to Berkeley and Montagne, recorders during this phase included Fries, Léveillé, Currey, Cooke, Massee, Watt and Lloyd (Sathe, 1979; Natarajan, 1995). The second phase (1900-1969) started with Paul Henning's significant contributions which have described another 32 genera and 68 species from India (Natarajan, 1995). A significant feature of the second phase was the involvement, besides European and American workers, of a number of Indian workers in research on higher fungi (Sathe, 1979). Special mention should be made of the work on Indian fungi by E.J. Butler at Pusa (Bihar) in the post of Imperial Mycologist who has produced the first authoritative list, *Fungi of India*, in collaboration with G.R. Bisby (Butler and Bisby, 1931). This publication was updated until the latest edition by Sarbhoy et al*.* (1996). Notable Indian workers of this period were Professor S.R. Bose (Calcutta, West Bengal) and Professor K.S. Thind (Punjab University, Chandigarh). The third phase of the work is said to have started in the early 1970s and continuing till date provided much needed impetus with the development of an edible mushroom industry in India. After that, several researchers are continuing their study all over India on mushroom diversity and their uses as food and medicine (Patil et al*.,* 1995; Swapna et al., 2008; Das, 2010, Sachan et al., 2013). Details of region wise studies undertaken on mushroom diversity in India have been discussed below.

North India

Several reports on higher fungi and mushroom have been conducted from northern India which includes North Western region, Eastern Himalaya proper and North-Eastern hilly areas. North western region of India includes Punjab, Haryana, Chandigarh and Gujarat while the Eastern Himalaya proper includes the northern parts of Assam, the whole of Arunachal Pradesh and Sikkim, and North-Eastern covers the hilly states of Nagaland, Meghalaya, Manipur, Mizoram and Tripura (Khoshoo, 1992). Berkeley in 1876 was probably the first to report higher fungi from the Kashmir valley. Later, T. N. Kaul and his group provided fragmentary records on higher fungi in the late 1960s working at the Regional Research Laboratory, Srinagar and Kashmir. Due to sustained work carried out by Kaul, Kapoor and Abraham from Northern India, 262 higher fungi have been recorded from Kashmir valley, among which 226 taxa were agarics (Abraham, 1991). They described a number of species of *Coprinus, Morchella, Pleurotus, Lycoperdon, Calvatia* and *Helvella.* A significant contribution to their study was made by Professor Watling from Edinburgh, UK, who, besides providing constant guidance to these workers, published a list of 119 species of higher fungi from the Kashmir valley, based on his personal collection (Watling and Gregory, 1980).

North-Western Himalaya has been the centre of intensive research on higher fungi since the 1950s. An edible species of *Agaricus,* namely *Kbasianulosus* was first reported from Punjab of North-West Himalaya by Paracer and Chahal (1962). Now there are two active centers (Department of Botany, Punjab University, Chandigarh and Punjabi University, Patiala) of research on macrofungi in this region and collections have mostly been made from North-West Himalaya. Professor K. S. Thind (Punjab University, Chandigarh) has published a series of papers on operculate discomycetes, particularly *Pezizales*. A total of 226 operculate discomycetes have been recorded from India so far; the major contribution from Thind and his associates. Thind and his associates have also worked on clavarioid homobasidiomycetes in the Himalaya, recording 181 taxa in 20 genera from Indo-Himalaya (Thind, 1961; Kaul, 1992). Thind and his colleagues have also published a series of papers on the *Polyporaceae* of India, and later Rattan (1977) recorded 198 species of resupinate aphyllophoroid taxa from North-West Himalaya.

A number of reports on mushroom from North Western Himalaya have been provided by Atri and Saini since 1988 to till date from Department of Botany, Punjab University, Patiala (second center). Atri and Saini (1989) reviewed work on the *Russulaceae* worldwide including the Indian components. They have described many species of mushrooms which include *Russula, Lactarius* (Saini et al. 1988, Atri et al. 1991a), *Agaricus campestris* (Atri et al. 1991b), *Termitomyces* (Atri et al., 1995), *Agaricales* and *Gasteromycetes* (Saini and Atri, 1995), *Lepiota* (Atri et al., 1996). Atri et al. (1997) also studied the taxonomy, distribution, ecology and edibility of 30 taxa of genus *Russula* which are new records from India. To date only 81 taxa (55 of *Russula* and 26 of *Lactarius*) have been recorded from India.

Some fleshy fungi from Himachal Pradesh were described by Sohi et al. (1964). They prepared a list of 15 fleshy fungi of which 3 (viz; *Macrolepiota procera, Cantharellus minor* and *Cantharellus cibarius)* were noted as edible. Sohi et al. (1965) also described 10 species in which four belonging to *Morchella* (viz; *M. hybrida, M. angusticeps, M. conica, M. esculenta)* and two of *Helvella* (viz; *Emitra,* and *E. crispa)* are edible. Three important centers of work on macrofungi in the state of Himachal Pradesh are the Biosciences Department, University of Himachal Pradesh, Shimla; the Agricultural and Horticultural University, Solan, and the National Research Centre on Mushrooms (ICAR), Solan. Professor Lakhanpal, working at the University of Himachal Pradesh, Shimla, has made a major contribution with a list of 190 species of *Agaricales* occurring over the entire North-west Himalayan region (Lakhanpal, 1995). Agarwal et al. (1984) made additions to fleshy fungi of India by recording *Collybia albijorida, Calvaria flava, Amanita phalliodes, Lysurus borealis* and *Calyatia* species from Palampur district of Himachal Pradesh. A review of Himalayan *Agaricales* was also conducted by Lakhanpal (1993) and listed all genera by family and the number of species present in India and their distribution in both north-western and eastern Himalaya. An attempt has been made by Pande et al. (2004) to give an assessment of the species diversity of epigeous ectomycorrhizal fungi of the temperate forests of Western Himalaya, based on studies carried out in this region. They have reported several major genera in terms of species of *Amanita* (15 sp.), *Russula* (13 sp.), *Boletus* (12 sp.), *Lactarius* (9 sp.), *Hygrophorus* (4 sp.) and *Cortinarius* (4 sp.).

A new record of twenty eight species of the macrofungi distributed in eighteen genera belonging to ten families of the order *Agaricales* have been reported by Upadhyay et al. (2007) from North Western Himalaya, India (Table 1). Futher, Vishwakarma et al. (2011) have reported some medicnal mushrooms (*Ganoderma lucidum*, *A. campestris*, *Hydnum repandum*, *Coprinus comatus*, *M. esculenta* and *Cantharellus cibarius*) from Garhwal Himalaya, Uttarakhand, India. Later, macrofungal diversity in moist temperate forests of Garhwal Himalaya has reported by M.P. Vishwakarma and his group (Vishwakarma et al., 2012). As a result of their study, total 40 taxa belonging to 11 families were identified (Table 1).

Sharma and Sidhu (1991) reported the occurrence and distribution of *Geoglossaceae* in the Eastern Himalayan ranges of India. They maintained that the Himalaya in general and Eastern Himalaya and adjoining hills in particular are relatively rich in *Geoglossaceae*. They surveyed localities in and around West Bengal, Meghalaya, Assam and Arunachal Pradesh states and recorded 12 species distributed among nine genera with ecological notes (Table 1). In India as a whole, the family is represented by 48 species within nine genera. Verma et al. (1987) described fleshy fungal flora of the north-eastern hills (NEH) India from Manipur and Meghalaya belonging to the family *Auriculariaceae, Clavariaceae, Cantharellaceae, Tricholomataceae, Pluteaceae, Paxillaceae, Cortinariaceae, Cycoperdaceae,* and *Sclerodermataceae* of Basidiomycotina and *Halvellaceae* of Ascomycotina. Again, Verma et al. (1995) recorded the results of a macrofungal survey of the NEH and confirmed ninety five species of higher fungi. Among these, 85 species were new records from the NEH region and others were from different locations of India.

Three new species of *Lactarius* (*L. sanjappae*, *L. mukteswaricus* and *L. verbekenae*) in different regions of Kumaon Himalaya were extensively studied and described by Das et al. (2004). Total 126 wild mushrooms from Barsey Rhododendron Sanctuary of the state Sikkim were also recently reported by Das (2010) which were enlisted with their scientific names, common names, distribution, growing period and status of edibility. Medicinally important 46 mushrooms were also highlighted with their medicinal properties. Acharya et al. (2010) have reported 151 species of Agaricales belonging to 42 genera from the Darjeeling and Sikkim hilly areas of Sikkim Himalaya. The number of representative species under each of the 42 genera varied with 13 genera having a single species each and the genera *Mycena* and *Collybia*, having 20 and 16 species, respectively. A total of 11 edible macrofungi

Table 1. Diversity of Indian mushrooms and their location.

Mushrooms diversity[1]	Location in India	References
Agaricus compestris *Cantharellus aurantiacus* *Cantharellus cibarius* *Coprinus comatus* *Lentinus subnudus* *Termitomyces microsporus* *Talbuminosa* *Volvariella terastius* *Truffles* and *Boletus* sp.	West Bengal	Bose and Bose (1941)
Volvariella diplasia *Pleurotus ostreatus* *Boletus crocatus* *Agaricus arvensis* and some puff-balls	Baroda State	Moses (1948)
15 fleshy fungi of *Macrolepiota procera, Cantharellus minor* and *C. cibarius*	Himachal Pradesh	Sohi *et al.* (1964)
10 species of which four belonging to *Morchella* (viz; *M. hybrida, M. angusticeps,* *M. conica, M. esculenta)* and two of Helvella (viz; *Emitra,* and *E. crispa)*	Himachal Pradesh	Sohi *et al.* (1965)
Calocybe indica and *Termitomyces eurhizus*	West Bengal	Purkayastha and Chandra (1974; 1975)
3 species belong to *Calvatia,* 2 to *Lycoperdon* and one each to *Geastrum* and *Bovista*	West Bengal	Gupta *et al.* (1974)
58 species of *Agaricus*, *Amanita*, *Chlorophyllum*, *Coprinus*, *Macrolepiota*, *Pleurotus*, *Termitomyces* and *Volvariella*	Lucknow, Uttar Pradesh	Pathak and Gupta (1979)
Collybia albijorida, Calvaria flava, *Amanita phalliodes, Lysurus borealis* and *Calyatia* sp.	Palampur, Himachal Pradesh	Agarwal *et al.* (1984)
Agaricus argyropotamicus, *Agaricus solidipes* and *Strophariapokhraensis*	Garhwal district, Uttar Pradesh	Dancholia and Bahukhandi, (1988)
12 species distributed in nine genera: *Cudonia*, *Leotia*, *Maasoglossum*, *Microglossum*, *Mitrula*, *Thuemenidium*, *Spathularia*, *Trichoglossum* and *Geoglossum.*	West Bengal, Meghalaya, Assam and Arunachal Pradesh	Sharma and Sidhu (1991)
Auricularia delicata, *A. auricula- Judea,* *A. mesentrica,* *Phellorina inquinans,* *Boletus spp.,* *Termitomyces microcarpus,* *Tstriatus, Pleurotus pulmonarius,* *R. ostreatus, P. sapidus,* *P. sajor-caju,* *Agaricus compestris,* *Volvariella bombycina, V. speciosa* and *Lepiota* spp.	Rajasthan, India	Sharma *et al*. (1992)

Table 1. Contd.

Mushrooms diversity[1]	Location in India	References
Termitomyces mammiformis and *T. tyleranus*	Punjab, India	Atri *et al,* (1995)
Cantharellus luteocomus, *Lentinus giganteus,* *Marasmins caryotea,* and *Pholiota ealaensis*	South India	Joseph *et al.* (1995)
Volvariella nigrodisca, *V. taylori, Vapalotricha* and *V. glandiformis*	Kerala, India	Pradeep *et al.* (1998)
Lentinus sanjappae, *L*. *mukteswaricus* and *L*. *verbekenae*	Kumaon Himalaya	Das *et al*. (2004)
Morchella esculenta, *M. conica* (Pers.) Fr., *M. deliciosa* (Fr.) Jct., *M. angusticeps* Peck, *M. crassipes* (Vent.) Pers. and *M. semilibera* (DC.) Fr.	Himachal Pradesh, Punjab, Jammu and Kashmir and Uttaranchal	Negi (2006)
Eighteen genera belonging to ten families of the order *Agaricales* are Agaricaceae (*Agaricus*), Amanitaceae (*Amanita*), Bolbitiaceae (*Agrocybe*), Coprinaceae (*Lacrymaria*), Cortinariaceae (*Cortinarius, Gymnopilus, Phaeocollybia*), Entolomataceae (*Entoloma*), Hygrophoraceae (*Hygrotrama*), Pluteaceae (*Pluteus*), Stophariaceae (*Phollota*) and Tricholomataceae (*Collybia, Laccaria, Lepista, Calocybe, Clitocybe, Melanoleuca, Tricholomopsis*)	North Western Himalaya	Upadhyay *et al*. (2007)
Ganoderma lucidum, *Agaricus campestris*, *Hydnum repandum*, *Coprinus comatus*, *Morchella esculenta*, *Cantharellus cibarius*	Garhwal Himalaya, Uttarakhand, India	Vishwakarma et al. (2011)
Xyrocomus chrysenteron *Suilleus spragaei* *Russula aquosq* *Russula solaris* *Russula violacea* *Nictalis asterophora* *Agaricus campestris* *Macrolapiota procera* *Amanita veginata* *Amanita pantherina* *Amanita caesarea* *Termytomyces microcarpus* *Termytomyces hemi* *Ganoderma lucidum* *Thelephora caryophyllea* (Schaeff.) Pers., *Coltricia cinnamomea* (Pers.) Murr., and *Guepinia helvelloides*	Amarkantak Biosphere Reserve, Madhya Pradesh, India	Dwivedi et al. (2012)

Table 1. Contd.

Mushrooms diversity[1]	Location in India	References
Total 40 taxa belonging to 11 families. Two families and 2 taxa belonged to class- Ascomycetes viz: Family- Helvellaceae and Morchellaceae and nine families and 38 taxa to class-Basidiomycetes viz: Family-Agaricaceae, Amanitaceae, Boletaceae, Cantharellaceae, Coprinaceae, Ganodermataceae, Hydnagiaceae, Lycoperdaceae and Russulaceae.	Garhwal Himalaya, Uttarakhand, India	Vishwakarma et al. (2012)
Agaricus bisporus Quell *Agaricus campestris* L. *Auricularia auricular* (Hook.) *Cantharellus cibarius* Fr. *Ganoderma lucidum* (Leys ex. Fr.) karsten *Lenzites betulina* Fries *Lycoperdon perlatum* Pers. *Termitomyces mummiformis* (Heim.) *Tricholoma luscinum* Fr. *Tricholoma colossus* Fr. (Quell.) *Tricholoma strictipes* Fr	Dhemaji District, Assam, India	Gogoi and Sarma (2012)
Scleroderma citrinum, *Psilocybe subtropicalis,* *Ganoderma applanatum,* *Cyptotrama asprata* and *Entoloma serrulatum*	Rajouri district, Jammu & Kashmir, India	Anand and Chowdhry (2013)
Gomphus floccosus (Schw.) Singer *Tricholoma virdiolivaceum* stev. *Craterellus odoratus* (Schwein.) Fr. *Lactarius volemus* (Fr.) Fr. *Cantharellus cibarius* *Tricholoma saponaceum* (Fr.) P. Kumm. *Tricholoma* sp. *Laccaria lateritia* Malencon *Albatrellus* sp. *Ramaria* sp. and *Clavulina* sp.	Khasi hills of Meghalaya, India	Khaund and Joshi (2013)
Russula sharmae, *R. dubdiana* and *R. sikkimensis*	West district of Sikkim, India	Das et al. (2013)
Russula emetica *Russula delica* *Termitomyces eurrhizus* *Termitomyces* sp. *Agaricus silvaticus* *Agaricus* sp. *Volvorella volvacea* *Volvorella* sp. *Lentinus sajor-caju* *Lentinus* sp. *Pleurotus ostreatus* *Pleurotus* sp.	Similipal Biosphere Reserve, Odisha, India	Sachan et al. (2013)

Table 1. Contd.

Mushrooms diversity[1]	Location in India	References
Lycoperdon sp.		
Calvatia gigantea		

[1]Mushroom diversity listed in chronological order from the year 1941 to 2013.

species (Table 1) in Dhemaji district, Assam were explored by Gogoi and Sarma (2012). Recently, Khaund and Joshi (2013) have reported diversity of wild edible mushrooms from Khasi hills of Meghalaya, India. During their study period, a total of 11 different species were identified based on morphology that belongs to 9 genera and 8 families (Table 1). Further, three new species of *Russula* (*Russula sharmae*, *R. dubdiana* and *R. sikkimensis*) from Sikkim (India) have been reported by Das et al. (2013).

Another centre of work in the northern India is the National Botanical Research Institute, Lucknow, Uttar Pradesh. Pathak and Gupta (1979) reported 58 species of agaricus from Lucknow area distributed among 25 genera. Prominent genera were *Agaricus*, *Amanita*, *Chlorophyllum*, *Coprinus*, *Macrolepiota*, *Pleurotus*, *Termitomyces* and *Volvariella*. Danchola and Bahukhandi (1988) discovered *Agaricus argyropotamicus, Agaricus solidipes* and *Stropharia pokhraensis* as new Agaricus from Garhwal district of Uttar Pradesh.

One of the important areas of northern India is Rajasthan. An intensive survey of wild mushrooms was conducted throughout the state by A. Doshi working at the Department of Plant Pathology, Rajasthan College of Agriculture for 8 years (1989-1996). Sharma et al. (1992) reported fifteen species of fungi from Rajasthan and many of these are first record of genus *Auricularia; (A. delicata, A. auricula-judea, A. mesentrica), Phellorina inquinans, Boletus sp., Termitomyces microcarpus, Termitomyces striatus, Pleurotus pulmonarius, Pleurotus ostreatus, Pleurotus sapidus, Pleurotus sajor-caju, Agaricus compestris, Volvariella bombycina, Volvariella speciosa* and *Lepiota* spp. Doshi and Sharma (1997) provided a detailed list of macrofungi occurring in the region with mycoecological notes. A total of 173 species belonging to 95 genera were recorded from this area. Most genera (18) were gasteromycetes or aphyllophoroid taxa (17). Special mention should be made of two edible gasteromycetes, *Phellorinia inquinans* Berk and *Podaxis pistillaris*, tonnes of which can be collected from desert areas. *P. inquinans* is associated with sand dunes in the area (Singh, 1994).

Morchella has a wide distribution in India and is very common in the temperate zones of forests in Jammu and Kashmir, Punjab, Himachal Pradesh and Uttaranchal (Negi, 2006). Six species of *Morchella* have been identified by Negi (2006), which include *M. esculenta*, *M. conica*, *Morchella deliciosa*, *M. angusticeps*, *Morchella crassipes* and *Morchella semilibera* (Table 1). Besides that, recently Anand and Chowdhry (2013) reported five wild mushrooms (*Scleroderma citrinum, Psilocybe subtropicalis, Ganoderma applanatum, Cyptotrama asprata* and *Entoloma* serrulatum) from Rajouri district of Jammu and Kashmir (JandK), India.

Central India

Mushroom research of central part of India covers Maharashtra, Madhya Pradesh, West Bengal and Odisha states. Moses (1948) identified the edible mushrooms of Baroda state including *Volvorella diplasia, P. ostreatus, Boletus crocatus, Agaricus arvensis* and some puff-balls. Mushroom recording in Maharashtra was neglected for a long time and only 21 species of agarics had been recorded from the state by year 1967 (Kamat et al., 1971). Intensive work in the region began only after 1974 when A.V. Sathe and his group, working at the Maharashtra Association for Cultivation of Sciences, published a series of papers mainly on *Agaricales* (Sathe, 1979; Sathe and Kulkarni, 1987). Later a comprehensive list of 231 mushrooms recorded from all regions of Maharashtra state was published by Patil et al. (1995). Recently Bhosle et al. (2010) reported 15 species and 3 varieties of *Ganoderma lucidum* (of which one variety remains unidentified) from the Western parts of Maharashtra (India) and in their study, only 9 valid *Ganoderma* species have been reported from India. Karwa and Rai (2010) also surveyed six different zones of Melghat forest of Amravati District, Maharashtra State from July 2005 to December 2008 for the availability of wild edible and medicinal mushrooms. In their study, out of total 153 species, ten species of *Agaricus* were recorded from different localities. Of these, seven species namely *Agaricus bitorquis, A. subrufescens, A. augustus, A. placomyces, A. essettei, A. basioanolosus* and *Agaricus* sp. nov (a new species) are being reported for the first time from this region (Table 1). Biodiversity of mushrooms of Amarkantak Biosphere Reserve, Madhya Pradesh have been reported by Dwivedi et al, (2012). They have collected 52 mushroom samples from Amarkantak region forests which were belonging to different genera out of which only 14 mushroom samples were identified up to species level (Table 1). Rests were identified only up to the genus level.

Bose (1921) reported a few edible species from undivided

Bengal. In 1940, Bose and Bose prepared a list of about 28 varieties of edible species including *A. compestris, Cantharellus aurantiacus, C. cibarius, C. comatus, Lentinus subnudus, T. microsporus*, *Termitomyces albuminosa*, *Volvariella terastia*, *Truffles* and *Boletus* sp. Two edible species, namely *Calocybe indica* and *Termitomyces eurhizus* have been reported by Purkayastha and Chandra (1974) from West Bengal. The former was a new species while the later was first recorded from India. Ten species of *Calvatia and Lycoperdon* have been incorporated in the list of edible fungi by Gupta et al. (1974). Out of the 10 species described, 7 were edible in their immature stage. Among seven edible mushroom, 3 species belong to *Calvatia,* 2 to *Lycoperdon* and one each to *Geastrum* and *Bovista.* Purkayastha devoted attention to wild edible mushrooms of West Bengal and succeeded in cultivating one of them, *C. indica* Purkayastha and Chandra. Purkayastha and Chandra (1985) compiled lists of Indian edible mushrooms which included 283 species of higher fungi. Recently a total of 14 species of fleshy mushrooms belonging to 8 genera and 6 families (Table 1) were reported by authors from Similipal Biosphere Reserve, Odisha, India (Sachan et al., 2013).

South India

Study on mushrooms in South India such as Tamil Nadu, Kerala, Karnataka and Andhra Pradesh was neglected as regards to studies on agarics until 1975 (Natarajan, 1995). The genus of *Volvariella* from Kerala, India was first time investigated by Pradeep et al. (1998). Out of ten species of *Volvariella* treated, *Volvariella nigrodisca, Volvariella taylori, Volvariella apalotricha* and *Volvariella gandiformis* are described and illustrated for the first time from Kerala by Pradeep et al. (1998). Natarajan listed 115 species of mushroom from Kerala (Kaul, 1992) and a macrofungal survey of Kerala was carried out at the Plant Pathology Department of Kerala Agricultural University at Vellayani, Thiruvananthapuram, by Ms Bhavani Devi from 1985 to 1988. The collections were made from 12 agroclimatic zones in four monsoon seasons and revealed the presence of 134 species of mushrooms (including 14 gasteromycete species) belonging to 45 genera (Bhavani Devi, 1995). Edible fruitning bodies included species of *Termitomyces*, *Volvariella*, *Pleurotus*, *Macro lepiota*, *Boletus* and *Calvatia*. *Tuber magnatum* Vitt. (Ascomycotina), a highly prized truffle, is regularly collected and consumed by tribal people in the forest area of the southern part of this state.

Staff of the Botany Department of Calicut University and the Tropical Botanic Garden and research Institute at Thiruvananthapuram were also surveyed macrofungi, but it was at only a preliminary stage. Natarajan started work at the Centre of Advanced Studies in Botany, University of Madras in 1975 and his group had collected mushrooms from the entire southern and south-western region. They started a series entitled ‘South Indian Agaricales’, publishing over two dozen papers. Natarajan (1995) presented a list of 230 agaric and bolete species distributed among 67 genera from southern Indian states excluding Kerala.

A survey of macrofungi diversity has been conducted in semi-evergreen and in moist deciduous forest of Shimoga District-Karnataka, India during 2005 to 2007 by Swapna et al. (2008). In their survey, a total of 778 species of macrofungi belonging to 43 families, 101 genera were enumerated of which 242 species were identified to genus level and 73 were identified to species level. Further, Pushpa and Purushothama (2012) have studied the biodiversity of Mushrooms in and around Bangalore (Karnataka), India and recorded 90 species in 48 genera belonging to 19 families in 05 orders. Among them, 28 species were found to be recorded for the first time in India.

NUTRITIONAL POTENTIAL OF MUSHROOMS

Man has been hunting for the wild mushrooms since ancient time (Cooke, 1977). Thousands of years ago, the fruiting body of higher fungi has been used as a source of food (Mattila et al., 2001) due to their chemical composition which is attractive from the nutrition point of view. During the early days of civilization, mushrooms were consumed mainly for their palatability and unique flavors. Present use of mushrooms is totally different from traditional because, lot of research has been done on the chemical composition of mushrooms, which revealed that mushrooms can be used as a diet to combat diseases. The early history regarding the use of mushrooms in different countries has been reviewed by number of workers (Rolfe and Rolfe, 1925; Bano and Rajarathnam, 1982; Wani et al., 2010). Rolfe and Rolfe (1925) mentioned that mushrooms like *A. campestris, M. esculenta, Helvella crispa, Hydnum coralloides, Hypoxylon vernicosum* and *Polyporus mylittae* were used much earlier in India. Lintzel (1941) recommended that 100 to 200 g of mushrooms (dry weight) is required to maintain an optimal nutritional balance in a man weighing 70 kg. Several researchers have determined the nutritional value of different mushrooms. Among them, Bano et al. (1963) determined the nutritive value of *Pleurotus flabellatus* as 0.974% ash, 1.084% crude fibre, 0.105% fat, 90.95% moisture, 0.14% non-protein nitrogen and 2.75% protein. Bano (1976) suggested that food value of mushrooms lies between meat and vegetables. Gruen and Wong (1982) indicated that edible mushrooms were highly nutritional and compared favorably with meat, egg and milk food sources. Crisan and Sands (1978) observed that mushrooms in general contain 90% water, 10% dry matter with the protein content varying between 27 and 48% and carbohydrates are less than 60% and lipids are between 2 to 8%. Orgundana and Fagade (1981) indicated that an average mushroom is about 16.5% dry matter out of which 7.4% is crude fiber, 14.6% is crude protein and 4.48% is fat and oil. In case of Indian mushrooms, several reports on nutritional status of different mushrooms have been published in different manner which is discussed below.

PROXIMATE COMPOSITION

Protein and amino acids

Protein is an important constituent of mushrooms (Agrahar-Murugkar and Subbulakshmi, 2005; Wani et al., 2010). Protein content of mushrooms depends on the composition of the substratum, size of pileus, harvest time and species of mushrooms (Bano and Rajarathnam, 1982). Protein content in *Pleurotus* sp. has been documented to range between 8.9 and 38.7% on dry weight basis (Bano and Rajarathnam, 1982). Rai and Sohi (1988) also reported protein content of *Agaricus bisporus* to be 29.3% on dry weight basis. Purkayastha and Chandra (1985) found 14 to 27% crude protein on dry weight basis in *A. bisporus, L. subnudus, C. indica* and *Volvariella volvacea*. Samajipati (1978) found 30.16, 28.16, 34.7 and 29.16% protein in dried mycelium of *A. campestris, A. arvensis, M. esculenta* and *M. deliciosa*, respectively. Sharma et al. (1988) reported 14.71 to 17.37% and 15.20 to 18.87% protein in the fruiting bodies of *Lactarious deliciosus* and *Lactarious sanguiffus*, respectively. Nutritional analysis of two edible wild mushrooms (*Schizophyllum commune* and *Lentinula edodes*) from northeast India have been studied by Longvah and Deosthale (1998) and reported that protein content of *L. edodes* (26%) is much higher than the *S. commune* (16%). Nutritional values of seven wild edible mushrooms were analyzed by Agrahar-murugkar and Subbulakshmi (2005) which are commonly consumed in the Khasi hills of Meghalaya and reported that 27.3, 27.5, 21.1, 24.1, 21.1, 21.2, 19.0% protein content present in *Calvatia gigantea, Clavulina cinerea, C. cibarius, Ramaria brevispora, Russula integra, Gomphus floccosus* and *Lactarius quieticolor*, respectively.

Pushpa and Purushothama (2010) have analyzed the nutrition of five mushroom species and found 21.60, 41.06, 27.83, 26.25, 18.31% protein in *C. indica, A. bisporus, P. florida, Russula delica* and *Lyophyllum decastes*, respectively. Jagadeesh et al. (2010) analyzed the proximate composition of *V. bombycina* and found 25.5% crude protein in mycelia and 28.3% in fruit body (Table 2). Nutrient composition of *Lentinus tuberregium* in both wild and cultivated type were analyzed by Manjunathan and Kaviyarasan (2011) and found that the cultivated variety had higher concentration of protein (25%) than the wild one (18.07%). The nutritional values of 10 edible mushrooms from Western Ghats of Kanyakumari district have been analyzed by Johnsy et al. (2011) and reported that edible mushrooms are highly valued as a good source of protein ranged from 28.93 to 39.1% of dry weight (Table 2). Manjunathan et al. (2011) reported the proximate compostion of four wild mushrooms from Tamil Nadu, India in which *A. polytricha* had the highest concentration of protein (37%) and *Clitocybe sp.* had the least (24.8%). Recently, nutrient content of 15 selected mushrooms of Nagaland, India have been studied by Kumar et al. (2013) and found 22.50 to 37.80% protein (Table 2). Further, Singdevsachan et al. (2013) reported the nutrient values of two wild mushrooms (*Lentinus sajor-caju* and *Lentinus torulosus*) from Similipal Biosphere Reserve, Odisha, India where highest protein content (28.36%) was found in *L. sajor-caju* and lowest (27.31%) in *Lentinus torulosus*. However, protein contents of mushrooms were reported to vary according various factors such as mushroom strain/type, composition of growth media, time of harvest, management techniques, handling conditions, and the preparation of the substrates (Manzi et al., 2001).

In terms of the amount of crude protein, mushrooms rank below animal meats but well above most other foods including milk (Chang, 1980). Mushrooms in general have higher protein content than most other vegetables (Bano and Rajarathnam, 1988). On a dry weight basis, mushrooms normally contain 19 to 35% proteins as compared to 7.3% in rice, 12.7% in wheat, 38.1% in soybean and 9.4% in corn (Crisan and Sands, 1978; Bano and Rajarathnam, 1988). Verma et al. (1987) reported that mushrooms are very useful for vegetarians because they contain some essential amino acids which are found in animal proteins. Mushrooms contain all the essential amino acids required by an adult (Hayes and Haddad, 1976). Gupta and Sing (1991) reported 41.4% essential amino acids in *P. pistillaris*. Longvah and Deosthale (1998) also analyzed the amino acid content of two edible wild mushrooms (*Schizophyllum commune* and *L. edodes*) from northeast India and reported that 34% and 39% essential amino acids are present in *S. commune* and *L. edodes* respectively. Agrahar-murugkar and Subbulakshmi (2005) also analyzed the essential amino acid of seven wild edible mushrooms from the Khasi hills of Meghalaya and found average ranges between 16.3 (lysine) and 45.8% (methionine). The digestibility of *Pleurotus* mushrooms proteins is as that of plants (90%) whereas that of meat is 99% (Bano and Rajarathnam, 1988). The protein conversion efficiency of edible mushrooms per unit of land and per unit time is far more superior compared to animal sources of protein (Bano and Rajarathnam, 1988).

Carbohydrate

The carbohydrate content of mushrooms represents the

Table 2. Proximate composition of some Indian mushrooms shown in percentage.

Species	Protein	Carbohydrate	Lipids/fats	Ash	Fiber	References
Agaricus arvensis	32.87	32.91	-	0.18	0.14	Kumar et al. (2013)
Agaricus bisporus	41.06	28.38	2.12	7.01	18.23	Pushpa and Purushothama (2010)
Agaricus bisporus	33.48	46.17	3.10	5.70	20.90	Manikandan (2011)
Agaricus heterocystis	32.23	48.55	2.90	11.42	19.7	Manimozhi and Kaviyarasan (2013)
Agaricus langei	35.14	34.83	-	14.10	3.28	Kumar et al. (2013)
Auricularia auricula	4.20	82.80	8.30	4.70	19.80	Manikandan (2011)
Auricularia auricula	36.3	33.23	1.63	7.07	8.4	Johnsy et al. (2011)
Auricularia auricula-judae	36.30	33.23	-	7.07	2.81	Kumar et al. (2013)
Auricularia polytricha	37 .0	38.48	0.74	6.87	21.97	Manjunathan et al. (2011)
Boletus aestivalis	32.76	52.07	-	14.97	12.13	Kumar et al. (2013)
Calocybe indica	17.69	64.26	4.10	7.43	3.40	Manikandan (2011)
Calocybe indica	21.60	49.20	4.96	12.80	13.20	Pushpa and Purushothama (2010)
Calvatia gigantea	27.3	-	1.0	6.3	22.0	Agrahar-murugkar and Subbulakshmi (2005)
Cantharellus cibarius	21.1	-	1.6	13.2	12.8	Agrahar-murugkar and Subbulakshmi (2005)
Cantharellus cibarius	34.17	47.00	-	7.78	1.40	Kumar et al. (2013)
Clavulina cinerea	27.5	-	2.5	13.9	8.4	Agrahar-murugkar and Subbulakshmi (2005)
Clitocybe sp.	24.8	42.0	1.24	15.73	13.04	Manjunathan et al. (2011)
Cookeina sulcipes	28.93	50.20	-	6.55	0.16	Kumar et al. (2013)
Flammulina velutipes	17.60	73.10	1.90	7.40	3.70	Manikandan (2011)
Gomphus floccosus	21.2	-	5.3	8.0	9.2	Agrahar-murugkar and Subbulakshmi (2005)
Grifola frondosa	31.47	40.77	1.49	5.13	7.0	Johnsy et al. (2011)
Hypsizygus tessulatus	37.80	51.20	-	9.09	12.90	Kumar et al. (2013)
Lactarius hygrophoroides	44.93	42.00	-	2.00	10.58	Kumar et al. (2013)
Lactarius quieticolor	19.0	-	2.6	6.6	14.4	Agrahar-murugkar and Subbulakshmi (2005)
Lentinus edodes	32.93	47.60	3.73	5.20	28.80	Manikandan (2011)
Lentinus edodes	22.8	64.4	2.1	6.0	-	Longvah and Deosthale (1998)
Lentinus sajor-caju	28.36	68.24	02.42	04.88	-	Singdevsachan et al. (2013)
Lentinus squarrosulus	37.13	47.83	2.58	8.33	11.33	Johnsy et al. (2011)
Lentinus tigrinus	18.07	60.0	2.25	5.14	14.69	Manjunathan et al. (2011)
Lentinus torulosus	27.31	64.95	1.36	13.16	-	Singdevsachan et al. (2013)
Lentinus tuber-regium	28.93	50.2	2.17	6.56	12.17	Johnsy et al. (2011)
Lepiota lilacea	28.12	49.33	-	8.09	11.98	Kumar et al. (2013)
Lepiota magnispora	27.55	35.00	-	3.05	5.20	Kumar et al. (2013)
Lepista irina	26.12	50.20	-	3.16	6.08	Kumar et al. (2013)
Lyophyllum decastes	18.31	34.36	2.14	14.20	29.02	Pushpa and Purushothama (2010)
Macrolepiota rhacodes	34.31	48.0	2.25	11.80	4.78	Manjunathan et al. (2011)
Melanoleuca grammopodia	36.27	33.04	-	4.13	8.12	Kumar et al. (2013)
Panus fulvus	27.06	33.04	-	3.11	6.08	Kumar et al. (2013)
Pleurotus florida	27.83	32.08	1.54	9.41	23.18	Pushpa and Purushothama (2010)
Pleurotus ostreatus	30.40	57.60	2.20	9.80	8.70	Manikandan (2011)
Pleurotus ostreatus	37.63	43.4	2.47	10.17	4.2	Johnsy et al. (2011)
Pleurotus pulmonarius	37.63	43.40	-	10.17	4.12	Kumar et al. (2013)
Pleurotus roseus	30.27	42.97	2.02	5.57	4.2	Johnsy et al. (2011)
Pleurotus sajor-caju	39.1	38.57	1.17	5.73	4.9	Johnsy et al. (2011)
Pleurotus sajor-caju	19.23	63.40	2.70	6.32	48.60	Manikandan (2011)

Table 2. Continued.

Species	Protein	Carbohydrate	Lipids/fats	Ash	Fiber	References
Ramaria brevispora	24.1	-	1.3	10.9	8.8	Agrahar-murugkar and Subbulakshmi (2005)
Russula delica	26.25	34.88	5.38	17.92	15.42	Pushpa and Purushothama (2010)
Russula integra	21.1	-	4.5	11.5	6.4	Agrahar-murugkar and Subbulakshmi (2005)
Schizophyllum commune	15.9	68.0	2.0	8.0	-	Longvah and Deosthale (1998)
Schizophyllum commune	22.50	32.43	-	10.10	6.50	Kumar et al. (2013)
Termitomyces heimii	34.2	39.03	2.11	16.8	9.73	Johnsy et al. (2011)
Termitomyces microcarpus	29.4	46.53	2.33	11.2	11.5	Johnsy et al. (2011)
Volvariella bombycina (Fruit body)	28.30	38.90	2.72	10.90	24.60	Jagadeesh et al. (2010)
Volvariella bombycina (Mycellia)	25.50	34.75	1.15	9.03	31.80	Jagadeesh et al. (2010)
Volvariella volvacea	37.50	54.80	2.60	1.10	5.50	Manikandan (2011)
Volvariella volvacea	30.57	43.53	2.04	10.37	9.67	Johnsy et al. (2011)

-: No results.

bulk of fruiting bodies accounting for 50 to 65% on dry weight basis. Free sugars amounts to about 11%. Nutritional analysis of two edible wild mushrooms (*S. commune* and *L. edodes*) from northeast India have been studied by Longvah and Deosthale (1998) and reported that 64.4% carbohydrate content present in *L. edodes* and 68% in *S. commune* (16%). Jagadeesh et al. (2010) reported that 34.75 and 38.9% of carbohydrate content present in mycelia and fruit body of *V. bombycina.* Pushpa and Purushothama (2010) have analyzed the nutrition of five mushroom species and found 49.20, 28.38, 32.08, 34.88, 34.36% carbohydrate content in *C. indica, A. bisporus, P. florida, R. delica,* and *L. decastes*, respectively. Nutrient composition of *L. tuberregium* in both wild and cultivated type were analyzed by Manjunathan and Kaviyarasan (2011) and found 58.05 and 55.8% carbohydrate in cultivated variety and in wild variety respectively. Manikandan (2011) reported that total carbohydrate content varies from 26-82% on dry weight basis in different mushrooms (Table 2). Nutritional values of wild mushrooms have been studied by Johnsy et al. (2011) and found good source of carbohydrates ranged from 33.23% in *A. auricula* to 50.2% in *L. tuber-regium* (Table 2). Proximate composition of four wild mushrooms have been revealed by Manjunathan et al. (2011) and found highest carbohydrate (48%) in *M. rhodocus* in comparsion to other studied mushrooms. Kumar et al (2013) reported the carbohydrate contents of 15 selected mushrooms from Nagaland, India ranged from 32.43% in *S. commune to* 52.07% in *Boletus aestivalis* (Table 2). Recently total carbohydrate contents of two wild mushrooms was studied by Singdevsachan et al. (2013) and found highest in *L. sajor-caju* (68.24%) and lowest in *L. torulosus* (64.95%).

Lipid/fat

In mushrooms, the fat content is very low as compared to proteins and carbohydrates. The fats present in mushroom fruiting bodies are dominated by unsaturated fatty acids. Singer (1961) determined the fat content of some mushrooms as 2.04% in *Suillus granulatus*, 3.66% in *Suillus luteus* and 2.32% in *A. campestris.* Crude fat content in the range of 1.08 to 9.4% with an average of 2.85% has been reported in *Pleurotus* species (Bano and Rajarathnam, 1982). On fresh weight basis, the fat content of 0.10 to 0.19% in *Pleurotus* species has been reported by Rai et al. (1988). Fat content of fresh *A. bisporus* (Lange) Sing and *P. ostreatus* (Jacq: Fr.) Kumm was analyzed by Manzi et al. (2001) and found to be 0.3 and 0.4 g/100 g, respectively. Longvah and Deosthale (1998) has reported that crude fat content (2%) were similar in two edible wild mushrooms (*S. commune* and *L. edodes*) from northeast India. Agrahar-murugkar and Subbulakshmi (2005) also reported the fat content (ranged from 1.0% in *C. gigantean* to 5.3% in *G. floccocus*) of seven different wild mushrooms collected from the Khasi hills of Meghalaya (Table 2). Kavishree et al. (2008) have analyzed twenty-three species of naturally grown and collected mushroom fruiting bodies from different geographic locations of India for their total fat and fatty acid contents and mushroom species were found to contain 0.6-4.7% total fat. These mushroom species were also high in unsaturated fatty acids (52-87%), compared to saturated fatty acids. Jagadeesh et al. (2010) also reported that 1.15 and 2.72% lipid contents were present in mycelia and fruit body of *V. bombycina*, respectively. Pushpa and Purushothama (2010) have also analyzed the fat content of five mushrooms which were 4.96, 2.12, 1.54, 5.38, 2.14% in *C. indica, A. bisporus, P. florida, R. delica,* and *L. decastes*, respectively. Manjunathan and Kaviyarasan (2011) reported that the fat content in the cultivated variety (1.54%) of *L. tuberregium* was lower than that in the wild one (1.6%). Johnsy et al. (2011) have studied the nutritional values of wild mushrooms from Western Ghats of Kanyakumari district and revealed very less amounts of fats ranged from 1.17% to 2.58% (Table 2). According to proximate composition of four wild mushrooms studied by Manjunathan et al. (2011), the fat contents was very less ranged from 0.74% to 2.25% (Table 2). Further fat contents of two wild mushrooms was determined by Singdevsachan et al. (2013) and found lowest amount of fats (2.42 and 1.36%) in both studied mushrooms (*L. sajor-caju* and *L. torulosus*, respectively).

Vitamins

Mushrooms are one of the best sources of vitamins especially vitamin B (Mattila et al., 1994, 2000). Manning (1985) gave a comprehensive data of vitamin content of mushrooms and some vegetables which are present in the world. But in India, the information on vitamin content of mushrooms has been lacking. Agrahar-murugkar and Subbulakshmi (2005) determined the vitamin C content (mg/g) in seven wild edible mushrooms commonly consumed in the Khasi hills of Meghalaya, India and found that 14.9, 41.8, 41.9, 28.0, 19.6, 25.8, 18.1 vitamin C present in *C. gigantea, C. cinerea, C. cibarius, R. brevispora, R. integra, G. floccosus* and *L. quieticolor,* respectively. Recently, vitamin content such as thiamine, riboflavin and ascorbic acid were analyzed by Singdevsachan et al. (2013) in wild mushrooms (*L. sajor-caju* and *L. torulosus*) from Similipal Biosphere Reserve, Odisha, India. The highest thiamine content was found in *L. torulosus* (0.19 mg/g) and lowest in *L. sajor-caju* (0.13 mg/g). Both the studied wild mushrooms were showed good quantities of ascorbic acid (17.75 mg/g in *L. sajor-caju* and 52.91mg/g in *L. torulosus*) whereas rifboflavin was not detected (Singdevsachan et al., 2013). Unfortunately, information on the bioavailability of vitamins from mushrooms has been lacking.

Mineral constituents

Ash content of different mushrooms is usually 0.18-15.73% of dry matter (Table 2). The fruiting bodies of mushrooms are characterized by a high level of well assimilated mineral elements. Major mineral constituents in mushrooms are Na, K, Ca, Mg, P, S and elements like As, Cd, Cr, Co, Cu, Fe, Mo, Mn, Ni, Pb, Se, Zn among others form minor constituents (Bano and Rajarathanum, 1982; Bano et al., 1981). The mineral content of wild edible mushrooms has been found to be higher than cultivated ones (Mattilla et al., 2001). Kaul (1978) has reported that *M. esculenta* contains Ca (0.57 mg/g), P (3.31 mg/g), Fe (1.21 mg/g) and K (3.83 mg/g). Bano et al. (1981) and Bisaria et al. (1987) have also assessed the minerals and heavy metals content in *Pleurotus* sp. which are given in Table 3. Longvah and Deosthale (1998) analyzed the two species of mushrooms (*S. commune* and *L. edodes*) from northeast India and found that both mushrooms appear to be rich in minerals (Table 3).

Micronutrient profile of seven wild edible mushrooms were also analyzed by Agrahar-murugkar and Subbulakshmi (2005) which are commonly consumed in the Khasi hills of Meghalaya (Table 3) and reported that the calcium (g%) content ranged from 0.42 in *C. cibarius* to 1.91 in *C. cineria*. Phosphorus (g%) levels were the highest in *C. cibarius* (0.58), followed by *R. brevispora* (0.51) whereas *R. integra* had the lowest levels with 0.24. *C. cinerea* had a very high content of iron (mg%) at 75.2. The rest fell in the range 7.17 (*R. brevispora*) to 56.2 (*R. integra*). Manganese (mg%) levels ranged between 4.41 in *C. gigantea* to 11.4 in *R. brevispora*. The copper (mg%) of the mushrooms studied was between 1.39 (*C. gigantea*) and 23.9 (*C. cinerea*). Zinc (mg%) levels varied between 6.76 in *R. brevispora* and 39.4 in *L. quieticolor*. Sodium (mg%) ranged from 0.14 in *G. floccosus* to 0.56 in *R. integra*. Potassium (mg%) levels varied between 17.0 (*L. quieticolor*) and 52.1 (*C. cinerea*). Magnesium (mg%) content was between 25.3 in *L. quieticolor* to 327 in *R. virescens*. The content of selenium (µg/kg), ranged from negligible levels in *G. floccosus* to very high levels in *L. quieticolor* (975) and *C. cibarius* (295). Mineral composition of *L. tuberregium* in both wild and cultivated type were also analyzed by Manjunathan and Kaviyarasan (2011) and found that the potassium concentration in the cultivated mushroom (90.8%) was higher than in the wild (7.53%). Zinc was distributed such that the cultivated variety had a higher concentration (4.9%) than the wild one (0.41).

Proximate composition of four wild mushrooms has been studied by Manjunathan et al. (2011) with their maco- and micromineral contents. Macro mineral such as calcium content was 208 mg/g for *Clitocybe* sp., and 195 mg/g for *M. rhodocus*. The highest sodium and potassium content (858.4 and 1369.1 mg/g respectively) found in *Clitocybe* sp. whereas *M. rhodocus* had the highest magnesium content (250 mg/g) (Table 3). Further, micro-mineral such as Iron content varied from *A. polytricha* with 16.3 mg/g to *M. rhodocus* with 85.6 mg/g. Copper content ranged from *A. polytricha* (0.3 mg/g) to *M. rhodocus* 9.0 mg/g. Manganese content in *M. rhodocus*, *Clitocybe sp*, *A. polytricha*, and *L. tigrinus* were 3.4, 2.7,

Table 3. Mineral nutrients of some Indian mushrooms.

Species	Ca	P	Fe	Mn	Cu	Zn	Na	K	Mg	Se	Cr	Pb	References
Agaricus Heterocystis[3]	81.0	-	39.0	39.0	3.72	1.9	39.0	422.0	39.0	-	-	-	Manimozhi and Kaviyarasan (2013)
Auricularia polytricha[3]	607	-	16.3	1.3	0.3	1.0	858.4	588.4	136	-	-	-	Manjunathan et al. (2011)
Calvatia gigantea[12]	630	330	10.7	4.41	1.39	10.3	0.18	22.3	150	91.2	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Cantharellus cibarius[12]	420	580	53.5	7.68	4.36	6.83	0.29	47.9	46.2	295	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Clitocybe sp.[3]	208	-	61.4	2.7	9.0	6.2	858.4	1369.1	120	-	-	-	Manjunathan et al. (2011)
Coprinopsis cinerea[12]	1910	420	75.2	6.79	23.9	11.1	0.33	52.1	43.8	0.17	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Gomphus floccosus[12]	1370	340	22.3	7.04	3.48	13.0	0.14	18.7	136	X	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Lactarius quieticolor[12]	1460	420	19.4	5.32	1.41	39.4	0.21	17.0	25.31	975	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Lentinus edodes[3]	127	493	20.1	-	0.9	4.3	-	-	200		0.140	-	Longvah and Deosthale (1998)
Lentinus sajor-caju[4]	-	0.10	2.37	0.12	-	-	-	0.14	-	-	-	-	Singdevsachan et al. (2013)
Lentinus tigrinus[3]	248	-	36.2	0.6	1.2	4.9	37.3	90.8	14	-	-	-	Manjunathan et al. (2011)
Lentinus torulosus[4]	-	0.24	2.94	0.05	-	-	-	0.85	-	-	-	-	Singdevsachan et al. (2013)
Lentinus tuberregium (Wild type)[1]	2.66	-	0.53	0.08	0.11	0.41	1.2	7.53	2.45	-	-	-	Manjunathan and Kaviyarasan (2011)
*Lentinus tuberregium (*Cultivated type)[1]	87	-	6.5	1.7	1.0	4.9	37.3	90.8	30.4	-	-	-	Manjunathan and Kaviyarasan (2011)
Macrolepiota rhacodes[3]	195	-	85.6	3.4	9.0	3.8	274.4	294.3	250	-	-	-	Manjunathan et al. (2011)
Pleurotus eous[3]	23	1410	9.0	-	17.8	82.7	78	4570	242	-	-	1.5	Bano et al. (1981); Bisaria et al. (1987), Rai (1994)
Pleurotus flabellatus[3]	24	1550	12.4	-	21.9	58.6	75	3760	292	-	-	1.5	Bano et al. (1981); Bisaria et al. (1987), Rai (1994)
Pleurotus florida[3]	24	1850	18.4	-	15.8	11.5	62	4660	192	-	-	1.5	Bano et al. (1981); Bisaria et al. (1987), Rai (1994)
Pleurotus sajor-caju[3]	20	760	12.4	-	12.2	29	60	3260	221	-	-	3.2	Bano et al. (1981); Bisaria et al. (1987), Rai (1994)
Ramaria brevispora[12]	530	510	7.17	11.4	16.7	6.76	0.31	35.5	217.2	5.28	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Russula integra[12]	1270	240	56.2	7.28	3.33	10.5	0.56	41.0	327	26.9	-	-	Agrahar-murugkar and Subbulakshmi (2005)
Schizophyllum commune[3]	188	408	12.3	-	0.9	5.7	-	-	227	-	0.133	-	Longvah and Deosthale (1998)

[1]Ca, P, Fe, Mn, Cu, Zn, Na, K and Mg contents in mg%; [2]Se content in µg/kg; [3]All mineral contents in mg/100g; [4]P and K in g/100 g and rest of the metals in mg/kg; X: negligible quantities; -: No results.

1.3 and 0.6 mg/g, respectively (Manjunathan et al., 2011). Recently, Singdevsachan et al. (2013) have reported the mineral contents of two wild mushrooms (*L. sajor-caju* and *L. torulosus*) from Similipal Biosphre Reserve, Odisha, India. *L. torulosus* showed the highest iron (2.94 mg/kg), potassium (0.85 mg/kg) and phosphorus (0.24 mg/kg) contents whereas *L. sajor-caju* showed the highest manganese (0.12 mg/kg) and nickel (0.05 mg/kg) contents (Table 3). However, both mushrooms did not show the presence of cobalt and cadmium content (Singdevsachan et al. 2013). The mineral proportions vary according to the species, age and the diameter of the fruiting body. It also depends upon the type of the substratum (Demirbas, 2001).

MEDICINAL POTENTIAL OF MUSHROOMS

Medical mycology is as old as traditional uses of mushrooms. They have been used in medicine since the Neolithic and Paleolithic eras (Samorini, 2001). Although mushrooms as medicine have been used in China since 100 A.D. (Gunde-Cimmerman, 1999), but it was only in 1960 that scientists investigated the basic active principles of mushrooms which are health promoting. Mushrooms have been used in health care for treating simple and age old common diseases like skin diseases to present day complex and pandemic disease like acquired immunodeficiency syndrome (AIDS). Mushrooms in the twentieth century are well known to people all over Asian countries as an important bio-source of novel secondary metabolites. In India, particularly the alternative systems of medicine, utilize the curative properties of mushrooms. The secondary metabolites of these mushrooms are chemically diverse and possess a wide spectrum of biological activities, which are explored in traditional medicines (Rai et al., 2005). In India, several mushrooms have been reported as medicinal mushrooms which have antioxidant, antimicrobial, anti-inflammatory activity with antitumor and other properties.

Antioxidant properties

Several researchers investigated that a number of medicinal mushrooms occurring in India possessed promising antioxidant properties. Extracts from fruiting bodies and mycelia of *Ganoderma lucidum*, *Phellinus rimosus* and several *Pleurotus* sp. occurring in South India were found to possess antioxidant activity with high free radical scavenging activity (Jones and Janardhanan, 2000; Ajith and Janardhanan, 2001; Lakshmi et al., 2003). Ethyl acetate, methanol and aqueous extract of *G. lucidum* has been reported to effectively scavenge the $O_2\cdot$ and $\cdot OH$ radicals, however the aqueous extract was not effective to inhibit the ferrous ion induced lipid peroxidation (Jones and Janardhanan, 2000) whereas ethanol extracts of the mycelium of *G. lucidum* showed high antiperoxidative activity (Lakshmi et al., 2003). The methanol extract of fruiting bodies of *P. florida* was found to possess $\cdot OH$ radical scavenging and lipid peroxidation inhibiting activities (Jose and Janardhanan, 2000). The extract also showed significant reducing power and radical scavenging property as evident from ferric reducing antioxidant power (FRAP) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radicals scavenging assay. Ethyl acetate, methanol and aqueous extracts of the *Phellinus rimosus* were effective to scavenge O_2^- generated from the photoillumination of riboflavin, $\cdot OH$ generated from Fenton's reaction, nitric oxide radical released from aqueous solution of sodium nitroprusside in a dose dependent manner (Ajith and Janardhanan, 2001). All these three extracts of *P. rimosus* also inhibited dose dependently ferrous ion induced lipid peroxidation in the rat whole liver homogenate.

Sheena et al. (2005) also studied the therapeutic potential of *G. lucidum* and reported that the sample of *G. lucidum* from South Indian tropics has greater antioxidant activity through suppression of formation capacity of the free radicals and also possesses high 2,2-azobis-3-ethylbenzthiazoline-6-sulphonilic acid (ABTS) and DPPH scavenging activity. The antioxidant potential from water and methanolic extracts of fruiting bodies of 23 species of mushrooms naturally grown in different geographic locations of India (forest area of Himachal Pradesh and Kerala) was measured by Puttaraju et al. (2006). The antioxidant ability of each species was analyzed for the total antioxidative status, employing multimechanistic antioxidative assays such as inhibition of lipid peroxidation, determination of reducing power, and free radical scavenging ability with determination of total phenolics, because the phenolics are known to contribute largely to antioxidant potential. *Termitomyces heimii* was identified as the best variety, which showed 37 mg of phenolics/g of sample, 418 units of reducing power ability (RPA)/g, and an IC_{50} of ~1.1 mg (dry weight)/mL, free radical scavenging activity (FRS) in the water extract followed by 11.2 mg of phenolics/g, 275 units of RPA/g, and an IC_{50} of ~2.7 mg (dry weight)/mL of FRS in the methanolic extract. Antioxidant and nitric oxide synthase (NOS) activation properties of *Armillaria mellea* Quel was evaluated by Rai et al. (2009). *In vitro* evaluation of antioxidant activities of *A. mellea* Quel showed significant inhibition of lipid peroxidation, potent hydroxyl and DPPH radical scavenging activity with IC_{50} values of crude, boiled and ethanolic extracts ranging from 36.3 to 388.92 µg/ml. Among three kinds of extracts, the ethanolic extract was the most effective in relation to antioxidant activity and NOS activation property. Antioxidant activity and bioactive compounds from six wild mushrooms (Lycoperdon perlatum, C. cibarius, Clavaria vermiculris, Ramaria formosa, Marasmius oreades, P. pulmonarius) of Western Ghats of Karnataka, India were studied by Ramesh and Pattar (2010). All the mushrooms showed high phenol and flavonoid content with promising antioxidant properties (Ramesh and Pattar, 2010). Antioxidant and phytochemical properties of ethanolic extracts from the wild edible mushroom Termitomyces reticulatus and their individual parts (Cap and Stipe) were evaluated by Loganathan et al. (2010) through the reducing power, β-carotene bleaching, ABTS and DPPH radicals scavenging activity methods. Antioxidant components like total phenol, flavonoid, β-carotene and lycopene were also determined and the amount of phenol was correlated with the antioxidant property. All the extracts showed potent antioxidant activities, in which the entire mushroom extract showed more antioxidant property when compared with the other two extracts (Cap and Stipe). Kumari et al. (2011) have investigated the antioxidant activity of *Cantharellus friessi, Cantharellus subcibarius, Cantharellus cinerius* and *P. florida* collected from North-Western Himalayan region of India including their bioactive compounds such as phenol, flavonoid, ascorbic acid and β-carotene. Among them *C. friessi* showed significantly higher antioxidant activity through β-carotene bleaching method and with the high phenol content (16.80 mg/g) than the other mushroom species. Methanolic extracts of cap and stipe of commercially obtained mushrooms *A. bisporus*, *Hypsizygus ulmarius*, and *C. indica* were analysed by Babu and Rao (2011) for their antioxidant activity in different chemical systems including reducing power, free radical scavenging, ferric reducing antioxidant power (FRAP), superoxide scavenging, peroxide scavenging, and metal chelating activities. All the three commercially grown mushrooms exhibited moderate to high antioxidant activities. All the activities increased steadily with increase in the concentration. *Hypsizygus ulmarius* cap showed excellent DPPH radical scavenging, peroxide scavenging, FRAP and reducing power abilities which may be attributed to its highest total phenol content whereas the excellent ferrous ion chelation and superoxide scavenging abilities exhibited by *A. bisporus* cap may be attributed to its highest flavonoid content (Babu and Rao, 2011). It has been reported that free radical-scavenging activity is greatly influenced by the phenolic composition of samples (Cheung et al., 2003) and the reducing power of mushrooms might be due to their hydrogen-donating ability (Shimada et al., 1992). Accordingly, above studied mushrooms might contain higher amounts of reductone, which could react with free radicals to stabilise and block radical chain reactions. Beside that, the activity difference among the results obtained from antoioxidant studies with the mushroom extracts might be related to the different conditions of measurement and the sensitivity of the assays. Therefore several methods should be used in parallel to elucidate the complex field of antioxidants and oxidation (Ciz et al., 2010).

Antimicrobial properties

The petroleum ether, chloroform, acetone and water extracts of the mushroom *Osmoporus odoratus* have been tested for their antibacterial activity against *Staphylococcus aureus, Streptococcus pyogenes, Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa*; the water extract alone showed antibacterial activity against the tested organisms and the results were comparable with that of ampicillin rather than chloramphenicol (Sivakumar et al., 2006). Two edible mushrooms (*A. bisporus* and *P. sajor-caju*) were assayed *in vitro* for their antimicrobial activities by Tambekar et al. (2006) using aqueous and organic solvent extracts. In their study, *E. coli 390*, *E. coli 739*, *Enterobacter aerogenes*, *P. aerugonisa* and *Klebsiella pneumonia* were most sensitive to aqueous, ethanol, methanol and xylene extracts of these mushrooms. *Pleurotus* species had a narrow antibacterial spectrum against Gram-negative bacteria and strongly inhibited the growth of the Gram-positive bacteria tested, including *B. subtilis*, and *M. luteus* (Loganathan et al., 2008). The antimicrobial activity of various solvent extracts (methanol, ethanol, acetone and aqueous extract) of *G. lucidum* was tested by Quereshi et al. (2010) against six species of bacteria: *E. coli*, *S. aureus*, *K. pneumoniae*, *B. subtilis*, *S. typhi* and *P. aeruginosa*. Acetone extract exhibited maximum antibacterial activity, while the most susceptible bacterium observed was *K. pneumoniae.* Methanolic extracts of six wild mushrooms (*L. perlatum*, *C. cibarius*, *C. vermiculris*, *R. formosa*, *M. oreades*, *P. pulmonarius*) of Western Ghats of Karnataka, India showed significant antimicrobial activity against *B. subtilis*, *S. aureus*, *E. coli*, *P. aeruginosa* and *Candida albicans* (Ramesh and Pattar, 2010).

Manjunathan and Kaviyarasan (2010) studied the solvent based effectiveness of antibacterial activity of edible mushroom *L. tuberregium* (Fr.). *In vitro* antimicrobial properties of *L. tuberregium* culture filterate extracted using four different solvent systems (Hexane, dichloromethane, chloroform and ethyl acetate) were the most active to inhibit the growth of *S. aureus*, *Micrococcus luteus*, *E. coli*, *Salmonella typhi* and *Shigella flexneri*. The antibacterial activity of *V. bombycina* extracts (hexane, chloroform, ethyl acetate and methanol) were evaluated by Jagadeesh et al. (2010) against the clinically important bacterial starins *B. subtilis, S. aureus, E. coli, K. pneumoni and P. aeruginosa* and reported that the *V. bombycina* extracts possess compounds which have the antibacterial properties.

The antibacterial and antifungal activity of methanol and aqueous extract of fruit bodies from *Phellinus* was tested by Balakumar et al. (2011) against five bacterial pathogens such as *E. coli*, *P. aeruginosa*, *S. typhi*, *S. aureus* and *Streptococcus mutans* and five fungal strains *Penicillium* sps., *Aspergillus fumigatous*, *Aspergillus* *niger*, *Aspergillus flavus* and *Mucor indicus*. The fruit body of *Phellinus* showed potential antibacterial activities against the selected strains whereas aqueous extract showed maximum inhibition zone (42 mm) against *P. aeruginosa* and the methanolic extract showed the maximum antifungal activity against *A. flavus* (35 mm). Ethyl acetate extract of four different edible mushrooms (*P. sajor-caju, V. volvaceae*, *A. bisporus* and *P. ostreatus*) were investigated for their antimicrobial activity against *B. subtilis*, *S. aureus*, *E. coli*, *K. pneumoniae* and *Proteus vulgaris* (Surekha et al., 2011). Among them, only *A. bisporus* and *P. ostreatus* showed effective inhibition zone against all pathogenic strains.

Anti-inflammatory properties

Ethanolic extract of cultured mycelium of *M. esculenta* were investigated by Nitha et al. (2006) for their anti inflammatory activity. The extract showed significant dose-dependent inhibition of both acute and chronic inflammation in mice model which was comparable to that of the standard reference drug, Diclofenac. In yet another report, the acute and chronic anti inflammatory activities of ethyl acetate and methanolic extracts from *G. lucidum* were determined by Sheena et al. (2005) through carrageenan induced acute and formalin induced chronic inflammatory models in mice. Both the extracts showed significant effect on carrageenan induced acute and formalin induced chronic inflammation in mice which was comparable with standard drug, diclofenac. However chloroform extract of *G. lucidum* also exhibited significant anti inflammatory activity (Joseph et al., 2009).

Antitumor properties

The methanolic and aqueous extracts of *G. lucidum* were tested by Jones and Janardhanan (2000) for antitumor activity which effectively inhibited Ehrlich's ascites carcinoma (EAC) cell line induced solid tumor in mice when administered orally (Jones and Janardhanan, 2000). Methanol extract of the fruiting bodies of *P. florida* and *P. pulmonarius* occurring in South India also showed profound antitumor activity against the EAC cell line induced solid tumor model in mice (Jose and Janardhanan, 2000; Jose et al., 2002). The three differrent extracts (ethyl acetate, methanol and aqueus) of *P. rimosus* were found to inhibit the Dalton's Lymphoma Ascites (DLA) cell line induced solid tumor and EAC cell line induced ascites tumor in mice whereas the antitumor effect was high in ethyl acetate extract than the other extracts (Ajith and Janardhanan, 2003). Antitumor activity of *G. lucidum* was again confirmed by Sheena et al. (2005) through the EAC cell line induced solid tumor model in mice where both the extracts (methanol and aqueous) showed significant antitumor properties by inhibiting the tumor development. Polysaccharides, extracted from mycelium and fruiting bodies of *L. tuberregium* effectively inhibited solid tumour proliferation in mice (Manjunathan and Kaviyarasan, 2010). Antitumour activity of the ethanolic extract from cultured mycelium of morel mushroom, *M. esculenta* was determined by Nitha et al. (2006) using both DLA cell line-induced solid tumor and EAC cell line-induced ascites tumor models in mice. The extract exhibited significant antitumor activity against both ascites and solid tumours (Nitha et al., 2006).

Immunomodulatory properties

In India, only a few studies have been carried out with mushrooms for immunomodulatory properties. Structural aspects of mushroom polysaccharides from *P. osreatus*, *Astraeus hygrometricus*, *P. sajor-caju* and *P. florida* has been studied at Vidyasagar University, West Bengal, India (Chakraborty, 2004; Rout et al., 2004; 2005) with their immunomodulatory effects. A water soluble glucan (Figure 1) was isolated from *P. florida* fruit bodies and investigated for its structural characterization and immunomodulatory effects by Rout et al. (2004) which exhibited significant macrophage activity through the release of nitric oxide whereas Chakraborty et al. (2004) investigated another water-soluble glucan (Figure 2) from an edible mushroom, *A. hygrometricus* and found that glucan is a strong immune-enhancing material showing strong splenocyte activation. A glucan (Figure 3) that was soluble in aqueous sodium chloride was isolated from the aqueous extract of the fruiting bodies of *P. florida* which stimulated the phagocytic activity of macrophages (Rout et al., 2005). Roy et al. (2009) studied an immune-enhancing water-soluble glucan (Figure 4) isolated from hot water extract of an edible mushroom, *P. florida*, cultivar Assam Florida and found that the glucan stimulates macrophages, splenocytes, and thymocytes. A heteroglycan (Figure 5) isolated from an aqueous extract of an edible mushroom, *L. squarrosulus* and analyzed for its structural chracterization with immune-enhancing activity by Bhunia et al. (2010) which showed macrophage as well as splenocyte and thymocyte activation. Dey et al. (2010) have also analyzed an immunoenhancing water-soluble polysaccharide (Figure 6) of an edible mushroom, *P. florida* blue variant and they have also found that the molecule activated macrophages, splenocytes, and thymocytes. A structural and biological study of a heteropolysaccharide (Figure 7) from aqueous extract of an edible mushroom, *P. ostreatus* has also been conducted by Maity et al. (2011) and revealed that the heteroglycan stimulates macrophages, splenocytes, and thymocytes (Table 4).

ETHNOMYCOLOGICAL KNOWLEDGE OF ETHNIC-TRIBES IN INDIA

The traditional uses of the mushroom are known to the

→6)-α-D-Glc$_p$-(1→

Figure 1. Repeating unit of glucan isolated by Rout et al. (2004).

→4)-α-D-Glc$_p$-(1→6)-β-D-Glc$_p$-(1→

A B

Figure 2. Repeating unit of glucan isolated by Chakraborty et al. (2004).

→3)-α-D-Glc$_p$-(1→3)-β-D-Glc$_p$-(1→3)-α-D-Glc$_p$-(1→

6

↑

1

α-D-Glc$_p$

Figure 3. Repeating unit of glucan isolated by Rout et al. (2005).

→3)-α-D-Glc$_p$-(1→3)-β-D-Glc$_p$-(1→3)-β-D-Glc$_p$-(1→6)-β-D-Glc$_p$-(1→

6

↑

1

α-D-Glc$_p$

Figure 4. Repeating unit of glucan isolated by Roy et al. (2009).

F D A C E

→6)-β-D-Glc$_p$-(1→6)-β-D-Glc$_p$-(1→6)-α-D-Gal$_p$-(1→3)-β-D-Glc$_p$-(1→4)-β-D-Glc$_p$-(1→

4 6

↑ ↑

A-L-Fuc$_p$ β-D-Glc$_p$

B G

Figure 5. Repeating unit of heteroglycan isolated by Bhunia et al. (2010).

C B D

→6)-β-D-Glc$_p$-(1→3)-α-D-Glc$_p$-(1→[6)-β-D-Glc$_p$-(1]$_3$→

3

↑

1

α-D-Gal$_p$

A

Figure 6. Repeating unit of polysaccharide isolated by Dey et al. (2010).

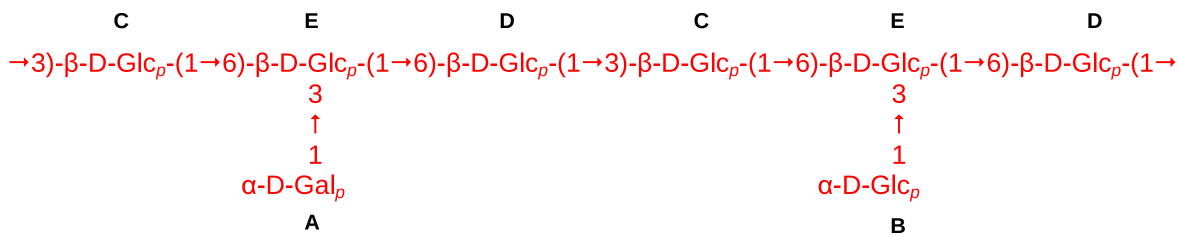

Figure 7. Repeating unit of heteropolysaccharide isolated by Maity et al. (2011).

Table 4. Medicinal properties of some Indian mushrooms.

Biological source	Medicinal properties	References
Agaricus bisporus	Antioxidant activity, antimicrobial activity, antiproliferative activity	Jagdish et al. (2009)
Astraeus hygrometricus	Immunoanhancing activity	Chakraborty et al. (2004)
Cantharellus cibarius	Antioxidant activity, antimicrobial activity	Ramesh and Pattar (2010)
Clavaria vermicularis	Antioxidant activity, antimicrobial activity	Ramesh and Pattar (2010)
Ganoderma lucidum	Antioxidant activity, antimutagenic activity	Jones and Janardhanan (2000); Lakshmi et al. (2004)
Lentinus squarrosulus	Immunoanhancing activity	Bhunia et al. (2010)
Lentinus tuberregium	Antibacterial activity	Manjunathan and Kaviyarasan (2010)
Lycoperdon perlatum	Antioxidant activity, antimicrobial activity	Ramesh and Pattar (2010)
Marasmius oreades	Antioxidant activity, antimicrobial activity	Ramesh and Pattar (2010)
Phellinus rimosus	Antioxidant activity and antitumor activity	Ajith and Janardhanan (2002; 2006)
Pleurotus florida	Antioxidant activity, antiinflammatory, immmunoanhancing activity	Jose and Janardhanan (2000); Jose et al. (2002); Roy et al. (2009); Dey et al. (2010)
Pleurotus ostreatus	Immunoenhancing activity	Maity et al. (2011)
Pleurotus pulmonarius	Antioxidant activity, antimicrobial activity	Ramesh and Pattar (2010)
Pleurotus pulmonarius	Antitumor activity	Jose et al. (2002)
Pleurotus sajor-caju	Antibacterial activity	Tambekar et al. (2006)
Ramaria formosa	Antioxidant activity, antimicrobial activity	Ramesh and Pattar (2010)
Volvariella bombycina	Antibacterial activity	Jagadeesh et al. (2010)

aborigionals of Africa, India, Brazil and other countries. Wild mushrooms are a valuable non-timber forest resource used by mycophilic societies and their use has been documented in many countries around the world (Chang and Lee, 2004, Roberto G.O et al., 2005; Sarma et al., 2010). They are sold in traditional markets (Roberto G.O et al., 2005) or commercially exploited as food (Bhaben et al., 2011) or medicines (Sachan et al., 2013). In Nigeria, Puff balls (*Lycoperdon pusilum* and *C. gigantea*) are used to cure sores, abrasion or bruises, deep cut, haemorrhages and urinary infections (Buswell and Chang, 1993). Traditional mycological knowledge of most Indian ethnic groups has proven to be extensive and profound, consuming nearly 283 species of wild mushrooms out of 2000 species recorded world over (Purkayastha and Chandra, 1985).

Ethnomycological aspects were also dealt with by few workers in different parts of India and world over (Harsh et al. 1993; Bulakh, 2001). Some of the wild edible mushrooms have also been reported from Manipur and Arunachal Pradesh of North East India (Sing and Sing, 1993; Sing et al., 2002) whereas, from Assam, Baruah et al. (1971) reported few Basidiomycetous fungus of Sibsagar District. In Central India *G. lucidum* is used as herbal medicine by the Baiga tribes to cure asthma and *Agaricus* sp. is used in goiter and *L. pusilum* in wound healing and also for controlling bleeding (Rai et al., 2005). Sarma et al. (2010) reported that some Ethnic Tribes of Western Assam use the wild edible mushroom as food source. Ethnic tribes such as Garos, Adivashis, Bodos and Rajbangshis of Western Assam are consuming at least seven species of mushrooms as vegetables. But the potentialities of such species are yet to be studied in detail (Sarma et al., 2010). According to Bhaben et al. (2011), the ethnic tribes of Nagaland, India were also using wild edible mushrooms for food purposes. Their investigation revealed that more than 12 ethnic groups of Nagaland were found to be mycophilic and to have traditional mycological knowledge (complete data not available). A total of 13 species of fleshy fungi under 9 genera and 6 families were identified which are being used by tribals of Nagaland. Srivastava et al. (2011) conducted an ethnobotanical survey for distribution and utilization of *Termitomyces* species in Gorakhpur forest division of Uttar Pradesh, India and reported that tribal people and forest dwellers are using *Termitomyces* species as food and for medicinal purposes (not clearly known but used in malnutrition, weakness and their nutritional disorders). Traditional uses and medicinal potential of *Cordyceps sinensis* has been studied by Panda and Swain (2011) in Sikkim, India and found that most local folk healers/traditional healers use cordyceps in their herbal medicine for the treatment of 21 ailments including cancer, bronchial asthma, bronchitis, TB, diabetes, cough and cold, erectile dysfunction, BHP, jaundice, alcoholic hepatitis, among others. Beside that, seven numbers of wild mushrooms such as *P. sajor-caju*, *T. heimii*, *T. microcarpus*, *V. volvaceae*, *A. auriculata*, *L. fusipes* and *L. tuberegium* are also consumed by the Kaani tribes of Kanyakumari district in their different recipe (Sargunam et al., 2012). Recently, a survey has been conducted by Sachan et al. (2013) on indegineous knowledge of ethnic tribes from Similipal Biosphere Reserve, Odisha for utilization of wild mushrooms as food and medicine. All these studied mushrooms (Table 1) are used by several tribals (Santal, Kolha, Munda, Khadia, Bhumija, Bhuyan, Bathudi, Kudumi, Ho, Mankdias) living in the Similipal forest for their food as well as herbal medicinal purposes to cure malnutrition, weakness, other nutritional disorder like diarrhea, high blood pressure, fever, asthama among others. (Sachan et al., 2013).

CONCLUSION

India with diverse habitats with varied ecological conditions, harbors wide varieties of mushrooms potentially rich with nutritional and medicinal values. Several mushrooms are known to be the sources of various bioactive substances like antibacterial, antifungal, antiviral, antiparasitic, anti-oxidant, antiinflammatory, antiproliferative, anticancer, antitumour, cytotoxic, anti-HIV, hypocholesterolemic, anti-diabetic, anticoagulant, hepatoprotective among others. These mushrooms have been used as ethnomedicines by tribals for treatment of various diseases. Many mushrooms still remain unreported and their nutritional as well as health benefits are unknown to us. If discovered, some of them may have high nutritional value and serve as valuable sources of bioactive compounds with many pharmaceutical applications. Further, several products such as antidiabetic mushroom powder, weight gain powder, sex enhancement medicine, mushroom chyawanprash, mushroom pickles among others. have been developed from mushrooms in India and other medicines such as anticancer, anti-tumor, anti-inflammatory among others. are under trials.

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