



Comprehensive Study on the *Ganoderma Lucidum*: A Medicinal Mushroom

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ABSTRACT

Ganoderma lucidum is a medicinal and basidiomycete white rot macro-fungus which has been used widely as “the mushroom of immortality”. *Ganoderma lucidum* is one of the major herbs used for the purpose of good health and longevity. It has been used widely as mushroom of immortality in Japan, China and Asian countries since ancient times and has numerous potential application for health improvement. This review article presents the comprehensive study of the *Ganoderma lucidum* with its applications.

Keywords: anti-cancer effect, cultivation, *Ganoderma lucidum*, polysaccharides

Introduction

Ganoderma lucidum has been recognized as an edible and medicinal mushroom and an oriental fungus, which belongs to Basidiomycota (Class: Agaricomycetes). It is mainly called as “Reishi or Manetake” in Japan, “Lingzhi” in China and “Youngzhi” in Korea (Sudheesh, Ajith, & Janardhanan, 2009)). In these countries, people appreciated *Ganoderma lucidum* also for its spiritual power along with medicinal uses as it was considered a symbol of good luck, prosperity, good health, longevity, and immortality. The Latin word *lucidus* means “brilliant” or “shiny” and denotes to the smoother mushroom surface and it mainly grows on dead and decaying parts and trunks of trees. It is highly useful herbs for the medicine purpose of any immune deficiency disease and has longevity for promoting health in China, Japan, and other Asian countries (KK Hapuarachchi et al., 2018). There are variety of *Ganoderma lucidum* commercial products that are available in several forms such as dietary supplements, powders, and tea (Galor, Yuen, Buswell, & Benzie, 2011). These products have a significant market value and are promoted as effective food supplements for health maintenance. This mushroom has various features like woody texture, large and dark in color with a glossy exterior.

Biochemical Constitutes of *Ganoderma lucidum*

According to various studies being conducted, it has been found that 90% portion of the total *Ganoderma lucidum* weight comprises water and remaining 10% contains other biochemical constitutes like protein about 10-40%, fat 2-8%, carbohydrates 3-28%, fiber 3-32% and ash 8-10% along with these constitutes which is also rich in elements such as calcium, minerals, phosphorus, potassium, magnesium, iron, copper, zinc and selenium which are part of 10% of the total weight of the mushroom (Zhou et al., 2007). Other than these constitutes, various molecules are also found in *Ganoderma lucidum* such as steroids, terpenoids, phenols, polysaccharides, nucleotides, and glycoproteins. All crucial amino acids and proteins particularly rich in lysine and leucine are also present. The most essential bioactive constitutes in *Ganoderma lucidum* are polysaccharides, peptidoglycans, and terpenes (Moncalvo & Ryvarden, 1997; Zhao et al., 2012).

Habitat

It is an annual mushroom that generally grows on a wide variety of dead or dying trees like deciduous trees especially oak, maple, elm, willow, sweet gum, magnolia, and locust. In Europe, Asia, North and South America *G. lucidum* is less frequently found on coniferous trees (eg. *Larix*, *Picea*, *Pinus*). It is also found on stumps, generally near the soil surface and occasionally on soils arising from buried roots. For the growth of mycelium of fungus, temperature plays a vital role. It should be controlled in the cultivation of mushroom. *G. lucidum* can grow at 30- 34C (Gao, Lan, Dai, Ye, & Zhou, 2004). However, the Optimum temperature for the growth of mushroom is 37°C and it has been observed that *Ganoderma lucidum* grows very rapidly at this optimum temperature at the rate of 7-8 mm/ day (Gao et al., 2004).

History of *Ganoderma lucidum* Cultivation

In 1781, *G. lucidum* was first reported by William Curtis based on the material grown in England and has been recognized as a “medicinal mushroom” in the past 2000 years and used in folk medicines of China and Japan, mainly in the treatment of hepatopathy, chronic hepatitis, nephritis, hypertension, asthma, gastric ulcers and bronchitis. In China, it has been preserved for over 4000 years as a longevity promoting tonic (Chang & Buswell, 1999). There are more than 120 *Ganoderma* species have been reported worldwide and 98 species out of 120 have been found in China (Rupeshkumar, Chettri, & Paarakh, 2016). However, two species of *Ganoderma* have been reported by (Lv, Zhao, Duan, Tang, & Li, 2012) such as *lucidum* and *sinense* have been used as lingzhi in China (Sliva, 2006). Lingzhi is basically a “woody polypore” has been employed as medicinal mushroom (McMEEKIN, 2004; Pegler, 2002) and its concept is originated in India (Pegler, 2002). In traditional Chinese books, *Ganoderma* on the basis of color of fruiting body was classified into six species depending on different triterpenoid patterns such as “*Kokushi* (black), *Hakushi* (white), *Sekishi* (red), *Shishi* (violaceous), *Oushi*(yellow) and *Seishi* (blue)”(Szedlay, 2002).

Table 1 - Classification of *Ganoderma lucidum* by color of fruiting bodies and their uses (Liu, Yuan, Chung, & Chen, 2002)

Sr. no.	Color	Chinese name	Japanese name	Taste	Medicinal uses
1.	Black	<i>Kokushi</i>	<i>Kuroshiba</i>	Salty	Improves lung function
2.	White	<i>Hakushi</i>	<i>Shiroshiba</i>	Hot	Protects kidney
3.	Red	<i>Sekishi</i>	<i>Akashiba</i>	Bitter	Acids internal organs and improves memory
4.	Yellow	<i>Oushi</i>	<i>Kishiba</i>	Sweet	Strengthen spleen function
5.	Blue	<i>Seishi</i>	<i>Aoshiba</i>	Sour	Improves eyesight and liver function
6.	Purple / violaceous	<i>Shishi</i>	<i>Murosakishiba</i>	Sweet	Enhances the function of eyes joints, helps complexion

Cultivation

Recently *Ganoderma* species has been acquired globally to meet the demand of natural mushroom and herbal medicine in tropical Asian countries. In ancient times, people used wild *Ganoderma*, which is difficult to collect and to maintain its quality. Therefore, it was only consumed by wealthy people. Nowadays, it is being cultivated at large proportion for the consumption of general population and its artificial cultivation was first started in 1937 (Liu et al., 2002). The first successful attempt of *Ganoderma* cultivation was performed by a Chinese technician in the Institute of Microbiology, Chinese Academy of Sciences, Beijing in 1969 by using spore separation cultivation method (Perumal, Stalin, Chandrasekenthiran, Sumathi, & Saravanakumar, 2009). Since then, it leads to the popularity of *Ganoderma* cultivation in China, Japan, and Korea (Yu & Shen, 2003). Further, traditional cultivation was implemented on inoculation of one-meter-long natural logs which may be broad leaf hardwoods and cut form living trees without sterilization (Li et al., 2016). Its fruiting bodies usually took 6-24 months to emerge, but cropping could be done for five years (Pegler, 2002). But since 1980s, new methods have been developed that use comparatively short logs of 15cm or less (Li et al., 2016). Nowadays, this method is followed by most of the commercial *Ganoderma* natural log growers in China, Korea, and Japan (A. W. Chen, 2002). Using this method, it takes numerous months to produce fruiting bodies and continuous production throughout the year to ensure quality control by using mycelia and culture broth-based products (A. W. Chen, 2002).

Table 2- Some species of *Ganoderma* grown at commercial level worldwide and their characteristics

Sr. no.	Name of species	Common name	Mycological characters	Ecology	Edibility	References
1.	<i>Ganoderma lucidum</i>	Lingzhi or Reishi	Pores on hymenium Cap is offset or indistinct Hymenium attachment is irregular or not applicable Stipe is bare or lacks stipe Spore print is brown	Saprotrophic or parasitic	Edible	(Arora, 1986)
2.	<i>Ganoderma sinense</i>	Zizhi (Purple Ganoderma)	Pores on hymenium Cap is offset Hymenium attachment is irregular or not applicable Stipe is bare Spore print is brown	Saprotrophic	Edible but unpalatable	(KK Hapuarachchi et al., 2019)
3.	<i>Ganoderma tsugae</i>	Hemlock varnish shelf	Pores on hymenium Cap is flat Hymenium is adnate Stipe is bare Spore print is brown	Saprotrophic or parasitic	Inedible	(Mizuno et al., 1995)

4.	<i>Ganoderma applanatum</i>	Bear bread or artist's bread	Pores on hymenium No distinct cap Hymenium is decurrent Lacks a stipe Spore print is brown	Parasitic	Inedible	(Lallawmsanga & Carrasco, 2022)
5.	<i>Ganoderma neo-japonicum</i>	Imazeki or Black lingzhi	Shape of fruiting body is umbrella or horseshoe Spore pattern is brown Flesh color of the cross section of umbrella is salmon pink to brown	Saprotrophic		(Du, Dong, Wang, & Yao, 2019)



(a)



(b)



(c)



d)



(e)



(f)

Figures- (a.) *Ganoderma lucidum* (Reishi mushroom), (b.) *Ganoderma lucidum* life cycle and reproduction stages, (c.) *Ganoderma sinense*- purple reishi, (d.) *Ganoderma applanatum*- Artist's fungus, (e.) *Ganoderma tsugae*- Songshan Lingzhi, (f.) *Ganoderma neo-japonicum* culture slant

Biological applications

Ganoderma lucidum has been used for various purpose to promote the health system such as for immune system regulator, anti-cancer agent, and antioxidant and stress reducer etc. Recently, this type of mushroom is widely used in traditional Chinese medicine. When *G. lucidum* is supplemented, it has anti-oxidative effects and has therapeutic effects on insulin resistance. It helps to reduce the prostate cancer risk, metabolic syndrome conditions and reduces the immune system activities when the immune system is overstimulated (H.-Z. Chen & Chen, 2004).

Important uses of Ganoderma species

Ganoderma species are extensively researched owing to their highly valuable medicinal values, chemical constituents with potential nutritional and therapeutic value (Manavalan, Manavalan, Thangavelu, & Heese, 2013). The fruiting bodies of *Ganoderma* species has been widely used as dietary supplements in some regions of the world like China, Japan, and North America (K Hapuarachchi, Wen, Jeewon, & Wu, 2016). *Ganoderma* species are rich in antioxidant compounds (Paterson, 2006) and help to reduce the oxidative damage by directly scavenging free radicals generated in the cell (Rawat, Mohsin, & Singh, 2011; Wong, Chao, Chan, Chang, & Liu, 2004). Different products made from different part of fruiting body, mycelia, or spores of *Ganoderma lucidum* are sold in several form such as tea, coffee, powder, drinks, dietary supplements, syrups, spore products, toothpastes, soaps and lotions. It has also been commercialized as a food and drug supplements which improve the body's immune system and metabolic functions (Lai, Gao, & Zhou, 2004; Obodai et al., 2017). It was also used as Bonsai products for decoration purpose of gardens, ornaments and many other art products.

Therapeutic applications of Ganoderma species

Different bioactive compounds present in *Ganoderma lucidum* which are responsible for the cure of a number of pharmacological and therapeutic effects such as B-D- glucans for Immunomodulation (Singh, Doshi, Pancholy, & Pathak, 2013; Wang et al., 2002), Ganoic acid-A,-F,-DM,-T,-Q for Anti-inflammatory effect (Cao & Lin, 2002), B-D- glucans, GA-T for Anti-cancer and anti- tumor effect (Akihisa et al., 2007), chloroform extract as Antioxidant, GA-B,-C₂ & -G for anti- aging effect (Tang, Liu, Zhao, Wei, & Zhong, 2006), Ganopoly for Anti-diebitic effect, Neutral and Acidic proteins, bound Polysaccharide, Ganodermin for Antibacterial effect.

Conclusion

In this article, the major focus has been given on the numerous studies of *Ganoderma lucidum* that it has the potential to regulate different body systems. In this study various type of properties, benefits and applications have been discussed to understand the phenomenon of *Ganoderma lucidum*. It is worth noting that the usage of *Ganoderma lucidum* would become beneficial in modern medicinal system for improving the health.

References

- Akihisa, T., Nakamura, Y., Tagata, M., Tokuda, H., Yasukawa, K., Uchiyama, E. & Kimura, Y. (2007). Anti - inflammatory and anti - tumor - promoting effects of triterpene acids and sterols from the fungus *Ganoderma lucidum*. *Chemistry & biodiversity*, 4(2), 224-231.
- Arora, D. (1986). *Mushrooms demystified: a comprehensive guide to the fleshy fungi*.
- Cao, L. Z. & Lin, Z. B. (2002). Regulation on maturation and function of dendritic cells by *Ganoderma lucidum* polysaccharides. *Immunology letters*, 83(3), 163-169.
- Chang, S. T. & Buswell, J. A. (1999). *Ganoderma lucidum* (Curt.: Fr.) P. karst.(Aphylophoromycetidae)– a mushrooming medicinal mushroom. *International Journal of Medicinal Mushrooms*, 1(2).
- Chen, A. W. (2002). Natural log cultivation of the medicinal mushroom, *Ganoderma lucidum* (Reishi). *Mushroom Growers's Newsletter*, 3(9), 2-6.
- Chen, H.Z. & Chen, J.W. (2004). A preliminary report on solid-state fermentation of *Ganoderma lucidum* with Radix astragali containing medium. *Zhong xi yi jie he xue bao= Journal of Chinese integrative medicine*, 2(3), 216-218.
- Du, Z., Dong, C.H., Wang, K., & Yao, Y.J. (2019). Classification, biological characteristics and cultivations of *Ganoderma*. *Ganoderma and Health: Biology, Chemistry and Industry*, 15-58.
- Galor, S., Yuen, J., Buswell, J. & Benzie, I. (2011). *Ganoderma lucidum* (Lingzhi or Reishi): a medicinal mushroom. *Herbal Medicine: Biomolecular and Clinical Aspects*. (2nd ed). Boca Raton: CRC Press/Taylor & Franis.
- Gao, Y., Lan, J., Dai, X., Ye, J. & Zhou, S. (2004). A phase I/II study of Ling Zhi mushroom *Ganoderma lucidum* (W. Curt.: Fr.) Lloyd (Aphylophoromycetidae) extract in patients with type II diabetes mellitus. *International Journal of Medicinal Mushrooms*, 6(1).
- Hapuarachchi, K., Elkhateeb, W., Karunarathna, S., Cheng, C., Bandara, A., Kakumyan, P. & Wen, T. (2018). Current status of global *Ganoderma* cultivation, products, industry and market.
- Hapuarachchi, K., Karunarathna, S., McKenzie, E., Wu, X., Kakumyan, P., Hyde, K. & Wen, T. (2019). High phenotypic plasticity of *Ganoderma sinense* (Ganodermataceae, Polyporales) in China. *Asian Journal of Mycology*, 2(1), 1-47.
- Hapuarachchi, K., Wen, T., Jeewon, R. & Wu, X. (2016). *Ganoderma lucidum* are the beneficial medical properties substantiated. *Mycosphere Essays*, 15, 687-715.
- Lai, T., Gao, Y. & Zhou, S. (2004). Global marketing of medicinal Ling Zhi mushroom *Ganoderma lucidum* (W. Curt.: Fr.) Lloyd (Aphylophoromycetidae) products and safety concerns. *International Journal of Medicinal Mushrooms*, 6(2).
- Lallawmsanga, A. & Carrasco, B. J. (2022). Diversity of the Fungi Kingdom: Molecular Tools to Distinguish Mushrooms Considered Safe and Unsafe for Human Health.
- Li, W., Lou, L. L., Zhu, J. Y., Zhang, J. S., Liang, A. A., Bao, J. M. & Yin, S. (2016). New lanostane-type triterpenoids from the fruiting body of *Ganoderma hainanense*. *Fitoterapia*, 115, 24-30.
- Liu, X., Yuan, J. P., Chung, C. K. & Chen, X. J. (2002). Antitumor activity of the sporoderm-broken germinating spores of *Ganoderma lucidum*. *Cancer letters*, 182(2), 155-161.
- Lv, G. P., Zhao, J., Duan, J. A., Tang, Y. P. & Li, S. P. (2012). Comparison of sterols and fatty acids in two species of *Ganoderma*. *Chemistry central journal*, 6, 1-8.
- Manavalan, T., Manavalan, A., Thangavelu, K. P. & Heese, K. (2013). Characterization of optimized production, purification and application of laccase from *Ganoderma lucidum*. *Biochemical Engineering Journal*, 70, 106-114.

- McMeekin, D. (2004). The perception of *Ganoderma lucidum* in Chinese and Western culture. *Mycologist*, 18(4), 165-169.
- Mizuno, T., Wang, G., Zhang, J., Kawagishi, H., Nishitoba, T. & Li, J. (1995). Reishi, *Ganoderma lucidum* and *Ganoderma tsugae*: bioactive substances and medicinal effects. *Food Reviews International*, 11(1), 151-166.
- Moncalvo, J. M. & Ryvarden, L. (1997). A nomenclatural study of Ganodermataceae Donk. (No Title).
- Obodai, M., Mensah, D. L. N., Fernandes, Â., Kortei, N. K., Dzomeku, M., Teegarden, M. & Takli, R. K. (2017). Chemical characterization and antioxidant potential of wild *Ganoderma* species from Ghana. *Molecules*, 22(2), 196.
- Paterson, R. R. (2006). *Ganoderma*—a therapeutic fungal biofactory. *Phytochemistry*, 67(18), 1985-2001.
- Pegler, D. (2002). Useful Fungi of the World: the Ling-zhi-The mushroom of immortality. *Mycologist*, 16(3), 100-101.
- Perumal, K., Stalin, V., Chandrasekenthiran, S., Sumathi, E. & Saravanakumar, A. (2009). Extraction and characterization of pigment from *Sclerotinia* sp. and its use in dyeing cotton. *Textile research journal*, 79(13), 1178-1187.
- Rawat, A., Mohsin, M. & Singh, S. (2011). Evaluation of polyphenolic contents and antioxidant activity of wildy collected *Ganoderma lucidum* from central Himalayan hills of India. *Asian Journal of Plant Science & Research*.
- Rupeshkumar, M., Chettri, U. & Paarakh, P. M. (2016). *Ganoderma lucidum*: A Review with Special Emphasis on the Treatment of Various Cancer. *Journal of Applied Pharmacy*, 8(4).
- Singh, S., Doshi, A., Pancholy, A. & Pathak, R. (2013). Biodiversity in wood-decay macro-fungi associated with declining arid zone trees of India as revealed by nuclear rDNA analysis. *European Journal of Plant Pathology*, 136, 373-382.
- Sliva, D. (2006). *Ganoderma lucidum* in cancer research. *Leukemia Research*, 30(7), 767-768.
- Sudheesh, N., Ajith, T. & Janardhanan, K. (2009). *Ganoderma lucidum* (Fr.) P. Karst enhances activities of heart mitochondrial enzymes and respiratory chain complexes in the aged rat. *Biogerontology*, 10(5), 627-636.
- Szedlay, G. (2002). Is the widely used medicinal fungus the *Ganoderma lucidum* (Fr.) Karst. sensu stricto? *Acta microbiologica et immunologica hungarica*, 49(2-3), 235-243.
- Tang, W., Liu, J. W., Zhao, W. M., Wei, D. Z. & Zhong, J. J. (2006). Ganoderic acid T from *Ganoderma lucidum* mycelia induces mitochondria mediated apoptosis in lung cancer cells. *Life sciences*, 80(3), 205-211.
- Wang, Y. Y., Khoo, K. H., Chen, S. T., Lin, C. C., Wong, C. H. & Lin, C. H. (2002). Studies on the immuno-modulating and antitumor activities of *Ganoderma lucidum* (Reishi) polysaccharides: functional and proteomic analyses of a fucose-containing glycoprotein fraction responsible for the activities. *Bioorganic & medicinal chemistry*, 10(4), 1057-1062.
- Wong, K. L., Chao, H. H., Chan, P., Chang, L. P. & Liu, C. F. (2004). Antioxidant activity of *Ganoderma lucidum* in acute ethanol - induced heart toxicity. *Phytotherapy Research*, 18(12), 1024-1026.
- Yu, Y. & Shen, M. (2003). The history of Lingzhi (*Ganoderma* spp.) cultivation. *Mycosystema*, 22(Supp 1), 3-9.
- Zhao, H., Zhang, Q., Zhao, L., Huang, X., Wang, J. & Kang, X. (2012). Spore powder of *Ganoderma lucidum* improves cancer-related fatigue in breast cancer patients undergoing endocrine therapy: a pilot clinical trial. *Evidence-Based Complementary and Alternative Medicine*.
- Zhou, X., Lin, J., Yin, Y., Zhao, J., Sun, X. & Tang, K. (2007). Ganodermataceae: natural products and their related pharmacological functions. *The American journal of Chinese medicine*, 35(04), 559-574.