CHAPTER TWO

2. LITERATURE REVIEW

2.1 Origin and Taxonomy of *Ganoderma* spp.

The fungus *Ganoderma* is a species of Basidiomycota (Table 2.1), which belongs to *Polyporaceae* (or *Ganodermaceae*) of the order *Aphyllophorales* (Mizuno *et al.*, 1995). A generalized life cycle of Basidiomycetes is shown in Figure 2.1. Under appropriate environmental conditions, the heterokaryon is induced to produce fruiting bodies containing basidial cells in which karyogamy, meiosis and spore formation occur in rapid succession (Raper, 1978).

Ganoderma spp. differ from ordinary mushrooms belonging to the order *Agaricales* in that they have pores rather than gills on the under surface of the fruit bodies (Hudson, 1986). The fruiting body is called "Reishi" in Japanese and in China, it is known as "Lingzhi" (Mizuno *et al.*, 1995).

Karsten (1881) first established the genus *Ganoderma* for the laccate and stipitate white rot fungus *Polyporus lucidus* W. Curt. (cited in Moncalvo *et al.*, 1995). It was later amended by Patoaillard (1889) to include all 48 polypores species having double-walled basidiospores. Murrill (1902, 1908) later published synopses of species occurring in North America, describing seven new temperate species including *G. tsugae*, *G. sessile*, *G. zonatum*, *G. sulcatum*, *G. oregonense*, *G. sequoiae*, and *G. nevadense*, along with 10 others from tropical areas (cited in Moncalvo *et al.*, 1995).

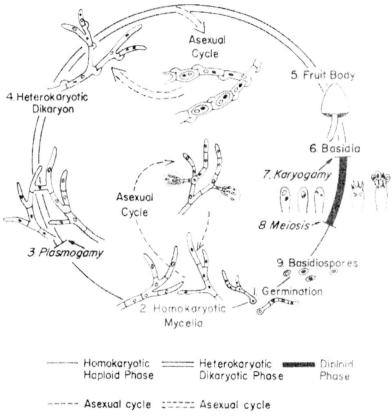


Figure 2.1: A generalized scheme of the life cycle of Basidiomycetes (adapted from Raper, 1978)

Over 250 *Ganoderma* species have so far been described worldwide (Alexandra *et al.*, 1998). Most of them based on variable and overlapping characters (Moncalvo *et al.*, 1995; Alexandra *et al.*, 1998). As a consequence, there are many synonyms and several species complexes have been recognized. The genus can be divided into two recognizable groups: the *Ganoderma lucidum* (Curtis: Fr.) P. Karst and *G. applanatum* (Pers.) Pat. complexes (Alexendra *et al.*, 1998). The taxonomy of *Ganoderma* is controversial since morphological characters alone appear insufficient to distinguish between the different species (Moncalvo *et al.*, 1995; Alexandra *et al.*, 1998).

However, the shape and chemical property of basidiospores are believed to be more stable under environmental constraints than many other morphological characters. For this reason, basidiospore morphology has played a key role in mushroom classification at all taxonomic levels (Tham, 1998). For example, Donk (1964) created the family *Ganodermaceae* to group species of polypores with double walled basidiospore.

Besides morphological traits of fruit bodies, additional taxonomic characters have been investigated for systematics of *Ganoderma*. Nobles (1948, 1958, 1965), Stalpers (1978), Bazzalo and Wright (1982) Adaskaveg and Gilbertson (1986), Hseu (1990), and Wang and Hua (1991) conducted cultural studies of various *Ganoderma* species.

Isoenzyme electrophoretic phenotypes were also used by Hseu (1990), Wang and Hua (1991) and recently by Alexandra et al. (1998). These methods produced new characters for the studies at the species level, but their use was not investigated at higher taxonomic levels (Moncalvo *et al.*, 1995). Intercompatibility studies have also been reported in the *G. lucidum* complex byAdaskaveg and Gilbertson(1986), Peng, (1990) and Hseu (1990) and in *G. applanatum* complex by Yeh (1990).

More recently, attempts of using PCR-amplified ribosomal DNA sequences to differentiate the *Ganoderma* species seem to be promising and claimed to be conclusive in classifying the *Ganoderma* taxa (Moncalvo *et al.*, 1995). However, their basal relationships were not completely resolved (Alexandra *et al.*, 1998).

In short, for unambiguous identification of the *Gonoderma* species, a combination of more than one taxonomic character need to be made.

2.2 Pharmacologically Active Components in *Ganoderma* spp.

In Chinese folklore, the fruit body of *Ganoderma* has been regarded as a panacea for all types of diseases. This is probably due to its demonstrated efficacy as a popular remedy to treat hepatopathy, chronic hepatitis, hypertension, arthritis, insomnia, asthma, arteriosclerosis, diabetes, and many others (Jong and Birmingham, 1992). Recent application of modern analytical techniques has, in a number of cases, provided a scientific basis for these earlier empirical observations (Chang and Buswell, 1996). Many of the pharmacologically active components (Table 2.2) have been isolated from the basidiocarps and mycelium of *Ganoderma* spp., and these have been identified as:

- Polysaccharides
- Bitter terpenoids
- Steroids
- Organic germanium
- Nucleotides
- Others

Table 2.2: Pharmacologically active compounds and their medicinal benefits from the mushroom *Ganoderma*

Benefit	Compound	Reference
Analgesic	Adenosine	Shimizu et al. (1985) Kasara and Hikino (1987)
Antihepatotoxic	Ganoderic acids R, S Ganosterone	Hirotani et al. (1986) Liu et al. (1980)
Antiinflammatory	β-Glucan G-A	Ukai et al. (1983b)
Antititumor	Polysaccharides	Ito et al. (1977) Matsumoto et al. (1978)
	Polysaccharide GL-1	Miyazaki and Nishijima (1981)
	Polysaccharide G-Z	Sasaki et al. (1971)
	β-D-Glucan	Sone et al. (1985) Mizuno and Hazama (1986) Kishida et al. (1988)
	β-D-Glucans F-1-1a1-β, F-1-1a2-β	Usui et al. (1983)
	β-D-Glucan G-A	Ukai et al.(1983a)
	Polysaccharide-protein complex	Kim et al.(1980) Kang et al. (1981)
Cardiotonic	Alkaloids	Chen (1986)
	Polysaccharides	Chen (1986)
Histamine release inhibitor	Ganoderic acid C, D	Kohda et al. (1985)
	Cyclooctasulfur	Tasaka et al. (1988a)
	Oleic acid	Tasaka et al. (1988b)
Hypocholesterolemic	Ganoderic acid B	Komoda et al. (1989)
	Ganoderic acid Mf	Lin et al. (1988)
	Ganodermic acid T-O	Lin et al. (1988)
Hypoglycemic	Ganoderans A, B	Hikino et al. (1985)
	Ganoderan C	Tomoda et al. (1986)
Hypotensive	Ganoderol B Ganoderic acids B, D, F, H, K, S, Y	Morigiwa et al. (1986)
Immunomodulatory	Polysaccharides	Nakashima et al.(1979)
	Polysaccharide BN_3C	Xie et al.(1985)
	Protein LZ-8	Kino et al.(1989)
Interferon inducing antiviral	RNA	Kandefer-Szerszen et al. (1979)

Neural-muscular restorative	Uridine, uracil	Yu and Zhai (1979) Zhang (1980)
Platelet aggregation inhibitor	Adenosine	Shimizu et al.(1985)
Protein synthesis, nucleic acid synthesis enhancer	Polysaccharide D_6	Guan and Cong (1982)
Radiation protection	Polysaccharide	Chu et al. (1988)

Source: Jong and Birmingham (1992)

2.2.1 Polysaccharides

Recent studies have shown that the carcinostatic substance (antitumor property) in *Ganoderma* spp. is a polysaccharide, having a β-(1→3)-D-glucan chain as the active site (Mizuno *et al.*, 1995). This substance appears to act as a new type of carcinostatic agent by enhancing the host's immune system (immunotherapy). Unlike the general carcinostatic agent in chemotherapy, it appears to be non toxic (Mizuno *et al.*, 1995).

In the search for antimicrobial substances, Tseng et al. (1981) fed mice with a water extract of *Ganoderma* 48 hours before injecting lethal dose of *E. coli*. Approximately 60 to 85% of the *Ganoderma*-fed mice survived, whereas the control group suffered 100% fatality (Tseng *et al.*, 1981), demonstrating significant preventive ability of the test mice. Hsu et al. (1986) also found that the water extract of *Ganoderma* to be bacteriostatic, inhibiting the growth of *Staphylococcus*, *Streptococcus* and *Bacillus pneumonia*. They postulated that the polysaccharides might be the main immune-modulators, increasing the RNA and DNA in the bone

marrow where the antibodies are being produced (Tseng *et al.*, 1981; Hsu *et al.*, 1986).

2.2.2 Bitter terpenoids

The fruiting body of *Ganoderma* is a rich source of bitter terpenoids, a characteristic not found in any mushroom (Jong and Birmingham, 1992). The bitterness varies in degree depending on the place of production, cultivation conditions, its strain, etc (Mizuno *et al.*, 1995). This bitterness is however not found in the cultured mycelium or substances produced in the culture medium and in *Kokushi* (black *Ganoderma* spp.) (Mizuno *et al.*, 1995, Jong and Birmingham, 1992). Although the relationship between bitterness and pharmacological effects is not fully understood, bitterness serves as a marker for pharmacological evaluation and classification of *Ganoderma* species (Jong and Birmingham, 1992).

The bitter components and related compounds have been shown to be a group of highly oxidized lanostane triterpenoids (Figure 2.2) (Jong and Birmingham, 1992; Mizuno *et al.*, 1995). Triterpenoids are compounds with carbon skeleton based on six isoprene units (CH_2=C(CH_3)-CH=CH_2) (Table 2.3), which derived biosynthetically from the acyclic C_{30} hydrocarbon, squalene (Harborne, 1973). They have relatively complex cyclic structures, most being either alcohols, aldehydes or carboxylic acids (Harborne, 1973). They are usually colorless, crystalline, often high in melting point, optically active substances and generally difficult to characterize due to their lack of chemical reactivity (Harborne, 1973).

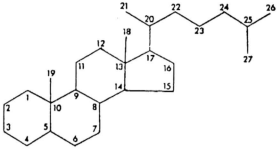


Figure 2.2: Lanostane triterpenoid skeleton (adapted from Lin *et al.*, 1988).

Table 2.3: The main classes of terpenoids (modified from Harborne, 1973)

No of isoprene units	Carbon number	Name or class	Occurrence/ example
1	C_5	Isoprene	Many
2	C_{10}	Monoterpenoids	Essential oils, iridoids
3	C_{15}	Sesquiterpenoids	Essential oils, bitter principles
4	C_{20}	Diterpenoids	Resin acids, phytol, vitamin A, gibberellins
6	C_{30}	Triterpenoids	Sterols, steroids, saponins
8	C_{40}	Tetraterpenoids	Carotenoids
n	C_n	Polyisoprene	Rubber, gutta

The triterpenoids isolated from *Ganoderma* spp. have been shown to possess antihypertensive action (Morigiwa *et al.*, 1986) and hypocholesterolemic activity (Kabir *et al.*, 1988; Shiao *et al.*, 1987, 1988), which respectively suppresses the elevation of blood pressure and eliminates blood cholesterol in spontaneously hypersensitive rats. In addition, the triterpenoids were also proved to display histamine release inhibiting effects (antiallergy activities), cytotoxic effects and anti-human immunodefiency virus (anti-HIV) activities (Min *et al.*, 1998).

Morigiwa et al. (1986) found that a 70% methyl alcohol extract of *G. lucidum* exhibit an inhibitory activity on angiotensin converting enzyme (antihypertensive action) prepared from hog kidney. From this extract, they isolated and characterized five new lanostane triterpenoids, ganoderal A (Figure 2.3), ganoderols A and B, and ganoderic acids K and S. In addition, they also managed to isolate five known triterpenoids, ganoderic acids Y, F, H, B and D (C). Eight of the compounds were inhibitory, with ganoderic acid F having the greatest inhibitory effect.

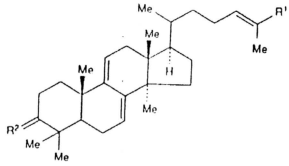


Figure 2.3: Ganoderal A. R^1 = CHO, R^2 = O (Morigiwa *et al.*, 1986)

Kabir et al. (1988) tested the effect of the *Ganoderma* powder on the lipid levels of spontaneous hypertensive rats in order to evaluate its effect on cholesterol metabolism. The level of total plasma cholesterol, liver cholesterol and triglyceride were significantly lower in *Gonoderma*-fed rats when compared to the control (Kabir *et al.*, 1988). The active hypercholesterolemic constituents were later isolated and characterized as ganodermic acids R, S (Figure 2.4), O and Q (Shiao *et al.*, 1987, 1988) and ganodermic acid T-O (Lin *et al.*, 1988). These compounds lower the cholesterol level of test animals by inhibiting the cholesterol synthesis and/ or accelerating the metabolism of cholesterol (Shiao *et al.*, 1988).

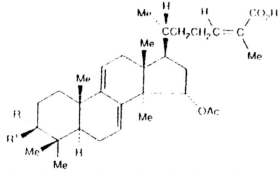


Figure 2.4: Ganodermic acids R (I) and S (II). I: R = AcO, R^1 = H; II: R = H, R^1 = AcO (Shiao *et al.*, 1987)

Kohda et al. (1985) investigated the histamine-release inhibitory action of a methanol extract from the fruit body of *G. lucidum* on rat mast cells. From the physiologically active fraction of the extract, two new triterpenes, named ganoderic acid C and D were isolated. Tasaka et al. (1988a,b) also identified active fractions in a chloroform extract from *G. lucidum* broth that significantly inhibit histamine release from rat peritoneal mast cell. Palmitic acid, stearic acid, oleic acid, and linoleic acid were later isolated from these active fractions.

It has been reported that triterpenoids isolated from cultured mycelia of *Ganoderma* spp. including ganoderic acids R, T, U, W, X, Y and Z showed a cytotoxic based carcinostatic effect on hepatoma cells *in vitro* (Toth *et al.*, 1983). In addition, eight tetracyclic triterpene acids, applanoxidic acids A to H, isolated from *G. applanatum* were also found to have antitumour activity (Chairul *et al.*, 1994).

More recently, chloroform soluble fraction of methanol extract from the spores of *G. lucidum* showed good inhibitory activity against HIV-1 protease. From this fraction, ten compounds were isolated and ganoderiol F, ganolucidic acid A, lucidumol B, ganodermanondiol and ganodermanontriol showed significant anti-HIV-1 protease activity with IC_{50} values of 20 to 90 μM (Min *et al.*, 1998).

2.2.3 Steroids

Ergosterol (provitamin D_2) has been reported in concentrations of 0.3-0.4% in *G. lucidum* (Kac *et al.*, 1984). However, further analysis has confirmed that the main component of the steroid fraction is 24-methylcholesta-7,22-dien-3β-ol (stellasterol) (Kac *et al.*, 1984; Mizuno *et al.*, 1995). Recently, ganodesterone has also been isolated (Mizuno *et al.*, 1995). All of these sterols are actually triterpenes, which may function as components in the lipid membrane, sex hormones or growth factors in the fungi (Griffin, 1994).

2.2.4 Organic germanium

Germanium appears to play a role as an oxygen catalyst enriching the supply of oxygen to the blood, an antioxidant, an electro-stimulant, and an immune enhancer (Asai, 1980). Correlation between the antitumor activity (interferon-inducing activity) of *Ganoderma* and its germanium contents is also of interest because the germanium is said to neutralize pain during the final stages of cancer (Mizuno *et al.*, 1995).

The fact that *G. lucidum* possesses high medicinal properties has been linked to the presence of an unusually high level of organic germanium (800-2000 ppm) found in the fruiting body (Mizuno *et al.*, 1995). However, Tong (1994a) did not lend support to such claim because the amount of germanium tested in the raw mushroom fruiting body and the numerous Lingzhi products (including those sold in Malaysia) contained less than 30 ppm, which is well below the level claimed above.

Tong et al. (1994b) also found that the mycelium of *G. lucidum* should be considered as the source of organic germanium since it accumulates higher concentration of germanium as compared to the fruiting body. Further, the germanium level in the fungal mycelium could also be increased several fold by incorporation of inorganic germanium in the growth medium and optimization of the growth conditions (Tong *et al.*, 1994a,b).

2.2.5 Nucleotides

Intravenous injections of ribonucleic acid (RNA) isolated from the fruiting body of *G. applanatum* were found to prolong the life of virus infected mice. Further investigation showed that the RNA disrupts the viral diseases by inducing interferon production (Kandefer-Szerszen *et al.*, 1979). In addition, *in vitro* experiments were carried out and showed that the same RNA provided normal cells with 90% protection against the vaccinia virus (Kandefer-Szerszen *et al.*, 1979).

Besides *G. applanatum*, RNA, 5'-GMP, 5'-XMP were also isolated from the fruit body of *G. lucidum* and in higher levels in the mycelium (Kim and Nam, 1984). These nucleotides found in the water or alcohol extract, possess antithrombotic activity (platelet aggregation inhibition action) (Mizuno *et al.*, 1995).

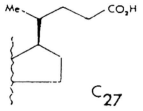
2.2.5 Others

Hikino et al. (1985) showed that a water extract of the dried fruit body of *G. lucidum* decreased plasma sugar level in normal and alloxan-induced hyperglycemic mice. They then isolated two homogenous glycans, ganoderans A and B as the active principles. Tomoda et al. (1986) also isolated ganoderan B and a new ganoderan C from the fruit bodies of *G. lucidum* which showed to reduced blood glucose concentration when administered intraperitoneally into alloxan-induced hyperglycemic mice.

2.3 Triterpenoids Isolated from *Ganoderma* spp.

Currently, more than 100 different triterpenoids are known to occur in *Ganoderma* spp., all with a basic skeleton of lanostane type structure (Figure 2.2). The triterpene content was found to increase after the appearance of the fruit bodies and was more concentrated in the outer or older sections (Miyahara *et al.*, 1987).

The vast majorities of triterpenoids are ganoderic (C_{30}) and lucidenic (C_{27}) acids (Figure 2.5) (Nishitoba *et al.*, 1984), but ganodermic acids, ganoderenic acids, lucidone, ganoderal, and ganoderols are also present (Jong and Birmingham, 1992).



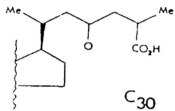


Figure 2.5: C_{27} and C_{30} triterpenoids (adapted from Nishitoba *et al.*, 1984).

The triterpenoids can vary from strain to strain and from one growth stage of the fungus to another through side-chain cleavage and skeleton oxidation (Nishitoba *et al.*, 1987c). The ganoderic acids can be divided into three types according to their location (Hirotani and Furuya, 1990). Ganoderic acids A, B, and H (type I), which are 3β-substituted or 3-keto compounds were detected only in the fruit body. In contrast, ganoderic acids R,S and T (type III), which have a 3α-substituent were the major triterpenoids of the mycelium (Figure 2.6) (Hirotani and Furuya, 1990).

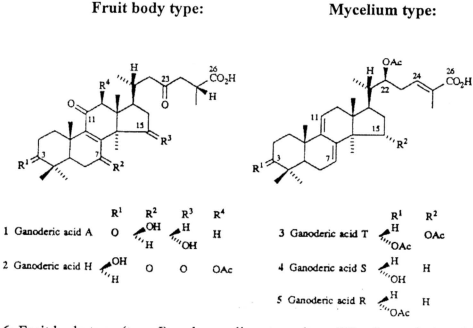


Figure 2.6: Fruit body type (type I) and mycelium type (type III) of ganoderic acids (adapted from Hirotani and Furuya, 1990)

The general methods of solvent extraction and column chromatography of the extract followed by preparative TLC are effective in most cases for the isolation of the triterpenoids (Mahato *et al.*, 1992). Extraction is usually by means of methanol, ethanol, acetone, chloroform, ether, or a mixture of these solvents (Harborne, 1973). Depending on whether the extract contain acidic or non-acidic triterpenoids and/ or the aim of the investigator, the extract can be further purified or treated with other reagents before column chromatography.

Ganoderic acids A (Figure 2.6) and B from *G. lucidum* were first isolated and described by Kubota et al. (1982). The fruit body was extracted with chloroform and

dried under reduced pressure (Figure 2.7). There is no additional chemicals added to the crude extract before column chromatography. Adopting similar extraction and isolation procedures, Toth et al. (1983) later isolated ganoderic acids T through Z. They determined that ganoderic acids T and Z containing the same terminally carboxylated side chain showed to have cytotoxic activity *in vitro* on hepatoma cells.

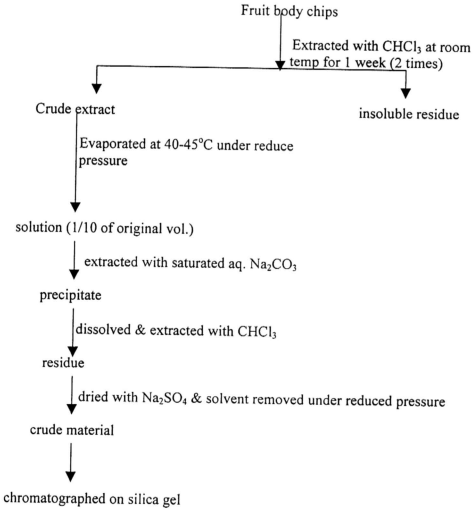


Figure 2.7: Isolation of ganoderic acids A and B by Kubota et al. (1982) [1]

Hirotani et al. (1985) extracted the fruit body with methanol and made the residue alkaline before further re-extracted with chloroform. The residue was then acidified and washed before column chromatography (Figure 2.8). They successfully isolated known ganoderic acids A and B and elucidated the structure of ganoderic acid C. Adopting the same extraction procedures, Hirotani and Furuya (1986) later isolated ganoderic acid E and F.

Kikuchi et al. (1985a, b; 1986a, b, c) extracted the dried fruit body of *G. lucidum* with ether. The extracts were separated into acidic fraction and a neutral fraction. The acidic fraction was methylated with diazomethane and was separated repeatedly by a combination of silica gel column chromatography and thin layer chromatography (TLC). (Figure 2.9). New triterpenoid ganoderic acids C2, D, E, F, G, H, I, and K, lucidenic acids D, E, and F, and ganolucidic acids A and B were isolated and characterized.

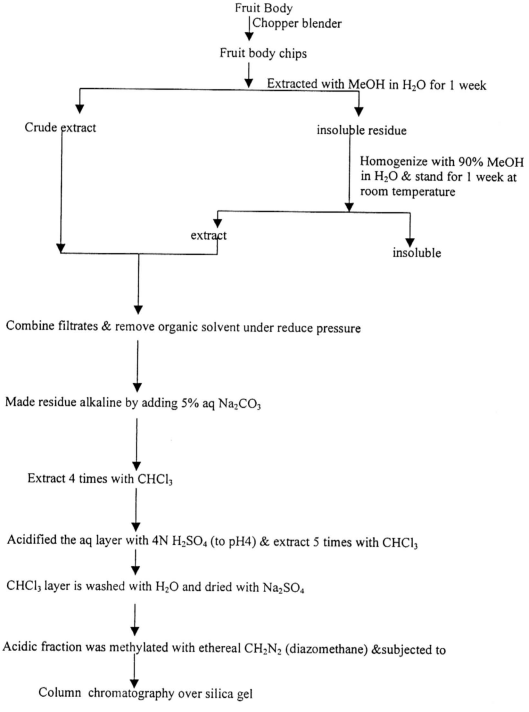


Figure 2.8: Isolation procedures adopted by Hirotani et al. (1985a, b) and Hirotani and Furuya (1986).

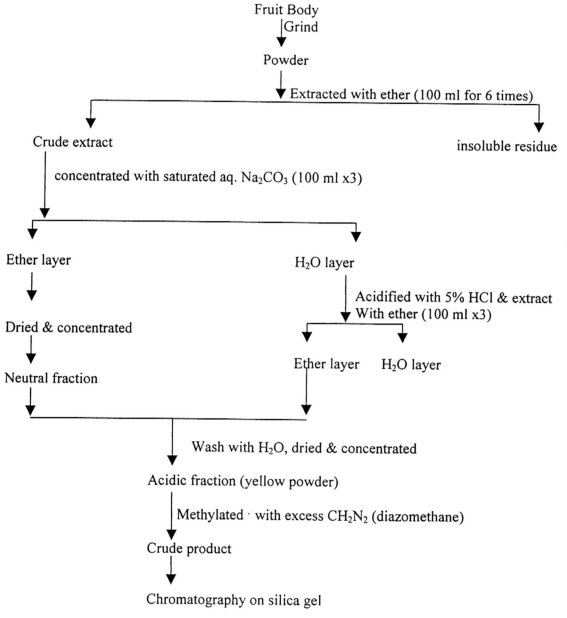


Figure 2.9: Isolation procedures adopted of by Kikuchi et al. (1985 a, b; 1986a, b).

Much of the isolation and characterization of triterpenoids from *G. lucidum* have been carried out by Nishitoba and co-workers. The extraction and isolation scheme adopted is shown in Figure 2.10. They extracted the dried chipped fruit bodies with ethanol and separated into chloroform soluble and water soluble layers. The chloroform layer was acidified and dried before loading into silica gel-packed column They managed to isolate lucidenic acids A, B, C, D, and E (Nishitoba *et al.*, 1984, 1985a, b, c). In addition, ganoderic acids A B, C, D and lucidone A, B were also successfully isolated and characterized (Nishitoba *et al.*, 1985a, b, c). Among these bitter terpenoids, lucidenic acid D (Figure 2.11) showed the most intense bitterness. They later found that the spatial relationship of the hydrophobic methyl groups to the three functional oxygen atoms plays an important role in generating the bitterness (Nishitoba *et al.*, 1988a, b, c).

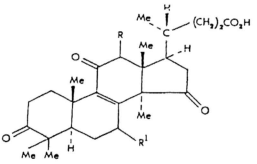


Figure 2.11: Lucidenic acid D. R = O, R^1 = O (Nishitoba *et al.*, 1985c)

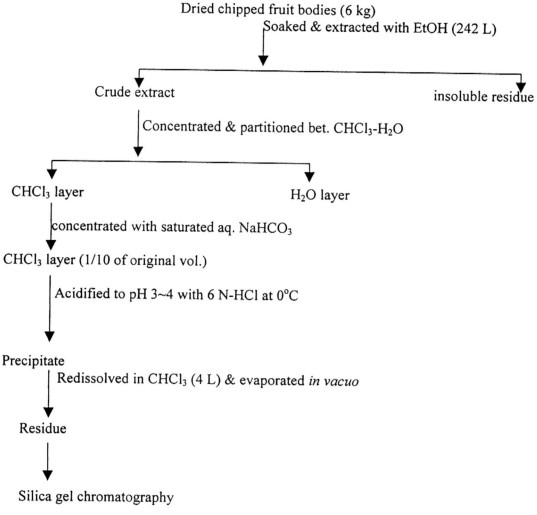


Figure 2.10: Isolation procedures adopted by Nishitoba et al.(1984; 1985a,b,c).

Besides the fruit body, significant amounts of triterpenes can also be obtained from the mycelial mat of static cultures. The extraction and isolation procedures are similar to that of the fruiting body described above. Novel ganoderic acids Ma, Mb, Mc, Md, Me, Mf, Mg, Mh and Mk have been isolated from the mycelial mat of *G. lucidum* (Nishitoba *et al.*, 1987a,b,c). Hirotani et al (1987) also determined six new ganoderic acid derivatives, O, P, Q, R, S, and T from the cultured mycelium of *G. lucidum*. Ganolucidic acid D, with an allylic alcohol group in the side chain, was postulated as an intermediate between the mycelial components and terpenoids of the fruit body (Nishitoba *et al.*, 1988a).

Most of these researchers included acid hydrolysis in their isolation steps. This is because triterpenoids occur in nature either in the free state or as glycosides (Mahato *et al.*, 1992). In the latter case, cleavage of that sugar moiety by acid hydrolysis is sometimes necessary before isolation and purification of the triterpenoid moiety. However, acid hydrolysis of glycosides often leads to artifacts (Mahato *et al.*, 1992). Alternatively, hydrolysis using alcoholic-alkali metal solution containing a trace of water has proved to be useful for isolation of labile aglycones (Mahato *et al.*, 1992).

In the cases of complex mixtures of closely related isomeric products, normal silica gel column chromatography is not effective in separation. Special techniques, such as HPLC, GC-MS, and capillary column chromatography are found to be helpful (Mahato *et al.*, 1992). For example, twenty-four oxygenic lanostanoid acids, including

separated by reversed-phase HPLC (cited in Mahato *et al.*, 1992). The capacity factor obtained in MeOH-H_2O and MeCN-H_2O solvent systems were useful for the correlation of the molecular polarities due to the presence of multiple oxygenated functional groups in the products. The number and position of functional groups, as well as their stereochemistry, play important roles in governing the polarity of these compounds in the reversed phase-HPLC (Mahato *et al.*, 1992).

2.4 Analytical Techniques

Thin layer chromatography (TLC) and gas –liquid chromatography (GLC) permit quick detection and identification of terpenoids (Harborne, 1973). Paper chromatography (PC) is hardly ever used, although once it was very important for steroid separations (Bush, 1961). Separations on paper are occasionally valuable for distinguishing different glycosidic triterpenoids (Bush, 1961).

TLC is practically always used and carried out on layers of silica gel. For the analysis of oxygen-containing terpenes (e.g. carvone), silica gel layers should not be activated prior to use, since the moisture present aids the separation (Harborne, 1973). On the other hand, for terpene alcohols, the silica gel need to be activated and best separated with paraffin-impregnated plates in 70% methanol. Another modification is to separate the terpenes according to the number of double bonds. This involves TLC on silica gel plates spread as a slurry with 2.5% aqueous $AgNO_3$ instead of with water (Harborne, 1973).

The high level development in spectroscopic methods has tremendously enhanced the structure elucidation of natural products. Although the development in each spectroscopic methods are remarkable, the structural information now available to the natural product chemists, through nuclear magnetic resonance (NMR) spectroscopy is probably greater and more easily obtained than by any other single technique (Mahato *et al.*, 1992).

NMR spectroscopy is now almost invariably used either for conformation of a proposed structure or structural proof of complete unknowns (Mahato *et al.*, 1992). The structures several new lanostane-type tetracyclic triterpenoids isolated from the fruit body of *G. lucidum* were elucidated by detailed analyses of ^{1}H and ^{13} C-NMR spectra using two-dimensional ^{1}H-^{1}H and ^{1}H-^{13}C shift correlation techniques (Kikuchi *et al.*, 1986a, b). For example, ^{1}H-^{1}H shift correlated spectra (COSY) allowed in some cases the assignment of most of the proton signals. In particular, the signals due to methyl groups, except the C-30 (4α)-and C-31 (4β)-methyl groups, were precisely assigned on the basis of the presence of long range coupling between H_3-19 and H-1α, H_3-18 and H-12α, and H_3-21 and H-22 (cited in Mahato *et al.*, 1992).

A compilation of the triterpenoids isolated from *Ganoderma* spp. during the period 1982-1994 along with available physical data, spectroscopy and X-ray analysis used for their characterization is given in Table 2.4.

Table 2.4: Triterpenoids isolated from *Ganoderma* spp.(compiled from Mahato *et al.*, 1992; Mahato and Sen, 1997).

Species	Triterpenoid Mp, [α]D spectra/X-ray analysis reported	Basic skeleton	Groups	Reference
G. appalatum	Ganoderenic acid F, +93°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,7,11,15,23-Oxo; 26-COOH; (20E)$\Delta^{8,20(22)}$	Nishitoba et al. (1989)
	Ganoderenic acid G, +189°, UV, IR, ^{1}H, $^{13}CNMR$, HRMS	lanostane	3,7,11,23-Oxo; 15α-OH; 26-COOH; (20E)$\Delta^{8,20(22)}$	Nishitoba et al. (1989)
	Ganoderenic acid H; Me ester, +61°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,7,11,15,,23-Oxo; 26-COOH; (20E)$\Delta^{8,20(22)}$	Nishitoba et al. (1989)
	Ganoderenic acid I; Me ester, +96°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,15α-OH,7,11,23-Oxo; 26-COOH; (20E)$\Delta^{8,20(22)}$	Nishitoba et al. (1989)
	Furanoganoderic acid, +70°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,7,11,23-Oxo; 26-COOH; (20E)$\Delta^{8,20,22}$,21-23epoxy	Nishitoba et al. (1989)
	Ganoderenic acid AP; Me ester, +71°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,7,11,23-Oxo; 12β,15α,20-OH,26-COOH; Δ^{8}	Nishitoba et al. (1989)
	Applanoxidic acid E, 138-139°, +145.0°, UV, IR, ^{1}H, $^{13}CNMR$, HRMS	lanostane	3,12,23-tri-oxo,15β-OH,7α,8α-epoxy, 26-CO_2H $\Delta^{9(11),26}$	Chairul et al. (1994)
	Applanoxidic acid F, 145-146°, UV, IR, ^{1}H, $^{13}CNMR$, HRMS	lanostane	3,12,15,23-tetra-oxo, 7α,8α-epoxy, $\Delta^{9(11),26}$	Chairul et al. (1994)
	Applanoxidic acid G, 129-130°, +126.0°, UV, IR, ^{1}H, $^{13}CNMR$, HRMS	lanostane	3,12,23-tri-oxo,15β,20-di-OH,7α,8α-epoxy, 26-CO_2H $\Delta^{9(11),16}$	Chairul et al. (1994)
	Applanoxidic acid H, 161-163°, +54.0°, UV, IR, ^{1}H, $^{13}CNMR$, HRMS	lanostane	3β,12α,20-tri-OH,7α,8α-epoxy, 15,23-di-oxo,26-CO_2H $\Delta^{9(11),26}$	Chairul et al. (1994)
	Applanoxidic acid A, 220°, +88.0°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,12,23-tri-oxo,26-CO_2H, 7α,8α-epoxy, 15α-OH, $\Delta^{9(11),20}$	Tokuyama et al. (1991)
	Applanoxidic acid B, 224-225°, +114.6°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β-OH,12,15,23-tri-oxo, 7α,8α-epoxy, 26-CO_2H $\Delta^{9(11),20}$	Tokuyama et al. (1991)

	Applanoxidic acid C, 140-142°, +18.9°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,12,15,23-tetra-oxo, 20-OH,7α,8α-epoxy, 26-CO_2H $\Delta^{9(11),16}$	Tokuyama et al. (1991)
	Applanoxidic acid D, 206-207°, +11.1°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,20-di-OH,12,15,23-tri-oxo, 26-CO_2H $\Delta^{9(11),16}$	Tokuyama et al. (1991)
G. lucidum	Ganoderic acid A, +153.8°, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,23-Oxo; 12β,15α,20-OH,26-COOH; Δ^{8}	Kubota et al. (1982)
	Ganoderic acid B, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,7β-OH;11,15,23-Oxo,26-COOH; Δ^{8}	Kubota et al. (1982)
	Ganoderic acid C, 184.5-185.5°, +184.9°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,15,23-Oxo; 7β-OH;26-COOH; Δ^{8}	Nishitoba et al. (1984)
	Lucidenic acid A, 194-195°, +173.3°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,15,23-Oxo; 7β-OH;24-COOH; Δ^{8}, 25,26,27-nor	Nishitoba et al. (1984)
	Lucidenic acid B, 179-181°, +168.9°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,15-Oxo; 7β,12-OH;24-COOH; Δ^{8}, 25,26,27-nor	Nishitoba et al. (1984)
	Lucidenic acid C, 199-200°, +140°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,7β,12-OH;11,15-Oxo;24-COOH; Δ^{8}, 25,26,27-nor	Nishitoba et al. (1984)
	Lucidenic acid D; Me ester, +136°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,15-Oxo; 12β-OAc;24-COOH; Δ^{8}, 25,26,27-nor	Kikunchi et al. (1985a)
	Lucidenic acid E; Me ester, 140-144°, +86°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β-OH;12β-OAc,7,11,15-Oxo;24-COOH; Δ^{8}, 25,26,27-nor	Kikunchi et al. (1985a)
	Lucidenic acid F; Me ester, 208-211°, +195°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,15-Oxo; 24-COOH; Δ^{8}, 25,26,27-nor	Kikunchi et al. (1985a)
	Ganoderic acid D; Me ester, 199-200°, +98°, UV, IR, ^{1}H, MS	lanostane	3β,7β,15α-OH;11,23-Oxo;26-COOH; Δ^{8}	Kikunchi et al. (1985a)
	Ganoderic acid E; Me ester, 206-208°, +167°, ^{1}H, $^{13}CNMR$	lanostane	3,7,11,15,23-Oxo;26-COOH; Δ^{8}	Kikunchi et al. (1985a).
	Ganoderic acid F; Me ester, 111°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,7,11,15,23-Oxo;12β-OAc;26-COOH; Δ^{8}	Kikunchi et al. (1985a)

Ganoderic acid G; Me ester, 134-135°, +64°, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,7β,12β-OH;11,15,23-Oxo;26-COOH; Δ^{8}	Kikunchi et al. (1985b)
Ganoderic acid I; Me ester, 279-281°, +132°, ^{1}H, $^{13}CNMR$	lanostane	3β,7β,20-OH;11,15,23-Oxo;26-COOH; Δ^{8}	Kikunchi et al. (1985b)
Ganolucidic acid A; Me ester, 192-194°, +188°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,23-Oxo;15α-OH;26-COOH; Δ^{8}	Kikunchi et al. (1985b)
Ganolucidic acid B; Me ester, 167-169°, +114°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,15α-OH;11,23-Oxo;26-COOH; Δ^{8}	Kikunchi et al. (1985b)
Ganoderic acid C, UV, IR, ^{1}H, $^{13}CNMR$, MS, X-ray analysis	lanostane	3β-OH;12β-OAc,7,11,15,,23-Oxo;26-COOH; Δ^{8}	Hirotani et al. (1985)
Ganoderenic acid A, +127.8°, UV, IR, $^{1}HNMR$, MS	lanostane	3,11,23-Oxo;7β,15α-OH;26-COOH;(20E) $\Delta^{8,20(22)}$	Komoda et al. (1985)
Ganoderenic acid B, +102.9°, UV, IR, $^{1}HNMR$, MS	lanostane	3β,7β-OH;11,15,23-Oxo;26-COOH;(20E) $\Delta^{8,20(22)}$	Komoda et al. (1985)
Ganoderenic acid C, +66.2°, UV, IR, $^{1}HNMR$, MS	lanostane	3β,7β,15α-OH;11,23-Oxo;26-COOH;(20E) $\Delta^{8,20(22)}$	Komoda et al. (1985)
Ganoderenic acid D, 214-216°, +163.4°, UV, IR, $^{1}HNMR$, MS	lanostane	3,11,15,23-Oxo;7β-OH;26-COOH;(20E) $\Delta^{8,20(22)}$	Komoda et al. (1985)
Ganoderal A, 127-128°, +27°, UV, $^{1}HNMR$, MS	lanostane	3 -Oxo;26-CHO;(24E) $\Delta^{7,9(11),24}$	Morigiwa et al. (1986)
Ganoderol A, 99-101°, +33°, UV, $^{1}HNMR$, MS	lanostane	3 -Oxo;26-OH;(24E) $\Delta^{7,9(11),24}$	Morigiwa et al. (1986)
Ganoderol B, 171-173°, +61°, UV, $^{1}HNMR$, MS	lanostane	3β,26-OH;(24E) $\Delta^{7,9(11),24}$	Morigiwa et al. (1986)
Ganoderic acid S, 168-169°, UV, $^{1}HNMR$, MS	lanostane	3 -Oxo;26-COOH;(24E) $\Delta^{7,9(11),24}$	Morigiwa et al. (1986)

Ganoderic acid K, +48°, UV, ^{1}HNMR, MS	lanostane	3β,7β-OH;12β-OAc;11,15,23-Oxo; 26-COOH; Δ^{8}	Morigiwa et al. (1986)
Ganoderic acid R, 201-202°, +8.7°, UV, IR, ^{1}H, ^{13}CNMR	lanostane	3α,22(S)-OAc; 26-COOH;(24E) $\Delta^{7,9(11)24}$	Hirotani et al. (1986)
Ganoderic acid T, 200-202°, +23°, UV, IR, ^{1}H, ^{13}CNMR	lanostane	3α,15α,22(S)-OAc; 26-COOH;(24E) $\Delta^{7,9(11)24}$	Hirotani et al. (1986)
Ganoderic acid Ma, -16°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3α,7α-OAc; 15α-OH;26-COOH;(24E) $\Delta^{8,24}$	Nishitoba et al. (1987)
Ganoderic acid Mb, -4.0°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3α,15α,22-OAc; 7α-OH;26-COOH;(24E) $\Delta^{8,24}$	Nishitoba et al. (1987)
Ganoderic acid Mc, -23°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3α,15α,22-OAc; 15α-OH;26-COOH;(24E) $\Delta^{8,24}$	Nishitoba et al. (1987)
Ganoderic acid Md, 180-182°, -20°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3α,22-OAc; 7α-OMe;26-COOH;(24E) $\Delta^{8,24}$	Nishitoba et al. (1987)
Ganoderic acid Me, +53°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3α,15α-OAc; 7α-OH;26-COOH;(24E) $\Delta^{7,9,(11)24}$	Nishitoba et al. (1987)
Ganoderic acid Mf, +42°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3α-OAc; 15α-OH;26-COOH;(24E) $\Delta^{7,9(11),24}$	Nishitoba et al. (1987)
Ganoderiol A, 232-234°, +20°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3β,24,25,26-OH;$\Delta^{7,9(11)4}$	Sato et al. (1986)
Ganoderiol B, UV, ^{1}H, ^{13}CNMR, MS	lanostane	3-Oxo;15α,26,27-OH;$\Delta^{7,9(11),24}$	Sato et al. (1986)
Ganodermanondiol, 182-183°, +45.8°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3-Oxo;24(S),25-OH;$\Delta^{7,9(11)}$	Fujita et al. (1986)
Ganodermanontriol, 161-162°, +35.7°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3-Oxo;24(S),25,26-OH;$\Delta^{7,9(11)}$	Fujita et al. (1986)
Ganoderic acid K; Me ester, 166-167°, +156°, UV, IR, ^{1}H, ^{13}CNMR, MS	lanostane	3β,15α-OH;7,11,,23-Oxo; 26-COOH; Δ^{8}	Kikuchi et al. (1986a)

Compound B8; Me ester, 158-163°, +128°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	7α,15α-OH;3,11,,23-Oxo; 26-COOH; Δ^{8}	Kikuchi et al. (1986a)
Compound B9, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,7α,15α-OH;11,,23-Oxo; 26-COOH; Δ^{8}	Kikuchi et al. (1986a)
Compound C5', 118.5-121.5°, +101°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3,11,15,13-Oxo; 7β,12β-OH; 26-COOMe; Δ^{8}	Kikuchi et al. (1986b)
Compound C6, 146-148°, +128°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,12β-OH;7,11,15,23-Oxo; 26-COOMe; Δ^{8}	Kikuchi et al. (1986b)
Methyl ganoderate M, 206-210°, UV, IR, $^{1}HNMR$, MS, CD	lanostane	3,11,15,33-Oxo; 7β,12α-OH; 26-COOMe; Δ^{8}	Nishitoba et al. (1987)
Methyl ganoderate N, 164-167°, +153°, UV, IR, ^{1}H, $^{13}CNMR$, MS, CD	lanostane	3,11,15,33-Oxo; 7β,20-OH; 26-COOMe; Δ^{8}	Nishitoba et al. (1987)
Methyl ganoderate O, 168-171°, UV, IR, $^{1}HNMR$, MS, CD	lanostane	3,11,15,33-Oxo; 20-OH; 26-COOMe; Δ^{8}	Nishitoba et al. (1987)
Triterpene ester, 227-229°, UV, IR, $^{1}HNMR$, MS, CD	lanostane	3,11,15,23-Oxo; 7β,12β-OH; 26-COOMe; (20E)$\Delta^{8,20(22)}$	Nishitoba et al. (1987)
Methyl lucidenate H, 190-192°, +136°, UV, IR, ^{1}H, $^{13}CNMR$, MS, CD	lanostane	3β,7β,28-OH; 11,15-Oxo;24-COOMe; Δ^{8}.25,26,27-nor	Nishitoba et al. (1987)
Methyl lucidenate I, +118°, UV, IR, ^{1}H, $^{13}CNMR$, MS, CD	lanostane	3β,28-OH; 11,15-Oxo;24-COOMe; Δ^{8}.25,26,27-nor	Nishitoba et al. (1987)
Methyl lucidenate J, +78°, UV, IR, $^{1}HNMR$, MS, CD	lanostane	3β,12β,28-OH; 7,11,15-Oxo;24-COOMe; Δ^{8}.25,26,27-nor	Nishitoba et al. (1987)
Methyl lucidenate K, UV, IR, $^{1}HNMR$, MS, CD	lanostane	3,7,11,15-Oxo;12α-OH;24-COOMe; Δ^{8}.25,26,27-nor	Nishitoba et al. (1987)
Methyl lucidenate L, UV, IR, $^{1}HNMR$, MS, CD	lanostane	3β,12β-OH; 7,11,15-Oxo;24-COOMe; Δ^{8}.25,26,27-nor	Nishitoba et al. (1987)
Methyl lucidenate M, UV, IR, $^{1}HNMR$, MS	lanostane	3β,7α,15α-OH;11-Oxo;24-COOMe; Δ^{8}.25,26,27-nor	Nishitoba et al. (1987)

Epoxyganoderiol A, +65°, UV, IR, ^{1}H, $^{13}CNMR$, MS, CD	lanostane	3-Oxo;7α,26-OH;Δ^{8},24(S),25(S)-epoxy	Nishitoba et al. (1988a)
Epoxyganoderiol B, +35°, UV, IR, ^{1}H, $^{13}CNMR$, MS, CD	lanostane	3-Oxo;26-OH; $\Delta^{7,9(11)}$,24(S),25(S)-epoxy	Nishitoba et al. (1988a)
Epoxyganoderiol C, +43°, UV, IR, ^{1}H, $^{13}CNMR$, MS, CD	lanostane	3β;26-OH; Δ^{8},24(S),25(S)-epoxy	Nishitoba et al. (1988a)
Ganoderal B, +94°, UV, $^{1}HNMR$, MS	lanostane	3-Oxo; 7α-OH; 26-CHO; (24E)$\Delta^{8,24}$	Nishitoba et al. (1988a)
Ganodermic acid Ja, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α;15α-OH; 26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Ganodermic acid Jb, 200-202°, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β;15α-OH; 26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Ganodermic acid P1, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α;22β-OAc; 15α-OH,26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Ganodermic acid P2, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β-OH;15α,22β-OAc; 26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Ganodermic acid R, 126-129°, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α,15α-OAc;26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1987)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,15α-OAc;26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1987)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α-OH;15α-OAc;23-Oxo;26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988b)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α-OAc;15α-OH;23-Oxo;26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Triterpene acid, 198-199°, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α,15α-OAc;23-Oxo;26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α-OAc;15α,22(S)-OH;26-COOH; $\Delta^{7,9(11),,24}$	Shiao et al. (1988)
Ganodermic acid T-N, 145-146°, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,15α,22(S)-OH;26-COOH; $\Delta^{7,9(11),,24}$	Lin et al. (1988)
Ganodermic acid T-O, 160-162°, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β-OH,15α-OAc;26-COOH; $\Delta^{7,9(11),,24}$	Lin et al. (1988)
Ganodermic acid T-Q, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β-OAc,15α-OH;26-COOH; $\Delta^{7,9(11),,24}$	Lin et al. (1988)

Ganoderiol C, IR, ^{1}H, $^{13}CNMR$, HRMS of its 24, 26-diacetate	lanostane	3-Oxo;7α-OEt,24,25,26,-OH; Δ^{8}	Nishitoba et al. (1988b)
Ganoderiol D, $^{13}CNMR$	lanostane	3,7-Oxo;24,25,26,-OH; Δ^{8}	Nishitoba et al. (1988b)
Ganoderiol E; triacetate, +18°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,26,27-OH;7-Oxo, $\Delta^{8,24}$	Nishitoba et al. (1988b)
Ganoderiol F, 116-120°, +42°, UV, IR, ^{1}H, $^{13}CNMR$, MS	lanostane	3-Oxo;26,27-OH; $\Delta^{7,9(11),24}$	Nishitoba et al. (1988b)
Ganoderiol G, +34°, IR, $^{1}HNMR$, MS	lanostane	3-Oxo;7α-Ome;24,25,26,-OH; Δ^{8}	Nishitoba et al. (1988b)
Ganoderiol H, 200-201.5°, +22°, UV, IR, ^{1}H, $^{13}CNMR$, HRMS	lanostane	3β,24,25,26-OH;7-Oxo; Δ^{8}	Nishitoba et al. (1988b)
Ganoderiol I, +53°, IR, $^{1}HNMR$, HRMS	lanostane	3-Oxo;15,26,27-OH; 7α-OMe;$\Delta^{8,24}$	Nishitoba et al. (1988b)
Ganolucidic acid E, +154°, UV, IR, $^{1}HNMR$, HRMS	lanostane	3,11-Oxo;15α-OH;26,-COOH; (24E);$\Delta^{8,24}$	Nishitoba et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α,15α22α-Oxo;26-COOH; $\Delta^{7,9,(11),24}$	Lin et al. (1988)
Triterpene acid, 178-180°, UV, ^{1}H, $^{13}CNMR$, MS	Lanostane	3β,15α,22β-OH,26-COOH;$\Delta^{7,9,(11),24}$	Lin et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α,15α-OAc,22α-OH,26-COOH;$\Delta^{7,9,(11),24}$	Lin et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,15α-OAc,22α-OH,26-COOH;$\Delta^{7,9,(11),24}$	Lin et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α,15α-OH,22β-OH,26-COOH;$\Delta^{7,9,(11),24}$	Lin et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3β,15α-OH,22β-OAc,26-COOH;$\Delta^{7,9,(11),24}$	Lin et al. (1988)
Triterpene acid, UV, ^{1}H, $^{13}CNMR$, MS	lanostane	3α,15α-OAc,26-COOH;$\Delta^{8,24}$	Lin et al. (1988)