CHAPTER 1

INTRODUCTION

1.1 General Introduction

Cancer or malignant disease is the third leading cause of death worldwide (12% all of deaths), only preceded by cardiovascular disease (30% all of deaths), by infectious and parasitic disease (19% all of deaths) (Mathers *et al.,* 2001). Between 2000 and 2020, the total number of cases of cancer in the developing world is predicted to increase by 73% and to increase by 29% in the developed world (Parkin, 2001). Cancer was the major cause of death in America, Europe, Asia and Thailand (Statistical annex, 2002) but in Hongkong it was the leading cause of death in 1996-2001 (Stanley, 2001). Interestingly, cancer is the first leading cause of death in Thailand for several years and the rate of people dying is still increasing every year. Statistics from National statistical office of Thailand indicated that 49,628 Thai people died from cancer in 2003 (National statistical office, 2003).

There are several types of cancer which are the cause of millions of deaths. Among them, lung cancer is the most common cancer in the world (Ferlay *et al*., 2001) and it is the second cause of death in Thai cancer patients (National statistical office, 2003). Another type of cancer is prostate cancer, a serious problem of male health; it is the fifth leading cause of death among men in the world (Statistic annex, 2004) including a major cause of death among men in European countries (Parkin *et al*., 1997). It ranks second after lung cancer in male cancer deaths and there were nearly 145,000 cases and 56,000 deaths in the European Union in 1998 (Davidson and Gabbay, 2004). Prostate cancer incidence rates are strongly affected by diagnostic practices and therefore difficult to interpret, but mortality rates show that death from prostate cancer is about 10 times more common in North America and Europe than in Asia (Ferlay *et al*., 2001). Prostate cancer is estimated to account for about 1.6 million new cases worldwide in 2007 (World Health Data Mortality Bank, 1992). In Thailand, there were 0.4/100,000 deaths in 1999 and an increase to 1.5/100,000 in 2003 (National statistical office, 2003).

All these data indicate that these diseases are still a difficult problem on a world wide basis and represent a major cause of death in both men and women. Surgery, radiation and cancer chemotherapy are major remedies for treating cancer patients. Cancer chemotherapy now plays an important role in the treatment of many malignancies either curative (by itself or used as an adjuvant to surgery and/or radiation) or in palliative care, depending upon the specific tumor situation (Carter, 1982). The objective of cancer chemotherapy is to kill cancer cells with as little damage as possible to normal cells (Halliwell and Gutteridge, 1988) so the discovery of anticancer agents must be related to novel molecular targets which should be defined and developed for specific typical cancer cells but are less toxic to normal cells or have a unique mechanism of action for a specific type of cancer (Pezzuto, 1997).

Plant-based systems have a long history of use in traditional health care (Houghton, 1995). World Health Organization estimated that approximately 80% of the world's inhabitants rely mainly on traditional medicines for their primary health care and at least 119 chemical substances derived from 90 plant species can be considered as important drugs currently in use in one or more countries (Farnsworth *et al.,* 1985). 74% of these 119 compounds were discovered as a result of chemical studies directed at the isolation of the active substances from plants used in traditional medicine (Cragg *et al.,* 1997). Therefore, the usage of ethnopharmacology, or traditional use, is channeled for discovery of new biologically-active molecules (Houghton, 1995).

1.2 Introduction of cytotoxicity

The National Cancer Institute (NCI) in the USA has established the development of a method for initial screening and has defined the term 'cytotoxic'. A cytotoxic agent is toxic to tumor cells *in vitro* which is the method for studying bioactive compounds from plants and allows large numbers of plant extracts to be screened for activity especially cytotoxic compounds against many types of cancer cell lines. This assay is particularly useful for bioassay-guided fractionation of plant extracts. It is not always possible to test against cancer in an animal model and is more sensitive to most antitumor agents than *in vivo* assay and also costs less and requires less test material and time.

1.3 Introduction of antioxidant

Free radicals are produced from many sources e.g. UV radiation, smoke, pollution, heavy metals, rancid fatty acids, etc. In addition, oxidants or free radicals are generated as by-products during body functions such as respiration, oxidative energy metabolism and immune activity. Oxygen molecules and reactive oxygen species (ROS) are oxidizing agents which cause extensive damage to DNA, protein, and lipid due to taking electrons from another species (Halliwell and Gutteridge, 1999 and Ames, *et al*., 1993). This damage is a major contributor to aging and to degenerative diseases of aging such as cancer, cardiovascular diseases, immune-system decline, brain dysfunction and cataracts (Ames, *et al*., 1993). The mechanism of free oxygen radicals in cancer is based on the fact that oxidative stress can stimulate expansion of mutated cells and promote proliferation in mammalial cells after the initiation of cancer development by radiation and chemical mutation (Itharat, 2002). Besides, oxidative damage to proteases and oxidative injury to local tissues may promote tumor progression and metastasis (Mates and Sanchez-Jemenez, 2000). The data from WHO reported that more than 80% and 45% of lung cancers occur in men and women who smoke (Gaudin, 2003). The development of prostate cancer is implicated in diets high in red meat, dairy products and animal fat, although the data are not entirely consistent (Michaud *et al*., 2001; Schuurman, *et al*., 1999 and Chan *et al*., 2001). Numerous observational studies have found that lung cancer patients take less fruit, vegetables and related nutrients (such as β-carotene) than controls (World Cancer Research Fund/American Institute for Cancer Research, 1997 and The Stationery Office, 1998). Some evidence has suggested that vitamin E (Heinonen *et al*., 1998) and selenium (Clark *et al*., 1998) as antioxidant agent might have a protective effect against prostate cancer. Also, these data indicated that antioxidant activity of medicinal plants should reduce the risk of cancer occurring and inhibit mutation of normal cells.

1.4 Introduction of apoptosis

Necrosis and apoptosis are the patterns of cell death. Necrosis can be induced in massive cell injury often accompanied by inflammation. In contrast to the accidental death of cells that results from an acute injury, apoptosis or programmed cell death is an active process with specific morphological changes, which are characterized by chromatin condensation, nuclear DNA fragmentation, cell shrinkage, plasma membrane blebbing, and membrane enclosed cell fragment (apoptosis body) formation (Zhang, *et al.*, 2003). Apoptosis or programmed cell death is a distinct intrinsic cell death program that occurs in various physiological and pathological situations (Hengartner, 2000). Killing of tumor cells by cytotoxic therapies (e.g. chemotherapy, γ-irradiation, immunotherapy or suicidal gene therapy) is predominantly mediated by triggering apoptosis in cancer cells (Herr and Debatin, 2001). Nowadays, the central theme of cancer research is to understand how the tumor cells resist apoptosis in response to triggers which typically induce cell cycle arrest or cell death in their untransformed counterparts and evidences have suggested that the rate of cell death, the other side of the balance, is just as important (McGill and Fisher, 1997).

1.5 Introduction to this study

In Thailand, many people have used traditional medicine as an alternative treatment for cancer (Subchareon, 1998). Folk doctors of Southern Thailand have used many medicinal plants in cancer drug formulae (Itharat *et al.*, 1998). These traditional medicines are prepared by boiling the plant material in water or soaking in alcohol and are commonly used by Thai people to prepare the drug for oral intake. An investigation of a traditional drug formula for treatment of cancer patients found it to be composed of twelve plants: *Bridelia ovata* Decne, *Curcuma zedoaria* (Berg) Roscoe, *Derris scandens* (Roxb.) Benth, *Dioscorea membranacea, Drynaria quercifolia* Linn, *Erythrophleum teysmannii* Craib., *Moringa oleifera* Lamk, *Nardostachys jatamansi* DC, *Rhinacanthus nasutus* (L.) Kurz, *Sapindus rarak* DC., *Smilax corbularia* Kunth and *Strychnos nux-vomica* L.. This preparation is used by folk doctors to treat cancer in Southern Thailand and it can reduce the pain symptoms of patients and improve the condition of treated patients. Surprisingly, there is no research of some plants against cancer cells especially lung and prostate cancer and also no report about apoptosis and test antioxidant activity in these plants. Therefore, the objective of the study should be to test cytotoxic activity against lung and prostate cancer which cause high death rates in man and also test antioxidant activity. Bioassay guide fractionation was used for isolated cytotoxic compounds against these cancer cells and they also tested the rate of apoptosis against cancer cells and antioxidant activity. These results would provide additional useful data on the biological activities of these plants and support the use of folk doctors to treat cancer patients.

1.6 Review of Literatures

1.6.1 *Bridelia ovata* Decne.

Bridelia ovata Decne. (Euphorbiaceae), its Thai vernacular names are Maka, Mai maka (General); Cham-cha maka, Kong (Northern); Kong kaep (Chiang Mai); Salao, Si-wa-la (Karen-Mae Hong Son); Khi lao mat ka (Khon Kaen); Mat ka (Nong Khai); Samsa (Loei) and Khai maka, Som ka (Central). It is distributed in Myanmar, Thailand, Andaman & Nicobar Islands, Northern Malaysia, Eastern Java and Lesser Sunda Islands in Indonesia. In Thailand it is distributed throughout the north, northeast, southeast, southwest, central and peninsular regions. It is found in sandy beach, savannah, dry evergreen and deciduous forest, moist monsoon forest; on sandy, calcareous soil or limestone; locally common at sea level up to 800 m. The leaves are used in Thailand for wrapping cigarettes and medicinally against lues (syphilis) and as a purgative (Smitinand and Larser, 2005).

The description of *Bridelia ovata*, shown in Figure 1-1, is a scrambling shrub to tree up to 8 m high; branchlets glabrous, with scattered lenticels. The stipules are narrowly triangular, up to 7-10 mm by up to 1.2 mm, glabrous, early caducous. Leaves are have petiole 4-6 mm long, glabrous; blade elliptic (to oblong), 5-18 cm by 2-8 cm, chartaceous, glabrous on both sides, base (slightly cordate to) obtuse, entire margin, apex obtuse to rounded (to bluntly acute); venation prominent on both sides with nerves 13-17 pairs, joining the marginal vein, tertiary veins reticulate to scalariform. It has glomerules with 1 to more than 20 subsessile to shortly pedicelled flowers. Flowers are yellowish green, staminate ones 3-5 mm in diameter, pistillate ones 4-6 mm in diameter, pedicel 1.5-2 mm long. Sepals are glabrous, greenish cream tinged red. Petals are elliptic, whitish yellow, roundish or notched apex. Stamens are staminal column. Anthers are shortly ellipsoid. Ovaries are globose. Fruits are pale greenish purple to black; endocarps 2, semigloboid, brown. Seeds are semigloboid with lateral furrow and reddish black (Smitinand and Larser, 2005)

Figure 1-1 *Bridelia ovata* Decne. (original picture)

1.6.2 *Curcuma zedoaria* (Berg.) Roscoe

Curcuma zedoaria (Berg.) Roscoe (Zingiberaceae), its common names in various countries are Khamin oi (Thailand) (Saralamp *et al*., 2000); Zedoary (English); Zedoarwurzel, Zittwer (Germany); Zedoaire, Zedoaire bulbeux (France); Zedoaria (Italian); Kachura, Kalihaladi (Hindi); Temoelawa (Java) (Kirtikar and Basu, 1980); Gajusutsu (Japan) (Matsuda *et al*., 2001a) and Er-chu (China) (Mau *et al*., 2003). It is in considered to be a native of North-Eastern India and spread by cultivation throughout the Indian subcontinent and Malaysia. It is widely distributed in South and Southeast Asian countries including China, Vietnam, India and Japan. It has been extensively cultivated as a vegetable, spice and perfume in South and Southeast Asian countries. The rhizome of this plant is used medically as a stomachic, carminative, diuretic, antidiarrheal, anti-emetic, anti-inflammatory, antipyretic, antimicrobial remedies, stimulant, and antioxidant and also to treat cure ulcers, wounds and other kinds of skin disorder (Mau *et al*., 2003; Matsuda *et al*., 2001b; Syu *et al*., 1998; Yoshioka *et al*., 1998).

Description of *Curcuma zedoaria* (Berg.) is shown in Figure 1-2 and Figure 1-3. This plant is a perennial herb. It is a rhizome, or underground stem, like turmeric and ginger. The rhizome is similar to turmeric, but the rhizome and leaf are large (Saralamp *et al.,* 2000), and tuberous with many branches. The interior of the rhizome is yellow and the dried rhizome has an agreeable musky odour with a slight smell of camphor and a pungent bitter taste. The main tubers called bulbs are ovoid about 8 x 5 cm, with many short, thick branches and tuberous roots which are called fingers (Morikawa *et al*., 2002; Purseglove *et al*., 1981). The leaf shoots are up to 1 metre tall with about 4-6 leaves with long green petioles. Its leaves are oblong-lanceolate, finely acuminate, and glabrous on both surfaces, clouded with purple down the middle, 30-60 cm long. The inflorescences are 22 cm tall and separate from the leaf shoots. The spikes are about 16 cm tall, with the lowest green bracts, the middle bracts tipped with purple and the uppermost bracts entirely purple. The flowers, about five to each bract, are pale yellow in spikes. The flowering bracts are 3.8 cm long, ovate, recurved, cymbiform, green tinged with red. The bracts of the coma are crimson or purple about 5 cm long. The calyx is obtuse, 3-toothed and about 8 mm long. The funnel-shaped corolla is a tube twice as long as the calyx. The lip is broad, suborbicular, deflexed, and deep yellow. The capsule is ovoid, thin and smooth. Seeds are ellipsoid with a white lacerate aril (Kirtikar and Basu, 1980; Hooker, 1894).

Figure 1-2 Bulb and finger of *Curcuma zedoaria* (Berg.) Roscoe, the orange rhizome of *Curcuma longa* Linn (left side) compared with the yellow rhizome of *Curcuma zedoaria* (Berg.) Roscoe (right side) (original picture)

Figure 1-3 The upper stem and flower of *Curcuma zedoaria* (Berg.) Roscoe (from http://arboretum.sfasu.edu/gaylilies/curcuma/Curcuma zedoaria syn-inodora.ipg, 2004)

1.6.3 *Derris scandens* (Roxb.) Benth

Derris scandens (Roxb.) Benth is a plant of the family Fabaceae, its common name is Thaowan priang. It is scattered along the edges of deciduous and evergreen forests throughout the country. It is widely distributed in Malaysia, China and North Australia (Hooker, 1883). The bark produces fibers for making ropes (Smitinand, 1985). The slender stems were used as an antipyretic, diuretic, analgesic, laxative and expectorant (Boonyaprapatsorn and Chokchaijalearnporn, 2000).

A description of *Derris scandens* (Roxb.) Benth is shown in Figure 1-4. This plant is a small woody climber up to 15-20 m long; without tendrils, with black-gray bark. Leaves are obtuse or acute at the base, about 1/4 - 1/2 ft. long; odd-pinnately compound, alternate and stipulate with 3-5 pairs of leaflets opposite. The leaflets have petioles 2-3 mm long; ovate about 2-5 cm × 1-3 cm, bright green, the acute apex of the lower pairs is smaller than the upper pairs. Flowers have very long raceme with distant nodes. Sepals are tubular and deep purple. Petals are white to pink; polypetalous, papilenaceous, the banner is 5-8 mm long. Petals have 2 wings 8-9 mm long and 2 keels 8-9 mm. Stamens have 9+1 pattern, diadelphous filaments, white and 7-8 mm long. The ovary is the superior part of the plant. It is simple, green, and hairy, 5 mm long, curved, and has a capitate stigma. It has one carpel and one locule. The fruit is a legume. It is dry, hairy, flat, oblong, acute and about 2 cm × 5-10 cm. The seed is round, flat, and about 3 x 4 mm (Hooker, 1883; Wara-Aswapati *et al*., 2005).

Figure 1-4 *Derris scandens* (Roxb.) Benth (original picture)

1.6.4 *Dioscorea membranacea* Pierre

Dioscorea membranacea Pierre is a member of Dioscoreaceae, its Thai vernacular names are Phak lum phua, Phak khanong ma, Khao-yen tai and Khrua that (Supatanakul *et al*., 1985). It is distributed from Thailand westwards to north Burma and eastwards into Cambodia; southwards passing beyond the Isthmus of Kra into Malaysia, it grows on limestone at its southern limit (Burkill, 1951). Its rhizome has been used to treat cancer for a long time by folk doctors (Itharat, 2002; Subchareon, 1998).

A description of *Dioscorea membranacea* Pierre is shown in Figure 1-5. The rhizome is a wide running, perhaps even to 2 m. It is dark brown with white flesh. The stem is slightly ridged and unarmed. Leaves are deeply trifid above a cordate base with the short acuminate 9 nerved, two primary nerves reaching the forerunner tip along with the midrib and the second pair reaching the tips of the letheral lobes. The petioles are 1/2-2/3 of the length of the blade. Male flowers have small subsessile cymes with up to 4 flowers, sepals 1 mm long, and long-ovate. Stamens, alike the filaments insert just below the sepals 0.3 mm long. The anther is small and introse. Female flowers are on downwardly directed spike-like racemes. Outer sepals are obovate, inner ones are lanceolate, and the inner are a little shorter than the outer. Style is short. Capsules are apart, about 1 -2 cm (Burkill, 1951).

Figure 1-5 *Dioscorea membranacea* Pirre (original picture)

1.6.5 *Drynaria quercifolia* (Linn)

Drynaria quercifolia (Linn) is a member of Drynariaceae, its Thai vernacular names are Kratae tai mai (Central); Kut kha hok, Chao-wa-no, Phu-dong-khae (Karen/Northern); Dao-ka-lon (Malay/Peninsular); Bai huu chang, Sabai nang, Hua wao (South-western); Sa-mong (Suai/Surin). It is distributed from Sri Lanka, India to South of China and Indochina, Malaysia throughout to Fiji and tropical Australia. It is widely distributed in Thailand including the north: Chiang Rai, Chiang Mai (Doi Saket), Phisanulok (Thung Salaeng Luang), Tak; north-eastern: Nong Khai;

south-eastern: Chanthaburi (Khao Sabap, Makham), Chon Buri (Si Racha, Ko Sichang), Trat (Ban Saphan Hin); south-western: Kanchanaburi (Sai Yok, Wangka, Thung Kang Yang), Prachuap Khiri Khan (Huai Yang, Bang Saphan); peninsular: Phangnga (Takua Thung), Krabi, Surat Thani (Ko Tao, Ban Don), Nakhon Si Thammarat (Khao Luang), Phuket (Ban Ma Phrao), Phatthalung (Ko Si Ko Ha), Trang, Satun, Yala (Bannang Sata). It grows on rather dry rocks on hillsides in light shade or at the edge of forests, and is fairly common at low altitudes (Smitinand and Larsen, 1989). The slender stem and rhizome were used for diuretic and antidiabetic treatment (Boonyaprapatsorn and Chokchaijalearnporn, 2000).

A description of *Drynaria quercifolia* (Linn) is shown in Figure 1-6. This plant is a creeping rhizome, about 1.5 cm diameter, with densely dark brown scales. It gradually narrows from base to tail apex, up to 1.8 cm long and 1.3 mm broad. The margin is paler and densely toothed. Nest-leaves are sessile, ovate, up to 32 by about 20 cm, shallowly lobed; lobes close, 5 by 3 cm, rounded to moderately acute at apex, entire. Foliage-leaves have stipes about 25 cm long. They are stramineous, very narrowly winged throughout, densely scaly at base with those like rhizome-scales. The laminaes are oblong to narrower, up to 80 by about 50 cm, deeply pinnatifid, continuous to the adjacent ones by rather broad wings more than 1 cm in breadth. Lobes are ascending, gradually narrowing from base to acute or acuminate apex, entire and more or less crisped at the margin. The veins are distinct on both surfaces, finely anastomosing with more than 10 rows of areoles between main veins. They are coriaceous, shining pale green, and glabrous. Sori are round or oblong and they have two rows between adjacent main veins (Smitinand and Larsen, 1989).

Figure 1-6 *Drynaria quercifolia* (Linn) (original picture)

1.6.6 *Erythrophleum teysmannii* Craib

Erythrophleum teysmannii Craib is in Caesalpiniaceae Family, its Thai vernacular names are Sak (South-western); Khrak, Yi daeng (Peninsular); Phan sat (Central, North-eastern), and its distribution is West Cambodia. In Thailand, it is distributed from the eastern: Nakhon Ratchasima; central: Saraburi; south-western: Ratchaburi (Teysmann 6046, type) to peninsular regions: Surat Thani. It grows widely in evergreen forests and it bears fruit from May to July. The timbers are excellent for posts (Smitinand and Larsen, 1984).

A description of *Erythrophleum teysmannii* Craib is shown in Figure 1-7. It is a tree up to 30 m high. Leaves are glabrous, rhachis, and about 10-50 cm long. It has pinnae 2-4 pairs, the rhachis 10-30 cm long. The rhachis has 10-16 leaflets which are lanceolate, 4-8 by 2.5-4 cm, obtuse-emarginate to acuminate at the tip, cuneate or rounded and unequal at the base, glabrous. Petioles are circa 3 mm. Flower is unknown. Pods are about 12-15 by 4 cm, stipitate circa 5 mm. It has 6-8 seeds, about 14 x 7 mm. Funicle are 6 mm long (Smitinand and Larsen, 1984). It had no traditional used report.

Figure 1-7 *Erythrophleum teysmannii* Craib
(from http://www.sc.mahidol.ac.th/scmi/epf/Plant Pic/PunChart.jpg, 2005)

1.6.7 *Moringa oleifera* Lamk.

Moringa oleifera Lamk. (synonym: *Moringa pterygosperma* Gartn.) is in the Moringaceae Family, its Thai vernacular names are Ma-Khorn-Khorm (North), Pak-E-Hum (Chiang Mai, North-eastern) and Ka-Nang-Doeing (Karen; a member of a hill tribe living at the western frontier of Thailand). It is distributed from the western Himalayas and Oudh and it is spread by cultivation throughout the India and tropical countries (Hooker, 1879). The parts of this plant are used as traditional medicine such as roots for an analgesic and an anti-inflammatory; bark for a cardiotonic; and flowers for a stimulant (Boonyaprapatsorn and Chokchaijalearnporn, 2000).

A description of *Moringa oleifera* Lamk. (The Horse-radish tree) is shown in Figure 1-8. This plant is a small tree: corky bark, soft wood and pungent root. Leaves are usually 3-pinnate, about 1-2 ft long. Petioles are slender and sheathing at the base. It has pinnae 4-6 pairs and leaflets 6-9 pairs, about 1/2-3/4 in. The leaflets are pale beneath and on opposite side. Petiolules are slender and glands are hairy linear. Panicles are spreading with linear bracts. Flowers have one in.

diameter pedicels and scented honey. Sepals are reflex linear-lanceolate. Petals are narrowly spathulate. Fertile filaments are villous at the base and the ovary is hairy. The pod is pendulous with 9 ribs, about 9-18 in. Seeds are 3-gonous winged at the angles (Hooker, 1879).

Figure 1-8 *Moringa oleifera* Lamk.
(from www.delange.org/ Moringa/Moringa.htm, 2006)

1.6.8 *Nardostachys jatamansi* DC.

Nardostachys jatamansi DC. is a member of Valerianaceae, its common names are Goge-cha-da-mang-sri (Thai), Muskroot, Indian Spikenard, Jatamanshi, and Jatamashi. This herb is found in India, Nepal, Bhutan, and Sikkim. It grows in the Himalayas at altitudes from 9,000-17,000 feet. This plant is used as an analgesic, antibacterial, antifungal and antihepatotoxic medication (Debelmas and Hache, 1976; George and Pandalai, 1949; Mishra *et.al*., 1995; Ali *et al.*, 2000).

A description of *Nardostachys jatamansi* DC. is shown in Figure 1-9. This plant is a woody rootstock, which is stout, long, and covered with fibres from the petioles of withered leaves. The stem is more or less pubescent upward, often glabrate below, subscapose and 4-24 in. long. Radical leaves are 6-8 by 1 in., longitudinally nerved, glabrous or slightly pubescent, narrowed into the petiole with 1 or 2 pairs of cauline which is sessile, oblong or subovate and 1-3 in. long. Flowers are the flower-head. It has usually 1, 3 or 5 flower heads which have oblong and pubescent bracts, about 1/4 in. long. Cocrolla-tube is about 1/4 in. long and it has hair within. Fruit is about 1/6 in., covered with ascending white hairs, crowned by the ovate, acute, often dentate calyx-teeth. There are two forms of this plant: a large-flowered, with usually glabrous bracts, and a smaller one, with the 1/6 in. long of corolla-tube, and the short dense hairy bracts which occur intermediately various (Hooker, 1881).

Figure 1-9 *Nardostachys jatamansi* DC. (from www.efloras.org/florataxon. aspx?flora_id=110&taxon_id=10936, 2006)

1.6.7 *Rhinacanthus nasutus* (L.) Kurz

Rhinacanthus nasutus (L.) Kurz is a plant of the family Acanthaceae (synonyms: *Rhinacanthus communis* Nees), its common names are Thong-phan-chang and Yaa-man-kai (central). It is widely distributed in tropical countries including Southeast Asia, South China and India. This plant scatters along the edges of evergreen forest. It is usually grown for ornament and requires sandy and well-drained soil. They can be propagated by seed or cutting. The whole plants, leaves, and root have been used for the treatment of skin diseases such as ringworm, amputating necrosis of the penis, cancer, rash, falling hair, and abscess pain. In addition, the leaves and stems have been used for health promotion (Farnsworth and Bunyapraphatsara, 1992).

Description of *Rhinacanthus nasutus* (L.) Kurz is shown in Figure 1-10. This plant is a small shrub, up to 1.5 m high. The stem is obtusely quadrangular, when young it is covered with fine, up curved hair. Leaves are simple opposite. The leaves are elliptic to lanceolate with in size of 4-6 by 2-3 cm, entire, light green; shortly pubescent and having acute base and apex. Flowers are white, in short axillary clusters; densely appressed pubescent and bisexual. The calyx is divided into 5 deeply acute parted, light green, 5-6 mm long. The corolla tube is about 2 cm, having brownish purple spots at the throat of the tube, bilabiate, upper lip erect, bifid; lower lip 3 lobed; 4 stamens, insert in the throat; ovary 2-loculed. Capsule is loculicidally 2-valved (Farnsworth and Bunyapraphatsara, 1992).

Figure 1-10 *Rhinacanthus nasutus* (L.) Kurz (original picture)

1.6.10 *Sapindus rarak* DC.

Sapindus rarak DC. (Sapindaceae; synonyms: *Sapindus emarginatus* Wall.), its common names are Cha-sae, Sa-le-de (Karen-Mae Hong Son); Makhum-dee-khwaai (Central, Peninsular); Prakhum-dee-khwaai, Sompoi-thet, Masak (Northern); Soap nut tree, Soapberry (English) and Ritha (Nepali). This plant is found in the altitude range of 1000 - 1200 m. subtropical in dry and open sites. Seeds are used as soaps and they are eaten (Gyeltshen, *et al.*, 2005).

A description of *Sapindus rarak* DC. is shown in Figure 1-11. This plant is a medium size tree, 5-10 m high, having the top broad and densely foliaged. Bark is smooth or fissured and grayish-brown. Leaves are pari- or imparipinnate, ranging up to 1½ ft. Leaflets are oblong-lanceolate or subfalcate, 6-10 by 2-3 cm, having base acute and unequal, acuminate at apex; margin entire; glabrous when adult. Petioles are not winged. Panicles are tawny-velvety about 6-14 in. Flowers are small, white or pale yellow, about 1/5 in., in terminal panicles, widely branched, consisting of short yellowish hair; sex separate; sepals 4 or 5, petals 5, both densely appressed-pubescent on the outside; stamens 8, filaments long-hairy. Ovary is 3-loculed with ovule in each locule. Fruit are mostly globose, 2 cm in. diameter, wrinkled, brown, with round black seed (Hooker, 1875; Farnsworth and Bunyapraphatsara, 1992).

Figure 1-11 *Sapindus rarak* DC. (from http://www.aidsthai.org/module/module20/webadmin/images/mkd.jpg, 2006)

1.6.11 *Smilax corbularia* Kunth

Smilax corbularia Kunth is a member of Smilacaceae and its synonyms are *S. hypoglauca* Benth, *S. corbularia* Kunth var. *hypoglauca* (Benth) T.Koyama, *S. peguana* A.DC., *S. balansaeana* H.Bon ex Gagnep., *S. pseudochina* Lour. Its Thai vernacular names are Hua Khao Yen Wok, Hua Khao Yen Nuea. It is rather widely distributed in South-Eastern Asia from Southern China and upper Burma through Thailand and Indonesia southwards to the Malaysian Peninsula and South Eastwards to Borneo (Koyama, 1975). It is found in tropical evergreen and lower mountain forest from sea level to ca. 2000 m. In Thailand, the rhizome is used to treat venereal disease (Perry, 1980) and cancer (Vimonkunakorn, 1979; Pornsiriprasert, *et al*., 1986).

The description of *S. corbularia* Kunth which is shown in Figure 1-12 is a small herb climber up 2 to 4 m long; with woody stem and dense branches. The branches are straight with internodes 3-10 cm long. Leaves are highly variable in shape and thickness. The blades are elliptic, cuneate, rounded or shallowly cordate at the base with a coriaceous, acuminate tip at the apex, and about 3-10 cm long by 1.5-5 cm wide. They are fresh-green and shiny on the upper surface, and strongly glaucous and more or less white-powdery on the lower side. Petioles are short, about 7-15 mm long and the tendrils develop only on sterile branches and stems. Flowering branches are 5-20 cm long and upper leaves reduced to bracts. The umbels with peduncles are 5-12 mm long. The staminate umbels have 10 to 40 flowers and the pistillate umbels have 8 to 20 flowers. The stamens have reddish perianth with free petals. There are 6 nearly sessile stamens with the elliptic anther, 1.3 mm long. The pistillate has a greenish to yellowish perianth, 1.5-2 mm long, with oblique petals. The ovary is ellipsoid, contracted at the apex, 2 mm long, 1.5 mm wide, capped with 3-lobed stigma. There are 3 needle-like staminodes, 1.25 mm long. Berries are globose, purplish-black, 6-8 mm across with 1 to 3 seeds (Koyama, 1975)

Figure 1-12 *Smilax corbularia* Kunth (original picture)

1.6.12 *Strychnos nux-vomica* Linn

Strychnos nux-vomica Linn is in the Strychanaceae family, its common names are Nux-vomica tree, Snake wood, Poison Nut, Semen strychnos, Quaker Buttons (English) and Kra-gee, Kra-kling, Toom-kadang, Sahlang-tom, Sahlang-ji (Thai). It is distributed throughout tropical India. This plant is found in the altitude range of 0 - 4000 m. Nux-Vomica contains the alkaloids, Strychnine and Brucine, also traces of strychnicine, and a glucoside Loganin, about 3 percent fatty matter, caffeotannic acid and a trace of copper. The pulp of the fruit contains about 5 percent of loganin together with the alkaloid strychnicine. The dry seeds are called "Goge-kra-kling", have a bitter taste, and are used as a stimulant on the gastro-intestinal tract, for increasing appetite and a cardiotonic but it is highly toxic in high dosages. It is not widely used as a drug but used for rat's bane (Hooker, 1883; Grieve, 2005; The government Pharmaceutical Organization, 2005)

Description of *Strychnos nux-vomica* Linn is shown in Figure 1-13. This plant is a medium-sized tree (40 ft.) with a short, crooked, thick trunk, the wood is white hard, close grained, durable and the root is very bitter. Branches are irregular, covered with a smooth ash-colored bark. The young shoots are deep green and shiny. Leaves are opposite, obtuse base, about 3½ by 2 in. with 1/5 in. of petiole. Peduncles are 1/2-2 in. with 1-2 in diameter of cymes. The flowers are small, greenywhite, funnel shaped, in small terminal cymes, blooming in the cold season and having a disagreeable smell. The corolla-tube is 1/4-1/2 in. and the lobes are glabrous and less than 1/6 in. with a few hairs lower down the tube. Anther-cells are glabrous and oblong. The style is glabrous, long with a small capitate stigma. The fruit is about the size of a large apple with a smooth hard rind or shell which when ripe is a lovely orange color, filled with a soft white jelly-like pulp containing five seeds covered with a soft woolly-like substance, white and horny internally. The seeds are discoid about 1/2 in. diameter. They have the shape of flattened disks densely covered with closely appressed satiny hairs, radiating from the centre of the flattened sides and giving to the seeds a characteristic sheen. They are very hard, with a dark grey horny endosperm in which the small embryo is embedded; no odor but a very bitter taste (Hooker, 1883; Grieve, 2005).

Figure 1-13 *Strychnos nux-vomica* Linn (original picture)

1.7 Chemical constituents of the investigated species

The reports of chemical constituents of these twelve plants are shown in Table 1-1 to 1-11. Their chemical structures are showed in Figure 1-14 to 1-23.

Table 1-1 Chemical constituents found in *Bridelia ovata* Dence.

Botanical name	Part of plant used	Chemical constituents	References
B. ovata	Branches	Campesterol (1)	Boonyaratavej *et al.*, 1992
		Cinnamic acid (2)	Boonyaratavej *et al.*, 1992
		Friedelin (139)	Boonyaratavej *et al.*, 1992
		β-Sitosterol (3)	Boonyaratavej *et al.*, 1992
		Stigmasterol (4)	Boonyaratavej *et al.*, 1992

Table 1-2 Chemical constituents found in *C. zedoaria* (Berg.) Roscoe

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	Curcumin (5)	Syu *et al.*, 1998
		Bisdemethoxycurcumin (6)	Syu *et al.*, 1998; Matsuda *et al.*, 1998
		Demethoxycurcumin (7)	Syu *et al.*, 1998
		3,7-Dimethylindan-5-carboxylic acid (8)	Syu *et al.*, 1998
		Guaidiol (9)	Syu *et al.*, 1998
		Camphene (10)	Mau *et al.*, 2003
		Camphor (11)	Mau *et al.*, 2003
		1,8-Cineole (12)	Mau *et al.*, 2003
		α-Pinene (13)	Mau *et al.*, 2003
		β-Pinene (14)	Mau *et al.*, 2003
		α-Terpineol (15)	Mau *et al.*, 2003
		β-Bisabolene (16)	Mau *et al.*, 2003
		α-Curcumene (17)	Mau *et al.*, 2003
		β- Turmerone (18)	Mau *et al.*, 2003; Lee *et al.*, 2002; Hong *et al.*, 2001

Table 1-2 (continued)

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	Zingiberene (19)	Mau *et al.*, 2003
		α-Cadinol (20)	Mau *et al.*, 2003
		β-Elemene (21)	Mau *et al.*, 2003
		γ- Elemene (22)	Mau *et al.*, 2003
		β-Elemenone (23)	Mau *et al.*, 2003
		Elemol (24)	Mau *et al.*, 2003
		Calarene (25)	Mau *et al.*, 2003
		α-Calacorene (26)	Mau *et al.*, 2003
		α-Selinene (27)	Mau *et al.*, 2003
		β- Selinene (28)	Mau *et al.*, 2003
		Germacrene B (29)	Mau *et al.*, 2003
		5-Isopropylidene-3,8-dimethyl-1 (5H)-azulenone (30)	Mau *et al.*, 2003
		Isospathulenol (31)	Mau *et al.*, 2003
		Spathulenol (32)	Mau *et al.*, 2003
		β-Farnesene (33)	Mau *et al.*; 2003

Table 1-2 (continued)

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	α-Humulene (34)	Mau *et al*., 2003
		2-Decanone (35)	Mau *et al*., 2003
		Farnesol (36)	Mau *et al*., 2003
		2-Nonanone (37)	Mau *et al*., 2003
		2-Undecanone (38)	Mau *et al*., 2003
		Furanodiene (39)	Matsuda *et al*., 1998
		Zederone (40)	Matsuda *et al*., 1998; Kouno and Kawano, 1985
		Germacrone (41)	Matsuda *et al*., 1998; Sakui *et al*., 1992
		13-Hydroxygermacrone (42)	Matsuda *et al*., 1998; Shiobara *et al*., 1985
		Curdione (43)	Matsuda *et al*., 1998
		Dehydrocurdione (44)	Matsuda *et al*., 1998
		Neocurdione (45)	Matsuda *et al*., 1998

Table 1-2 (continued)

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	Curcumenol (46)	Matsuda *et al.*, 1998; Hikino *et al.*, 1968
		Isocurcumenol (47)	Matsuda *et al.*, 1998
		Isoprocurcumenol (48)	Matsuda *et al.*, 1998; Hikino *et al.*, 1968
		Aerugidiol (49)	Matsuda *et al.*, 1998
		Zedoarondiol (50)	Matsuda *et al.*, 1998; Kouno and Kawano, 1985
		Curcumenone (51)	Matsuda *et al.*, 1998; Shiobara *et al.*, 1985
		Zedoarofuran (52)	Matsuda *et al.*, 2001
		(+)-Germacrone-4,5-epoxide (53)	Matsuda *et al.*, 2001
		Glechomanolide (54)	Matsuda *et al.*, 2001
		Gajutuslactone A (55)	Matsuda *et al.*, 2001
		Bisacumol (56)	Matsuda *et al.*, 2001a
		Bisacurone (57)	Matsuda *et al.*, 2001a

Table 1-2 (continued)

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	Curcumenolactone A (58)	Matsuda *et al*., 2001a
		Curcumenolactone B (59)	Matsuda *et al*., 2001a
		Curcumenolactone C (60)	Matsuda *et al*., 2001a
		β-Eudesmol (61)	Matsuda *et al*., 2001a
		Isofuranodienone (62)	Matsuda *et al*., 2001a
		Alismoxide (63)	Matsuda *et al*., 2001a
		7α, 11α-Epoxy-5β-hydroxy 9-guaiaen-8-one (64)	Matsuda *et al*., 2001a
		Isozedoarondiol (65)	Matsuda *et al*., 2001a
		Zedoalactone B (66)	Matsuda *et al*., 2001a
		Curcumadione (67)	Matsuda *et al*., 2001a
		4-Epicurcumenol (68)	Matsuda *et al*., 2001b
		β-Dictyopterol (69)	Matsuda *et al*., 2001b
		ar-Turmerone (70)	Matsuda *et al*., 2001b; Lee *et al*., 2002; Hong *et al*., 2001
		Zedoarolide B (71)	Matsuda *et al*., 2001b

Table 1-2 (continued)

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	Neocurcumenol (72)	Matsuda *et al*., 2001b
		Zedoarolide A (73)	Matsuda *et al*., 2001b
		ar-Curcumene (74)	Tang and Eisenbrand, 1992
		β- Curcumene (75)	Tang and Eisenbrand, 1992
		Curcumanolide A (76)	Shiobara *et al*., 1985
		Curcumanolide B (77)	Shiobara *et al*., 1985
		Curzeone (78)	Shiobara *et al*., 1985
		Zedoarol (79)	Shiobara *et al*., 1985
		Curzerene (Isofuranogermacrene) (80)	Hikino *et al*., 1968
		Procurcumenol (81)	Hikino *et al*., 1968
		Curzerenone (82)	Hikino *et al*., 1968
		Epicurzerenone (83)	Hikino *et al*., 1968
		Furanodienone (84)	Hikino *et al*., 1975
		Pyrocurzerenone (85)	Hikino *et al*., 1975

Table 1-2 (continued)

Botanical name	Part of plant used	Chemical constituents	References
C. zedoaria	Rhizomes	(4*S*,5*S*)-Germacrone-4,5-Epoxide (86)	Yoshihara *et al.*, 1984
		Curcarabranol A (87)	Yoshikawa *et al.*, 1998
		Curcarabranol B (88)	Yoshikawa *et al.*, 1998
		4*S*-Didydrocurcumenone (89)	Yoshikawa *et al.*, 1998
		Furanogermenone (90)	Shibuya *et al.*, 1987
		Curcumadiol (91)	Kouno and Kawano, 1985
		Curcumol (92)	Kouno and Kawano, 1985
		Polysaccharide	Evan, 2002; Kim *et al.*, 2000

Table 1-3 Chemical constituents found in *Derris scandens* (Roxb.) Benth

Botanical name	Part of plant used	Chemical constituents	References
D. scandens	Stems	Eturunagarone	Rao *et al.*, 1994
		Derrisisoflavones A (93)	Sekine *et al.*, 1999
		Derrisisoflavones B (94)	Sekine *et al.*, 1999
		Derrisisoflavones C (95)	Sekine *et al.*, 1999
		Derrisisoflavones D (96)	Sekine *et al.*, 1999
		Derrisisoflavones E (97)	Sekine *et al.*, 1999
		Derrisisoflavones F (98)	Sekine *et al.*, 1999
		Lupalbigenin (99)	Sekine *et al.*, 1999
		Scandinone (100)	Sekine *et al.*, 1999; Mahabusarakam *et al.*, 2004
		Erysenegalensein E (101)	Sekine *et al.*, 1999
		Lupinisol A (102)	Sekine *et al.*, 1999
		Lupinisoflavone G (103)	Sekine *et al.*, 1999
		5, 7,4′ Trihydroxy-6, 8-diprenyliso-flavone (104)	Sekine *et al.*, 1999
		Derriscanoside A (105)	Dianpeng *et al.*, 1999

Table 1-3 (continued)

Botanical name	Part of plant used	Chemical constituents	References
D. scandens	Stems	Derriscanoside B (106)	Dianpeng *et al.*, 1999
		Derriscandenosides A (107) (Tetraacetate of 7,8-dihydroxy-4′-methoxyisoflavone 8-*O*-β-glucopyranoside)	Rukachaisirikul *et al.*, 2002
		Derriscandenosides B (108) (Heptaacetate of 7,8-dihydroxy-4′-methoxyisoflavone 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside)	Rukachaisirikul *et al.*, 2002
		Derriscandenosides C (109) (Hexaacetate of 8-hydroxy-4′, 7dimethoxyisoflavone 8-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside)	Rukachaisirikul *et al.*, 2002
		Derriscandenosides D (110) (Hexaacetate of afromosin 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside	Rukachaisirikul *et al.*, 2002

Table 1-3 (continued)

Botanical name	Part of plant used	Chemical constituents	References
D. scandens	Stems	Derriscandenosides E (111)	Rukachaisirikul *et al.*, 2002
		(Hexaacetate of irisolidone 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside	
		Diadzein 7-*O*-[α-rhamnopyranosyl (1→6)]-β-glucopyranoside (112)	Markham and Mabry, 1968; Rukachaisirikul *et al.*, 2002
		Formononetin 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside (113)	Parthasarathy *et al.*, 1976; Rukachaisirikul *et al.*, 2002
		Genistein 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside (114)	Guang *et al.*, 1998; Rukachaisirikul *et al.*, 2002
		Formononetin 7-*O*-β-glucopyranoside (115)	Cui *et al.*, 1993; Rukachaisirikul *et al.*, 2002
		8-Hydroxy-4′,7-dimethoxyisoflavone 8-*O*-β –glucopyranoside (116)	Fujita *et al.*, 1982; Rukachaisirikul *et al.*, 2002
		7-Hydroxy-4′,8-dimethoxyisoflavone 7-*O*-β-glucopyranoside (117)	Mitrocotsa *et al.*, 1999; Rukachaisirikul *et al.*, 2002

Table 1-3 (continued)

Botanical name	Part of plant used	Chemical constituents	References
D. scandens	Stems	Scandenal (118) (3′-formyl-4′,5 dihydroxy 2″, 2″ dimethylchromeno [6,7:5″,6″] isoflavone)	Mahabusarakam *et al*., 2004
		Scanderone (119) (4′,5-Dihydroxy-3′-prenyl-2″,2″ dimethylchromeno-[7,8:6″,5″] isoflavone	Mahabusarakam *et al*., 2004
		Flemichapparin B (120)	Lin *et al*., 1991; Mahabusarakam *et al*., 2004
		Flemichapparin C (121)	Aditachaudhury and Gupta, 1986; Mahabusarakam *et al*., 2004
		Isorobustone (122)	Garcia *et al*., 1986; Mahabusarakam *et al*., 2004

Table 1-3 (continued)

Botanical name	Part of plant used	Chemical constituents	References
D. scandens	Stems	5-Hydroxy-2'',2''-dimethylchromeno [6,7:5'',6''] 2''',2''' dimethylchromeno [3',4':5''',6'''] isoflavone (123)	Maximo *et al.*, 2000; Mahabusarakam *et al.*, 2004
		Ulexone A (124)	Maximo *et al.*, 2000; Mahabusarakam *et al.*, 2004
		Chandalone (125)	Falshaw *et al.*, 1969; Mahabusarakam *et al.*, 2004
		Maackiain (126)	Obara and Matsubara, 1981; Mahabusarakam *et al.*, 2004
		Isochandalone (127)	Tahara *et al.*, 1989; Mahabusarakam *et al.*, 2004

Table 1-3 (continued)

Botanical name	Part of plant used	Chemical constituents	References
D. scandens	Stems	Santal (128)	Bohm and Choy, 1987; Mahabusarakam *et al.*, 2004
		Lupiwighteone (129)	Hakamatsuka *et al.*, 1991; Mahabusarakam *et al.*, 2004
		3′-Methylorobol (130)	Kikuchi *et al.*, 1989; Mahabusarakam *et al.*, 2004
		Genistein (131)	Sang and Min, 2000; Mahabusarakam *et al.*, 2004
		Scandione (132) (2′,2″-dihydroxy-4′-methoxy 4″,5″ methyl enedioxybenzil)	Mahabusarakam *et al.*, 2004

Table 1-4 Chemical constituents found in *Dioscorea membranacea* Pierre

Botanical name	Part of plant used	Chemical constituents	References
D. membranacea	Rhizomes	Dioscorealide A (133)	Itharat *et al*., 2003
		Dioscorealide B (134)	Itharat *et al*., 2003
		Dioscoreanone (135)	Itharat *et al*., 2003
		Stigmasterol (4)	Itharat, 2002
		β-Sitosterol (3)	Itharat, 2002
		Diosgenin 3-*O*-α-*L*-rhamnopyranosyl (1→2)-β-*D* glucopyranoside (prosapogenin A of dioscin) (136)	Itharat, 2002
		Diosgenin 3-*O*-β-*D*-glucopyranosyl (1→3)-β-*D* glucopyranoside (prosapogenin of gracillin) (137)	Itharat, 2002
		β-sitosterol 3-*O*-β-*D*-glucopyranoside (138)	Itharat, 2002

Table 1-5 Chemical constituents found in *Drynaria quercifolia* Linn

Botanical name	Part of plant used	Chemical constituents	References
D. quercifolia	Rhizomes	Friedelin (139)	Ramesh *et al.*, 2001
		Epifriedelinol	Ramesh *et al.*, 2001
		β-Amyrin (140)	Ramesh *et al.*, 2001
		β-Sitosterol (3)	Ramesh *et al.*, 2001
		β-Sitosterol 3-β-D-glucopyranoside	Ramesh *et al.*, 2001
		Naringin (141)	Ramesh *et al.*, 2001

Table 1-6 Chemical constituents found in *Moringa oleifera* Lamk

Botanical name	Part of plant used	Chemical constituents	References
M. oleifera	Seeds	*O*-Ethyl-4-(α-*L*-rhamnosyloxy) benzyl carbamate	Guevara *et al*., 1999
		4 (α-*L*-rhamnosyloxy)-benzyl isothiocyanate	Guevara *et al*., 1999
		Niazimicin	Guevara *et al*., 1999
		Niazirin (149)	Guevara *et al*., 1999
		β-Sitosterol (3)	Guevara *et al*., 1999
		Glycerol-1-(9-octadecanoate)	Guevara *et al*., 1999
		3-*O*-(6'-*O*-oleoyl-β-*D*-glucopyranosyl)-β-sitosterol	Guevara *et al*., 1999
		β-sitosterol-3-*O*-β-*D*-glucopyranoside	Guevara *et al*., 1999
		Cis-9-octadecenoic (oleic acid) (142)	Vlahov *et al*., 2002; Tsaknis *et al*., 1999
		Cis-11-eicosenoic acid (143)	Vlahov *et al*., 2002

Table 1-6 (continued)

Botanical name	Part of plant used	Chemical constituents	References
M. oleifera	Seeds	Cis-11-octadecenoic acid (vaccenic acid) (144)	Vlahov *et al.*, 2002
		Behenic acid (145)	Tsaknis *et al.*, 1999
		Palmitic acid (146)	Tsaknis *et al.*, 1999
		β-sitosterol (3)	Tsaknis *et al.*, 1999
		Stigmasterol (4)	Tsaknis *et al.*, 1999
		Campesterol (1)	Tsaknis *et al.*, 1999
	Leaves	α-Tocopherol (147)	Ching and Mohamed, 2001
		Niazirinin (148)	Faizi *et al.*, 1994
		Niazirin (149)	Faizi *et al.*, 1994
		4-[(4'-*O*-acetyl-α-*L*-rhamnosyloxy) benzyl] isothiocyanate (150)	Faizi *et al.*, 1994
		Niaziminin A	Faizi *et al.*, 1994
		Niaziminin B	Faizi *et al.*, 1994
	Freeze-dried leaves	(+)-Catechin (151)	Siddhuraju and Becker, 2003
		(-)-Epicatechin (152)	Siddhuraju and Becker, 2003

Table 1-6 (continued)

Botanical name	Part of plant used	Chemical constituents	References
M. oleifera	Freeze-dried leaves	Ferulic acid (153)	Siddhuraju and Becker, 2003
		Ellagic acid (154)	Siddhuraju and Becker, 2003
		Myricetin (155)	Siddhuraju and Becker, 2003
		Quercetin (156)	Siddhuraju and Becker, 2003
		Butein (157)	Siddhuraju and Becker, 2003
		Apigenin (158)	Siddhuraju and Becker, 2003
		Kaempferol (159)	Siddhuraju and Becker, 2003
		Isorhamnetin (160)	Siddhuraju and Becker, 2003
		Rhamnetin (161)	Siddhuraju and Becker, 2003
	Dehydrated leaves	Vitamin A (162)	Nambiar *et al.*, 2003

Table 1-7 Chemical constituents found in *Nardostachys jatamansi* DC

Botanical name	Part of plant used	Chemical constituents	References
N. jatamansi	-	Norseychelanone	Rücker *et al.*, 1976
	-	β-Patchoulenes	Rücker *et al.*, 1976
	-	Patchouli alcohol	Rücker *et al.*, 1976
	Roots	Calarenol (163)	Sastry *et al.*, 1967a
		Dihydrocalarenol (164)	Sastry *et al.*, 1967a
		Calarane (165)	Sastry *et al.*, 1967a
		Calarene (166)	Sastry *et al.*, 1967a
		Nardostachone (167)	Sastry *et al.*, 1967b
		Tetrahydronardostachone (168)	Sastry *et al.*, 1967b
		Tetrahydro nardostachol (169)	Sastry *et al.*, 1967b
		Tetrahydronardostachane (170)	Sastry *et al.*, 1967b
		Jatamansin (171)	Shanbhag *et al.*, 1964
		Oroselol (172)	Shanbhag *et al.*, 1964
		Dihydrojatamansin (173)	Shanbhag *et al.*, 1964
		Jatamansinol (174)	Shanbhag *et al.*, 1964
		Seselin (175)	Shanbhag *et al.*, 1964

Table 1-7 (continued)

Botanical name	Part of plant used	Chemical constituents	References
N. jatamansi	Roots	Dihydroseselin (176)	Shanbhag *et al.*, 1964
		Jatamansinone (177)	Shanbhag *et al.*, 1964
		Angelicin (178)	Shanbhag *et al.*, 1965
		Diketone (179)	Shanbhag *et al.*, 1965
		Monoacetyl khellactone (180)	Shanbhag *et al.*, 1965
		Khellactone (181)	Shanbhag *et al.*, 1965
		Nardostachysin	Chatterjee *et al.*, 2000

Table 1-8 Chemical constituents found in *Rhinacanthus nasutus* (L.) Kurz

Botanical name	Part of plant used	Chemical constituents	References
R. nasutus	Roots	Rhinacanthin-A (182)	Wu *et al*., 1988; Wu *et al*., 1998a; Wu *et al*., 1998b; Singh *et al*., 1992.
		Rhinacanthin-B (183)	Wu *et al*., 1988; Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-G (184)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-H (185)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-K (186)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-L (187)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-M (188)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-O (189)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-P (190)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-Q (191)	Wu *et al*., 1998b
		Dehydro-α-lapachone	Wu *et al*., 1998a; Wu *et al*., 1998b
		p-Hydroxy-benzaldehyde (192)	Wu *et al*., 1998b
		Methyl vanilate	Wu *et al*., 1998b
		Syringaldehyde (193)	Wu *et al*., 1998b

Table 1-8 (continued)

Botanical name	Part of plant used	Chemical constituents	References
R. nasutus	Roots	β-Amyrin (140)	Wu *et al*., 1995
		Glutinol	Wu *et al*., 1995
		Lupeol (194)	Wu *et al*., 1988; Wu *et al*., 1995; Wu *et al*., 1998b
		Wogonin (195)	Wu *et al*., 1998b
		Oroxylin A (196)	Wu *et al*., 1998b
		Stigmasterol (4)	Wu *et al*., 1988
		β-Sitosterol (3)	Wu *et al*., 1988
		(+)-Praeruptorin	Wu *et al*., 1998b
		Allantoin (197)	Wu *et al*., 1998b
	Leaves and roots	Rhinacanthin-J (198)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-I (199)	Wu *et al*., 1998a; Wu *et al*., 1998b
		Rhinacanthin-N (200)	Wu *et al*., 1998a; Wu *et al*., 1998b
	Leaves and stems	Rhinacanthone (201)	Kodama *et al*., 1993
		Vanillic acid (202)	Wu *et al*., 1995
		Syringic acid (203)	Wu *et al*., 1995

Table 1-8 Chemical constituents found in *Rhinacanthus nasutus* (L.) Kurz

Botanical name	Part of plant used	Chemical constituents	References
R. nasutus	Roots	Rhinacanthin-A (182)	Wu *et al.*, 1988; Wu *et al.*, 1998a; Wu *et al.*, 1998b; Singh *et al.*, 1992.
		Rhinacanthin-B (183)	Wu *et al.*, 1988; Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-G (184)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-H (185)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-K (186)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-L (187)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-M (188)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-O (189)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-P (190)	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-Q (191)	Wu *et al.*, 1998b
		Dehydro-α-lapachone	Wu *et al.*, 1998a; Wu *et al.*, 1998b
		p-Hydroxy-benzaldehyde (192)	Wu *et al.*, 1998b
		Methyl vanilate	Wu *et al.*, 1998b
		Syringaldehyde (193)	Wu *et al.*, 1998b

Table 1-8 (continued)

Botanical name	Part of plant used	Chemical constituents	References
R. nasutus	Aerial parts	Rhinacanthin-F (207)	Kernan *et al.*, 1997
	Whole plants and roots	Rhinacanthin-C (209)	Sendl *et al.*, 1996; Wu *et al.*, 1998a; Wu *et al.*, 1998b
		Rhinacanthin-D (210)	Sendl *et al.*, 1996; Wu *et al.*, 1998a; Wu *et al.*, 1998b

Table 1-9 Chemical constituents found in *Sapindus rarak* DC

Botanical name	Part of plant used	Chemical constituents	References
S. rarak	Pericarps	Quebrachitol	Chag *et al.*, 1998
		Mukurozioside IIb	Chag *et al.*, 1998
	Fruits	Hederagenin 3-*O*-(2-*O*-Acetyl-β-*D*-xylopyranosyl)-(1→3)-α-*L*-rhamnopyranosyl-(1→2)-α-*L*-arabinopyranoside (211)	Kanchanapoom *et al.*, 2001
		23-*O*-Acetyl-hederagenin 3-*O*-(4-*O*-Acetyl-β-*D*-xylopyranosyl)-(1→3)-α-*L*-rhamnopyranosyl-(1→2)-α-*L*-arabinopyranoside (212)	Kanchanapoom *et al.*, 2001
		Oleanolic Acid 3-*O*-(4-*O*-Acetyl-β-*D*-xylopyranosyl)-(1→3)-α-*L*-rhamnopyranosyl-(1→2)-α-*L*-arabinopyranoside (213)	Kanchanapoom *et al.*, 2001

Table 1-10 Chemical constituents found in *Smilax corbularia* Kunth

Botanical name	Part of plant used	Chemical constituents	References
S. corbularia	Rhizomes	Diosgenin	Sukdayan *et al.*, 1985

Table 1-11 Chemical constituents found in *Strychnos nux-vomica* L.

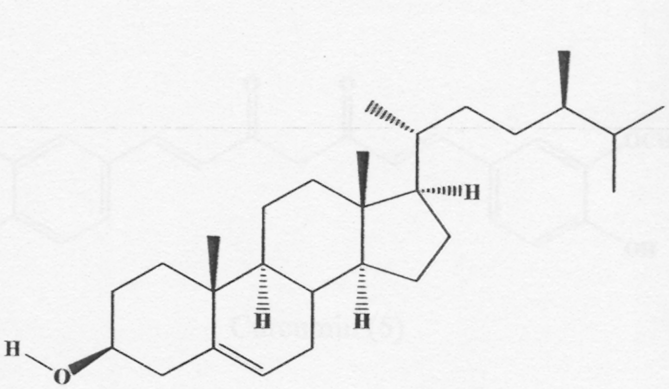
Botanical name	Part of plant used	Chemical constituents	References
S. nux-vomica	Seeds and stems	Strychnine (214)	Frédérich *et al*., 2003; Baser *et al*., 1979; Yang and Yan, 1993; Nicoletti *et al*., 1979
		Brucine (215)	Frédérich *et al*., 2003; Baser *et al*., 1979; Nicoletti *et al*., 1979
		Protostrychnine	Baser *et al*., 1979
	Seeds	β-Colubrine (216)	Yang and Yan, 1993; Nicoletti *et al*., 1979
		Pseudostrychnine (217)	Yang and Yan, 1993; Nicoletti *et al*., 1979
		Strychnine N-oxide (218)	Yang and Yan, 1993
		Brucime	Yang and Yan, 1993
		Brucine N-oxide (219)	Yang and Yan, 1993
		Novacine (220)	Yang and Yan, 1993; Nicoletti *et al*., 1979

Table 1-11 (continued)

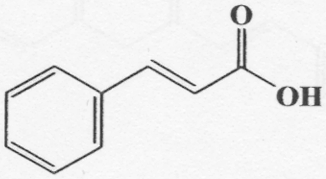
Botanical name	Part of plant used	Chemical constituents	References
S. nux-vomica	Seeds	Vomicine (221)	Yang and Yan, 1993; Nicoletti *et al.*, 1979
		Icajine (222)	Yang and Yan, 1993; Nicoletti *et al.*, 1979
		Isostrychnine	Yang and Yan, 1993
		Isobrucine N-oxide	Yang and Yan, 1993
		Isostrychnine N-oxide	Yang and Yan, 1993
		Isobrucine	Yang and Yan, 1993
		α-Colubrine (223)	Nicoletti *et al.*, 1979
		Pseudobrucine (224)	Nicoletti *et al.*, 1979
		3-Hydroxy-α-colubrine (225)	Nicoletti *et al.*, 1979
		3-Hydroxy-β-colubrine (226)	Nicoletti *et al.*, 1979
		15-Hydroxyicajine (227)	Nicoletti *et al.*, 1979
		15-Acetoxystrychnine (228)	Nicoletti *et al.*, 1979
		15-Hydroxystrychnine (229)	Nicoletti *et al.*, 1979
		6′-*O*-Acetylloganic acid (230)	Zhang *et al.*, 2003
		4′-*O*-Acetylloganic acid (231)	Zhang *et al.*, 2003

Table 1-11 (continued)

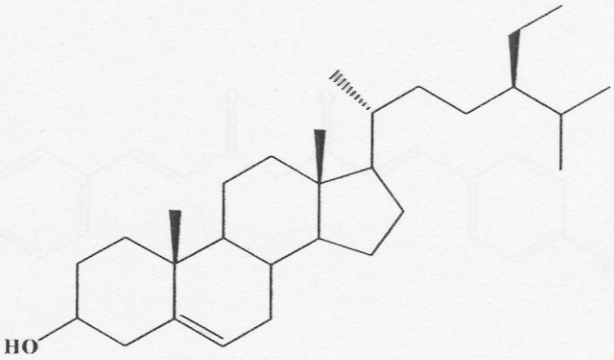
Botanical name	Part of plant used	Chemical constituents	References
S. nux-vomica	Seeds	3′-*O*-Acetylloganic acid (232)	Zhang *et al*., 2003
		Loganic acid (233)	Zhang *et al*., 2003
		7-*O*-Acetylloganic acid (234)	Zhang *et al*., 2003
		Polysaccharide	Corsaro *et al*., 1995
	Fruit pulps	Salidroside (235)	Bisset *et al*., 1989
		Cuchiloside	Bisset *et al*., 1989



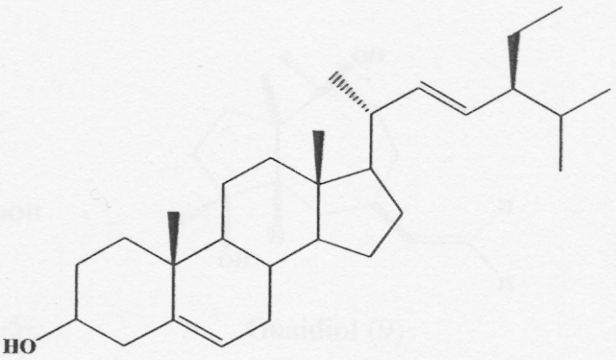
Campesterol (1)



Cinnamic acid (2)

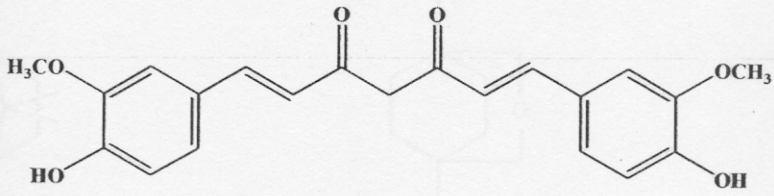


β-sitosterol (3)

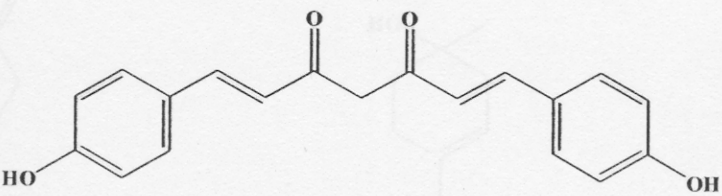


Stigmasterol (4)

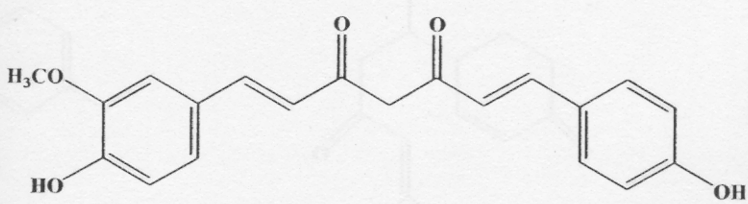
Figure 1-14 Structures of some chemical constituents found in *B. ovata*



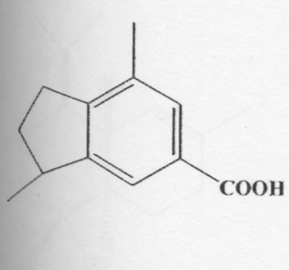
Curcumin (5)



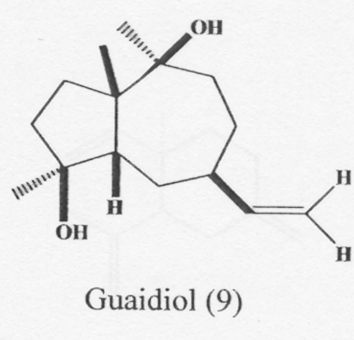
Bisdemethoxycurcumin (6)



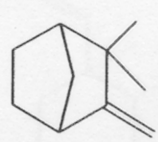
Demethoxycurcumin (7)



3,7-Dimethylindan-5-carboxylic acid (8)

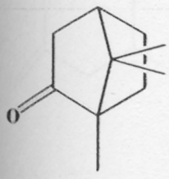


Guaidiol (9)

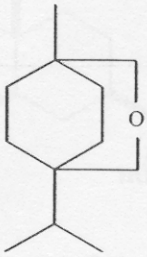


Camphene (10)

Figure 1-15 Structures of some chemical constituents found in *C. zedoaria*

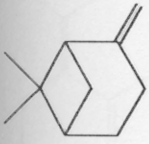


Camphor (11)

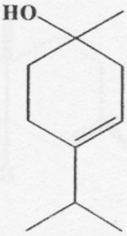


1,8-Cineole (12)

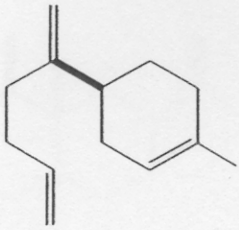
α-Pinene (13)



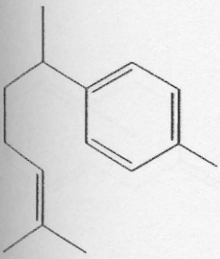
β-Pinene (14)



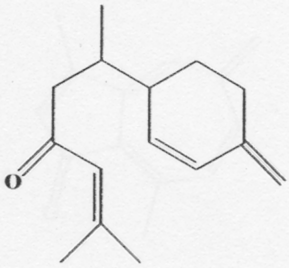
α-Terpineol (15)



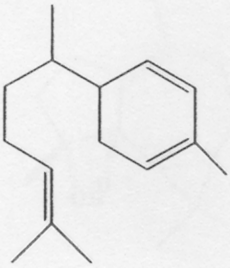
β-Bisabolene (16)



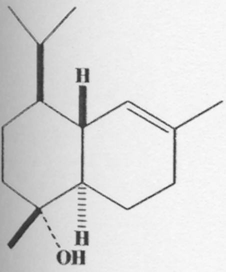
α-Curcumene (17)



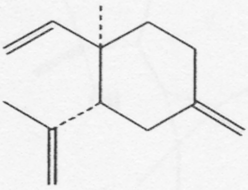
β-Turmerone (18)



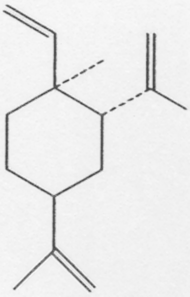
Zingiberene (19)



α-Cadinol (20)

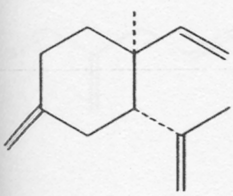


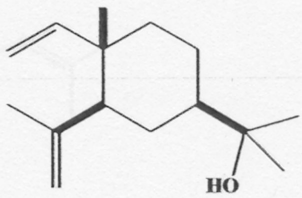
β-Elemene (21)

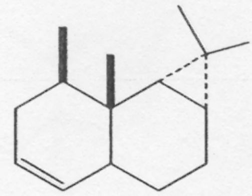


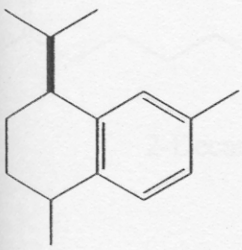
γ-Elemene (22)

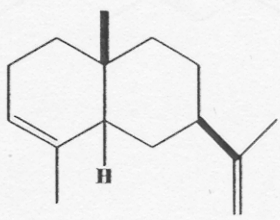
Figure 1-15 (continued)

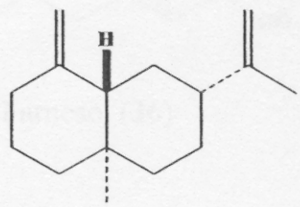

β-Elemenone (23)

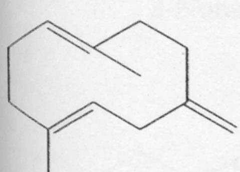

Elemol (24)

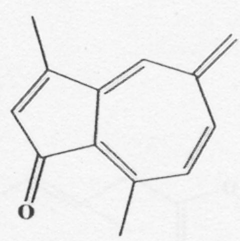

Calarene (25)

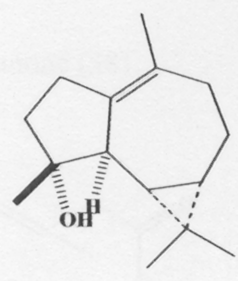

α-Calacorene (26)


α-Selinene (27)


β-Selinene (28)


Germacrene B (29)


5-Isopropylidene-3,8-dimethyl-1 (5H)-azulenone (30)


Isospathulenol (31)

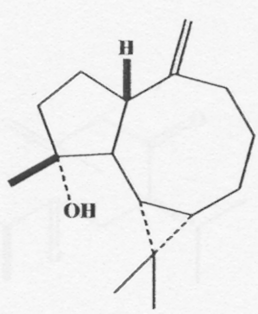
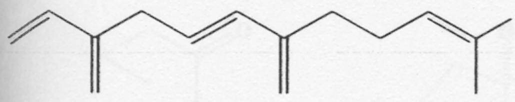
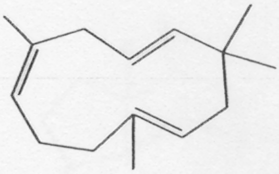

Spathulenol (32)

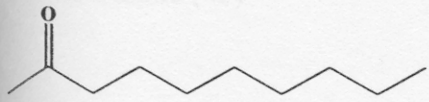
Figure 1-15 (continued)



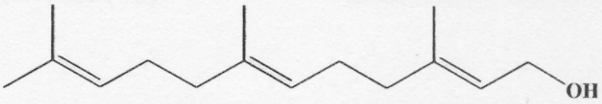
β-Farnesene (33)



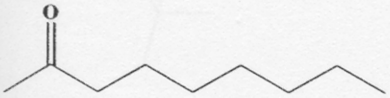
α-Humulene (34)



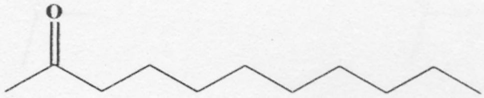
2-Decanone (35)



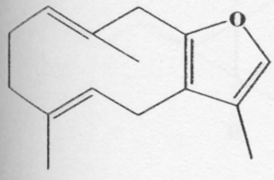
Farnesol (36)



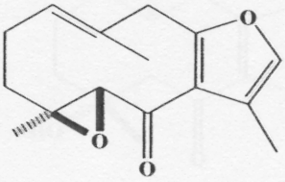
2-Nonanone (37)



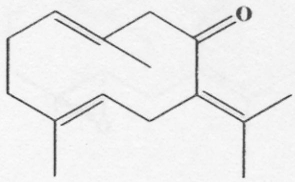
2-Undecanone (38)



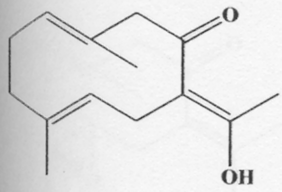
Furanodiene (39)



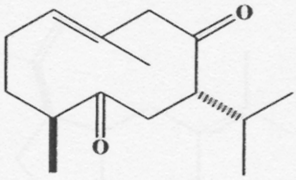
Zederone (40)



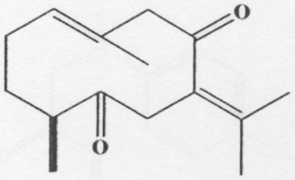
Germacrone (41)



13-Hydroxygermacrone (42)

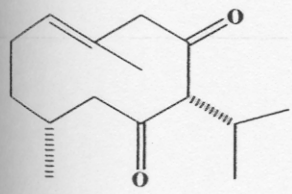


Curdione (43)

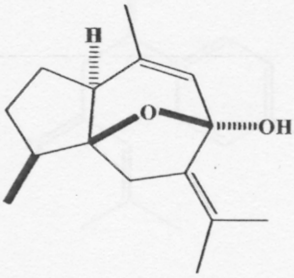


Dehydrocurdione (44)

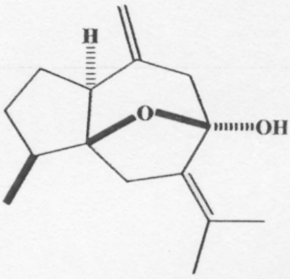
Figure 1-15 (continued)



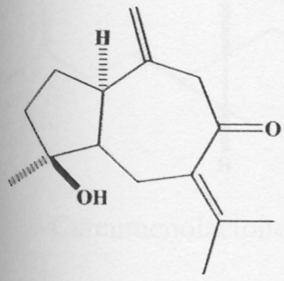
Neocurdione (45)



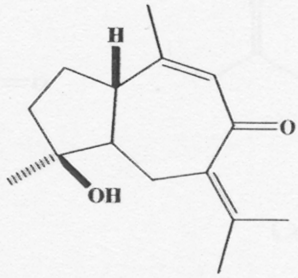
Curcumenol (46)



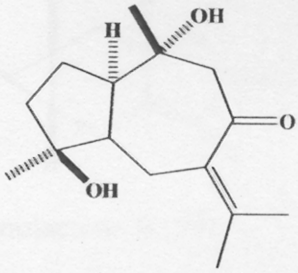
Isocurcumenol (47)



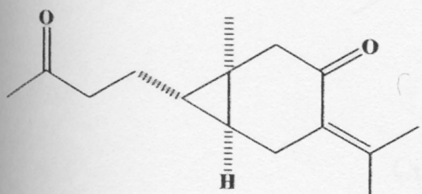
Isoprocurcumenol (48)



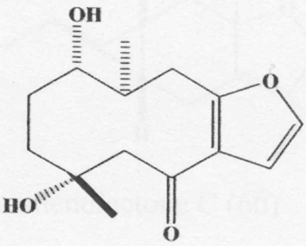
Aerugidiol (49)



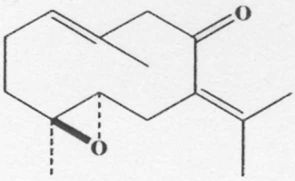
Zedoarondiol (50)



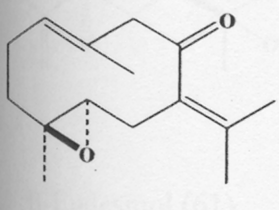
Curcumenone (51)



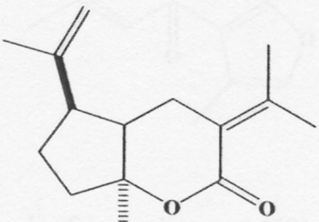
Zedoarofuran (52)



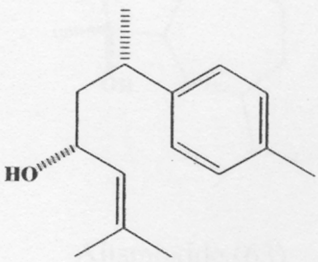
(+)-Germacrone-4,5-
Epoxide (53)



Glechomanolide (54)

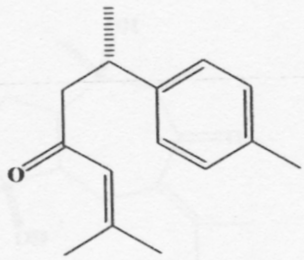


Gajutuslactone A (55)

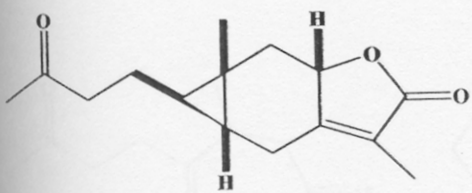


Bisacumol (56)

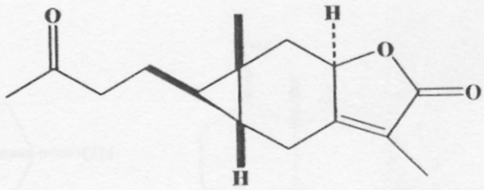
Figure 1-15 (continued)



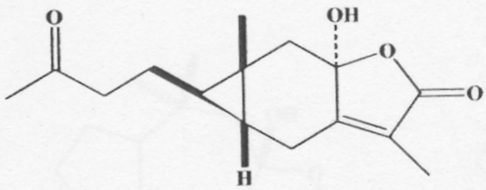
Bisacurone (57)



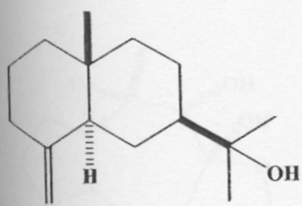
Curcumenolactone A (58)



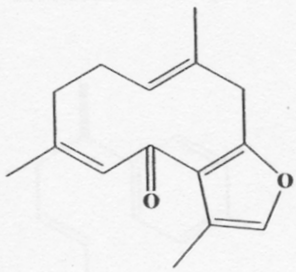
Curcumenolactone B (59)



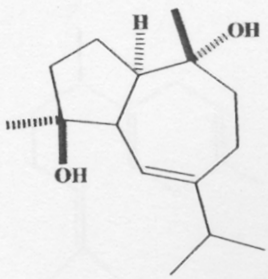
Curcumenolactone C (60)



β-Eudesmol (61)

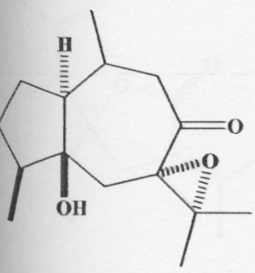


Isofuranodienone (62)

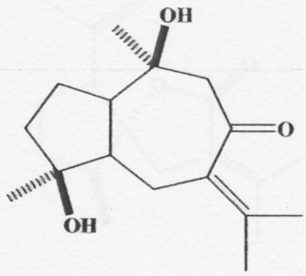


Alismoxide (63)

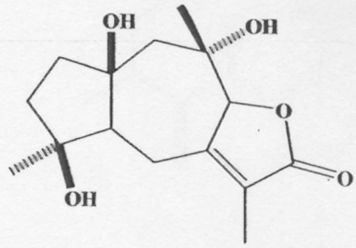
Figure 1-15 (continued)



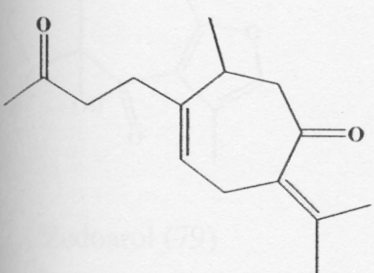
7α, 11α-Epoxy-5β-hydroxy 9-guaiaen-8-one (64)



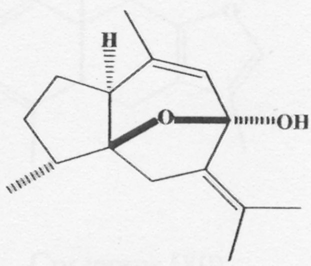
Isozedoarondiol (65)



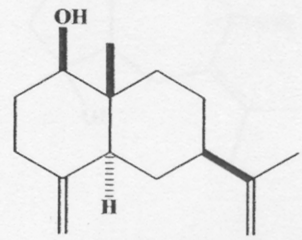
Zedoalactone B (66)



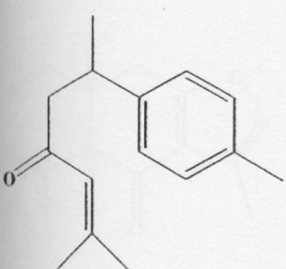
Curcumadione (67)



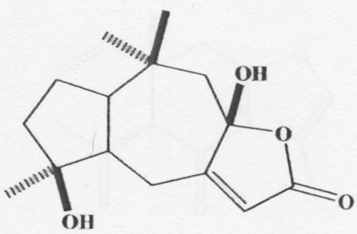
4-Epicurcumenol (68)



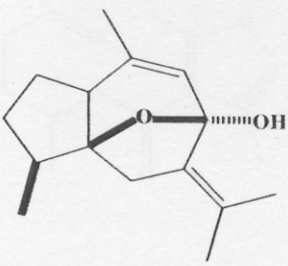
β-Dictyopterol (69)



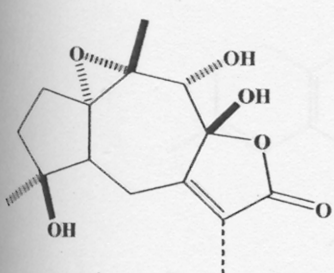
ar-Turmerone (70)



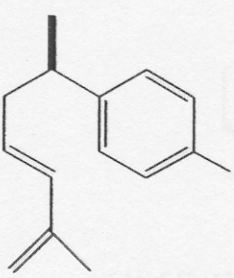
Zedoarolide B (71)



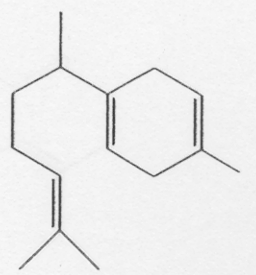
Neocurcumenol (72)



Zedoarolide A (73)

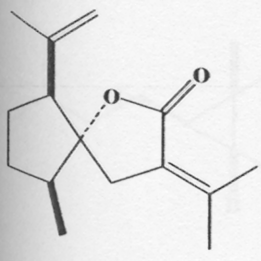


ar-Curcumene (74)

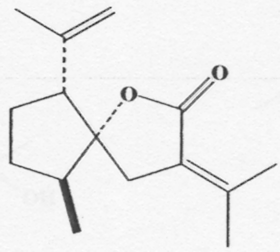


β- Curcumene (75)

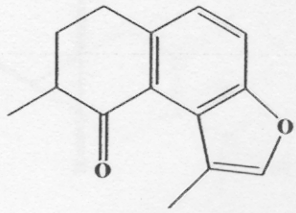
Figure 1-15 (continued)



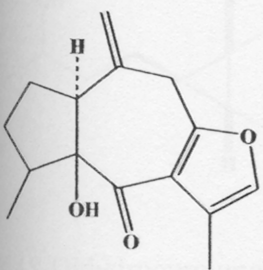
Curcumanolide A (76)



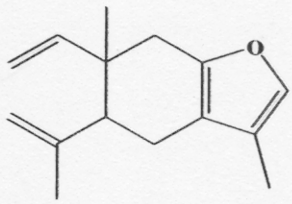
Curcumanolide B (77)



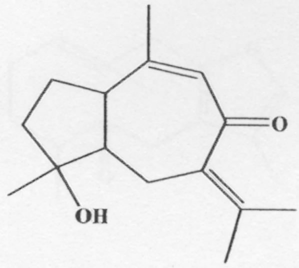
Curzeone (78)



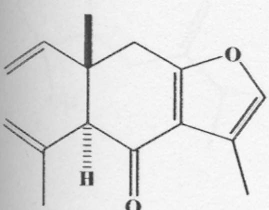
Zedoarol (79)



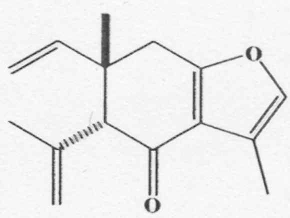
Curzerene (80)
(Isofuranogermacrene)



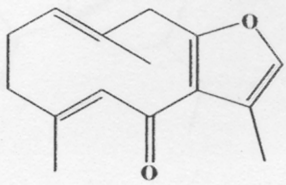
Procurcumenol (81)



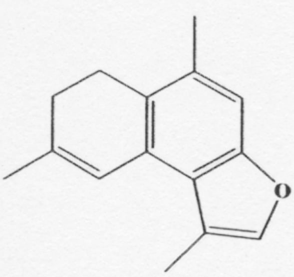
Curzerenone (82)



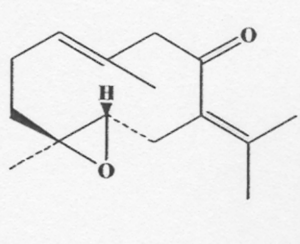
Epicurzerenone (83)



Furanodienone (84)

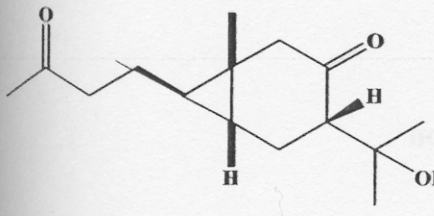


Pyrocurzerenone (85)

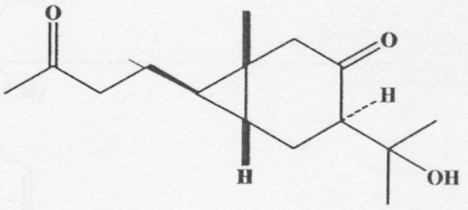


(4*S*,5*S*)-Germacrone 4,5-Epoxide (86)

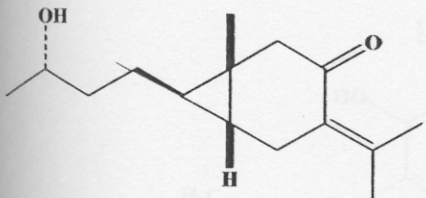
Figure 1-15 (continued)



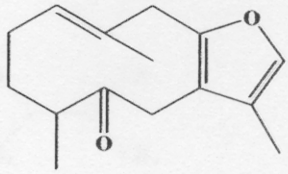
Curcarabranol A (87)



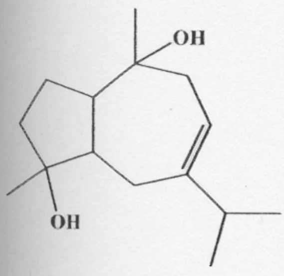
Curcarabranol B (88)



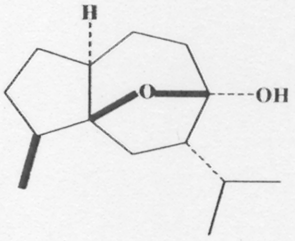
4*S*-Didydrocurcumenone (89)



Furanogermenone (90)

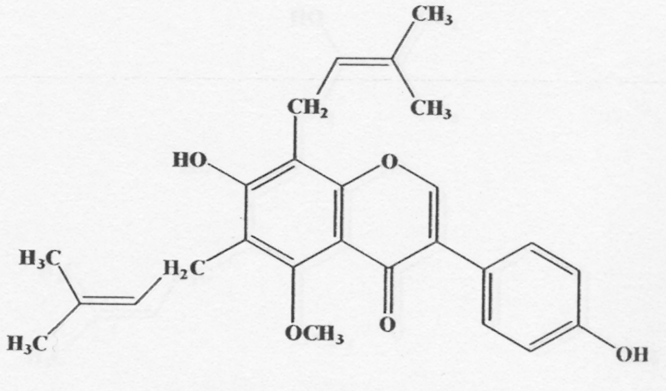


Curcumadiol (91)

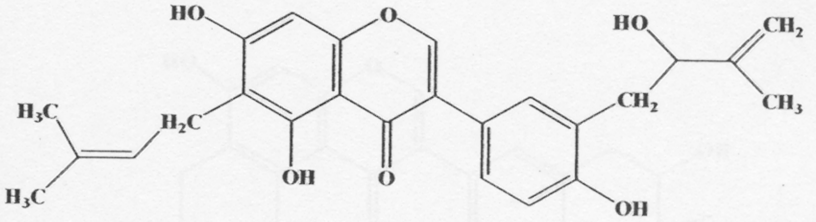


Curcumol (92)

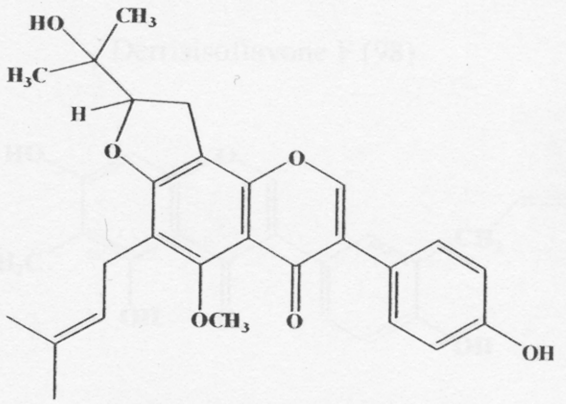
Figure 1-15 (continued)



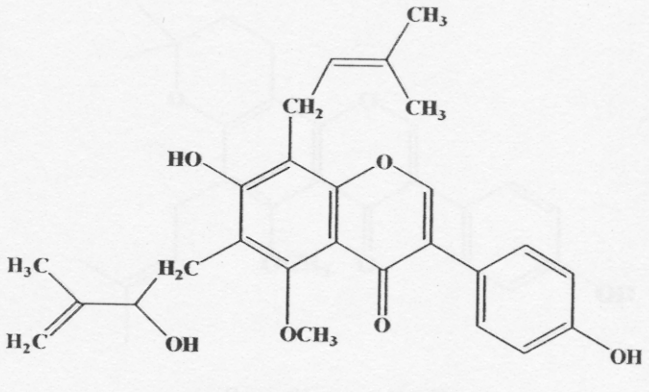
Derrisisoflavone A (93)



Derrisisoflavone B (94)

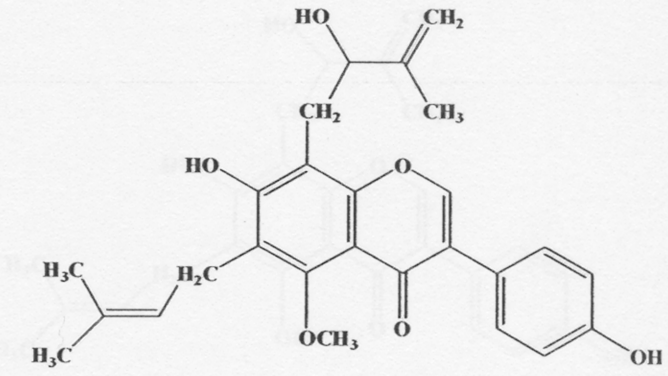


Derrisisoflavone C (95)

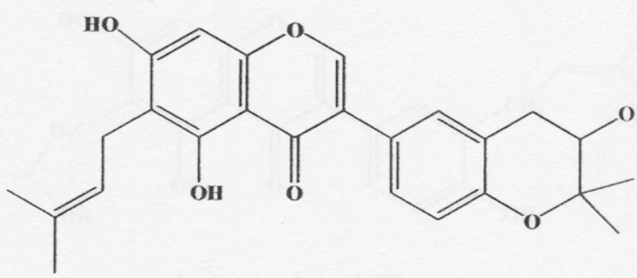


Derrisisoflavone D (96)

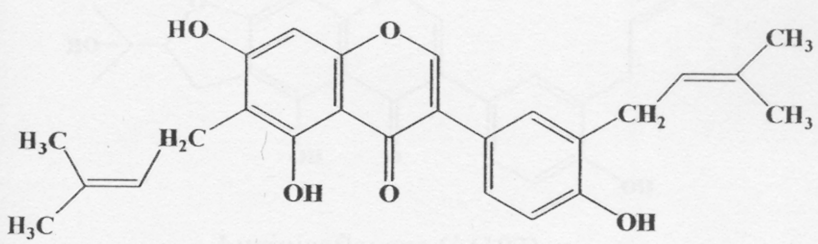
Figure 1-16 Structures of some chemical constituents found in *D. scandens*



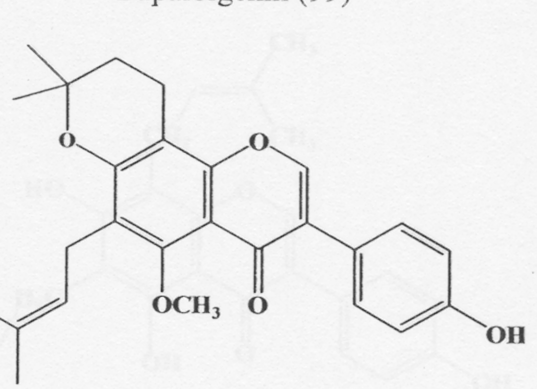
Derrisisoflavone E (97)



Derrisisoflavone F (98)

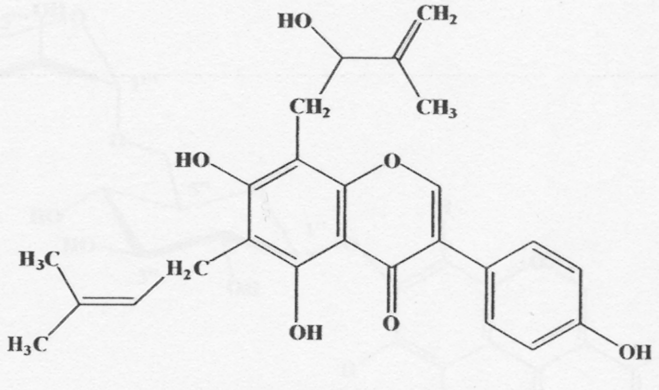


Lupalbigenin (99)

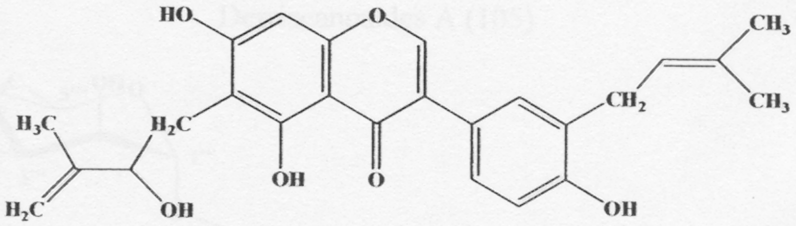


Scandinone (100)

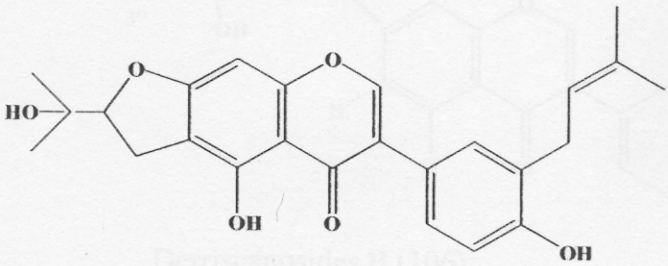
Figure 1-16 (continued)



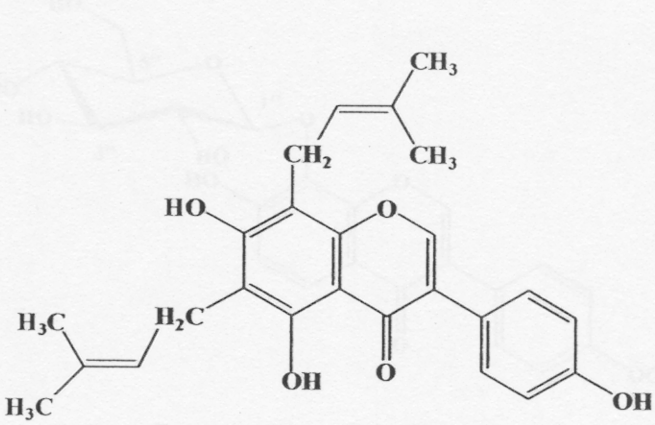
Erysenegalensein E (101)



Lupinisol A (102)

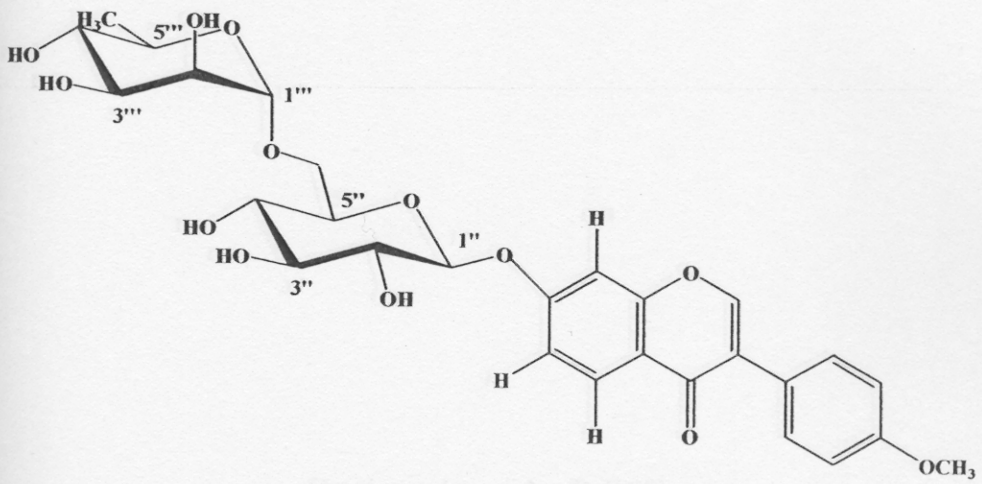


Lupinisoflavone G (103)

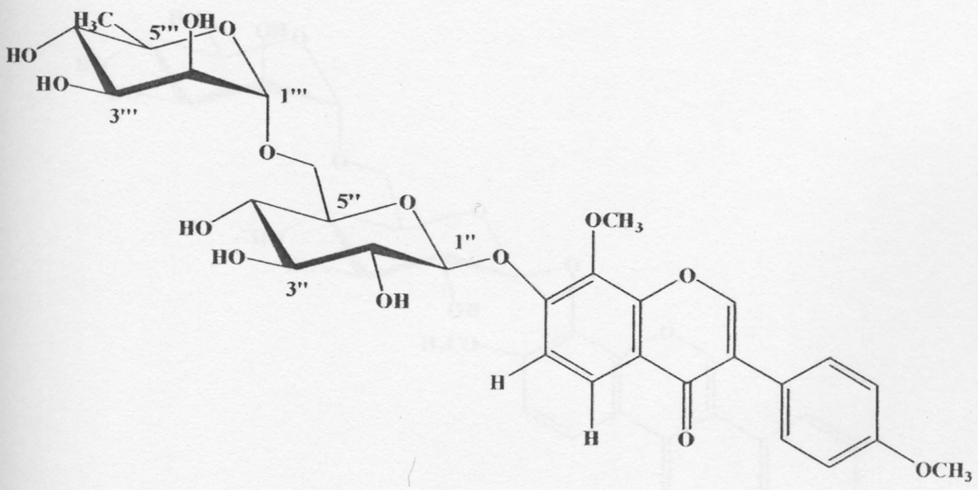


5, 7,4′ Trihydroxy-6, 8-diprenylisoflavone (104)

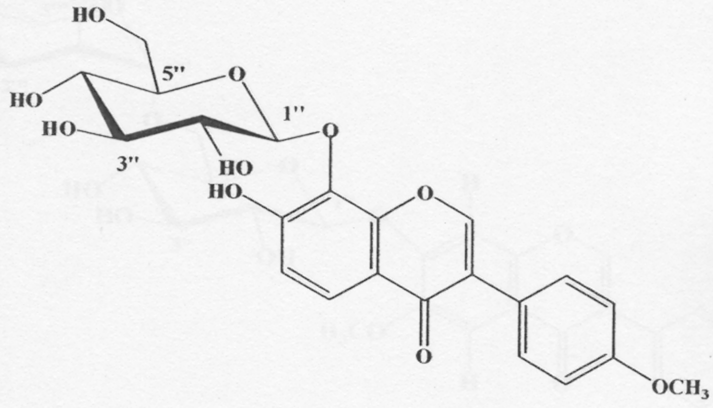
Figure 1-16 (continued)



Derriscanosides A (105)

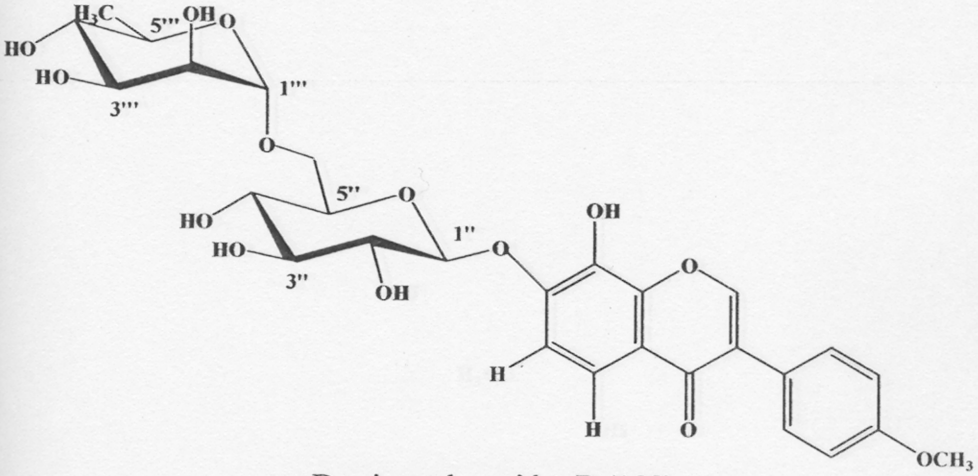


Derriscanosides B (106)

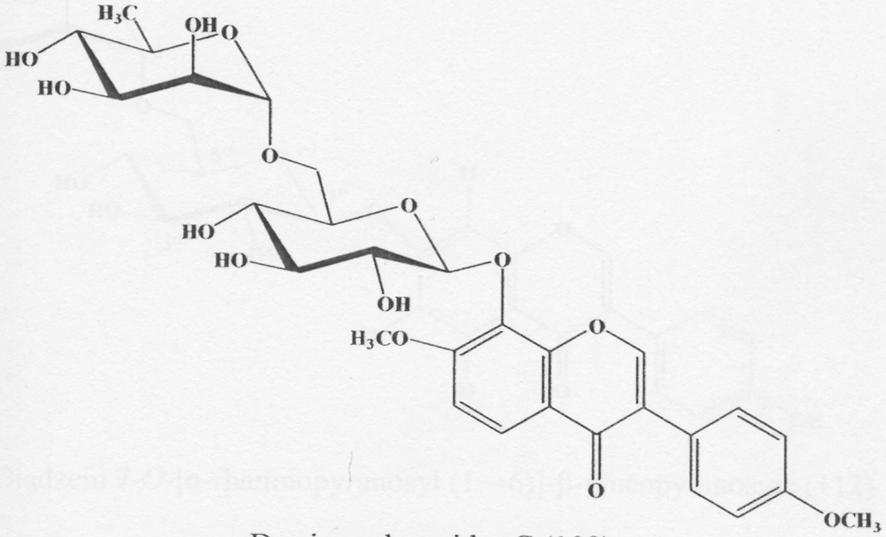


Derriscandenosides A (107)

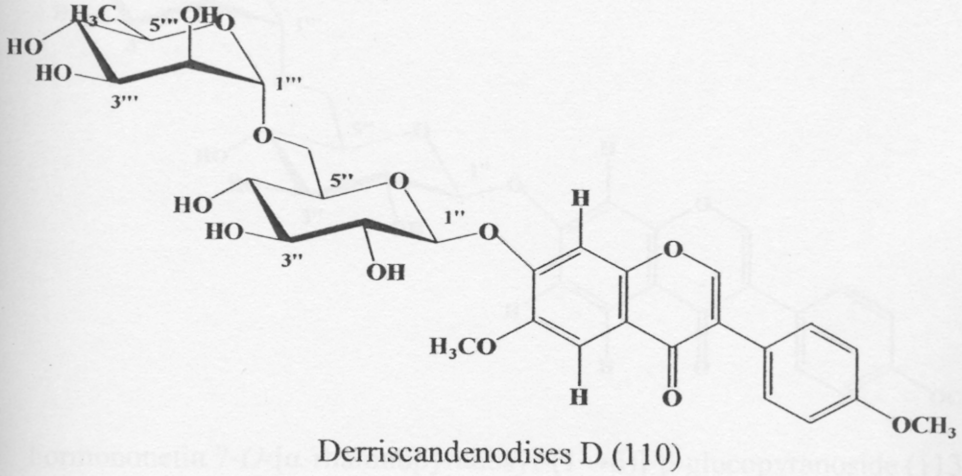
Figure 1-16 (continued)



Derriscandenosides B (108)

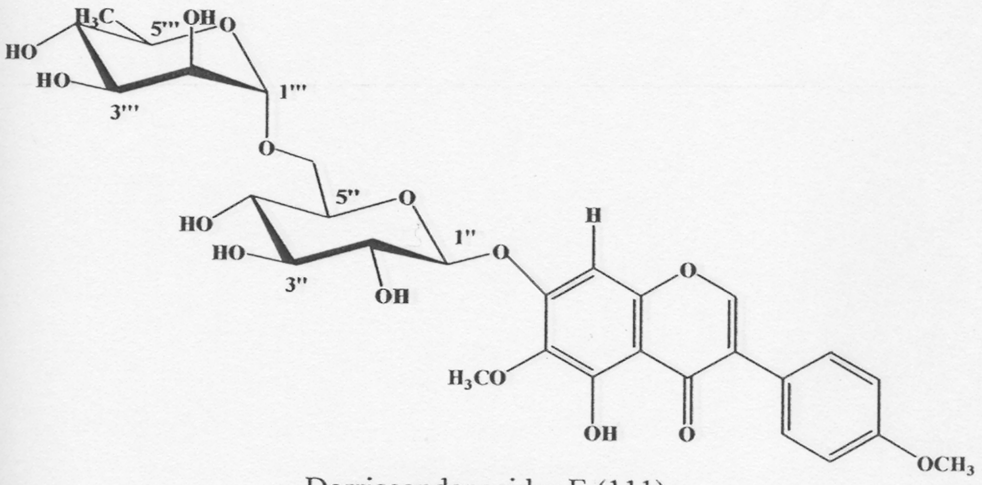


Derriscandenosides C (109)

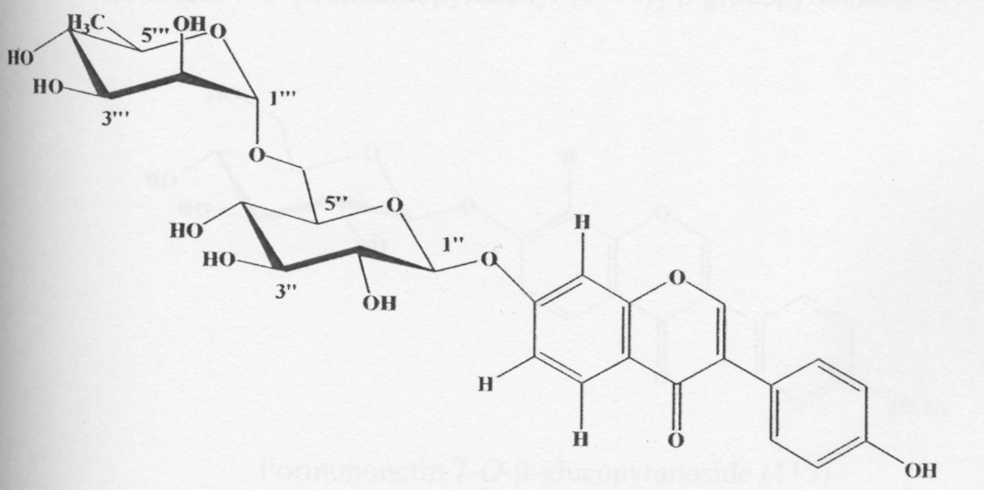


Derriscandenodises D (110)

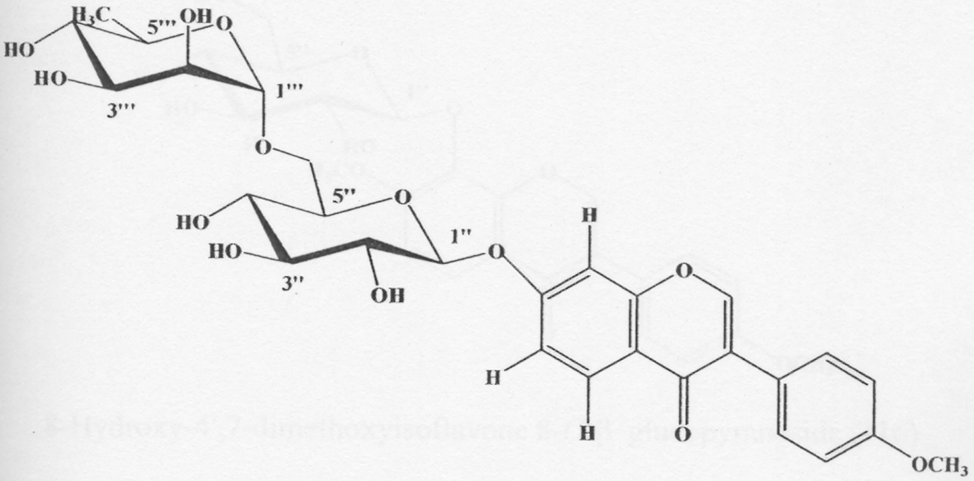
Figure 1-16 (continued)



Derriscandenosides E (111)

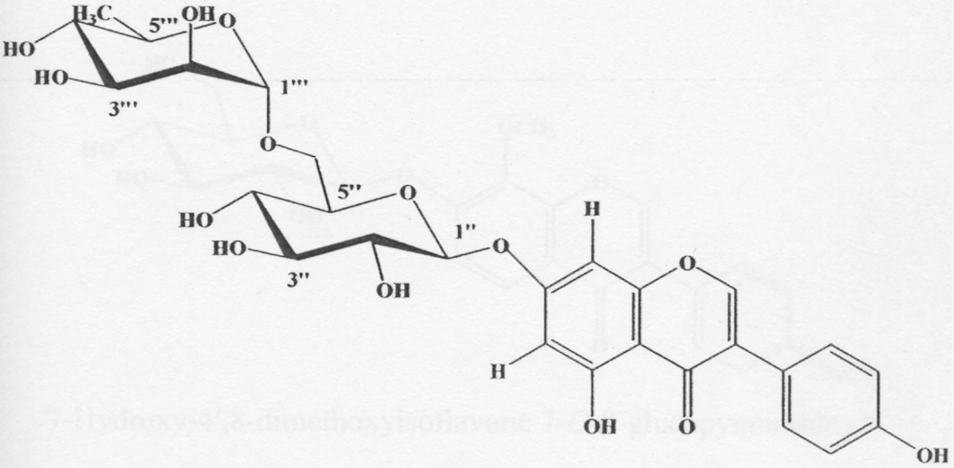


Diadzein 7-*O*-[α-rhamnopyranosyl (1→6)]-β-glucopyranoside (112)

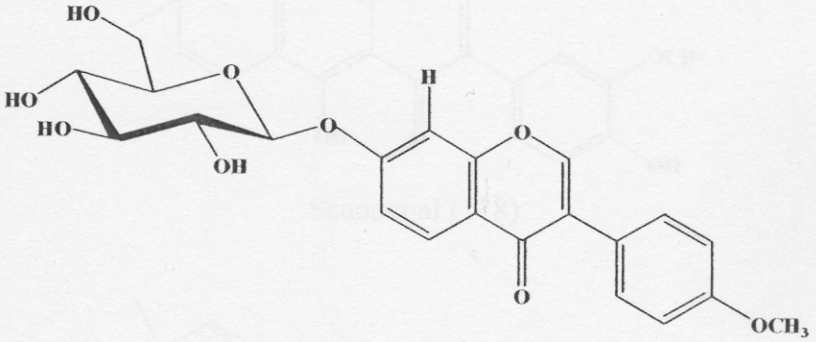


Formononetin 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside (113)

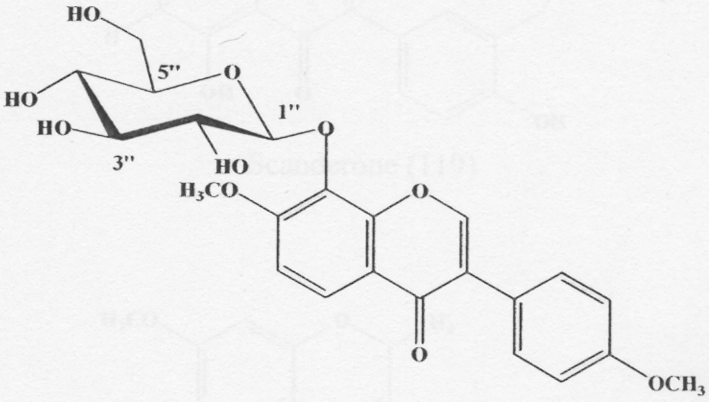
Figure 1-16 (continued)



Genistein 7-*O*-[α-rhamnopyranosyl-(1→6)]-β-glucopyranoside (114)

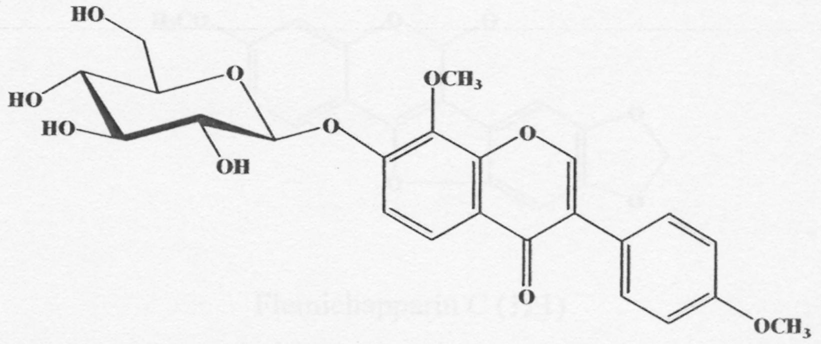


Formononetin 7-*O*-β-glucopyranoside (115)

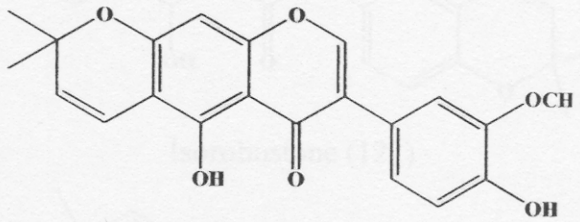


8-Hydroxy-4′,7-dimethoxyisoflavone 8-*O*-β–glucopyranoside (116)

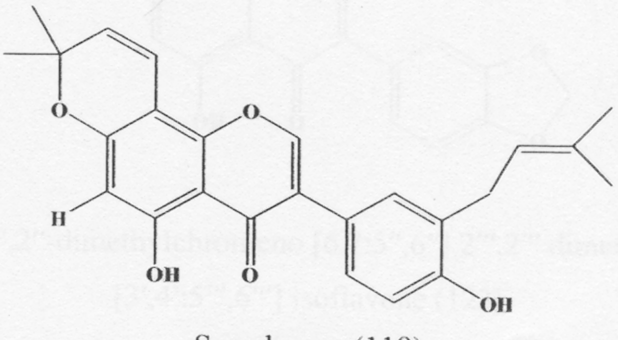
Figure 1-16 (continued)



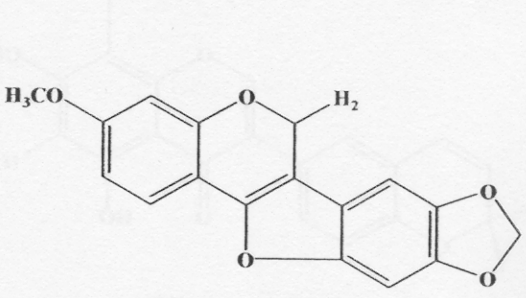
7-Hydroxy-4′,8-dimethoxyisoflavone 7-*O*-β-glucopyranoside (117)



Scandenal (118)

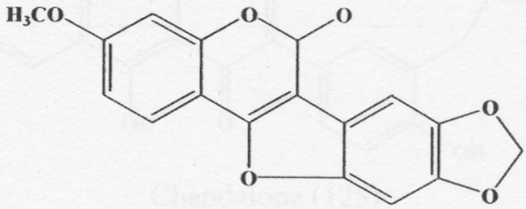


Scanderone (119)

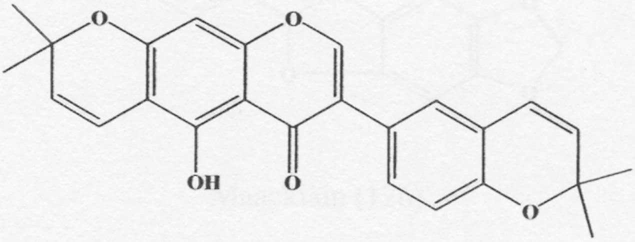


Flemichapparin B (120)

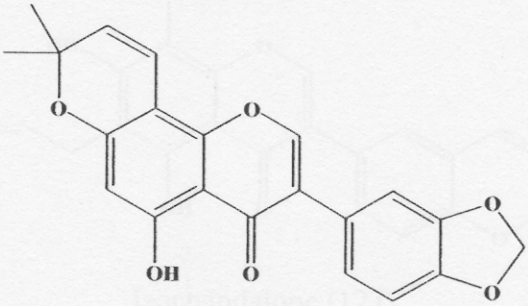
Figure 1-16 (continued)



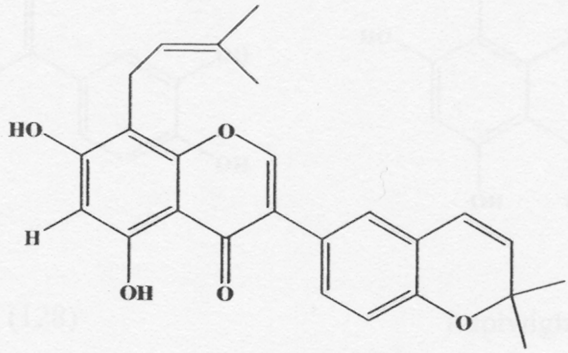
Flemichapparin C (121)



Isorobustone (122)

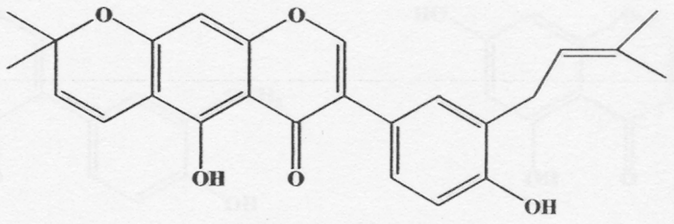


5-Hydroxy-2″,2″-dimethylchromeno [6,7:5″,6″] 2‴,2‴ dimethylchromeno [3′,4′:5‴,6‴] isoflavone (123)

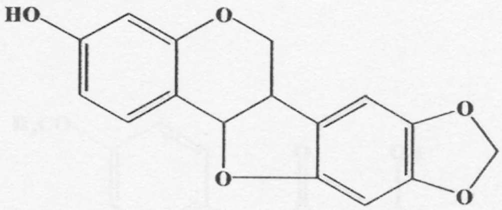


Ulexone A (124)

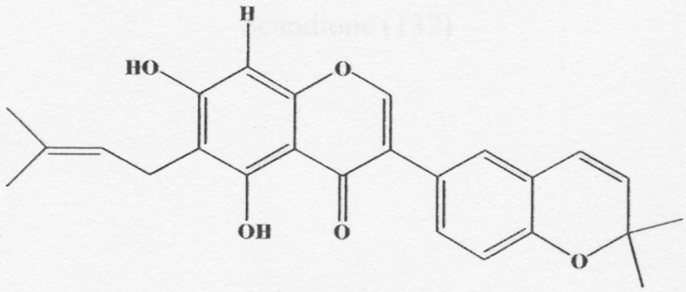
Figure 1-16 (continued)



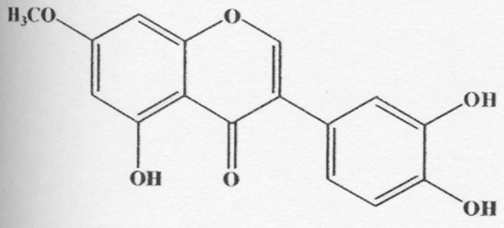
Chandalone (125)



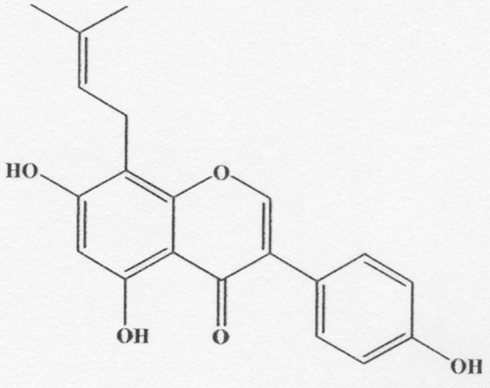
Maackiain (126)



Isochandalone (127)

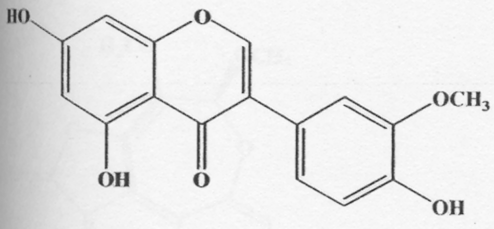


Santal (128)

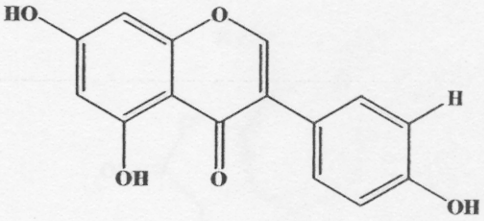


Lupiwighteone (129)

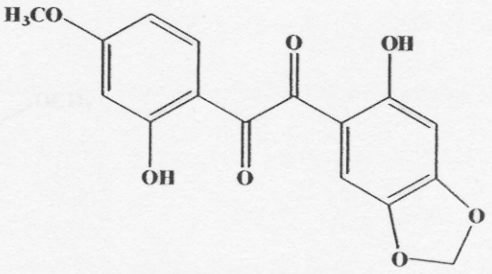
Figure 1-16 (continued)



3′-Methylorobol (130)

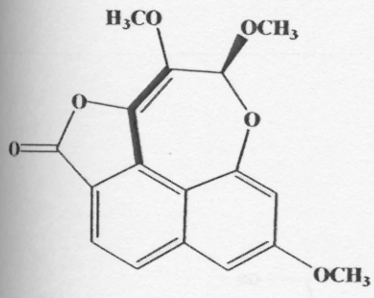


Genistein (131)

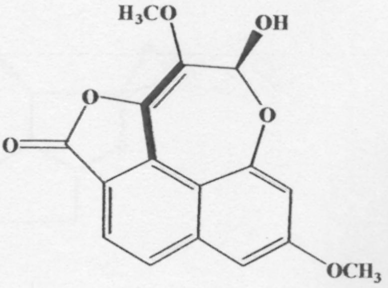


Scandione (132)

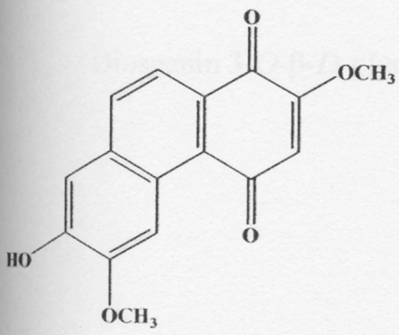
Figure 1-16 (continued)



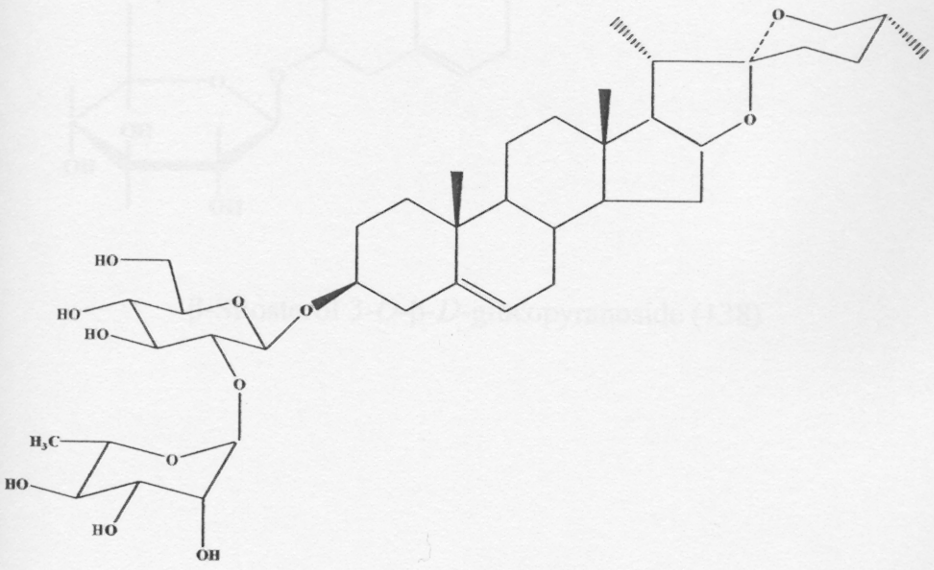
Dioscorealide A (133)



Dioscorealide B (134)

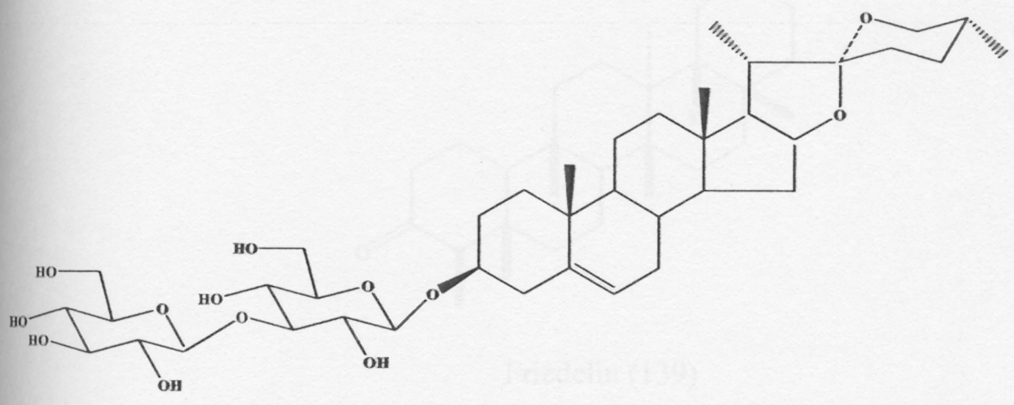


Dioscoreanone (135)

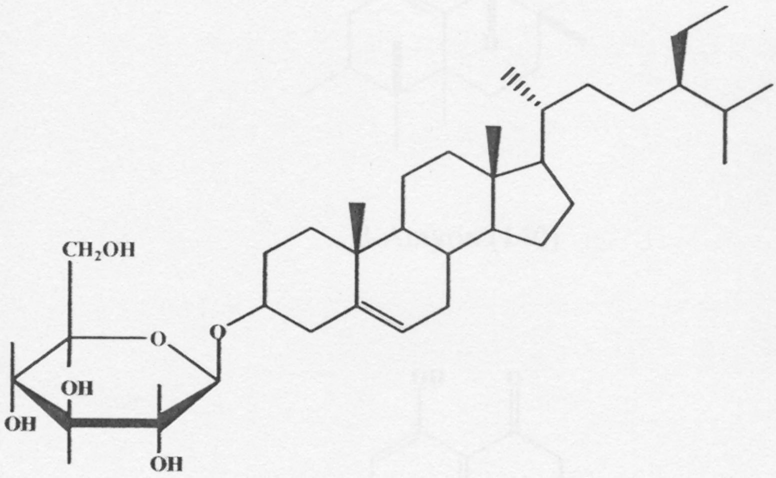


Diosgenin 3-*O*-α-*L*-rhamnopyranosyl (1→ 2)-β-*D*-glucopyranoside (136)

Figure 1-17 Structures of some chemical constituents found in *D. membranacea*

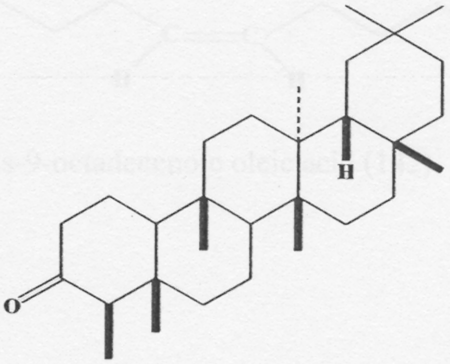


Diosgenin 3-*O*-β-*D*-glucopyranosyl (1→ 3)-β-*D*-glucopyranoside (137)

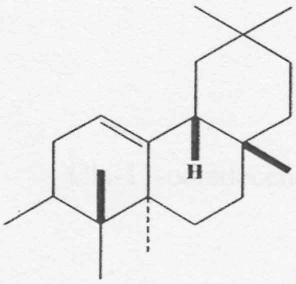


β-Sitosterol 3-*O*-β-*D*-glucopyranoside (138)

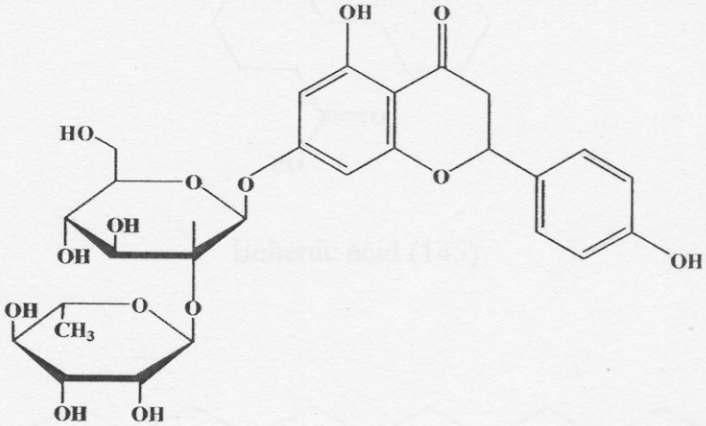
Figure 1-17 (continued)



Friedelin (139)

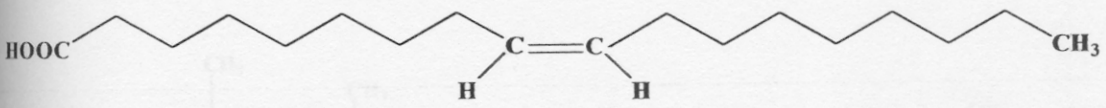


β-Amyrin (140)

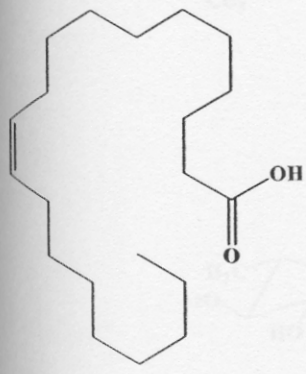


Naringin (141)

Figure 1-18 Structures of some chemical constituents found in *D. quercifolia*

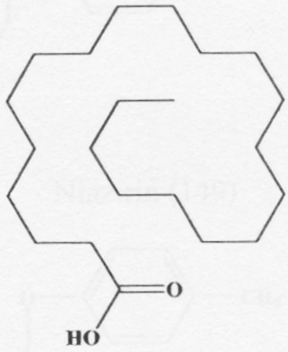


Cis-9-octadecenoic oleic acid (142)

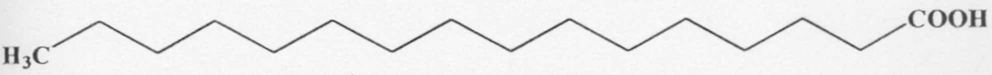


Cis-11-eicosenoic acid (143)

Cis-11-octadecenoic acid (vaccenic acid) (144)

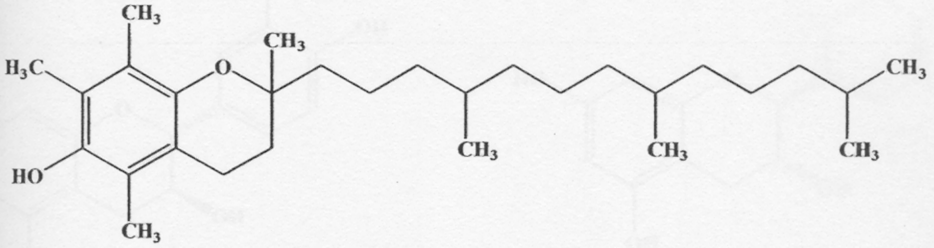


Behenic acid (145)

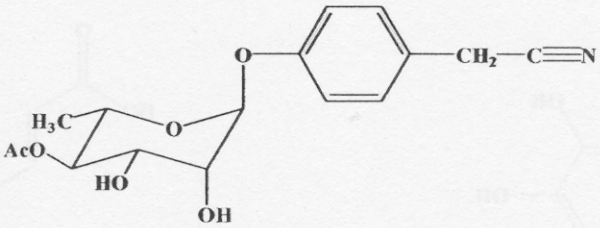


Palmitic acid (146)

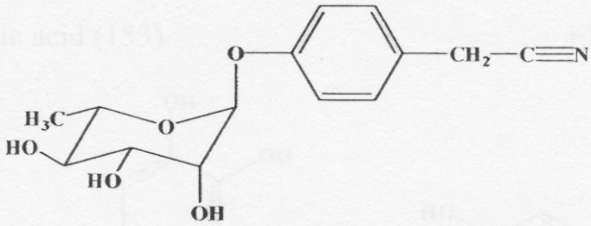
Figure 1-19 Structures of some chemical constituents found in *M. oleifera*



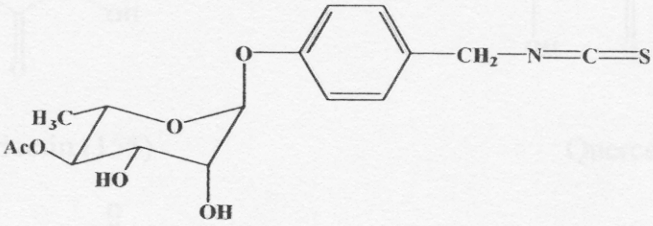
α-Tocopherol (147)



Niazirinin (148)

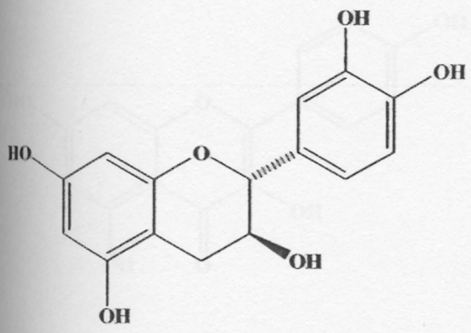


Niazirin (149)

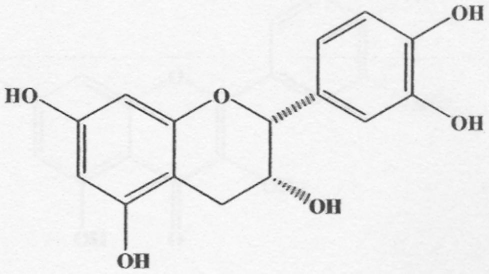


4-[(4'-O-acetyl-α-L-rhamnosyloxy) benzyl] isothiocyanate (150)

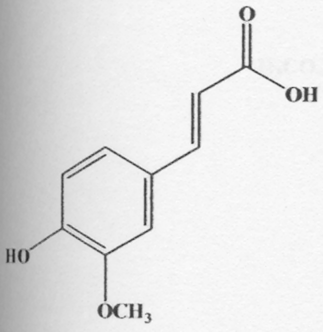
Figure 1-19 (continued)



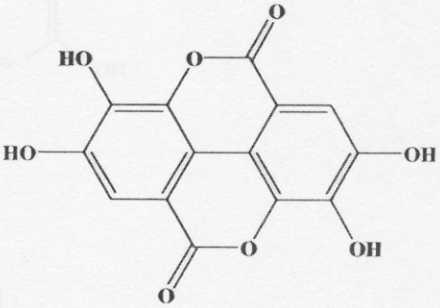
(+)-Catechin (151)



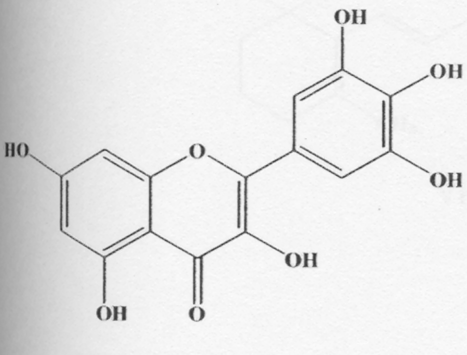
(-)-Epicatechin (152)



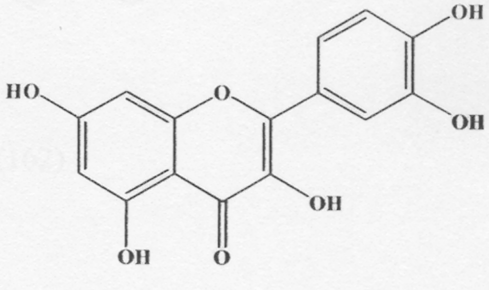
Ferulic acid (153)



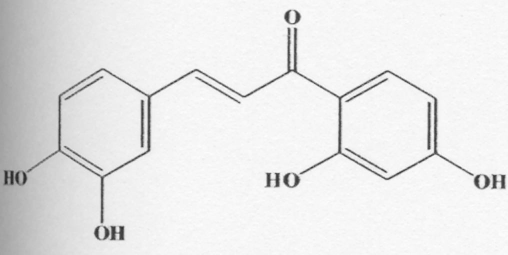
Ellagic acid (154)



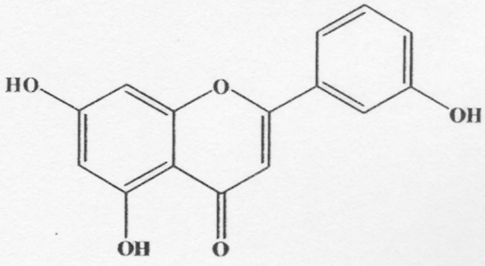
Myricetin (155)



Quercetin (156)

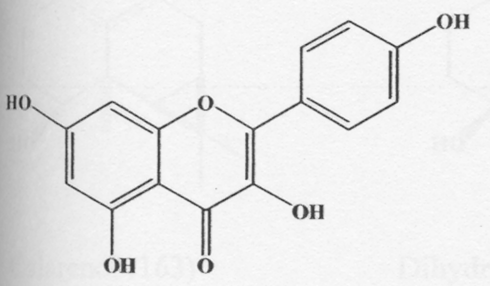


Butein (157)

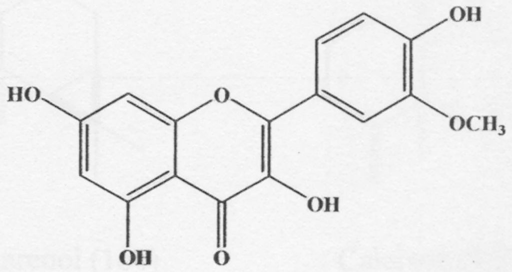


Apigenin (158)

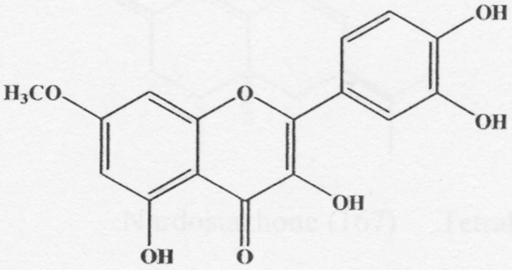
Figure 1-19 (continued)



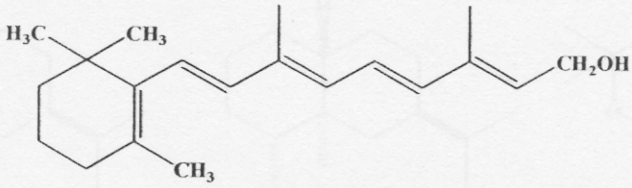
Kaempferol (159)



Isorhamnetin (160)

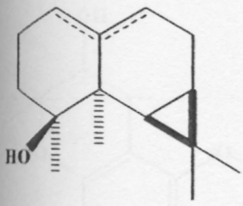


Rhamnetin (161)

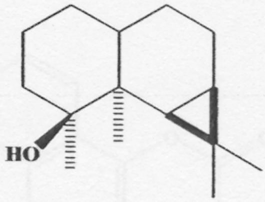


Vitamin A (162)

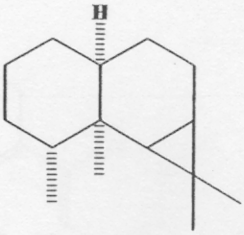
Figure 1-19 (continued)



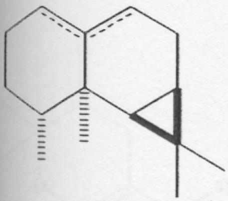
Calarenol (163)



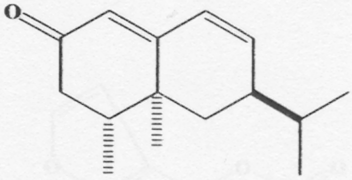
Dihydrocalarenol (164)



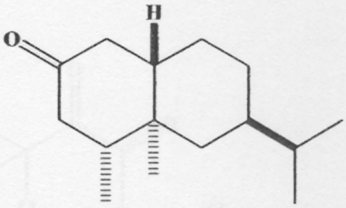
Calarane (165)



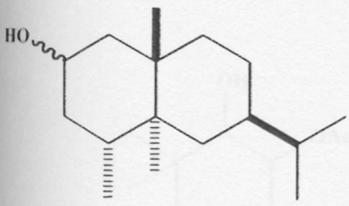
Calarene (166)



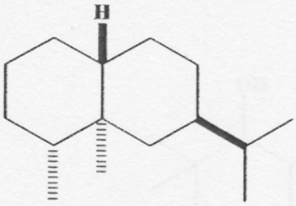
Nardostachone (167)



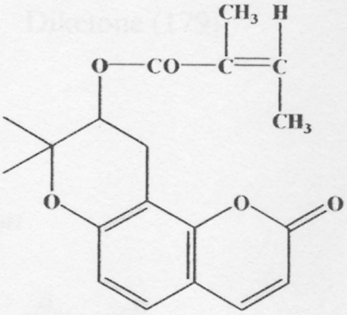
Tetrahydronardostachone (168)



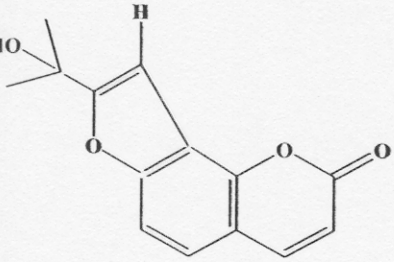
Tetrahydro nardostachol (169)



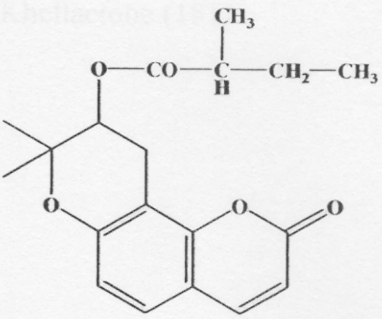
Tetrahydronardostachane (170)



Jatamansin (171)

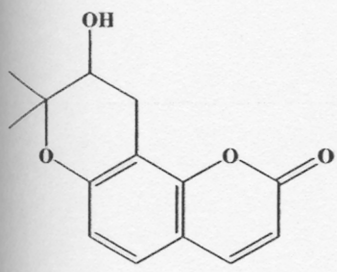


Oroselol (172)

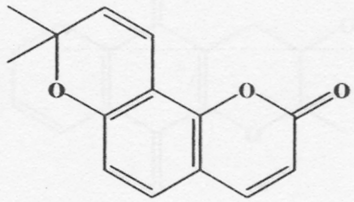


Dihydrojatamansin (173)

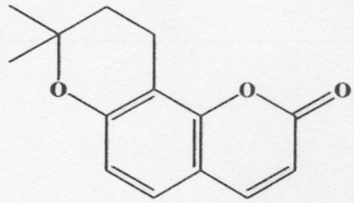
Figure 1-20 Structures of some chemical constituents found in *N. jatamansi*



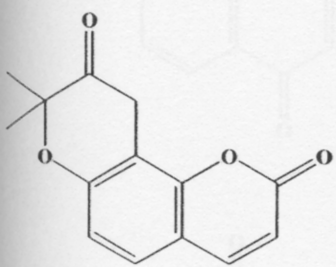
Jatamansinol (174)



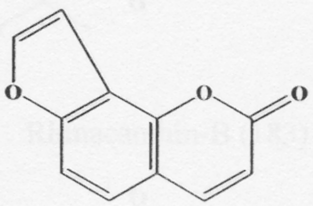
Seselin (175)



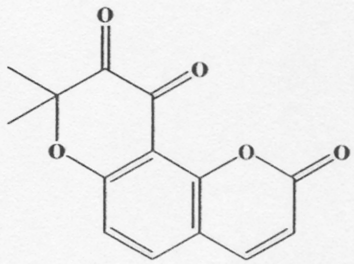
Dihydroseselin (176)



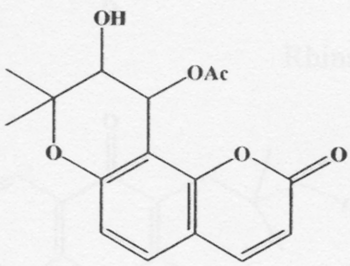
Jatamansinone (177)



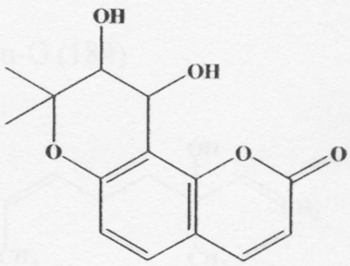
Angelicin (178)



Diketone (179)

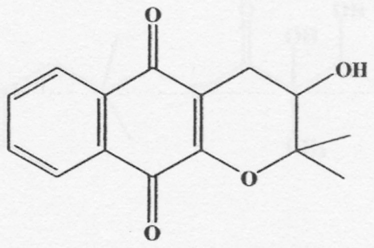


Monoacetyl khellactone (180)

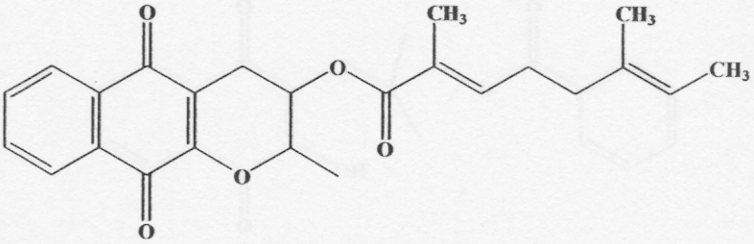


Khellactone (181)

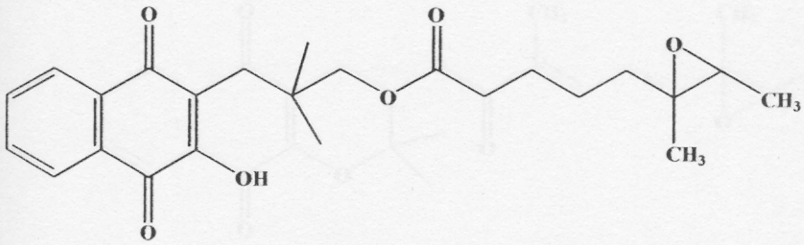
Figure 1-20 (continued)



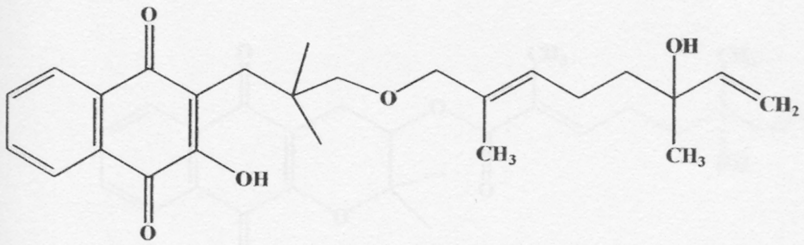
Rhinacanthin-A (182)



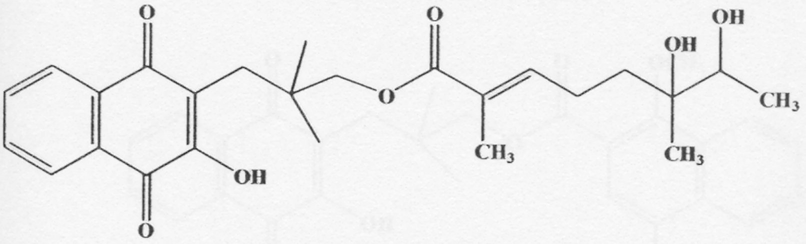
Rhinacanthin-B (183)



Rhinacanthin-G (184)

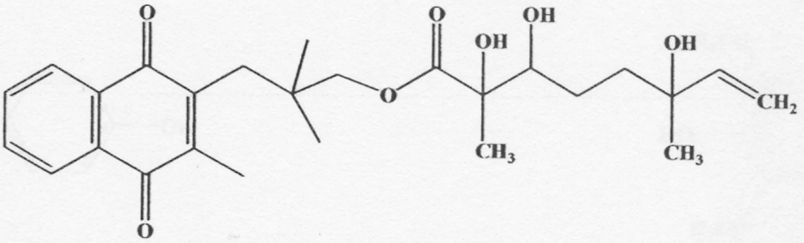


Rhinacanthin-H (185)

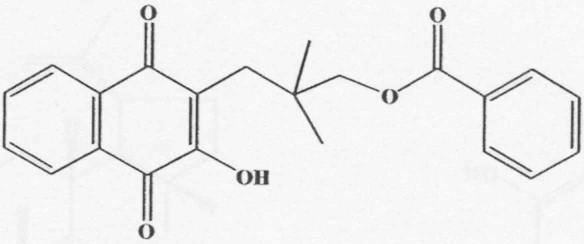


Rhinacanthuin-K (186)

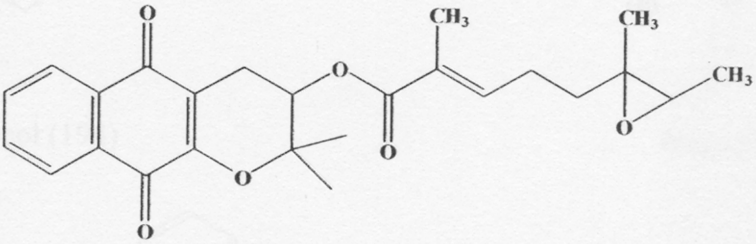
Figure 1-21 Structures of some chemical constituents found in *R. nasutus*



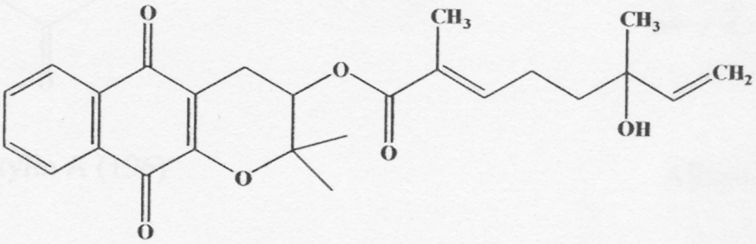
Rhinacanthin-L (187)



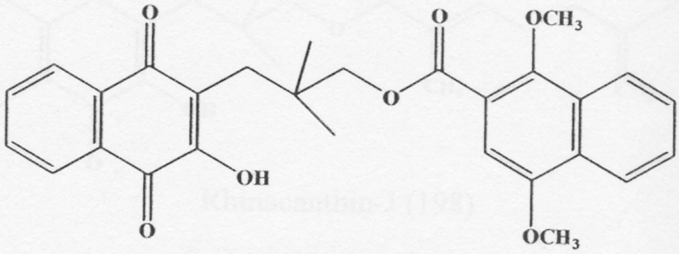
Rhinacanthin-M (188)



Rhinacanthin-O (189)

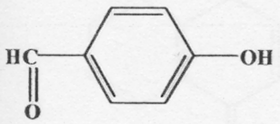


Rhinacanthin-P (190)

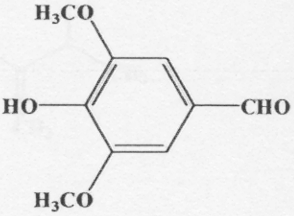


Rhinacanthin-Q (191)

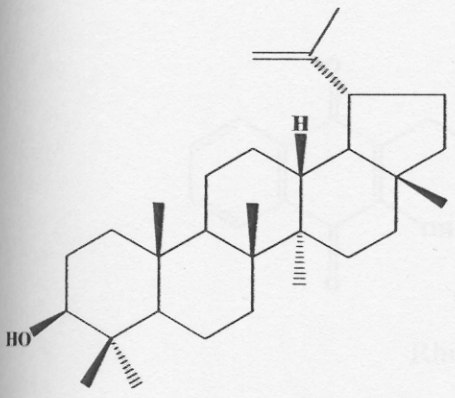
Figure 1-21 (continued)



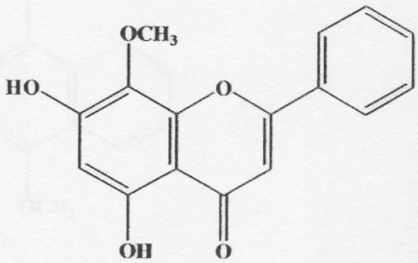
p-Hydroxy-benzaldehyde (192)



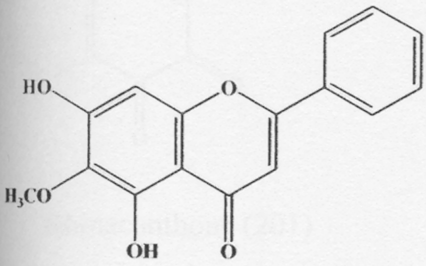
Syringaldehyde (193)



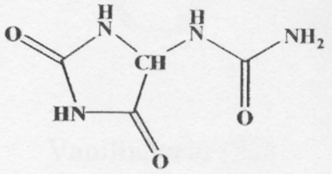
Lupeol (194)



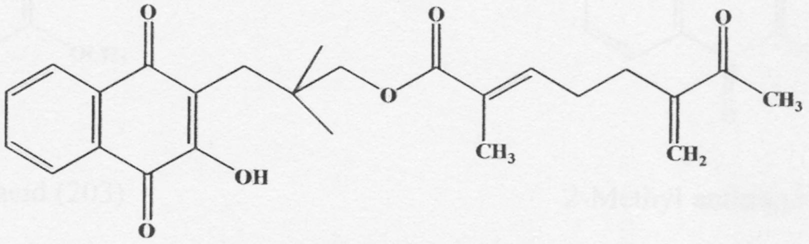
Wogonin (195)



Oroxylin A (196)

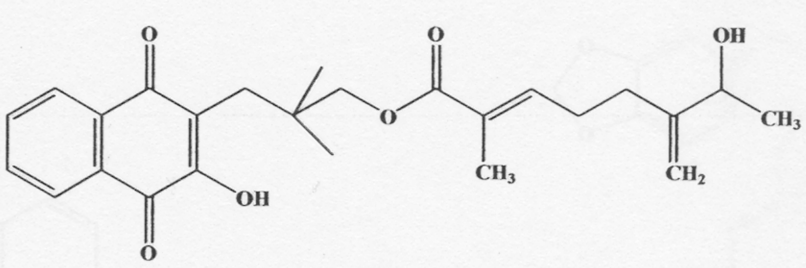


Allantion (197)

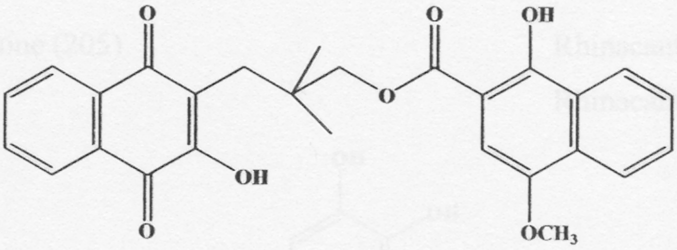


Rhinacanthin-J (198)

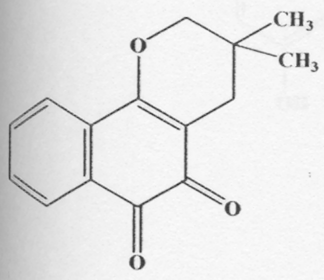
Figure 1-21 (continued)



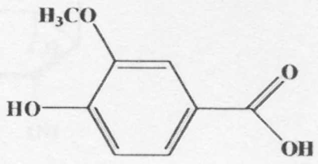
Rhinacanthin-I (199)



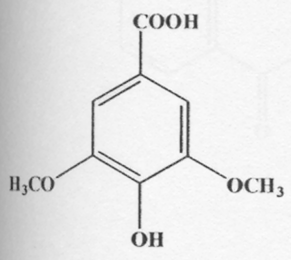
Rhinacanthin-N (200)



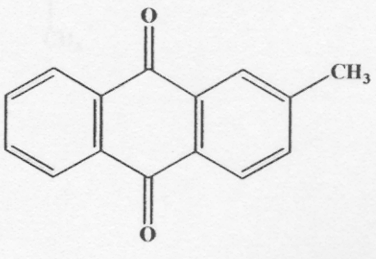
Rhinacanthone (201)



Vanillic acid (202)

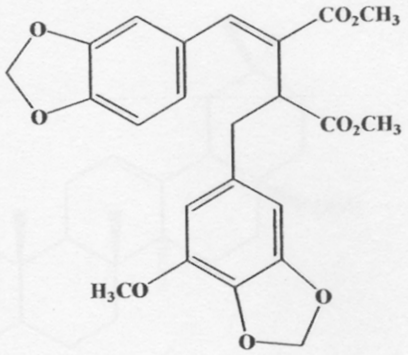


Syringic acid (203)



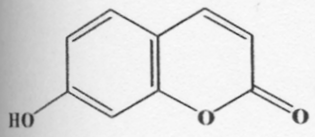
2-Methyl anthraquinone (204)

Figure 1-21 (continued)

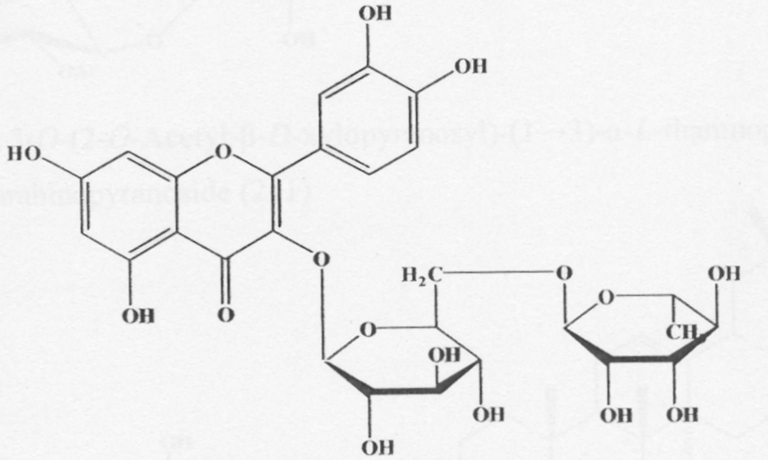


Rhinacanthin-E: Δ7E (206)

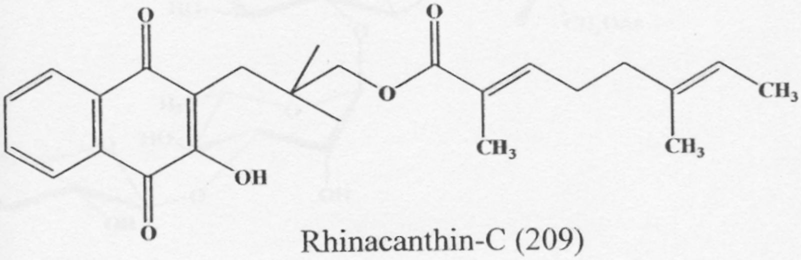
Rhinacanthin-F: Δ7Z (207)



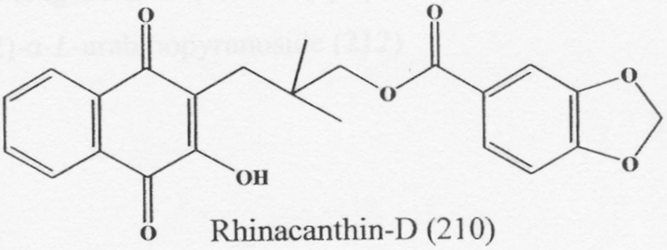
Umbelliferone (205)



Rutin (208)

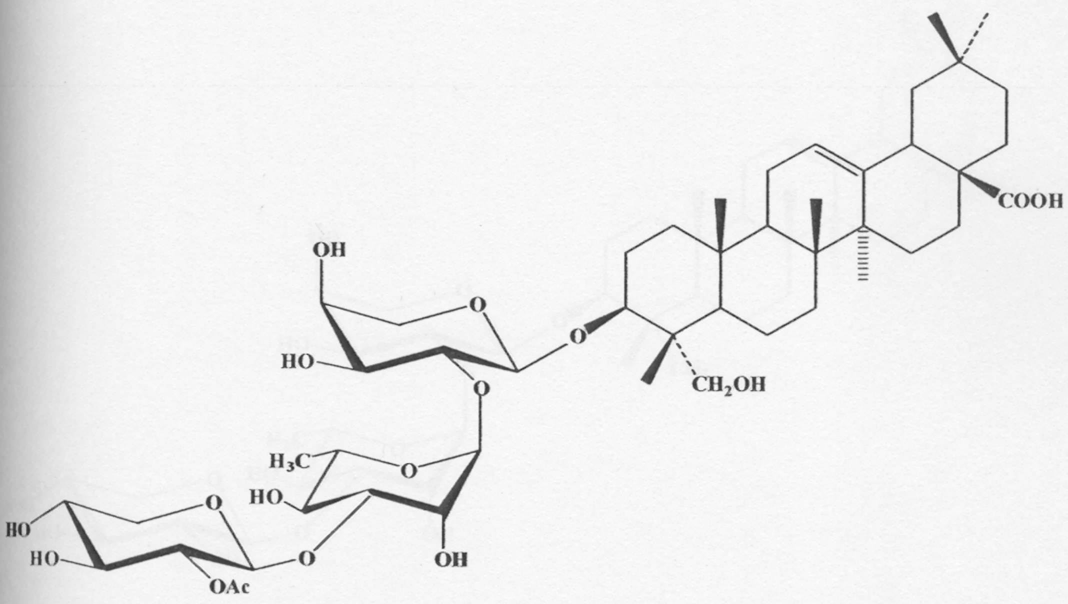


Rhinacanthin-C (209)

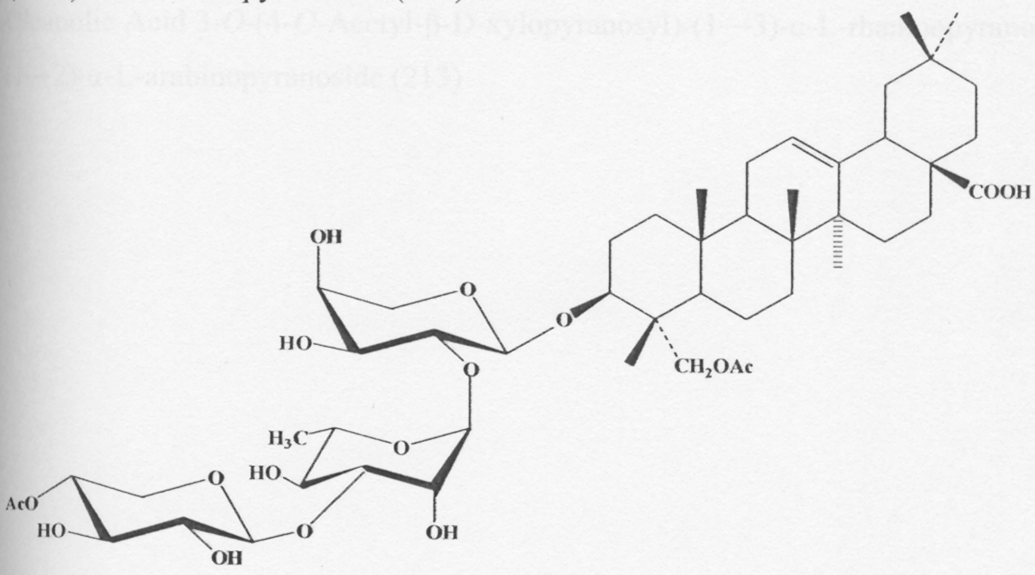


Rhinacanthin-D (210)

Figure 1-21 (continued)

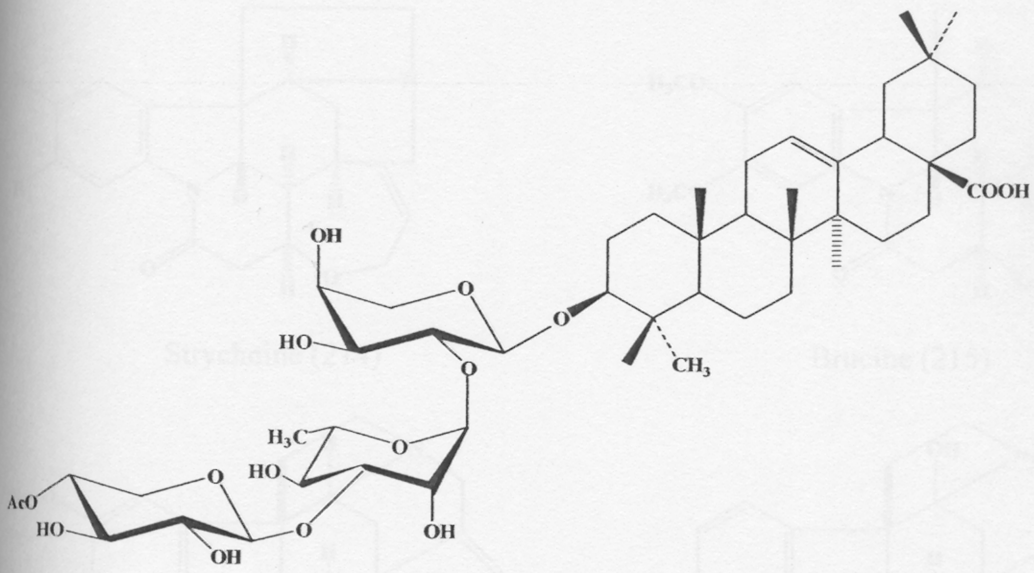


Hederagenin 3-*O*-(2-*O*-Acetyl-β-*D*-xylopyranosyl)-(1→3)-α-*L*-rhamnopyranosyl-(1→2)-α-L-arabinopyranoside (211)



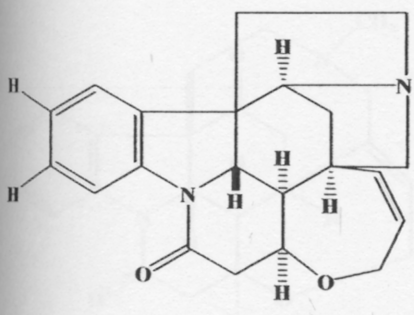
23-*O*-Acetyl-hederagenin 3-*O*-(4-*O*-Acetyl-β-*D*-xylopyranosyl)-(1→3)-α-*L*-rhamno pyranosyl-(1→2)-α-*L*-arabinopyranoside (212)

Figure 1-22 Structures of some chemical constituents found in *S. rarak*

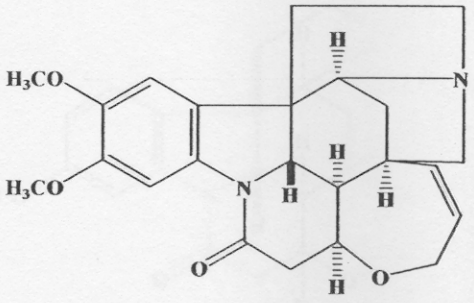


0leanolic Acid 3-*O*-(4-*O*-Acetyl-β-D-xylopyranosyl)-(1→3)-α-L-rhamnopyranosyl-(1→2)-α-L-arabinopyranoside (213)

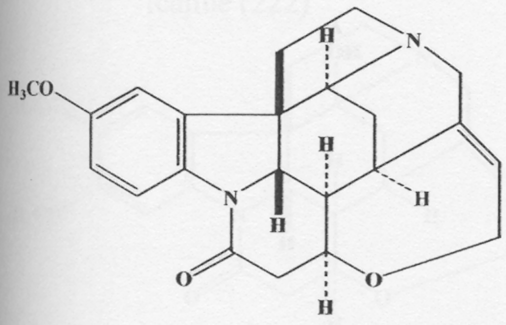
Figure 1-22 (continued)



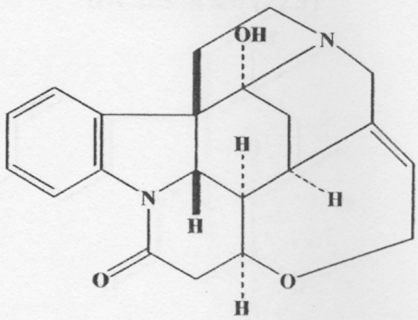
Strychnine (214)



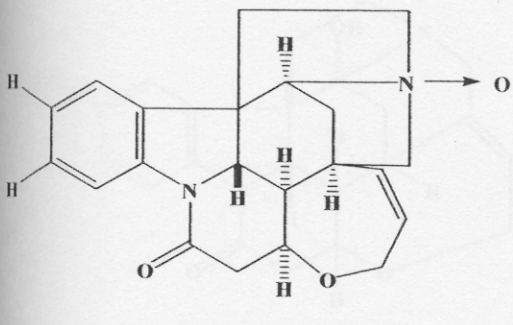
Brucine (215)



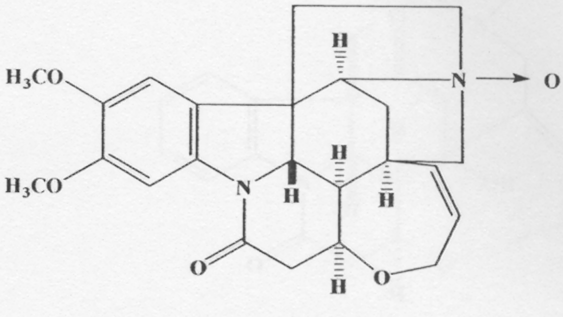
β-Colubrine (216)



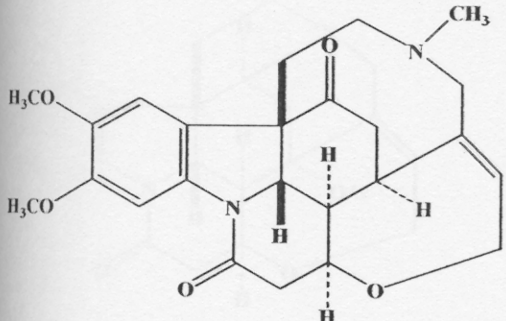
Pseudostrychnine (217)



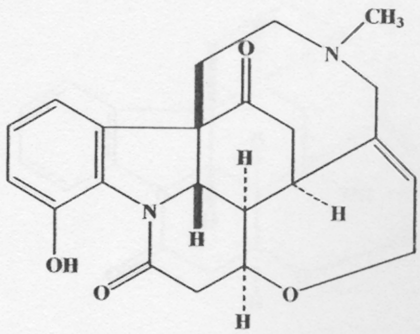
Strychnine N-oxide (218)



Brucine N-oxide (219)

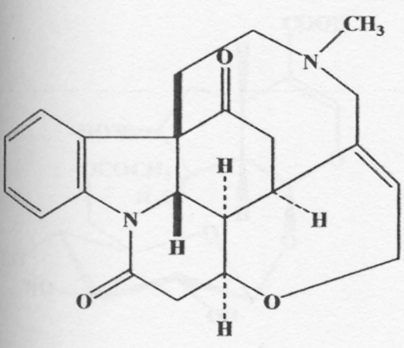


Novacine (220)

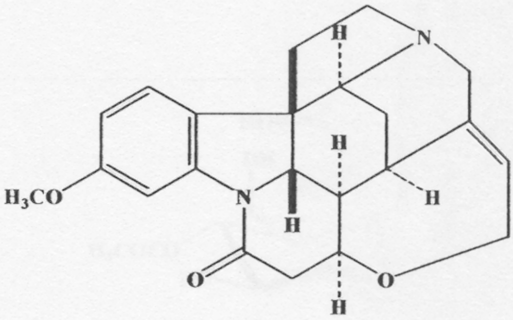


Vomicine (221)

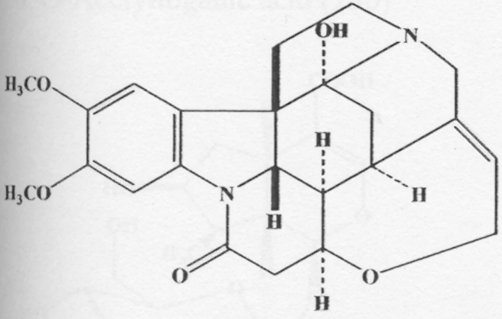
Figure 1-23 Structures of some chemical constituents found in *S. nux-vomic*



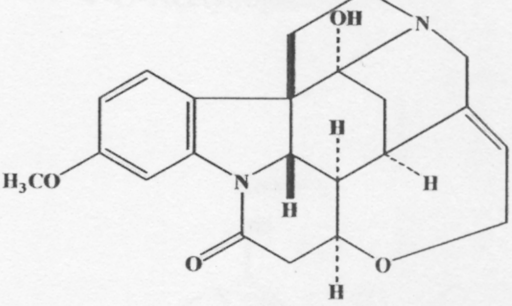
Icajine (222)



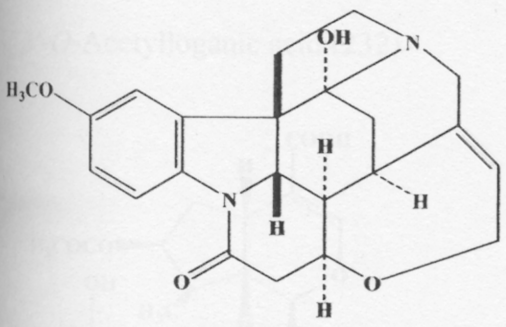
α-Colubrine (223)



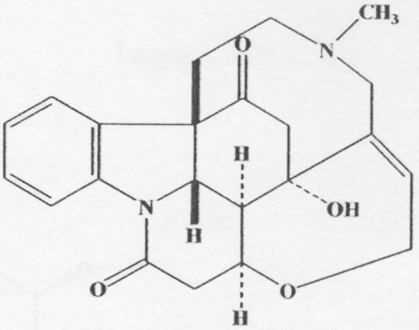
Pseudobrucine (224)



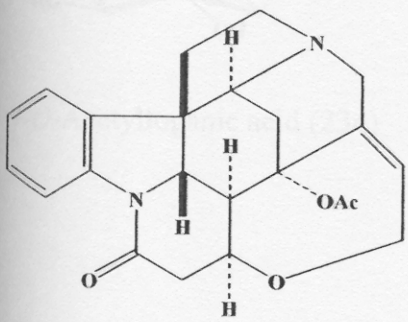
3-Hydroxy-α-colubrine (225)



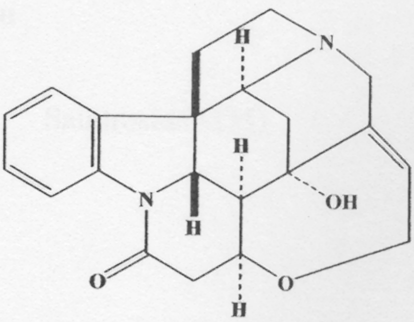
3-Hydroxy-β-colubrine (226)



15-Hydroxyicajine (227)

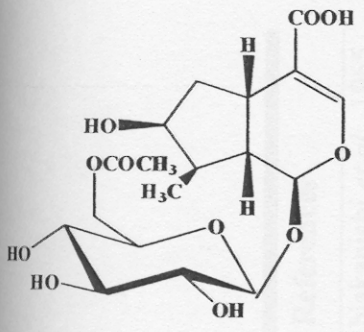


15-Acetoxystrychnine (228)

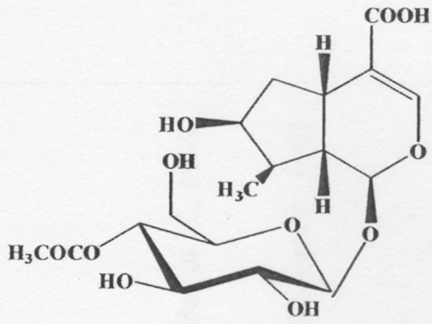


15-Hydroxystrychnine (229)

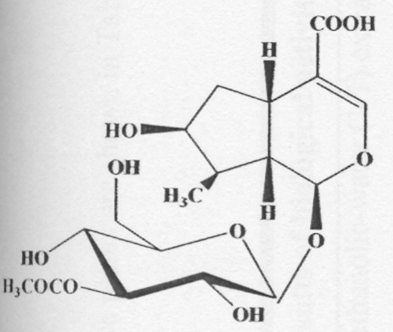
Figure 1-23 (continued)



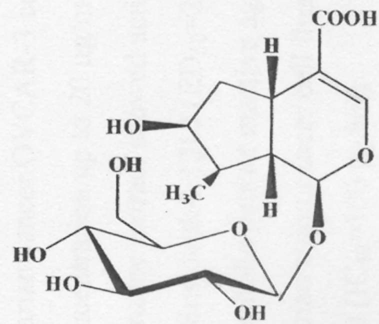
6′-*O*-Acetylloganic acid (230)



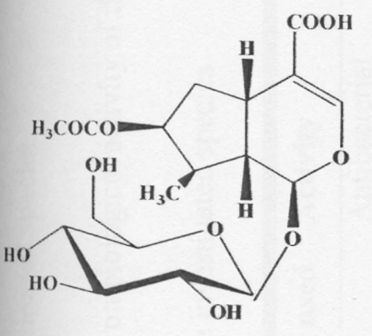
4′-*O*-Acetylloganic acid (231)



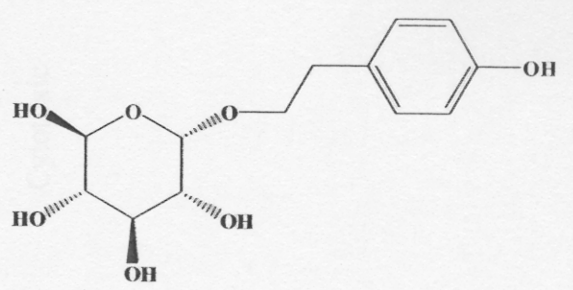
3′-*O*-Acetylloganic acid (232)



Loganic acid (233)



7-*O*-Acetylloganic acid (234)



Salidroside (235)

Figure 1-23 (continued)

1.8 Biological activities of the investigated species

Previous investigations on biological activity of these twelve plants are shown in Table 1-12.

Table 1-12 Biological activities of the investigated species

Botanical name	Part of plant used	Activity	Results of biological activities	References
B. ovata	Flowers	Antibacterial	Methanolic-water (1:1) extract active against *proteus vulgaris*	Nakanishi *et al.*, 1965
	Leaves	Antitumor	Methanolic-water (1:1) extract inactive against sarcoma cells	Nakanishi *et al.*, 1965
C. zedoaria	Rhizomes	Cytotoxic	3,7-dimethylindan-5-carboxylic acid, curcolonol and guaidiol showed no apparent activity against human ovarian cancer OVCAR-3 cells at concentration up to 20 μg/ml	Syu *et al.*, 1998
			Benzene extract showed activity against leuk-L1210 (ED_{50}=20 μg/ml)	Bae *et al.*, 1992
			Ethanolic extract inactive against human colon cancer cell line (COLO-320 (IC_{50}=100 μg/ml)	Smit *et al.*, 1995

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
C. zedoaria	Rhizomes	Cytotoxic	Water extract inactive against Hela cell at 10 mg/ml	Kosuge *et al*., 1985
			Methanolic extract showed weak activity against Hela-S3 cells (IC_{50}=21 μg/ml)	Nam and Yang, 1995
			Methanolic extract inactive against human-SNU-C4 and human-SNU-C1 cells	Park *et al*., 1993
		Antimutagenic	Water extract had a moderate antimutagenic activity against benzo[a]pyrene	Lee and Lin, 1988
		Antitumor	The chromatographic fraction showed antitumor activity at ED_{50}=1 mg/kg (IP, mouse) in ehrich-ascites cancer	Yokota *et al*., 1986
			Water extract given to mice by oral route strong active against Ehrlich-Ascites cancer at 150 mg/kg	Kosuge *et al*., 1985

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
C. zedoaria	Rhizomes	Antitumor	Ethanolic extract active against sarcoma 180 cell in mouse at 50 mg/kg (IP)	Itokawa *et al.*, 1982
			Water extract active against sarcoma 180 cell in mouse at 100 mg/kg	Itokawa *et al.*, 1988
			The polysaccharide fraction showed 50% inhibition in sarcoma 180 cells of mice at dose of 6.25 mg/kg/d	Kim *et al.*, 2000
		Antioxidant	The essential oil showed good antioxidant at 20 mg/ml in DPPH assay	Mau *et al.*, 2003
		Anti-inflammatory	Methanolic extract showed more than 80% inhibition of COX-2 and more than 70% inhibition of iNOS activity at 10 μg/ml	Hong *et al.*, 2002b

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
C. zedoaria	Rhizomes	Anti-inflammatory	β-Turmerone and ar-turmerone inhibited lipopolysaccharide (LPS)-induced prostaglandin E2 production in cultured mouse macrophage cells RAW 264.7 (IC_{50}=7.3 and 24 μM)	Hong *et al.*, 2002a
			β-Turmerone and ar-turmerone showed a potent inhibitory activity of COX-2 (IC_{50}=1.6 and 5.2 μg/ml) and iNOS (IC_{50}=4.6 and 3.2 μg/ml)	Lee *et al.*, 2002
			Dehydrocurdione at 200 mg/kg inhibited the carrageenan-induced paw edema and oral administration of dehydrocurdione at 120 mg/kg/day for 12 days reduced chronic adjuvant arthritis	Yoshioka *et al.*, 1998

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
C. zedoaria	Rhizomes	Anti-inflammatory	1,7-bis(4-hydroxyphenyl)-1,4,6-heptatrien-3-one and procurcumenol inhibited the production of tumor necrosis factor (TNF)-α by lipopolysaccharide (LPS)-activated macrophages (IC_{50}=12.3 and 310.5 μg/ml)	Jang *et al*., 2001
		Antihepatotoxic	Furanodiene, curcumenone, dehydrocurdione and curcumin showed a protective effect against D-galactosamine (D-GaIN)/lipopoly-saccharide-induced acute liver injury in mice and also inhibited an increase in serum aspartate aminotransaferase and alanine aminotransaminese	Morikawa *et al*., 2002; Matsuda *et al*., 2001; Matsuda *et al*., 1998

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
C. zedoaria	Rhizomes	AntiHIV-1	The 95%ethanolic extract and water extract showed HIV-1 integrase inhibition of virus-HIV-1 (IC_{50}= 62 and 50 μg/ml)	Tewtrakul *et al*., 2003
		Analgesic	The ID_{50} values (μmol/kg, IP) of curcumenol were 22 and 12 in writhing and capsaicin tests and 29 μmol/kg in the formalin model	De Fátima Navarro *et al*., 2002
D. scanders	Stems	Immunostimulant	Hydroalcoholic extract increased lymphocyte proliferation at concentration of 10, 100 ng/ml, 1, 5 μg/ml	Sriwanthana and Chavalittumrong, 2001
			Enhanced the lymphocyte proliferative and function of NK cells of normal individuals induced the IL-2 secretion (100 ng/ml)	Hoult *et al*., 1997

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
D. scandens	Stems	Hypotensive activity	Rhamnosyl-(1→6)-glucosy lisoflavones caused a decrease in mean arterial blood pressure of more than 75 mmHg and a decrease in heart rate more than 60 beats/min	Rukachaisirikul *et al.*, 2002
		Inhibition of myeloperoxide release	The aqueous extract reduced 88% of myeloperoxidase (MPO) released in rat peritoneal leukocytes	Laupattarakasem *et al.*, 2003
		Inhibitory activity against generation of leukotriene B_4	Ethanolic extract and water extract showed 29% and 89% inhibitory effect on 5-lipoxygenase activity, indicated by reduction in LTB_4 at 500 µg/ml	Laupattarakasem *et al.*, 2003
		Antioxidant	Water extract showed antioxidant effect (23% reduction) in hypoxan-thine/xanthine oxidase system	Laupattarakasem *et al.*, 2003

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
D. scandens	Stems	Antioxidant	Scandinone, derrisisoflavone A and santal exhibited potent radical scavenger effect by DPPH assay (63%, 82% and 87% scavenging, respectively)	Mahabusarakam *et al.*, 2004
		Anti-inflammatory	The aqueous extract showed reduction in paw edema test (82% for 100 mg/kg; 91% for 500 mg/kg)	Laupattarakasem *et al.*, 2003
		Antibacterial	Lupalbigenin showed strong inhibitory activity against *Staphylococcus. aureus* ATCC 25923 and methicillin-resistant strain MRSA SK-1 with MIC values of 4 and 2 μg/ml	Mahabusarakam *et al.*, 2004

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
D. membranacea	Rhizomes	Cytotoxic	Ethanolic extract showed activity against human lung cancer (COR-L23) (IC_{50}=6.2 μg/ml), human colon cancer (LS174-T) (IC_{50}=16.7 μg/ml), human breast cancer (MCF-7) (IC_{50}=12 μg/ml), human keratinocyte (SVK-14) (IC_{50}=70 μg/ml)	Itharat, 2002
		Antioxidant	Ethanolic extract showed the value of EC_{50} 16.5 μg/ml in DPPH assay and the value of EC_{50} 8.1 μg/ml in lipid peroxidation of liposome assay	Itharat, 2002
		Antimicrobial	Ethanolic extract active against *S. aureus* (MIC<1.25 mg/ml), *B.subtilis* (MIC<1.25 mg/ml), *E. coli* (MIC=2.5 mg/ml) and *E. floccosum* (MIC<1.25 mg/ml)	Itharat, 2002

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
M. oleifera	Seeds	Antitumor	4 (α-L-rhamnosyloxy)-benzyl isothiocyanate, niazimicin and β-sitosterol-3-*O*-β-*D*-glucopyranoside showed very significant inhibitory activity against Epstein-Barr virus-early antigen (EBV-EA) activation in Raji cells induced by 12-O-tetradecanoyl-phorbol-13-acetate (TPA)	Guevara *et al.*, 1999
		Antimicrobial	Aqueous extract activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus*	Cáceres *et al.*, 1991
		Diuretic activity	The aqueous extract showed diuretic activity at 1000 mg/kg	Cáceres *et al.*, 1992

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
M. oleifera	Seeds	Anti-inflammatory	The aqueous extract showed inhibition of acetylcholine-induced concentration with an ED50 of 65.6 mg/ml and inhibition of carrageenin-induced oedema at 1000 mg/kg	Cáceres *et al.*, 1992
	Leaves	Antitumor	Thiocarbamate and isothiocyanate-related compounds showed inhibition of tumor-promoter-induced Epstein-Barr virus activation in Raji cells.	Murakami *et al.*, 1998
		Antiviral	Ethanolic and water extract at a dose of 750 mg/kg per day delayed the development of skin lesions, prolonged the mean survival times and reduced the mortality of herpes simplex virus type 1 (HSV-1) infected mice	Lipipun *et al.*, 2003

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
M. oleifera	Leaves	Hypocholesterolemic	Water extract decreased the high-fat diet-induced increase in serum, liver, and kindney cholesterol levels by 14.35% (115-103.2 mg/100 ml of serum), 6.4% (9.4-8.8 mg/g wet weight) and 11.09% (1.09-0.97 mg/g wet weight) repectively	Ghasi *et al*., 2000
		Hepatoprotective	Ethanolic extract protect against liver damage induced by antitubercular drugs	Pari and Kumar, 2002
	Freeze-dried leaves	Antioxidant	Methanolic and ethanolic extracts showed high antioxidant activities, 65 and 67%, respectively, in the β-carotene-linoleic acid system	Siddhuraju and Becker, 2003

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
M. oleifera	Freeze-dried leaves	Antioxidant	Water, ethanolic and methanolic extracts exhibited good antioxidant activity (90-92%) in the linoleic acid peroxidation system at a concentration of 0.2 mg/ml	Siddhuraju and Becker, 2003
			Ethanolic and methanolic extracts exhibited ~80-90% inhibition effect at concentration of 0.4 mg/ml in the enzymetic lipid peroxidation of microsomal lipids induced by NADPH/ADP/Fe^{3+}	Siddhuraju and Becker, 2003
		Antimicrobial	Aqueous extract activity against *Pseudomonas aeruginosa* and *Staphylococcus aureus*	Caceres *et al.*, 1991

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
M. oleifera	Roots	Anti-inflammatory	The aqueous extract at dose of 750 mg/kg inhibited the development of oedema at 1, 3 and 5 hours (reduction by 54, 45 and 51% respectively) and reduced the carrageenin induced oedema at 750 mg/kg	Ndiaye *et al.*, 2002
		Anticancer	The cold absolute ethanolic extract showed inhibition of the cell cycle on the sea urchin egg development in blastulae (IC_{50}=53 μg/ml)	Costa-Lotufo *et al.*, 2005
			The cold absolute ethanolic extract showed cytotoxic activity against leukemia (CEM) in MTT assay (IC_{50}=13 μg/ml)	Costa-Lotufo *et al.*, 2005
	Pods and seeds	Hypotensive	Ethanolic extract showed hypotensive activity at dose 30 mg/kg	Faizi *et al.*, 1998

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
N. jatamansi	Rhizomes	Hepatoprotective	Ethanolic extract showed hepatoprotective activity at 800 mg/kg bodyweight (oral)	Ali *et al.*, 2000
		Hypotensive	Essential oil showed strong activity in dogs (IV) at dose 0.1 mg/kg	Funayama and Hikino, 1981
	Leaves	Antioxidant	Ethanolic (100%) extract inactive at concentration of 500 µg/ml	Tripathi *et al.*, 1999
R. nasutus	Leaves	Antifungal	Dichloromethane extract active against Cladosporium cucumerinum in agar plate at 100 µg	Cavin *et al.*, 1999
		Antioxidant	Dichloromethane extract inactive at 100 µg	Cavin *et al.*, 1999
	Leaves and stems	Anti-inflammatory	Water extract showed weak activity in macrophages by nitric oxide synthesis stimulation	Punturee *et al.*, 2004

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
R. nasutus	Aerial parts	Antiviral	Rhinacanthin C and rhinacanthin D exhibit inhibitory activity against cytomegalovirus (CMV) with EC_{50} values of 0.02 and 0.22 μg/ml	Sendl *et al*., 1996;
			Rhinacanthi E and Rhinacanthi F showed antiviral activity against influenza virus type A (EC_{50} = 1.7 and <0.94 μg/ml respectively) in hemedsorption inhibition assay	Kernan *et al*., 1997
	Roots	Cytotoxic	Pure compounds in methanolic extract showed cytotoxic activity against KB, P-338, A-549, HT-29 and HL-60 cells (EC_{50} = 0.14-19.9 μg/ml)	Wu *et al*., 1998b
	-	Antitumor	Rhinacanthone showed activity against Dalton's ascetic lymphoma (DAL) in mice	Thirumurugan *et al*., 2000

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
S. rarak	Dried fruits	Antifungal	Freeze dried powder active against dermatophytes, Cryptococcus neoformans and Candida albicans by agar disc diffusion method, inhibition zone diameters were 32.48, 30.24 and 19.16 mm	Wuthi-udomlert *et al*., 2000;
S. rarak	Pericarp	Analgesic	Ethanolic extract inhibited pain response induced by acetic acid and formalin in dose-related manner at dose of 25, 50 and 100 mg/kg	Rujjanawate *et al*., 2005
S. corbularia	Dried roots	Antitumor	Water extract active against tumor in rats (IP)	Pornsiriprasert *et al*., 1986
		Cytotoxic	Water extract weak active against CA-KB	Pornsiriprasert *et al*., 1986
			Water extract weak activity against 9KB cell	Pornsiriprasert *et al*., 1986

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
S. corbularia	Dried roots	Cytotoxic	Ethanolic (95%) and water extract inactive against mammary cancer cell (MCF-7) and huma colon cancer cell line (LS-174T) at 50 μg/ml	Itharat *et al.*, 2002

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
S. corbularis	Dried roots	Immunostimulant	A water extract of Thai remedy which had this plant component had an effect on cells involved in cancer immunity. Natural killer (NK) cells and monocyte/macrophages, were studied in 13 cancer patients. Treatment of the patients with the extract for 2 weeks significantly increased NK cell. It also increases the release of tumor necrosis factor from monocyte/macrophages (dose 0.5 l/day in female). The extract showed cytotoxic activity against K562 erythroleukemic cells.	Pornsiriprasert *et al.*, 1986

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
S. nux-vomica	Seeds	Cytotoxic	The IC_{50} of processed seeds were 155% and 212% of unprocessed ones in cell growth-inhibition assay and in [3H]TdR uptake assay, respectively and IC_{50} of Strychnos alkaloid fractions on Vero cell growth-inhibition assay were 0.45-0.80 $mmolL^{-1}$ and 0.5-12 $mmolL^{-1}$, respectively	Cai *et al.*, 1998
		Antinociceptive	Crude alkaloid fractions showed antinociceptive activity in the hot-plate test (100 μg/kg, IP) and in the acetic-induced writhing test (1 μg/kg, IP) in mice	Cai *et al.*, 1996

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
S. nux-vomica	Seeds	Antilipid peroxidetive	Alcoholic extract antilipid peroxidetive property in the free iron system	Tripathi and Chaurasia, 2000
		Antianalgesic	Brucine showed 109% PIP (pain inhibition percentage) with 30 mg/kg at 120 min after administration in hot-plate test. The maximal inhibition of the nociceptive response was 79.5% for brucine N-oxide at the dose of 200 mg/kg in writhing test	Yin *et al*., 2003
		Anti-inflammatory	Both brucine and brucine N-oxide showed effects 2 h. after drug admistration, 80.3% for brucin N-oxide and 46.1% for brucine at a dose of 200 mg/kg in carrageenan-induced rat paw edema	Yin *et al*., 2003

Table 1-12 (continued)

Botanical name	Part of plant used	Activities	Results of biological activities	References
S. nux-vomica	Seeds	Anti-inflammatory	Brucine (30 and 15 mg/kg) and brucine N-oxide (200 mg/kg) significantly decreased the content of 5-HT, while increasing the amount of 5-HIAA in rat's blood plasma.	Yin *et al.*, 2003
	Root barks	Antidiarrhoeal activity	Methanolic and water extract (3, 7.5 and 15 mg) against castor-oil induced diarrhoea in mice	Shoba and Thomas, 2001

1.9 Ojectives

1. To study cytotoxic activity against tumor cells and free radical scavenging activity of the extracts from twelve Thai medicinal plants.
2. To study chemical constituents of the active extracts which show free radical scavenging activity and/or cytotoxic activity against tumor cell lines.
3. To assess cytotoxic activity against tumor cells and/or apoptosis activity of the isolated compounds.