



CENTRAL LUZON STATE UNIVERSITY



ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES OF BIOACTIVE LIPIDS
DERIVED FROM *Ganoderma lucidum*

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An Undergraduate Thesis Submitted to the Faculty at the Department of
Biological Sciences, College of Arts and Sciences, Central
Luzon State University, Science City of Munoz, Nueva
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the Requirements for the Degree

BACHELOR OF SCIENCE IN BIOLOGY

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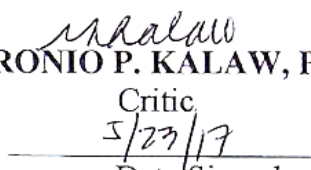
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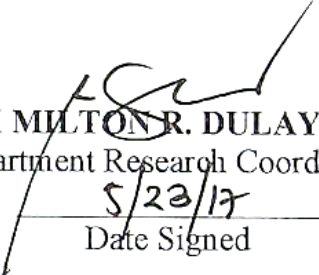
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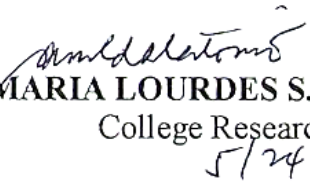

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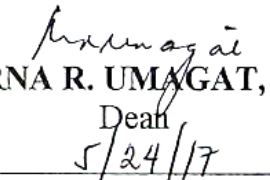

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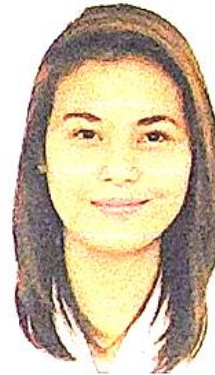

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ABSTRACT

YAMBOT, RUTH G. Bachelor of Science in Biology, Department of Biological Sciences, College of Arts and Sciences, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, June 2017. **ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES OF BIOACTIVE LIPIDS DERIVED FROM *Ganoderma lucidum*.**

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The antioxidant and antibacterial activities of bioactive lipids derived from *G. lucidum* were evaluated. Lipid extract were obtained using hexane and acetonitrile as solvents and concentrated using rotary evaporator. The radical scavenging activity and antibacterial property against the two bacterial pathogens were studied. Results revealed that *G. lucidum* lipid extracts exhibit radical scavenging activity. Hexane extract significantly registered the highest scavenging activity of 90.83%, followed by the acetonitrile extract having 65.14%. Antibacterial assay showed that *G. lucidum* acetonitrile extract inhibited the *S. aureus* growth with a mean diameter zone of inhibition of 10.57 mm. However, hexane extract did not show any antibacterial activity against the two bacterial pathogens..

Collectively, the two lipid extracts of *G. lucidum* possess antioxidant property as indicated by the radical scavenging activity. However, acetonitrile lipid derived from *G. lucidum* exhibited promising antibacterial potential against *S. aureus*.



LITERATURE CITED

- ALAM, N., AMIN, R., KHAN, A., ARA, I., SHIM, M.J., LEE, M.W. and T.S. LEE. (2008). Nutritional analysis of cultivated mushrooms in Bangladesh - *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus florida* and *Calocybe indica*. *Mycobiology*, 36(4): 228-232.
- ALUKO, E.R. and C.C. UDINIGWE. (2012). Food Protein-Derived Bioactive Peptides: Production, Processing, and Potential Health Benefits. *Journal of Food Science*, 77:11-24.
- AMERI, A., VAIDYA, J.G. and S.S. DEOKULE. (2011). In vitro evaluation of antistaphylococcal activity of *Ganoderma lucidum*, *Ganoderma praelongum* and *Ganoderma resinaceum* from Pune, India. *African Journal of Microbiology*, 64(11):1309-1321.
- AVER, E., AVER, G.A. and D.A. KOSE. (2014). Determination of antioxidant and antimicrobial activities of medically important mushrooms using different solvents and chemical composition via GC/MS analyses. *Journal of Food and Nutrition Research*, 2(8): 429-434.
- HALLIWELL, B. (1995). How to characterize an antioxidant-An update. *Biochemistry Society Symposium*, 61:73-101.
- BARROS, L., CALHELHA, R.C., VAS, J.A., FERREIRA, I.C.F.R., BAPTISTA, P. and L.M. ESTEVINHO. (2007). Antimicrobial activity and bioactive compounds of Portuguese wild edible mushrooms as methanolic extracts. *Europe Food Resources and Technology*, 225:151-156.
- BARROS, L., CRUZ, T., BAPTISTA, P., ESTEVINHO, L.M. and I.C. FERREIRA. (2008). Wild and commercial mushrooms as source of nutrients and nutraceuticals. *Food Chemicals Toxicology*, 46(8): 2-7.
- BENZIE, I. (2003). Composition of biochemistry, physiology, a molecular integrated physiology, *Biochemistry Society Symposium*, 136: 113-126.
- BERGER, G. (2006). Bioactive Lipids in *Schizophrenia*. *International Review of Psychiatry*, 16:20.
- BLAGOSKLONNY, M. (2005). Teratogens as anticancer drugs. *Cell Cycle*, 4(11): 15-21.
- BIOWEB. (2011). Taxonomical characteristics of *Ganoderma lucidum*. Retrieved from http://bioweb.uwlax.edu/bio203/2011/mestelle_zach/classification.html



- BONILLA, R. (2010).** Cost-Effective Solutions to the World-Wide Acetonitrile Shortage. Retrieved from <http://www.pharmpro.com/articles/04/ Cost-Effective-Solutions-to-the-World-Wide-Acetonitrile-Shortage/>
- CABISCOL, E., TAMARIT, J. and J. ROS. (2001).** Oxidative stress in bacteria and protein damage by reactive oxygen species. *International Microbiology*, 3: 3-8.
- CHANG, S.T., and P.G. MILES. (2004).** The nutritional attributes of edible mushrooms. In *Mushrooms: Cultivation, Nutritional Value, Medicinal effect, and Environmental Impact*. Boca Raton, FL CRC Press, p. 27-38.
- CHANG, U.M., LI, C.H., LIN, L.I., HUANG, C.P., KAN, L.S. and S.B. LIN. (2006).** Ganoderiol F, a ganoderma triterpene, induces senescence in hepatoma HepG2 cells. *Life Sciences*, 79(12): 1129-1139.
- CHOI, H.Y. and H.S. RYU. (2015).** Antioxidant and anticancer effects of water extract from *Pleurotus ostreatus*. *Korean Journal Food Nutrition*, 28(1): 60–65.
- CHRINOS, R., ROGEZ, H., CAMPOSA, D., PEDRESCHI, R. and Y. LARONDELLE. (2007).** Optimization of extraction conditions of antioxidant phenolic compounds from mashua (*Tropaeolum tuberosum* Ruiz & Pavon) tubers. *Separation and Purification Technology*, 55: 217-225.
- DIEKEMA, D.J., PFALLER, M.A., SCHMITZ, M.J., BELL, J., JONES, R.N. and M. BEACH. (2001).** Survey of infections due to *Staphylococcus aureus* species: frequency of occurrence and antimicrobial susceptibility of isolates collected in the United States, Canada, Latin America, Europe, the Western Pacific region for the SENTRY Antimicrobial Surveillance Program. *Clinical Infection*, 32: 114-132.
- DULAY, R.M.R., RAY, K. and C.T. HOU. (2015).** Optimization of liquid culture conditions of Philippine wild edible mushrooms as potential source of bioactive lipids. *Biocatalysis and Agricultural Biotechnology*, 4: 409–415.
- DULAY, R.M.R., KALAW, S.P., REYES, R.G., ALFONSO, N. and F. EGUCHI. (2012).** Teratogenic and toxic effects of Lingzhi or Reishi medicinal mushroom, *Ganoderma lucidum* (W. Curt.:Fr.) P. Karst. (Higher Basidiomycetes), on zebra fish embryo as model. *International Journal of Medicinal Mushrooms*, 14(5): 507-512.
- EGUCHI, F., KALAW, S.P., DULAY, R.M.R., MIYASAWA, N., YOSHIMOTO, H., SEYAMA T. and R.G. REYES (2015).** Nutrient composition and functional activity of different stages in the fruiting body development of Philippine paddy straw mushroom, *Volvariella volvacea* (Bull.:Fr.). *Advances in Environmental Biology*, 9(22): 54-65.



- EGUCHI, F., DULAY, R.M.R., KALAW, S.P., YOSHIMOTO, H., MIYAZAWA, N., SEYAMA, T. and R.G. REYES. (2014). Antihypertensive activities of Philippine wild edible white rot fungus (*Lentinus sajorcaju*) in spontaneously hypertensive rats as models. *Advances in Environmental Biology*, 8(24): 74-81.
- FAN, L., PAN, H., THOMAZ, A., PANDEY, S. and C.R. SOCCOL. (2006). Advances in mushroom research in the last decade. *Food Technology and Biotechnology*, 44(3): 303-311.
- FERREIRA, I.C.F.R., BAPTISTA, P., VILAS-BOAS, M. and L. BARROS. (2007). Free-radical scavenging capacity and reducing power of wild edible mushrooms from northeast Portugal: individual cap and stipe activity. *Food Chemistry*, 100:1511-1516.
- FUCHS, F.D. (2004). Princípios gerais do uso de antimicrobianos. In: Fuchs F, Wannamacher L, Ferreira M, editors. *Farmacologia Clínica – Fundamentos da terapêutica Racional*. 3rd ed. Rio de Janeiro, Guanabara Koogan, 18: 342.
- GALOR, S.W., BUSWELL, J.A., TOMLINSON, B. and I.F.F. BENZIE. (2004). Lingzhi polyphorous fungus in: herbal and traditional medicine: Molecular Aspects of Health. New York. Marcel Dekker Incorporated, pp. 179-228.
- GAO, J.J., HIRAKAWA, A., MIN, B.S., NAKAMURA, N. and M. HATTORI. (2006). In vivo antitumor effects of bitter principles from the antlered form of fruiting bodies of *Ganoderma lucidum*. *Journal of Natural Medicines*, 60(1): 42-48.
- GAO, J.J., MIN, B.S., AHN, E.M., NAKAMURA, N., LEE, H.K. and M. HATTORI. (2002). New triterpene aldehydes, lucialdehydes A-C, from *Ganoderma lucidum* and their cytotoxicity against murine and human tumor cells. *Chemical & Pharmaceutical Bulletin*, 50(6):837-840.
- GAO, Y., TANG, W., GAO, H., CHAN, E., LAN, J. and X. LI. (2005). Antimicrobial activity of the medicinal mushroom *Ganoderma*. *Food Reviews International*, 21(2):211-219.
- GUAN, S.H., XIA, J.M., YANG, M., WANG, X.M., LIU, X. and D.A. GUO. (2008). Cytotoxic lanostanoid triterpenes from *Ganoderma lucidum*. *Journal of Asian Natural Products Research*, 10(7-8):705-710.
- HSU, C.I., LIN, J.Y., TSAI, C.C. and R.H. LIN. (2003). Oral administration of an edible-mushroom-derived protein inhibits the development of food allergic reactions in mice. *Clinical Experiments on Allergy*, 33(11): 1595-1602.



- JAKUYAMAR, T., THOMAS, P.A. and P. GERALDINE. (2009).** In vitro antioxidant activities of an ethanolic extract of the oyster mushroom, *Pleurotus ostreatus*. African Journal of Biotechnology, 6(5) 1732-1739.
- JOSEPH, S., SABULAL, B., VARUGHESE, G., and K.K. JANARDHANAN. (2009).** Antioxidative and anti-inflammatory activities of the chloroform Extract of *Ganoderma lucidum* found in South India. Scientia Pharmaceutica, 77: 111-121.
- KALAW, S.P. and R.F ALBINTO. (2014).** Functional activities of Philippine wild strain of *Coprinus comatus* (O. F. Müll. : Fr.) Pers and *Pleurotus cystidiosus* O. K. Miller grown on rice straw based substrate formulation. Mycosphere, 5(5): 646-655.
- KAMRA, A. and A.B. BHATT. (2012).** Evaluation of antimicrobial and antioxidant activity of *Ganoderma lucidum* extracts against human pathogenic bacteria. International Journal in Pharmaceutical Science, 4(2): 359-362.
- KIM, Y.D., KIM, K.J. and D.B. CHO. (2003).** Antimicrobial activity of *Lentinus edodes* extract. Korean Journal of Food Preservations, 10(1):89-93.
- KIRK, P.M., CANNON, P.F., MINTER, D.W. and J.A. STALPERS (2008).** Dictionary of the Fungi (10th ed.) Wallingford, pp. 272.
- KLOOS, W.E. and T.L. BANNERMAN. (1994).** Update on clinical significance of coagulase-negative staphylococci. Clinical Microbiology, 7: 117-140.
- KOMODA, N., KOMUTA, K., and H. NANBA. (1989).** Ganoderic acid and its derivatives as cholesterol synthesis inhibitors. Chemistry on Pharmaceutical Bulletin, 37: 531-533.
- KRINSKY, N.I. (1992).** Mechanism of action of biological antioxidants Chemistry on Pharmaceutical Bulletin, 20:248-254.
- LANGSETH, L. (1996).** Oxidants, antioxidants and disease prevention. International life Science Institute, 8(12-14): 306-309.
- LEE, Y.L., YEN, M.T., and J.L., MAU. (2007).** Antioxidants properties of various extracts from *Hypsizigus marmoreus*. Food Chemistry, 104:1-9.
- LIN. Z.B. (2004).** Focus on antioxidative and free radicals scavenging activity of *Ganoderma lucidum*. Journal in Application of Pharmacology, 12:133-137.
- LINDEQUIST, U., NIEDERMEYER, T.H.J. and W.D. JULICH. (2005).** The pharmacological potential of mushrooms. CAM, 2: 285-299.



- LU, H., KYO, E., UESAKA, T., KATOH, O. and H.W. LEE (2003).** A water-soluble extract from cultured medium of *Ganoderma lucidum* (Reishi) mycelia suppresses azoxymethane-induction of colon cancers in male F344 rats. *Chemistry on Pharmaceutical Bulletin*, 10(2):375-379.
- LU, H.M., UESAKA, T., KATOH, O., KYO, E. and H. WATANABE. (2001).** Prevention of the development of preneoplastic lesions, aberrant crypt foci, by a water-soluble extract from cultured medium of *Ganoderma lucidum* (Reishi) mycelia in male F344 rats. *Chemistry on Pharmaceutical Bulletin*, 8(6):1341-1345.
- MARANAN, M., MOREIRA, B., BOYLE-VAVRA, S. and R. DAUM. (1997).** Antimicrobial resistance in staphylococci. *Epidemiology, molecular mechanisms, and clinical relevance. Infection Clinic, North America*, 11:813-849.
- MAU, J.L., CHANG, C.N., HUANG, S.J. and C.C. CHEN. (2004).** Antioxidant properties of methanolic extract from *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosus* mycelia. *Food Chemistry*; 87:111-118.
- MAU, J.L., TSAI, S.Y., TSENG, Y.H. and S.J. HUANG. (2005).** Antioxidant properties of hot water extracts from *Ganoderma tsugae* Murrill. *Chemistry on Pharmaceutical Bulletin*, 38: 589–597.
- MAU, J.L., LIN, H.C. and C.C. CHEN. (2002).** Antioxidant Properties of Several Medicinal Mushrooms. *Journal in Agricultural Food Chemistry*, 50: 6072 -6077.
- MAU, J.L., LIN, H.C. and C.C. CHEN (2001).** Non-volatile components of several medicinal mushrooms. *Food Resources International*, 34: 521-526.
- MIN, B.S., GAO, J.J., NAKAMURA, N. and M. HATTORI. (2000).** Triterpenes from the spores of *Ganoderma lucidum* and their cytotoxicity against meth-A and LLC tumor cells. *Chemical & Pharmaceutical Bulletin*, 48(7): 1026-1033.
- MORADALI, M.F., MOSTAFAVI, H., GHODS, S. and G.A. HEDJAROUDE. (2007).** Immunomodulating and anticancer agents in the realm of macromycetes fungi (macrofungi). *International Immunopharmacology*, 7: 701-724.
- NAGEL, R. (2002).** The embryo test with the Zebrafish *Danio rerio*—a general model in ecotoxicology and toxicology. *Chemistry on Pharmaceutical Bulletin*, 19(1): 38-48.
- NILE, S.H. and S.W. PARK. (2014).** Total, Soluble, and Insoluble Dietary Fiber Contents of Wild Growing Edible Mushrooms. *Czech Journal in Food Sciences*, 32(3): 302-307.



- NIU, X.M., LI, S.H., XIAO, W.L., SUN, H.D. and C.T. CHE. (2007). Two new lanostanoids from *Ganoderma resinaceum*. Journal of Asian Natural Products Research, 9(6-8):659-664.
- OKORO. O.I. (2012). Antioxidant activities and phenolic contents of three mushroom species, *Lentinus squarrosulus* Mont., *Volvariella esculenta* (Masse) Singer and *Pleurocybella porrigens* (Pers.) Singer. International Journal of Nutrition and Metabolism, 4(5): 72-76.
- OLUWASOLA, F., KOLAWOLE, D.O. and A. LAMIKANRA. (2013). Antibiotic resistance and virulence properties in *Escherichia coli* strains from cases of urinary tract infections. African Journal of Infectious Diseases, 7(1): 1-7.
- OYETAYO, V.O., DONG, C.H., and Y.J. YAO. (2009). Antioxidant and Antimicrobial Properties of Aqueous Extract from *Dictyophora indusiata*. The Open Mycological Journal, 3:20-26.
- PARK, E.J., LEE, J.S. and W.S. CHOI. (2011). Anti-cariogenic activities of mushroom extracted with various solvent systems. Korean Journal Food Science Technology, 43(6):783-6.
- PATEL, Y., NARAIAN, R. and V.K. SINGH. (2012). Medicinal Properties of *pleurotus* Species: A Review. World Journal of Fungal and Plant Biology, 3(1): 10-12
- PINELO, M., RUBILAR, M., JEREZ, M., SINEIRO, J. and M.J. NUNEZ. (2005). Effect of solvent, temperature, and solvent-to-solid ratio on the total phenolic content and antiradical activity of extracts from different components of grape pomace. Journal of Agricultural and Food Chemistry, 53: 2111-2117.
- PLATA, K., ROSATO, A.E. and G. WEGRZYN. (2009). *Staphylococcus aureus* as an infectious agent: overview of biochemistry and molecular genetics of its pathogenicity. Acta Biochimica Polonica, 56:597-612.
- PRASAD, P., PISIPATI, S., MUTAVA, R. and M. TUINSTRA. (2008). Sensitivity of grain sorghum to high temperature stress during reproductive development. Crop Science, 48: 1911-1917
- PRIYA, J.L. and V. SRINIVASAN. (2013). Studies on the antibacterial activities of mushroom. International Journal of Current Microbiology and Applied Sciences, 2(6): 184-189.
- QUERESHI, S., PANDEY, A.K. and S.S. SANDHU. (2010). Evaluation of antibacterial activity of different *Ganoderma lucidum* extracts. Journal Science of Resources, 3: 9-13.



- RAMARATHNAM, N., OSAWA, T., OCHI, H. and S. KAWAKISHI. (1995).** The contribution of plant food antioxidants to human health. *Trends on Food Science and Technology*, 6: 75-82.
- RATHE, S., RATHEE, D., KUMAR, V. and P. RATHEE. (2011).** Mushroom as therapeutic agents. *Brazilian Journal of Pharmacognosy*, 22(2): 459-474.
- RICE-EVANS, C.A. and A.T. DIPLOCK. (1993).** Current status of antioxidant therapy. *Free Radical Biological Medicine*, 15:77-96.
- SAHA, A.K., ACHARYA, S. and A. ROY. (2012).** Antioxidant level of wild edible mushroom: *Pleurotus djamor* (fr.) Boedijn. *Journal in Agricultural Technology*, 8(4): 1343-1351.
- SAKAGAMI, H. and M. TAKEDA. (1991).** Diverse Biological Activity of PSK, a protein bound polysaccharide from *Coriolus versicolor*. In mushroom, biology and mushroom products. Edited by S.T. Chang, J.A. Buswell & S.W. Chiu. The Chinese University Press. Hong Kong, p. 237-245.
- SCHLEIFER, K. H. (1983).** The cell envelope in staphylococci and staphylococcal infections. In C. S. F. Easmon and C. Adlam (ed.). Academic Press, Inc., London. 2; 387-428.
- SHAH, P.H.A., MODI, M.D., SHUKLA, M. AND S.K. LAHIRI. (2014).** Preliminary Phytochemical Analysis and Antibacterial Activity of *Ganoderma lucidum* collected from Dang District of Gujarat, India. *International Journal of Current Microbiology and Applied Sciences*, 3(3): 246-255.
- SHEENA, N., AJITH, T.A., MATHEW, A.T., and K.K. JANARDHANAN. (2003).** Antibacterial activity of three macrofungi, *Ganoderma lucidum*, *Navesporus floccosa* and *Phellinus rimosus* occurring in South India *Pharmacology and Biology*, 41: 564-567.
- SINGH, C.S., SHARMA, R., PATEL, Y. and V.K. SINGH. (2015).** Management of Agricultural Solid Wastes by Locally Isolated *Pleurotus* Species, a White Rot Fungi. *Asian Journal in Microbiology, Biotechnology and Environmental Science*, 13: 561-56.
- SINGLETON, P. (1999).** *Bacteria in Biology Biotechnology and Medicine* (5th ed.) Wiley, 444-454.
- SMITH, J.E., ROWAN, N.J. and R. SULLIVAN. (2002).** Medicinal mushrooms: a rapidly developing area of biotechnology for cancer therapy and other bioactivities. *Biotechnology Letters*, 24, 1839-1845.



- SO-RA, H., KI-HWA, K., KUN-OK, L. and O. TAE-JIN. (2015). Biological Activity Analysis of Different Solvent Extracts from *Pleurotus Ostreatus*. Indian Journal of Science and Technology, 8(26).
- S.P. WASSER. (2002). Medicinal Mushroom as a source of antitumor and immunomodulating polysaccharides. Applied Microbiology in Biotechnology, 60:258-274.
- TANG, W., LIU, J.W., ZHAO, W.M., WEI, D.Z. and J.J. ZHONG. (2006). Ganoderic acid T from *Ganoderma lucidum* mycelia induces mitochondria mediated apoptosis in lung cancer cells. Life Science, 80(3):205-211.
- THEKKUTTUPARAMBIL, A.A., and K.K. JANARDHANAN. (2007). Indian medicinal mushrooms as a source of antioxidants and antitumor agents. Journal in Clinical Biochemistry and Nutrition, 40 (3): 157-162.
- TIWARI, P., KUMAR, B., KAUR, M., KAUR, G. and H. KAUR. (2011). Phytochemical screening and extraction: A review. International Pharmaceutical Sciences, 1(1):98-106.
- TORTORA, J.G., FUNKE R.B. and L.C. CASE. (2002). Microbiology an Introduction. Media Update on 7th. DaRYL Fox, pp. 258-260.
- TSUNGAI, R., CHENJERAYI, K. CATHERINE, C., MUDADI, A.B. and M. TAKAFIRA. (2016). Antibacterial Properties of wild edible and non-edible mushrooms found in Zimbabwe. African Journal of Microbiology Research, 10 (26): 977-984.
- VOGT, R.L. and L. DIPPOLD. (2005). *Escherichia coli* O157:H7 outbreak associated with consumption of ground beef. Public Health Represent, 120 (2): 174-178.
- WASHINGTON, W., WILLIAM, A.S.J. and E. KONEMAN. (2006). *Staphylococcus aureus*: its prevalence and importance. Diagnostic Microbiology Lippincott. 27: 56-71.
- WASSER, S.P. and A.L. WEIS. (1999). Therapeutic effects of substances occurring in higher Basidiomycetes mushrooms: a modern perspective. Critical Revised of Immunology, 19: 65-96.
- WEISBERGER, J.H. (1999). Antimutagens and Anticarcinogens and effective worldwide cancer prevention. Journal of Environmental Pathology, Toxicology and Oncology. 18, 85-93.



WORLD HEALTH ORGANIZATION. (2010) report antimicrobial resistance (AMR).
http://www.who.int/mediacentre/news/releases/2010/amr_20100820/en/index.htm
1

XU, K., LIANG, X., GAO, F., ZHONG, J. and J. LIU. (2010). Antimetastatic effect of ganoderic acid T in vitro through inhibition of cancer cell invasion. *Process Biochemistry*, 45(8):1261-1267.

YIM, H.S., CHYE, F.Y. and S.K. HO. (2009). Lipid Extraction. *Asian Journal of Food Agricultural Industry*, 2(3): 392-401.

YIP, K., FUND, P. and S.T. CHANG. (1987). Hypotensive and renal effect of an extract of the edible mushroom *Pleurotus sajor-caju*. *Life Sciences*, 38: 1155.

YUE, Q.X., CAO, Z.W., GUAN, S.H., LIU, X.H., TAO, L., WU, W.Y., LI, Y.X., YANG, P.Y., LIU, X. and D.A. GUO. (2008). Proteomics characterization of the cytotoxicity mechanism of ganoderic acid D and computer-automated estimation of the possible drug target network. *Molecular Cell Proteomics*, 7(5): 949-961.

YUEN, J.W. and M.D. GOHEL. (2005). Anticancer effects of *Ganoderma lucidum*: a review of scientific evidence. *Nutrition Cancer*, 53(1):11-17.

ZJAWIONY. J.K. (2004). Biologically active compounds from Aphylophorales (Polypore) Fungi. *Journal of Natural Products*, 64: 300-310.