ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Assessment of Wild Mushrooms and Wood Decaying Fungi in Dilla University, Main Campus, Ethiopia

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Manuscript Info

Manuscript History:

Received: 12 September 2013
Final Accepted: 22 September 2013
Published Online: October 2013

Key words:
Ascomycota, Basdiomycota, Decay, Dilla University, Fungi, Mushroom

Abstract

Phylum Basdiomycota and Ascomycota are most terrestrial abundant fungi that have a great role to the environment and human kinds. They was serving as food and major source of pharmacologically active substances and also recycling of nutrient. Identity of the fungi associated with soil and responsible for wood decaying could lead to the development of more environmentally food supply systems and wood rot fung can be using their enzyme for industrial purpose. This study is part of an assessing programme aimed at identifying of Basdiomycota and Ascomycota fungi group from Dilla University, Main Campus. These fungi were commonly associated with dirt soil and wood fallen result in decay and rot of wood and solid waste material. Therefore, these fungi can be use as source of food, therapeutic agent and other may have a potential for Biotechnological purpose for enzyme production in industrial level.

Introduction

Fungi represent a diverse and widespread group of microorganisms whose numbers are estimated at more than 1.6 million species (Gardes and Bruns, 1996). There are approximately 1,600 wood decay species (Bennet et al., 2002). Traditional methods for identifying decay fungi are difficult and time consuming. Growing evidence based research has suggested benefits of consuming mushrooms as a functional foodor through the useof extracted bioactive compounds as dietary supplements, immunomodulators (biological response modifiers), and adjuvant tumor therapy (Chang, 2008; Guillam´on et al., 2010; Yu et al., 2009; Lindequist et al., 2005). Numerous compounds have been isolated from mushrooms and have great potential for development as mushroom nutraceutical and pharmaceutical products. Among these compounds, watersoluble polysaccharides and proteoglycans, proteins, and various constituents of small molecular mass are considered to have immunomodulatory potential by regulating several types of immune cells that function in antitumor or antimicrobial activities, including dendritic cells, macrophages, cytolytic T cells, and NK cells (Yu et al., 2009; Lindequist et al., 2005; Hsu et al., 2004; Ko et al., 1995).

The basidiomycetes are easily the largest, most important, and common group of fungi that cause wood decay. Most arborists know them as the mushrooms and conks that grow on living or dead trees and people have written volumes on wood decay caused by members of this group of fungi. It would be easy to leave the discussion of urban wood decay fungi to the basidiomycetes alone. Volumes I and II of North American Polypores by Gilbertson and Ryvarden (1986, 1987) identify nearly 500 different basidiomycetes responsible for decaying wood of living and dead trees. This list does not include the extensive group of gilled mushrooms and other types of basidiomycetes that also decay wood. Fortunately, only a relatively small group of decay fungi are commonly found on living trees in urban environments.

The second phylum of fungi, the ascomycetes (phylum Ascomycota), is a very large group of about 32,000 named species, with more being discovered each year. Fungi play key roles in all ecosystems as saprophytic, pathogens and symbionts (Mueller et al., 2007; Schmit and Mueller, 2007). They are essential in the recycling of nature, but little is known about their population dynamics, community structure, and diversity due to difficulties encountered with the identification, isolation, and quantification of many fungi (Kowalchuk, 1999). A few significant wood rotters are the ascomycetes.

Among the forest mycological communities these fungi are either saprobs on decaying wood and other organic material like cow dung, or are symbiotic with the living cells of plant roots, forming mycorrhizal associations with trees or parasitic on living plants (Bruns et al., 1991; O'Brien et al., 2005). These gilled fungi are very essential component of forest ecosystem.

The first investigations on the potential of basidiomycetes as sources of antibiotics were carried out in 1941 when extracts of fruiting bodies and mycelia cultures from over 2000 species were examined (Florey et al., 1949). Pleuromutilin, a diterpene that is especially useful for the treatment of mycoplasm infections in animals, was one of the first commercial antibiotics developed from basidiomycete origin (Rosa et al., 2003). The fact that basidiomycetes have been insufficiently investigated, together with the broad range of structural types of antibiotics which are produced by them, suggests that they may be a source of new and useful bioactive compounds (Anke, 1989). The ECM symbiosis involves a large number of fungal taxa, mostly filamentous baidiomycetes, and these fungi play an important role in seedling establishment and tree growth in different habitats across the globe (Tedersoo et al., 2010). It is accepted that in ECM a mutual benefit exist for both partners due to nutrient exchange in symbiotic organs. The fungus receives C as hexoses derived from host photosynthesis and the plant receives mainly N and P from the mycosymbiont. ECM also improves plant access to soil water resources and increases uptake of other Marco, and Micronutrients.

Basidiomycete's species are considered to be a very interesting group of fungi given their exceptional adjustment abilities to accommodate detrimental conditions of the environment where they continue to act as natural lignocellulose destroyers and include very different ecological groups such as white rot, brown rot, and leaf litter fungi (Cho et al., 2009). Lignin is the most abundant natural aromatic polymer on earth and degradation of this recalcitrant aromatic polymer is caused in nature by white rot fungi through a process that was defined as an enzymatic combustion (Kirk and Farrell, 1987). The ligninolytic system is an extracellular enzymatic complex that includes peroxidases, laccases, and oxidases responsible for the production of extracellular hydrogen peroxide (H_2O_2) (Ruiz-Dueñas and Martinez, 2009). Those enzyme systems exhibit differential characteristics depending on the species, strains, and culture conditions (Kirk and Farrell, 1987). The fungi absorb nutrients available in the ambient when the molecules are small, and when they are bigger the fungi uses their enzymes (Esposito and de Azevedo, 2004). The enzymes responsible for lignin degradation are mainly: lignin peroxidase (LiP), manganese peroxidase (MnP) and a copper containing phenoloxidase, known as laccase.

Agaricomycetes are a class of fungi in the phylum Basidiomycota; approximately 21,000 of 30,000 accepted species of Basidiomycota are Agaricomycetes and many of these live in soil (Hibbett et al., 2007; Kirk et al., 2008). The Agaricomycetes is adiverse class in both nutritional mode and fruiting body form (fruiting body being the macroscopic spore bearing structure of a fungus) (Carlile et al., 2001). Among the Agaricomycetes are species that are saprotrophs (organisms that feed by decomposing organic matter) and form mutualist symbioses with the roots of various plants ectomycorrhizae (ECM).

ECM fungi form associations with roots of angiosperms such as *Eucalyptus*, *Betula*, *Populus*, *Fagus*, and *Shorea* and gymnosperms such as *Pinaecea* (Brundrett, 2004). ECM fungi help to transport water and nutrients; they mobilize nitrogen (N), phosphorus (P), calcium (Ca), and magnesium (Mg) from solid mineral substrates through organic acid excretion (Landeweert et al., 2001) and from organic substrates by enzymatic digestion (Bending and Read, 1995; Tibbett and Sanders, 2002). Fungal hyphae provide a low cost method, relative to much more massive plant roots, that increases the volume of soil explored for soil nutrients.

Mushrooms have been exploited commercially world over and may be cultivated or gathered from the wild (Boa, 2004). The rate of consumption of fleshy fungi in many countries has increased in recent years and hence it becomes imperative to explore the treasure of wild mushroom (Pandey and Singh, 1978). As one of the most popular species on the international mushroom market, *Agaricus bisporus* has been undergoing a rapid increase in market share in recent years (Wu et al., 2002). The optimal temperature for cultivation of this commercially important mushroom is 22–25 °C. In general, tem-perature above 32 °C will impair the growth of mycelia and result in a fruit body of poor quality with long and thin stem and opened cap (Chen et al., 2003). The potential application of ligninolytic enzymes in biotechnology has stimuled their investigation (Vikineswary et al., 2006) and the understanding of physiological mechanisms regulating enzyme synthesis in lignocellulose bioconversion could be useful for improving the technological process of edible and medicinal mushroom production (Songulashvili et al., 2007). Ligninolytic enzymes have a potential in several industrial and biotechnological processes. This type of study will be helpful for people interested or scholors'to more investigation to culturing and for medicinal purpose. In addition, this is also helping for cleaning or recycling activities of solid wastes in biological and environmental sciences.

Finally it helps to create awareness for local and world people to utilize such resource. It is a best indication to cultivate of wild basidiomycete and ascomycetes fungi in the laboratory which have essential role in any aspects so, it is a promising prospective. Therefore, this study will contribute to the knowledge about wild mushroom and to expand the knowledge about wild mushroom. The main goals of this study were, to survey type fungi species found in Dilla University, Main Campus from different ecological niches and finally to identify them and to know their ecology and distribution.

MATERIALS AND METHODS

Survey of wild mushrooms

Different genera of wild mushrooms were collected from various locations that were grow naturally in different area and at summer season in Dilla University.Wild mushrooms were carefully dugout with the help of a knife and photographed in the field.

Identification of fungi

Collected wild mushrooms were characterized morphologically. Lastly, collected wild mushrooms were identified to genus and species level on the basis of morphological and the most updated keys for identifications at Department of Biology in Microbiology Laboratory.

Data analysis

The collected data were expressed through photograph and characterized morphologically.

RESULTS AND DISCUSSION

Wood Decaying Fungi

The collected wild mushrooms were identified based on their morphology. These fungi have a significant on the environment for recycling of nutrient through decaying (rotting) mechanisms of fallen wood tree and solid waste of agricultural products. Polypores are a major component of the basidiomycete fungi in forest ecosystems and as wood decayers and tree pathogens, they play important ecological roles. Polypore fungi are heterogeneous, showing a great variation in their macromorphological characteristics. Besides anatomical characteristics, biochemical, and molecular phylogenetic studies have been used to characterize the families of polypores (Hibbett and Donoghue 1995). Polypores has potential and enormous diversity in tropical forests, studies aiming at the discovery of bioactive compounds from polypores have reported difficulties such as slow growth rate and low product yields (Suay et al., 2000).

Figure 1. Shelf mushrooms grow on *Ficus sycomorus* dead wood during later summer at 2013at Dilla University

As shown at above in Fig 1, shelf mushrooms form shelf-like structures singly or in groups, and normally stick out from the trunk of fallen of *Ficus sycomorus*. *Ficus sycomorus* wood primarily decayed by terimtes and finaly the through opening the shelf mushroom are growing and appear their fruiting body. These fungi contain many pores so they are called polypore. Wood decay fungi are critical in nutrient cycling and improving soil fertility. Primary decomposers are characterized as organismsthat possess the enzymes needed to degrade complex polymers,

including lignin and cellulose, found in plant litter (Blanchette 1991). Lignin solidifies plant cell walls, provides strength and rigidity, and protects wood from microbial attack (Hatakka, 1994). It is estimated thatlignin is the second most abundant aromatic compound on Earth, second to cellulose (Ohkuma et al., 2001). A large proportion of Agaricomycetes arethe primary agents of lignocellulose degradation because these organisms posses the necessary enzymes, such as laccase, lignin peroxidases, and manganese peroxidises, needed to degrade lignin (Hatakka, 1994).

Figure 2. *Trametes versicolor*, Can grow on dead wood of *Ficus sycomorus* a colorful bracket fungus

As indicated in fig 2, they have green color on upper part so it was colorful bracket fungi. The top surface of the cap shows typical concentric zones of different colours. The MD Anderson has reported that it is a "promising candidate for chemoprevention due to the multiple effects on the malignant process, limited side effects, and safety of daily oral doses for extended periods of time (http://en.wikipedia.org/wiki/Trametes_versicolor). Many of polypores fungi are saprobic wood decayers, and as such, these fungi are most often found on logs, stumps, or other dead wood. Many polypores are typically tough and woody and produce basidiospores on walls of tubes of the undersurface hymenophore (the tissue that bears the fertile layer). Common names for the fruiting bodies or basidio-carps of polypores include conks, shelf, and bracket fungi (Zjawiony, 2004).

Figure 3. *Gyromitra spp*. grow under the surface of *Acacia africa* tree around root area in Dilla University.

As indicated in fig 3, some types of *Gyromitra spp.* were highly poisonous when raw, and these mushrooms have caused severe poisonings and even deaths in humans (Michelot and Toth, 1991). Clinical data are characterized primarily by vomiting and diarrhea, followed by jaundice, convulsions and coma (Hendricks, 1940). Gastrointestinal disorders distinguish this poisoning. Frequent consumption cancause hepatitis and neurological diseases (Köppel, 1993). Gyromitraspecies are considered to be edible mushrooms although their potential toxicity has been long known. They have caused numerous accidents, sometimes lethal (Giusti and Carnevale, 1974; Michelot, 1989).

Figure 4. Bracket fungus *Pycnoporus spp.* with a tough and Bright orange mushrooms growing on dry wood of fallen of *Acacia africa* tree in Dilla University Ethiopia.

As indicated in fig 4 *Pycnoporus spp*. mushrooms grown at later summer season. These fungi are used heavily for industry because of their ability to produce powerful lignolytic enzymes that break down lignin and tough polysaccharides in wood and paper. The major enzyme that differentiates this fungus from other white rotters is laccase and under the correct conditions *Pycnoporus spp.* can produce large concentrations of this enzyme. Other uses have been reported in Australia. Aboriginal culture uses it for curing mouth sores, ulcers, and teething of infants (http://en.wikipedia.org/wiki/Pycnoporus).

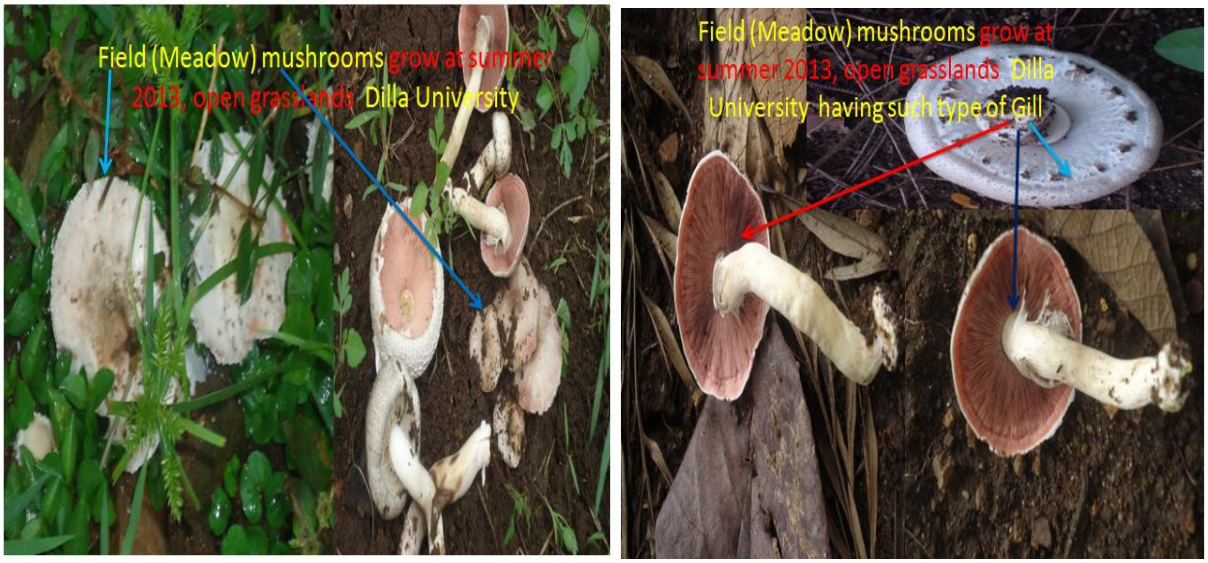

Figure 5. Field (Meadow) mushrooms (*Agaricus campestris*) grow at summer and occur in open grasslands.

As shown above in fig 5, this mushroom has chocolate color of gill. Mushrooms are found every where, in front yards, on shade trees, in parks, fields, and forests. Many species of mushrooms form slowly just beneath the surface of the soil, developing over a period of weeks or even months. When they are almost completely formed, if there is enough moisture present, the stem elongates rather suddenly and raises the cap up into the air, the cap expanding as it is raised. Evidence that mushrooms have been formed below the surface of the ground can be seen in the pieces of

dirt and debris that cling to the tops of freshly expanded specimens. In late autumn, late winter and early spring are very good time to see many of the mushrooms (Toma et al., 2013).

Figure 6. An agaric, *Schizophyllum commune*, and found on *Delonix regia* and sometime on old stone.

As indicated above in fig 6, *Schizophyllum commune* was growing on old stone and *Delonix regia* wood and having lobed structure on the edge of cap. The cap was shell-shaped, with the tissue concentrated at the point of attachment, resembling a stem. They have often wavy and lobed, with a rigid margin when old. It was tough, felty and hairy, and slippery when moist. It is found predominantly from autumn to spring on dead wood, in coniferous and deciduous forest. *S. commune* is, in fact, edible and widely consumed in Mexico and elsewhere in the tropics (Ruán-Soto et al., 2006).

Figure 7. *Clitocybe nuda* grow under *Acacia africa* tree on compost soil of paper, grass and wood in Dilla University

As shown in above fig 7, this mushroom has pink color during fruiting stage with close gill and natural growing. It is a saprotrophic species of mushrooms, growing on decaying Solid waste substrate. However, this mushrooms in Ethiopia nobody use for any purpose, it may because of lack awareness. This mushroom contains thermobile Hemolysin compound that degenerates, red blood cells, so it is not recommended to eat raw. However, the effects are relatively minor and the toxin is easily des troyed by cooking or parboiling. This mushroon also found in Ethiopia. *Clitocybe nuda* (also known as *Lepista nud*, commonly known as blewits) is an edible wood land mushroom found in Europe, North America, Asia, and

Australia (Barros et al., 2008). Due to its special fragrance and delicate texture, C. nuda has been cultivated in France, Holland, Britain, and Taiwan. Several bioactive extracts from C. nudahave been found to exhibit antioxidant and antimicrobial properties (Chen and Huang, 2009; Chen et al., 2012; Dulger et al., 2002; Mercan et al., 2006; Murcia et al., 2002). Wood blewit love hardwood barks, leaf compost, and composted manures. Clitocybe nuda is an edible mushroom under Basidiomycota division in Fungi kingdom. However, it is also known to cause allergic reactions in sensitive individuals, particularly when the mushroom is consumed in raw. Clitocybe nuda is an edible mushroom with bio-activity. Antimicrobial activity is one of the more important functions. This mushroom has shown great antifungal and antibacterial activities against plant pathogens in a previous study (Chen and Huang 2009). According to Yamac and Bilgili (2006), the extraction from fruit bodies has stronger activity against microbial growth than the extraction from mycelial cultures. Its antibacterial activity is very stable at high temperatures and over a wide range of PH. These properties of the extract make the extract suitable for use in a wide range of foods and food ingredients (Bo, 2012). This species is found in and around decomposingpiles of sawdust, in conifer duff, amongst leaves and in mature compost piles.

Figure 8. Horse mushroom, *Agaricus avensis* grow in the grass.

Horse mushroom fungi feed on soil, either consist living grass or dead grass, and the horse mushroom was appear their fruiting bodies at ground level. Their gills were black in color with broad cap as indicated in fig 8. Some Agaricomycetes are important pathogens of timber, vegetable crops, and even humans (Hibbett, 2006). Many species of Agaricomycetes act as primary decomposers of wood and other plant litter (Hibbett, 2006, Lynch, and Thorn, 2006).

CONCLUSION

Identification of wood decay fungi and wild mushrooms have challenged researchers for many years. Successful identification of wood decay fungi and wild mushrooms will increase as more researchers add to the database. This survey is the first to investigate wild mushrooms species and (wood decay) polypore fungi collected from dead trees of timber species and grass waste. Therefore, wild mushrooms and wood decay fungi have great contribution to the ecological recycling and as source of food and medicine. And also, it is possible to use for production of Ligninolytic enzymes are involved in the degradation of the complex and recalcitrant polymer lignin. Thus, there is a broad field of investigation that is almost entirely open to new findings and it is quite reasonable to propose that many new applications will be found in the near future.

ACKNOWLEDGMENTS

I am grateful thanks to Dilla University, Department of Biology, College of Natural, and Computational Sciences which are giving facilities to conduct this study.

REFERENCES

Anke, T. (1989). Basidiomycetes: a source for new bioactive secondary metabolites. Progress Industrial Microbiol. 27: 51–66.

Barros, L., Venturini, B. A., Baptista, P., Estevinho, L. M. and Ferreira, I. C. F. R. (2008). Chemical composition and biological pro-perties of Portuguese wild mushrooms: a comprehensive study. J. Agri. land Food Chem. 56(10): 3856–3862.

Bending, G. D. and Read, D. J. (1995). The structure and function of the vegetative mycelium of ectomycorrhizal plants. VI. activities of nutrient mobilizing enzymes in birch litter colonized by *Paxillus involutus* (Fr.) Fr. New Phytologist 130: 411-417.

Bennet, J.W., Wunch, K.G. and Faison, B.D. (2002). Use of fungi in Biodegradation.In: Manual of Environmental Microbiology. 2nd Ed. Christon J. Hurst. pp. 960-971.

Blanchette, R. A. (1991). Delignification by wood decaying fungi. Annu. Revi. Phytopathol. 29: 381-398.

Bo, L. (2012). Antibacterial activities of *Clitocybe nuda* extract on foodborne pathogens. Auburn University, Auburn.

Boa, E. (2004). Wild edible Fungi: A Global overview of their use and importance to people. Non Wood Forest Products Series, No. 17, FAO, Rome.

Brundrett, M. C. (2004). Diversity and classification of mycorrhizal associations. Biol. Rev. 79: 473-495.

Bruns, T.D., White, T.J. and Taylor, J.W. (1991). Fungal molecular systematics. Annu. Rev. Ecol. Syst. 22: 525–564.

Carlile, M. J., Watkinson, S. C. and Gooday, G. W. (2001). The Fungi, 2nd edition: Saprotrophs and ecosystems. Academic Press, London. Pp. 297-362.

Chang, S. T. (2008). Overviewofmushroomcultivationandutilization as functional foods, in Mushrooms as Functional Foods (Cheung, P C K ed), John Wiley & Sons, NewJersey, pp. 1–33.

Chen, J. and Huang, J. (2009). Control of plant diseases with secondary metabolite of *Clitocybe nuda.* New Biotechnol. 26:193-198.

Chen, J. T., Su, H. J. and Huang, J. W. (2012). Isolation and identification of secondary metabolites of *Clitocybe nuda* inhibition of zoospore germination of *Phytophthora capsici*. J. Agri. FoodChem. 60(30): 7341–7344.

Chen, R., Chen, L. and Song, S. (2003). Identification of thermotolerance related Genes in *A. bisporus*. Food Technol. Biotechnol. 41(4): 339–344.

Chenand, J.T. and Huang, J.W. (2009). Control of plant diseases with secondary metabolite of *Clitocybe nuda*. New Biotechnol. 26(3-4):193–198.

Cho, N.S., Wilkolazka, A.J., Staszczak, M., Cho, H.Y. and Ohga, S. (2009). The role of laccase from white rot fungi to stress conditions. J. Faculty Agri. 54(1): 81-83.

Dulger, B., Ergul, C.C. and Gucin, F. (2002). Antimicrobial activity of the macrofungus *Lepista nuda*. Fitoterapia 73(7-8): 695–697.

Esposito, E. and de Azevedo, J.L. (2004). Fungos: uma introdução à biologia, bioquímica e biotecnologia. Caxias do Sul: Editora da Universidade de Caxias do Sul (EDUCS). 510 p. ISBN 85-7061-244-3.

Farid, M. Hero, T., Ismael, M. and Nareen, Q. (2013). Faqi Abdulla, Survey and Identification of Mushrooms in Erbil Governorate. Res. J. Environ. Earth Sci. 5(5): 262-266.

Florey, H.W., Chain, W., Heatley, N. G, Jennings, M.A., Sanders, A.G., Abraham, E.P. and Florey, M.E. (1949). Antibiotics. Oxford University Press, London.

Gardes, M. and Bruns, T.D. (1996). ITS-RFLP Matching for identification of fungi. Methods Mol. Biol. 50:177-186.

Giusti, G.V. and Carnevale, A. (1974). A case of fatal poisoning by *Gyromitra esculenta*. Arch Toxicol. 33(1): 49-54.

Guillam, E. (2010). Edible mushrooms: roles in the prevention of cardiovascular diseases. Fitoterapia 8 (7): 715–723.

Hatakka, A. (1994). Lignin modifying enzymes from selected white rot fungi: production and role from in lignin degradation. F.E.M.S. Microbiol. Revi. 13:125-135.

Hendricks, H.V. (1940). Poisoning by false morel (*Gyromitra esculenta*). J.A.M.A. 114(17): 1625.

Hibbett, D. S. (2006). A phylogenetic overview of the Agaricomycotina. Mycologia 98: 917-925.

Hibbett, D. S., Binder, M., Bischoff, J. F., Blackwell, M., Cannon, P. F., Erikkson, O. E., Huhndorf, S., James, T., Kirk, P. M., Lucking, R., Lumbsch, H. T., Lutzoni, F., Matheny, P. B., McLaughlin, D. J., Powell, M. J., Redhead, S., Schoch, C. L., Spatafora, J. W., Stalpers, J. A.,Vilgalys, R., Aime, M. C., Aptroot, A., Bauer, R., Begerow, D., Benny, G. L., Castlebury, L. A., Crous, P. W., Dai, Y., Gams, W., Geiser, D. M., Griffith, G. W., Gueidan, C., Hawksworth, D. L., Hestmark, G.,Hosaka, K., Humber, R. A., Hyde, K. D., Ironside, J. E., Koljalg, U., Kurtzman, C. P., Larsson, K., Lichtwardt, R., Longcore, J., Miadlikowska, J., Miller, A., Moncalvo, J., Mozley-Standridge, S., Oberwinkler, F., Parmasto, E., Reeb, V., Rogers, J. D., Roux, C., Ryvarden, L., Sampaio, J., Schubler, A., Sugiyama, J., Thorn, R. G., Tibell, L., Untereiner, W. A., Walker, C., Wang, Z., Weir, A., Weiss, M., White, M. M., Winka, K., Yao, Y. and Zhang, N. (2007). A higher level phylogenetic classification of the Fungi. Mycol. Res. 111: 509-547.

Hibbett, D.S. and Donoghue, M. J. (1995). Progress toward a phylogenetic classification of the Polyporaceae through parsimony analysis of mitochondrial ribosomal DNA sequences. Canadian J. Botany 73(1): 853–861.

Hsu, H.Y., Hua, K.F., Lin, C.C., Lin, C.H., Hsu, J. and Wong, C.H. (2004). Extract of Reishi polysaccharides induces cytokine expression via TLR4-modulated protein kinase signaling path ways. J. Immunol.173 (10): 5989–5999.

http://en.wikipedia.org/wiki/Pycnoporus.

http://en.wikipedia.org/wiki/Trametes_versicolor.

Kirk, P. M., Cannon, P. F., Minter, D. W. and Stalpers, J. A. (2008). Dictionary of the Fungi. CAB International, Wallingford.

Kirk, T.K. and Farrell, R.L. (1987). Enzymatic "combustion": The microbial degradation of lignin. Annu. Rev. Microbiol. 41(1): 465-501.

Ko, J.L., Hsu, C.I., Lin, R.H., Kao, C.L. and Lin, J.Y. (1995). A new fungal immunomodulatory protein, FIP-fve isolated from the edible mushroom, Flammulina velutipes, and its complete amino acid sequence. European J. Biochem. 228(2): 244–249.

Köppel, C. (1993). Clinical symptomatology and management of mushroom poisoning. Toxicon. 31(12): 1513-1540.

Kowalchuk, G. A. (1999). New perspectives towards analysing fungal communities in terrestrial environments. Curr. Opinion Biotechnol. 10: 247-251.

Landeweert, R., Hoffland, E., Findlay, R. D., Kuyper, T. W. and van Breemen, N. (2001). Linking plants to rocks: ectomycorrhizal fungi mobilize nutrients from minerals. Trends Ecol. Evolution 16: 248-254.

Lindequist, U., Niedermeyer, T.H.J. and Ulich, W.-D.J. (2005). The pharmacological potential of mushrooms," Evidence Based Complementary and Alternative Medicine. 2(3): 285–299.

Lynch, M. D. J. and Thorn, R. G. (2006). Diversity of basidiomycetes in Michigan agricultural soils. Appl. Environ. Microbiol. 72: 7050-7056.

Mercan, N., Duru, M.E., Glu, A.T., Gezer, K., Kivrak, I. and Glu, H. T. (2006). Antioxidant and antimicrobial properties of ethanolic extract from *Lepista nuda* (Bull.) Cooke. Annu. Microbiol. 56(4): 339–344.

Michelot, D. (1989). Poisoning by *Geromitra esculenta*. J. Toxicol.Clin. Exp. 9(2): 83-99.

Michelot, D. and Toth, B. (1991). Poisoning by *Gyromitra esculenta*. J. Appl. Toxicol. 11(4): 235-243.

Mueller, G. M., Schmit, J. P., Leacock, P. R., Buyck, B., Cifuentes, J., Desjardin, D. E., Halling, R. E., Hjortstam, K., Iturriaga, T., Larsson, K.H., Lodge, D. J., May, T. W., Minter, D., Rajchenberg, M., Redhead, S. A., Ryvarden, L., Trappe, J. M., Watling, R. and Wu, Q. (2007). Global diversity and distribution of macrofungi. Biodiversity and Conservation 16: 37-48.

Murcia, M. A., Mart´ınez-Tome, M., Jim´enez, A. M., Vera, A. M., Honrubia, M. and Parras, P. (2002). Antioxidant activity of edible fungi (truffles and mushrooms): losses during industrial processing. J. Food Protection 65(10): 1614–1622.

O'Brien, H.E., Parrent, J.P., Jackson, J.A., Moncalvo, J.M. and Vilgalys, R. (2005). Fungal community analysis by large scale sequencing of environmental samples. Appl. Environ. Microbiol. 71: 5544–5550.

Ohkuma, M., Maeda, Y., Johjima, T. and Kudo. T. (2001). Lignin degradation and roles of white rot fungi: study on an efficient symbiotic system in fungus growing termites and its application to bioremediation. Riken Revi. 42: 39-42.

Pandey, G. and Singh, B.K. (1978). Indian mushroom. Sci. 1: 383-388.

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. Memórias do Instituto Oswaldo Cruz 98: 967–974.

Ruiz-Dueñas, F.J. and Martínez, A.T. (2009). Microbial degradation of lignin: how a bulky recalcitrant polymer is efficiently recycled in nature and how we can take advantage of this. Microbial Biotechnol. 2(2): 164-177.

Schmit, J. P. and Mueller, G. M. (2007). An estimate of lower limit of global fungal diversity. Biodiversity and Conservation 16: 99-111.

Songulashvili, G., Elisashvili, V., Wasser, S.P., Nevo, E. and Hadar, Y. (2007). Basidiomycetes laccase and manganese peroxidase activity in submerged fermentation of food industry wastes. Enzyme Microbial Technol. 41(1-2): 57-61.

Suay, I., Arenal, F., Asensio, F.J., Basilio, A., Cabello, M.A., Diez, M.T., Garcia, J.B., Val, A.G., Gorrochategui, J., HernAndez, P., PelAez, F. and Vicente, M.F. (2000). Screening of basidiomycetes for antimicrobial activities. Antonie van Leeuwenhoek 78: 129–139.

Tedersoo, L., May, T.W. and Smith, M.E. (2010). Ectomycorrhizal lifestyle in fungi: global diversity, distribution, and evolution of phylogenetic lineages. Mycorrhiza 20: 217-63.

Tibbett, M. and Sanders, F. E. (2002). Ectomycorrhizal symbiosis can enhance plant nutrition through improved access to discrete organic nutrient patches of high resource quality. Annu. Botany 89: 783-789.

Vikineswary, S., Abdullah, N., Renuvathani, M., Sekaran, M., Pandey, A. and Jones, G.E.B. (2006). Productivity of laccase in solid substrate fermentation of selected agroresidues by *Pycnoporus sanguineus*. Bioresource Technol. 97 (1): 171-177.

Wu, x., Xu, D., Liu, H. (2002). Anhui, Agri. Sci. Bull. 8: 59–60.

Yamac, M. and Bilgili, F. (2006). Antimicrobial activities of fruit bodies and/or mycelial cultures of some mushroom isolates. Pharmaceutical Biol. 44(9): 660-667.

Yu, S., Weaver, V., Martin, K. and Cantorna, M.T. (2009). The effects of whole mushrooms during inflammation. BMC Immunol. 10: 12.

Zjawiony, J. K. (2004). Biologically active compounds from Aphyllophorales (Polypore) fungi. J. Nat. Prod. 67: 300-310.