Introduction

A mushroom Ganoderma lucidum was acclaimed as a divine herb that could bestow longevity. It was also deemed an elixir of life that could augment good health and well-being (13). This is probably the case when certain mushrooms were treated as objects of worship or as objects of mysteries describing them as celestial herbs possessing panaceal properties (6). G. lucidum, also called Reishi or Lingzhi, is the most important elixir in the Orient and one of the most well-known medicinal fungus in the Chinese pharmacopoeia. It has been used in China for over thousands of years as a miraculous remedy to treat more than 20 different illnesses which include migraine and headache, hypertension, arthritis, asthma, bronchitis, gastritis, hemorrhoids, anorexia, hypercholesterolemia, nephritis, dysmenorrhea, hepatitis, constipation, lupus erythematosis, leukopenia, traumatic wounds, inflammation, various ulcers, cardiovascular problems and cancer including leukemia (4). Immunosuppressive activity of this mushroom has been also estimated (9). For centuries, Ganoderma lucidum has been used in Oriental medicine for the treatment of chronic bronchitis as an anti-allergic remedy (24,25). In some ancient reports LingZhi was praised for its effect of increasing memory and preventing forgetfulness in old age as for instance in the book Shen Nong Ben Cao Jing as early as in 456-536 AD. Although some of the therapeutic claims of this medicinal fungus may be exaggerated, recent scientific reports from many sources show that some of the therapeutic properties of G. lucidum can now be substantiated. Nowadays, modern research has revealed its active ingredients, which may be important not only for elucidating the mechanism of action of these molecules, but also for future analog drug development.

Pharmacologically Active Components in Ganoderma lucidum

Variety pharmacologically active compounds has been identified in Ganoderma lucidum. There are mainly steroids (ergosterol, ganodesteron, 24-methylcholesta-7,22-dien-3, or -60d), nucleosides and nucleotides (adenosin, guanosin, 5’-GMP, 5’-XMP, and 5’-deoxy-5’-methylthiophyl adenosine which is a strong platelet aggregation inhibitor). glycans and proteoglycans (polysaccharideprotein complexes Ganoderan B and C) with hypoglycemic activity, petaloglycan (MW 100 kDa) with blood pressure stabilizing effect, lectins, and cytotoxic polysaccharides (various hetero-(8-D-glycans) and triterpenoids (ganoderic acids) (5,17). Different vitamins, oils, coumarine-glycosids, and inorganic ions as Mg, Zn, Ca, Cu, Fe, and Ge were also identified in this mushroom. Germanium in the form of organic compound, bis-β-carboxyethyl germanium-sesquioxide, now called GE-132, was found in G. lucidum in high concentration. Medical research studies have indicated that GE-132 can induce gamma-interferon and activate macrophages and natural killer cells. Other results were reported showing beneficial effects on malignancies and rheumatomid arthritis (1).

Anti-inflammatory Compounds from Ganoderma lucidum

Stavinoha et al. (22) found G. lucidum to be a potent antiinflammatory agent. The water and/or methanolic extract of the fruiting body was active orally against both carrageenan induced inflammation and croton oil induced inflammation. Ammelioration of the pain and inflammati- on associated with arthritis has historically been attributed...
Anti-inflammatory Compounds from Ganoderma lucidum as a potential drugs in Alzheimer's disease

A number of indicators of active inflammation processes have been found in the brains of patients with Alzheimer's disease (20). Cerebral (amyloid protein deposition, characteristic of Alzheimer's disease, is associated with a predominantly local acute phase response that kindles release of various inflammatory and immune system mediators. The molecular events are accompanied by a typical profound cellular response which is largely controlled by microglia. Current evidence suggests that microglia are primarily responsible for inducing further neuronal damage by generating reactive oxygen species and proteolytic enzymes (8). Lesions in chronic neurodegenerative diseases, as Alzheimer's disease, are associated with a variety of proteins known to be involved in inflammatory processes (14). Researches in the United States and Canada have found that long-time ingestion of nonsteroidal anti-inflammatory drugs can slow the progression of the Alzheimer's disease and that use of nonsteroidal anti-inflammatory drugs is associated with reduced risk of Alzheimer's disease (2,3,15,19). In a report by Corrado et al. (7) reported on findings on 1417 men and 648 women from Baltimore Longitudinal Study of Aging which is 37 year study of normal aging. The results suggests that the use of nonsteroidal anti-inflammatory drugs is associated with decreased incidence of Alzheimer's disease. This research heightens the importance of the ancient reports where G. lucidum was praised for its effect of increasing memory and preventing forgetfulness in old age reported in Shen Nong Ben Cao Jing as early as in 456-536 AD (16). The mechanism of action of inflammatory drugs is based on their capability to inhibit the biosynthesis of prostanoids. Anti-inflammatory drugs are presumed to act by inhibiting cyclooxygenase and thereby in the metabolism of membrane-derived arachidonic acid into prostanoids (26). In past few years, two distinct isoforms of COX have been characterized, a constitutive isoform, COX-1, and a mitogen-inducible isoform, COX-2. The COX-2 represents a possible target of nonsteroid anti-inflammatory drugs action in neurodegenerative diseases (18). It seems that the future treatment strategies of Alzheimer's disease will likely include a combination of acetycholinesterase inhibitors and disease-modifying agents like nonsterose anti-inflammatory drugs (21) and triterpenoids from G. lucidum may be in the future so anti-inflammatory drugs with a good benefit.

**References**

to preparations of G. lucidum (12). Active compounds were isolated and identified as highly oxygenated acidic triterpenoids (11) by HPLC chromatography (23).

Chemical structures of the most important triterpenoids isolated from G. lucidum are summarized in Tables 1 and 2. Anti-inflammatory activity of many ganoderma triterpenoids is comparable with the effect of some nonsteroidal anti-inflammatory compounds such as indomethacin (10). Stavomila et al. (22) found that active compounds iso-

lated from G. lucidum is equivalent in anti-inflammatory activity to hydrocortisone. It does not show the typical side effects of steroids such as thymic involution nor appears to cause gastroopathy which is the major side effect of the non-

steroidal anti-inflammatory drugs such as aspirin.

![Anti-inflammatory Compounds from Ganoderma lucidum as a potential drugs in Alzheimer’s disease](image)

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Conclusions

A family of triterpenoids from the ganoderma lucidum, mysterious mushroom of Orient, to be potent anti-inflamma-

tory agents. This ancient drug was encouraged for its effect of increasing memory and preventing forgetfulness in old age and it is very probably that this effect could be employ in modern medicine in the treatment of Alzheimer’s disease.

References

2. Beard CM, Waring SC, O’Brien PC, Kadish LT, Kodansha International via Harper and Row, 1985. Current evidence suggests that microglia are primarily responsible for inducing further neuronal damage by generating reactive oxygen species and proteolytic enzymes (8). Lesions in chronic neurodegenerative diseases, as Alzheimer’s disease, are associated with a variety of proteins known to be involved in inflammatory processes (14). Reaches in the United States and Canada have found that long-term ingestion of nonsteroidal anti-inflammatory drugs can slow the progress of the Alzheimer’s disease and that use of nonsteroidal anti-inflammatory drugs is associated with reduced risk of Alzheimer’s disease (2,3,15,19). In a report by Corrada et al. (7) reported on finding on 1417 men and 648 women from Baltimore Longitudinal Study of Aging which is 37 year study of normal aging. The results suggests that the use of nonsteroidal anti-inflammatory drugs is associated with decreased incidence of Alzheimer’s disease. This research heightens the importance of the ancient reports where G. lucidum was praised for its effect of increasing memory and preventing forgetfulness in old age reported in Shen Nong Ben Cao Jing as early as in 456-536 AD (16).

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