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Antibacterial and antifungal activities of selected wild mushrooms from Southern Highlands of Tanzania

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Abstract

The antibacterial and antifungal activities of crude extracts of *Lactarius sp*, *Russula kivuensis*, *Amanita muscaria*, *Amanita phalloides*, *Lactarius gymnocarpoides* and *Lactarius densifolius* (wild mushrooms) were evaluated against. The results showed that, *A. muscaria* petroleum ether extract (MS1PE) exhibited moderate antimicrobial activity against *Shigella flexneri* and *Klebsiella oxytoca* with MIC of 1.56 mg/mL. Chloroform (MS1C), petroleum ether (MS1PE) and ethanol (MS1E) extracts of *A. muscaria* showed weak activity against *Vibrio cholera* and *Streptococcus pyogenes* (3.13 mg/mL). *Mycobacteria* were more resistant to all wild mushroom extracts. On the other hand, *A. muscaria* ethanol extract (MS1E) showed high activity against *Candida albicans* with MIC of 0.78 mg/mL moreover, it was least active against *Cryptococcus neoformans* (MIC = 12.5 mg/mL). The *A. muscaria* chloroform extract (MS1C) showed moderate activity against both *C. albicans* and *C. neoformans* (MIC = 1.56 mg/mL) while its petroleum ether extract (MS1PE) was weakly active against both *C. albicans* and *C. neoformans* (MIC of 6.25 mg/mL). The crude extracts of wild mushroom species tested showed inhibitory activity against some bacteria and fungi species giving insight into development of antimicrobial agent and its application in pharmacological activities.

Key words: Wild mushrooms, bioactive compounds, antibacterial, antifungal

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INTRODUCTION

Mushrooms contain functional or medicinal properties, which may be used as a source of biologically and physiologically active substances where its estimate is about 50% of the annual harvests of 5 million metric tons of mushrooms (Cheung *et al.*, 2003; Ferreira *et al.*, 2010). According to Mizuno (1995), Wasser (1995), Wasser *et al.* (1999) and Ferreira *et al.* (2010), approximately 700 species of higher Basidiomycetes have been found to possess significant pharmacological activities. Mushrooms have been reported to have great potential as a nutritionally functional food and a source of physiologically valuable and non-toxic medicines (Zaidman *et al.*, 2005; Aina *et al.*, 2013). Mushrooms have a pronounced potential for the production of useful bioactive metabolites similar to plants and they are prolific resource for drugs with biological activities (Thomas *et al.*, 1994; Aina *et al.*, 2013). Mushrooms have been found to have potential biological activities such as anti-bacteria, anti-fungi, antitumor, anti-inflammatory, anti-hepatotoxic activity, cardio-tonic activity, cholesterol level lowering activity, antiviral and immune-modulatory activity (Miles and Chang, 1997; Nkunya, 2002; Quang *et al.*, 2006; Petrova *et al.*, 2007; Mshandete and Cuff, 2008; Salahddin, 2008; Nyigo *et al.*, 2009; Ferreira *et al.*, 2010 and Saral, 2013). The enormous structural diversity of natural compounds originate from mushrooms offer prospective potential opportunities for discovering new drugs (Russo *et al.*, 2007). Therefore, due to the increasing demand for functional foods nutraceuticals and food supplements particularly for individuals with compromised immunity, wild mushroom species that are rich in bioactive compounds, are interesting candidates for evaluation as potential functional food substrates (Baraza *et al.*, 2007). Multi-drug resistance from synthetic drugs has prompted the use of natural products such as wild mushrooms as a possible source of bioactive compounds since they have little or no side effects. Most of the synthetic drugs are potentially toxic and not free of side effects on the hosts (Maregesi *et al.*, 2008) thus formulation of new antimicrobial agents and evaluation of the efficacy of natural plant products as a substitute for chemical antimicrobial agents is potential and of current concern (Pandian *et al.*, 2006; Maregesi *et al.*, 2008). Current problem of microbial drug resistance and increased concern on opportunistic infections makes the alternative drugs especially those originating from plants and Basidiomycetes to be prospective. Since few studies have been reported on the antimicrobial activity of different wild mushroom extracts in Tanzania, this study is aimed at screening bioactive compounds from different species of wild mushrooms as antibacterial and antifungal agents.

MATERIALS AND METHODS

Materials

The edible (*Lactarius densifolius*) and inedible (*Lactarius sp*, *Lactarius gymnocarpoides*, *Russula kivuensis*, *Amanita muscaria* and *Amanita phalloides*) wild mushrooms species were collected in Njombe and Iringa regions, Tanzania in January, 2014. The wild mushroom samples were identified by a taxonomist at the University of Dar Es Salaam where voucher specimens were deposited. Gram positive bacteria *Mycobacterium madagascariensis* (DSM 44641) and *Mycobacterium indicuspranii* (DSM 45239) were obtained from the Germany Resource Centre for Biological materials (DSMZ, Braunschweig, Germany). *Streptococcus pyogenes* (clinical isolate) were obtained from Muhimbili University of Health and Allied Sciences (MUHAS). Gram negative bacteria, *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 29953), *Salmonella kisarawe* (clinical isolate), *Salmonella typhi* (NCTC 8385), *Vibrio cholerae* (clinical isolate), *Klebsiella pneumoniae* (clinical isolate) *Shigella flexneri* (clinical isolate) and *Klebsiella oxytoca* (clinical isolate) were obtained from Muhimbili University of Health and Allied Sciences (MUHAS). Fungi strains *Candida albicans* (ATCC 90028) and *Cryptococcus neoformans* (clinical isolate) were obtained from Muhimbili University of Health and Allied Sciences (MUHAS). Nutrient agar, nutrient broth, Sabouraud dextrose agar and Sabouraud dextrose broth (liquid media) were purchased from HiMedia Laboratories, India. Iodo nitrotriazolium chloride (INT) was from (Sigma-Aldrich, USA). All other reagents and chemicals were of analytical grade.

Wild Mushroom Extracts Preparation

Fresh whole mushrooms (25 g) were ground using a blender (Singsung - Singapore) and extracted sequentially by soaking twice in 250 mL of ethanol and chloroform for 48 h. The extracts were filtered using a filter paper and further concentrated in vacuum evaporator (Heildolph, Germany). The concentrates were then stored at 4° C for further bioassays.

Antimicrobial Assay

Antimicrobial activity was determined according to the method of (Eloff, 1998). Sub-culturing of bacteria and fungi strains was done using Nutrient agar and Sabouraud dextrose agar respectively. Mycobacteria sub-culturing and testing was done using middle brook broth unlike to other bacteria and fungi strains. A 50 µL of the broth media were uploaded in each well of the 96 micro plate followed by 50 µL of the extract into the first wells of each row making a total volume of 100 µL.

Serial dilution was done by thorough mixing the broth and extracts in the first wells and then 50 μ L were drawn from each of the first row wells and put into the next row. The procedure was repeated down the columns of the plate to the last wells at the bottom end where at last 50 μ L was discarded (Maregesi *et al.*, 2013). Subsequently, 50 μ L of the test microbe's suspension 0.5 Mac Farland standard turbidity (Maregesi *et al.*, 2013) was prepared by adding microbe's inoculum into sterile distilled water and adjusted to get the right turbidity then added in each well to make the final volume of 100 μ L. A positive standard Gentamycin was used and Dimethyl sulphoxide (DMSO) was taken as negative control. The plates were then incubated at 32 °C for 24 h while those of mycobacteria were incubated at 37 °C for 24 h. The Minimum Inhibition Concentrations (MIC's) for each extract were determined by using 40 μ L of 0.02% p-iodo nitrotriazolium (INT) chloride dye dissolved in water was and then added in each well and incubated at 32 °C for 1 h (Eloff, 1998). Microbial growth was indicated by a colour change to pink and the lowest concentration which showed no microbial growth was regarded as MIC (Mwangomo *et al.*, 2012; Maregesi *et al.*, 2013).

Data Analysis

Results represent triplicate determinations. For the antimicrobial test, the minimum inhibitory concentration (MIC) which killed all the organisms was recorded.

RESULTS

The antimicrobial activities of crude extracts of one edible (*Lactarius densifolius*) and five inedible (*Lactarius sp*, *Lactarius gymnocarpoides*, *Russula kivuensis*, *Amanita muscaria* and *Amanita phalloides*) species of wild mushrooms against bacteria and fungi strains are shown in **Table 1 & 2**. The *A. muscaria* petroleum ether extract (MS1PE) showed moderate inhibitory activity against *S. flexneri*, and *K. oxytoca* with MIC of 1.56 mg/mL, however, it was weak against *S. pyogens* (MIC = 3.13 mg/mL) (**Table 1**). Chloroform (MS1C) and ethanol (MS1E) extracts of *A. muscaria* showed weak activity against *V. cholera* with MIC of 3.13 mg/mL. *Amanita phalloides* ethanol extract (MS2E) possessed weak activity against *E. coli* (MIC = 3.13 mg/mL). Other tested wild mushroom extracts (MS2E, MS2C, BM2E, MS4C and BM8C) possessed no activity against *S. flexneri*, *S. typhi*, *S. pyogens*, *V. cholera*, *K. pneumonia*, *P. aeruginosa*, *S. kisarawe* and *K. oxytoca* (**Table 1**). Also, all species of mycobacteria (*M. madagascariensis* and *M. indicuspranii*) were resistance to all wild

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mushrooms extracts tested (**Table 1 & 2**). Some of the tested mushroom extracts possessed inhibitory activity against fungi strains. *Amanita muscaria* ethanol extract (MS1E) exhibited moderate inhibitory activity against *C. albicans* with MIC of 0.78 mg/mL however, it was not active against *C. neoformans* (MIC = 12.50 mg/mL). *Amanita. muscaria* chloroform extract (MS1C) was moderate active against both *C. albicans* and *C. neoformans* (MIC = 1.56 mg/mL) besides, its petroleum ether extract (MS1PE) possessed weak activity against both *C. albicans* and *C. neoformans* (MIC = 6.25 mg/mL). All other wild mushroom extracts showed no inhibitory activity against both fungi species (**Table 2**).

Table 1. Inhibitory activity (MIC) of wild mushroom crude extracts against selected human pathogenic bacteria

Bacteria	Wild mushroom crude extracts (mg/mL)								
	MS1PE	MS1C	MS1E	MS2E	MS2C	BM2E	MS4C	BM8C	Gentamycin
<i>S. flexneri</i>	1.56	12.50	6.25	25.00	12.50	25.00	12.50	12.50	0.0015
<i>S. typhi</i>	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	0.0061
<i>V. cholera</i>	12.50	3.125	3.125	6.25	12.50	6.25	6.25	6.25	0.0015
<i>E. coli</i>	12.50	25.00	12.50	3.125	6.25	6.25	6.25	6.25	0.0015
<i>S. kisarawe</i>	12.50	12.50	6.25	12.50	25.00	25.00	25.00	25.00	0.0061
<i>S. pyogens</i>	3.125	6.25	6.25	6.25	6.25	25.00	25.00	25.00	0.0015
<i>K. pneumoniae</i>	12.50	6.25	6.25	25.00	25.00	25.00	25.00	25.00	0.0030
<i>P. aeruginosa</i>	6.25	6.25	6.25	25.00	25.00	25.00	25.00	25.00	0.0015
<i>K. oxytoca</i>	1.56	25.00	25.00	12.50	25.00	12.50	25.00	25.00	0.0030
<i>M. madagascariensis</i>	12.50	25.00	25.00	12.50	12.50	12.50	25.00	25.00	NT
<i>M. indicuspranii</i>	12.50	25.00	25.00	25.00	25.00	12.50	25.00	25.00	NT

Table 2: Inhibition activity (MIC) of wild mushroom crude extracts against selected human pathogenic fungi

Fungi	Wild Mushrooms crude extracts (mg/mL)								Fluconazole
	MS1C	MS1E	MS1PE	BM2E	MS4PE	MS4C	BM1C	BM8C	
<i>C. albicans</i>	1.56	0.78	6.25	12.50	25.00	25.00	25.00	25.00	0.006
<i>C. neoformans</i>	1.56	12.50	6.25	12.50	12.50	25.00	25.00	25.00	0.003

Key: MS1PE = *Amanita muscaria* petroleum ether extract, MS1C = *Amanita muscaria* chloroform extract, MS1E = *Amanita muscaria* ethanol extract, MS4PE = *Russula kivuensis* petroleum ether extract, MS2E = *Amanita phalloides* ethanol extract, MS2C = *Amanita phalloides* chloroform extract, BM2E = *Lactarius gymnocarpoides* ethanol extract, BM8C = *Lactarius densifolius* chloroform extract, MS4C = *Russula kivuensis* chloroform extract, BM1C = *Lactarius sp.* chloroform extract, BM2C = *Lactarius gymnocarpoides* chloroform extract, MS4E = *Russula kivuensis* ethanol extract, BM1E = *Lactarius sp.* ethanol extract and NT = Not tested.

DISCUSSION

Microbial infections possess a very serious public health problem all over the world especially in poor countries (Agada *et al.* 2012). The demonstration of antibacterial activity against both gram positive and gram-negative bacteria may be indicative of the presence of broad-spectrum antibiotic compounds (Tassou *et al.*, 1995; Agada *et al.*, 2012). According to Algiannis *et al.* (2001), proposed classification based on MIC values is as follows; extracts with MIC up to 0.5 mg/mL are considered as strong inhibitors, 0.6 - 1.5 mg/mL as moderate inhibitors and those with MIC values above 1.6 mg/mL as weak inhibitors. From this study, it was shown that some extract of wild mushrooms, exhibited moderate inhibitory activity against one or more bacterial and fungal species tested, whilst some showed weak or no activity to the bacteria and fungi species. In particular, among all extracts, petroleum ether and ethanol extracts of some wild mushrooms possessed moderate antimicrobial activity against tested microorganisms. The weak or inactive activity of *S. pyogens*, *K. pneumonia*, *P. aeruginosa*, *S. kisarawe* and *S. typhi* against wild mushroom extracts is similar to the findings reported by Priya and Srinivasan (2013), where *Ganoderma* showed medium inhibitory action against

Bacillus sp., and *Staphylococcus aureus*, low inhibitory action against *E. coli* and *K. pneumoniae* however, no inhibition zone was observed against *P. aeruginosa*. Additionally, *Lentinus edodes*, *Pleurotus obstrictus* and *Agaricus bisporus* strains showed no inhibition zone after 48 h of incubation against *Bacillus* spp., *S. aureus*, *E. coli*, *K. pneumoniae* and *P. aeruginosa*. This suggests that some of the tested microbes were resistant to wild mushroom crude extracts. The microbial resistance of *E. coli*, *S. typhimurium*, *P. aeruginosa* and *A. niger* was also reported by Maregesi *et al.* (2008) in which the strains were resistant to most of the plant extracts from *Barleria eranthemoides* (leaves) and *Lonchocarpus eriocalyx* (stem bark).

On the other hand, mycobacteria (*M. madagascariensis* and *M. indicuspranii*) were more resistant to all mushroom crude extracts. The observed inhibitory activities of crude extracts were lower as compared to Gentamycin and Fluconazole. Suay *et al.*, 2000, reported that crude form of the extracts or presence of many compounds may provoke each other and reduce activity. Thus, further studies on isolation, purification and screening of active compounds are necessary. Best to the knowledge, no studies have been done to evaluate antibacterial and antifungal activities of the wild mushroom species tested. Therefore, findings from this study showed that wild mushroom crude extracts may also exhibit antibacterial activity as compared to antifungal activity. Salahuddin (2008) reported that the *Schizophyllum commune* mushroom had more antibacterial activity than antifungal activity. Also, antibacterial activity of *Polypores* and gilled (*Agaricales*) mushrooms had more pronounced activity than antifungal Suay *et al.* (2000). Jonathan and Fasidi (2003), also suggested that the antifungal activities of the mushrooms *Lycoperdon pusilum* and *Lycoperdon giganteum* extracts against pathogenic tested fungi were very low. Also, Lauer *et al.* (1991) observed that *Lentinus adherens* mushroom extracts were less effective against pathogenic fungi compared to pathogenic bacteria. Generally, it is observed in many studies that the fungal and yeast strains are more resistant to antimicrobial compounds than bacterial strains (Nishizawa *et al.* 1990; Papadopoulou *et al.* 2005).

CONCLUSION

The wild mushrooms crude extracts showed moderate to weak activities against some species of bacteria and fungi. Also, some of the crude extracts exhibited no activity against some bacteria and fungi species. All extracts showed no inhibitory activity against two species of mycobacterium. Therefore, some species of wild mushrooms collected from Southern Highlands of Tanzania has a high potential to be used as natural antimicrobial agents. Hence, further studies on isolation and

screening of the active compounds might deliver a better source for emerging new therapeutic agents and therefore find its application in nutraceuticals and pharmaceuticals industries.

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REFERENCES

- Aina, D., J. Oloke, O. Awoyinka, E. Adebayo, O. Akoni, J. Agbolade and K. Odeniyi, 2013: Comparative Cytotoxic Effect of Metabolites from Wild and Mutant Strains of *Schizophyllum commune* Grown in Submerged Liquid Medium. *American Journal of Research Communication*, 7, 219-240.
- Agada, G.O.A., Chollom, S.C., Gotep. J.G., Gambo, N.N., Tyem, A.D., Okeke, I.O., Nwankiti, O.O., Okwori, A.E.J., 2012: Evaluation of Antimicrobial Potential of Ethanolic Leaf and Stem Bark Extracts of *Tamarindus indica*. *International Journal of Applied Microbiology Science*, 1, 26-34 .
- Algiannis, N., Kalpotzakis, E., Mitaku, S., Chinou, I. B., 2001: Composition and Antimicrobial Activity of Essential Oils of Two *Origanum* Species. *Journal of Agricultural and Food Chemistry*, 40, 4168–4170.
- Baraza, L., C. Joseph, M. Moshi and M. Nkunya, 2007: Chemical Constituents and Biological Activity of Three Tanzanian Wild Mushroom Species. *Tanzania Journal of Science*, 33, 1-7.
- Cheung, L. M., Cheung, P. C., & Ooi, V. E., 2003: Antioxidant activity and Total Phenolics of Edible Mushroom Extracts. *Food Chemistry*, 81, 249-255.

- Eloff, J., 1998: A Sensitive and Quick Microplate Method to Determine the Minimal Inhibitory Concentration of Plant Extracts for Bacteria. *Planta medica*, 64, 711-713.
- Ferreira, I.C.F.R, Vaz, J.A, Vasconcelos, M. H., & Martins, A., 2010: Compounds from wild mushrooms with antitumor potential. *Anti-Cancer Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Anti-Cancer Agents)*, 10, 424-436.
- Jonathan, S. and I. Fasidi, 2003: Antimicrobial Activities of Two Nigerian Edible Macro-fungi- *Lycoperdon pusilum* (Bat. Ex) and *Lycoperdon giganteum* (Pers.). *African Journal of Biomedical Research*, 6, 85-90.
- Maregesi, S. M., N. T. Nyamwisenda, D. Mwangomo and A. Kidukuli, 2013: *In Vitro* Antimicrobial Activity and Determination of Essential Metal and Ash Value Contents of *Trichodesma zeylanicum*. *International Journal of Research in pharmacology and pharmacerapeutic*, 2, 417-424.
- Maregesi, S. M., L. Pieters, O. D. Ngassapa, S. Apers, R. Vingerhoets, P. Cos, D. A. V. Berghe and A. J. Vlietinck, 2008: Screening of Some Tanzanian Medicinal Plants from Bunda District for Antibacterial, Antifungal and Antiviral Activities. *Journal of ethnopharmacology*, 119, 58-66.
- Miles, P. G. and S.-T. Chang, 1997: *Mushroom Biology: Concise Basics and Current Developments*. World Scientific. Singapore, 15-17 pp
- Mshandete, A. M. and J. Cuff, 2008: Cultivation of Three Types of Indigenous Wild Edible Mushrooms: *Coprinus cinereus*, *Pleurotus flabellatus* and *Volvariella volvocea* on Composted Sisal Decortications Residue in Tanzania. *African Journal of Biotechnology*, 7, 4551-4562.
- Mwangomo, D. T., M. J. Moshi and J. J. Magadula, 2012: Antimicrobial Activity and Phytochemical screening of *Antidesma venosum* Root and Stem Bark Ethanolic Extracts. *International Journal of Phytochemical and Pharmacology*, 2, 90-95.
- Nishizawa, K., I. Nakata, A. Kishida, W. A. Ayer and L. M. Browne, 1990: Some Biologically Active Tannins of *Nuphar variegatum*. *Phytochemistry*, 29, 2491-2494.
- Nkunya, M., 2002: Natural Chemicals for Disease and Insect Management. *Professorial Inaugural Lecture, University of Dar es Salaam*.
- Nyigo, V., L. Baraza, M. Nkunya, S. Mdachi, C. Joseph and A. Waziri, 2009: Chemical Constituents and Cytotoxicity of some Tanzanian Wild Mushrooms. *Tanzania Journal of Science*, 31, 1-4.

- Pandian, M., G. Banu and G. Kumar, 2006: A study of the Antimicrobial Activity of *Alangium salviifolium*. *Indian Journal of Pharmacology*, 38, 203.
- Papadopoulou, C., K. Soulti and I. G. Roussis, 2005: Potential Antimicrobial Activity of Red and White Wine Phenolic Extracts against Strains of *Staphylococcus aureus*, *Escherichia coli* and *Candida albicans*. *Food Technology and Biotechnology*, 43, 41-46.
- Petrova, A., K. Alipieva, E. Kostadinova, D. Antonova, M. Lacheva, M. Gjosheva, S. Popov and V. Bankova, 2007: GC-MS studies of the Chemical Composition of Two Inedible Mushrooms of the Genus *Agaricus*. *Chemistry Central Journal*, 1, 33-38.
- Priya, J. L. and Srinivasan, V., 2013: Studies on the Antibacterial Activities of Mushroom. *International Journal of Innovative Research and Development*, 2, 184-189.
- Quang, D. N., T. Hashimoto and Y. Asakawa, 2006: Inedible Mushrooms: A Good Source of Biologically Active Substances. *The Chemical Record*, 6, 79-99.
- Reis, F. S., E. Pereira, L. Barros, M. J. Sousa, A. Martins and I. C. Ferreira, 2011a: Biomolecule Profiles in Inedible Wild Mushrooms with Antioxidant Value. *Molecules*, 16, 4328-4338.
- Reis, F. S., E. Pereira, L. Barros, M. J. Sousa, A. Martins and I. C. F. R. Ferreira, 2011b: Biomolecule Profiles in Inedible Wild Mushrooms with Antioxidant Value. *Molecules*, 16, 4328-4338.
- Russo, A., M. Piovano, M. Clericuzio, L. Lombardo, S. Tabasso, M. Chamy, G. Vidari, V. Cardile, P. Vita-Finzi and J. Garbarino, 2007: Putrescine-1, 4-dicinnamide from *Pholiota spumosa* (Basidiomycetes) Inhibits Cell Growth of Human Prostate Cancer Cells. *Phytomedicine*, 14, 185-191.
- Salahuddin, M. A. H., 2008: Biological Activities of *Schizophyllum commune* Fr. *Master's Thesis* for The Degree of Master of Science, University of Malaya.
- Saral, M., 2013: Analysis on Essential Fatty Acid Ester of Mushroom *Pleurotus eous* and its Antibacterial Activity. *Asian Journal of Pharmaceutical and Clinical Research*, 6, 188-191.
- Suay, I., F. Arenal, F. J. Asensio, A. Basilio, M. A. Cabello, M. T. Díez, J. B. García, A. G. del Val, J. Gorrochategui and P. Hernández, 2000: Screening of Basidiomycetes for Antimicrobial activities. *Antonie van Leeuwenhoek*, 78, 129-140.

Tassou CC, Drosinos EH, Nychas GJE, 1995: Effects of Essential Oil from Mint (*Mentha piperita*) on *Salmonella enteitidis* and *Listeria monocytogenes* in Model Food Systems at 4°C and 10°C. *Journal of Applied Bacteriology*, 78: 593-600.

Thomas, P., R. Earl, P. Thomas and R. Earl, 1994: Enhancing the Food Supply. Opportunities in the Nutrition and Food Science. *The National Academies Press*, Washington, DC, 98-142.

Zaidman, B.-Z., M. Yassin, J. Mahajna and S. P. Wasser, 2005: Medicinal Mushroom Modulators of Molecular Targets as Cancer Therapeutics. *Applied Microbiology and Biotechnology*, 67, 453-468.