CHAPTER 1

Introduction

1.1 Historical Background

In Northern of Thailand, there are plenty of Lanna traditional wisdom especially traditional medicines. The knowledge inherited from their ancestors from generation to generation. Thus, it is very important to learn and retrieve the valuable knowledges from traditional healers before it is lost indefinitely. In order to encourage doctors and other healthcare professionals to use more traditional plants as the alternative medicine, more scientific data are required to support their claims and benefits. The present research work is interested in the study of biological activities of each plant containing in the Mahoog formula as Lanna folk medicine. Mahoog is a group of gastrointestinal diseases[1]. The exact cause of Mahoog disease is not well established. The important criteria for Mahoog diagnosis are twisting pains in lower abdomen, aching in the lower back and pelvic region, changing in the consistency and looks of feces, which being looser or harder than normal feces and mixed with blood, mucus, or fat and leading to difficulties to go to work. This disease is a chronic disease if left untreated.

To gather information from Lanna medicinal plants manuscripts and from the in-depth interview with traditional healers who specialize in plants used in the Mahoog formula from Chiang Mai, Chiang Rai and Lampang provinces found that the formula should consist of herbs which could to reduce the chronic inflammation, relieve pain, act as astringent, moderate blood tonic and result cause the disappearance of the rectal polyps[2-5]. In our previous study, 85 medicinal plants were found in 17 different formula[6].

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The predominant symptoms of Mahoog are pain, inflammation and wound infection. Especially, when the wound is occurring, it is accompanied with pain, reddening and edema within a short time, which are the classical magnifications inflammation. They are resulted from the releasing of eicosanoids, prostaglandins, leukotrienes, and reactive oxygen species (ROS). Not only is ROS produced in large amount at the site of the wound as a defense mechanism against invading bacteria, but also at the same time, the presence of free radicals may be interfere the process of wound healing, resulting in trauma and wound destruction or severe microbial infection[7, 8]. The present study will be focused on Lanna medicinal plants in Mahoog formula in their chemical constituents and the antioxidant and antibacterial activities. Data obtained from the study will be used as a scientific evidence to support the pharmacological properties of these medicinal plants.

1.2 Objectives

1.2.1 To study the chemical constituents of Lanna medicinal plants used in Mahoog formula

1.2.2 To investigate antibacterial and antioxidant activities of Lanna medicinal plants used in Mahoog formula

1.3 Literature Review

1.3.1 Lanna and Lanna medicinal plants

Lanna is the name of an ancient kingdom located in Northern of Thailand, covering an area of 8 provinces, including Chiang Mai, Chiang Rai, Phayao, Phrae, Nan, Lamphun, Lampang and Mae Hong Son. Chiang Mai is the center of the Lanna Kingdom.[9]

The lifestyle of the Lanna community has a close relationship with nature, combined with traditional beliefs in religion and culture, which contributes to the Lanna wisdom in healthcare. In Lanna community, most traditional healers are usually using medicinal plants in the treatment to be cured from the diseases for a long time. In the meaning of Lanna medicinal plants, Lanna medicinal plants are the medicinal plants that have a recognized medical use in the Lanna community by traditional healers.

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1.3.2 Mahoog

Brun and Schumacher[1] defined the term of Mahoog that "Mahoog is a group of intestinal diseases. The delimitation against lidsaduan and khaan of the intestines is vague". From their definition of Mahoog, the definition in modern medicine is a group of gastrointestinal diseases. The treatment of Mahoog is prevented and cured from hemorrhoid, bloody discharge and Irritable Bowel Syndrome (IBS). There are 3 types of Mahoog, include Mahoog lyad (bloody discharge), Mahoog phanladii (constipation), and Mahoog kon puud (external hemorrhoid). The symptoms of bloody discharge are twisting pains in the abdomen, frequent defections (4-5 times/day), loose fecal matter mixed with red blood and mucus, consequently patients become thin and emaciated and may sometimes result in death. The principle symptom of Mahoog phanladii is the constipation, this symptom is probably 5 days between defecations, hard feces mixed with mucus or fat, and patients may get weak and dizzy. The last one is external hemorrhoid, which major symptoms are the intestines being pressed out through the anus, resulting in a warm, smarting pain. Patients might go to the toilet 2-4 times/day, having little loosed feces mixed with fat, mucus and/or blood. Mahoog is provoking factors of external hemorrhoid are hard work and very spicy food. Statistically occur in men more than frequently women.

1.3.3 Antibacterial activity

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According to the gastrointestinal inflammation in Mahoog diseases, the objective to be inhibited or interfered the further wound or blood infection is considered. An antibacterial agent is a substance or a compound that inhibits or kills the growth of bacteria. In the present study, four standard bacteria: *Bacillus subtilis*, *Staphylococus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* were carried out to determine the antibacterial activity, by using the agar diffusion and broth dilution methods. Diffusion method is the widely used method for determining bacterial sensitivity to antibiotics, by putting a filter disc, or cylinder or a well containing

measured quantity of drugs on a solid medium seeded with the test bacteria. After incubation, the zone of bacterial inhibition in the plate is measured. Dilution method is used to determine the minimal concentration of antibacterials, which is the lowest concentration that can inhibit the growth of 50 % of microorganisms[10, 11]. In the present study, the testes bacterial ATCC strain play a role as reference standard and were performed to evaluate the antibacterial of samples.

1.3.4 Free radicals and active oxygen species

In general, electrons are present in pair. Free radicals are chemical species that have one or more ("odd or single") electrons. Free radicals are reactive and attack other molecules because unpaired electrons usually look for other electrons to become paired. Some radicals are unchangeable sufficient to lifetime although some radicals are not reactive.[12]

Active oxygen species or reactive oxygen species mean oxygen-containing molecules, which are very reactive molecules. Active oxygen and related species are important for the production of energy, phagocytosis, cell growth regulation, intercellular signaling and synthesis of biologically essential substances. They also play an important role signal transduction, which is necessary for cell function and communication. Nevertheless, it is reported that reactive oxygen species are a major cause of many diseases such as cancer, heart disease and aging.[13]

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1.3.5 Oxidative stress

Oxidative stress is an imbalance between pro-oxidant/free radical production and antioxidant defenses. An imbalance between oxidants and defense systems causes oxidative stress. Free radicals are a product as normal biochemical reactions in the body. Nevertheless, external factors might trigger the production of free radicals in the body, such as pollutions, exposure to sunlight, and smoking. Oxidative stress is one of the major cause of many diseases; such as cancer, neurodegenerative disorders, Alzheimer's disease, Parkinson's disease, which has an effect on the body's aging process too.[14]

1.3.6 Antioxidants

Halliwell has defined an antioxidant as "any substance that when present at low concentrations compared to those of an oxidizable substrate (e.g., lipid, protein, DNA) significant delays or prevents oxidation of that substrate". These definitions therefore include not only chain-breaking antioxidant (e.g. ascorbic acid, tocopherol, glutathione) but also enzymatic systems (for example: catalase, superoxide dismutase, glutathione peroxidase) and proteins used to sequester metals capable to HO• production (for example: albumin, ceruloplasmin, ferritin, transferrin, hemopexin and haptoglobulin.[15]

Type of antioxidants[16]

Antioxidants are divided into 2 types by source, synthetic antioxidants and natural antioxidants. Synthetic antioxidants include gallic acid derivatives, butylates hydroxytoluene (BHT), butylates hydroxyanisol (BHA) and tertiary butylhydroquinone (TBHQ). Natural antioxidants derive from many source including animal tissue, plants, microorganism, and fungi. Phenolic compounds are the large group of natural antioxidants. Three principles

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groups of antioxidant are flavonoids, tocopherol, and phenolic acid. Due to the synthetic antioxidant sometimes found toxicological evidence offer caution in their use, natural antioxidants have been enlarging used as alternative antioxidants.

Table 1.1 Advantage and disadvantage of natural and synthetic antioxidants[14]

Synthetic antioxidant	Natural antioxidant
Inexpensive	Expensive
Largely applied	Use prohibited to some product
Medium to high antioxidant activity	General ranging antioxidant activity
Increasing safety concern	Perceived as harmless substance
User banned for some of them	Enlarging use and expanding application
Poor water solubility	Wide range of water solubility
Decreasing interest	Increasing interest

1.3.7 Phenolic compounds

Phenolic compounds belongs to a large number of compounds consist of one aromatic hydrocarbon group and one or more OH groups. These compounds are originated as secondary metabolites via a shikimic acid pathway in plants[14]. The principal classes of phenolic compounds are presented in Table 1.3.

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Table 1.2 Classes of phenolic compounds found in plants[14]

Basic skeletons	Classes	Examples
C_6	Simple phenols	Phenol, guaiacol
	Benzoquinones	2,6- Dimethoxybenzoquinone
C_6-C_1	Hydroxybenzoic acids	Gallic, p-hydroxybenzoic, salicylic
C_6-C_2	Acetophenones	3-Acetyl-6-ethoxybenzaldehyde
	Phenylacetic acids	p-Hydroxyphenylacetic
C_6-C_3-C_6	Flavonoids	Quercetin, Catechin
	Isoflavonoids	Genistein
$(C_6$-$C_3)_2$	Lignans	Pinoresinol
$(C_6$-C_3-$C_6)_2$	Biflavonoids	Amentoflavone
$(C_6$-$C_3)_n$	Lignins	-
$(C_6)_n$	Catechol melanins	-
$(C_6$-C_3-$C_6)_n$	Condensed Tannins	-

1.3.8 Flavonoids[17]

Flavonoids are the biggest and ordinary distributed group of plant phenolics. The chemical structures of flavonoids are consisting 15 carbon with 2 aromatic rings linked to a three carbon chain. (Figure 1.1) The important flavonoids are including flavanones, flavanols, flavones, flavonol, anthocyanidins and isoflavones. (Figure 1.2)

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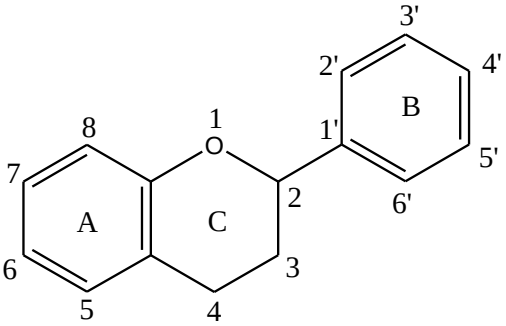
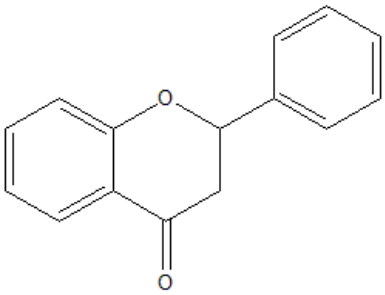
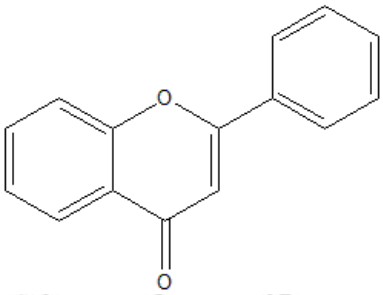


Figure 1.1 Basic structure of flavonoid skeleton



Flavanones



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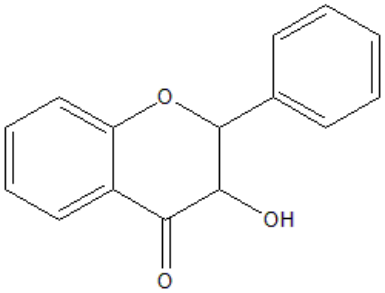
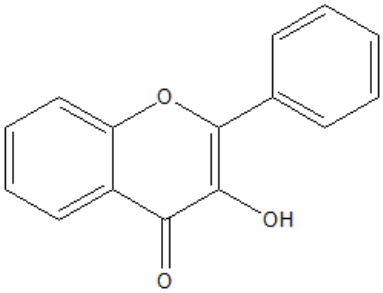
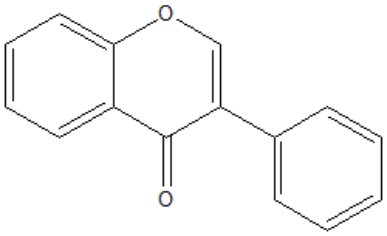


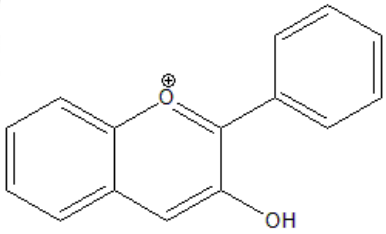
Flavanonols



Flavonols



Isoflavones



Anthocyanidins

Figure 1.2 The chemical structure of flavonoids

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The basic skeleton of all flavonoids is originated from three molecules of malonyl-CoA and one of 4-coumaroyl-CoA. (Figure 1.3)

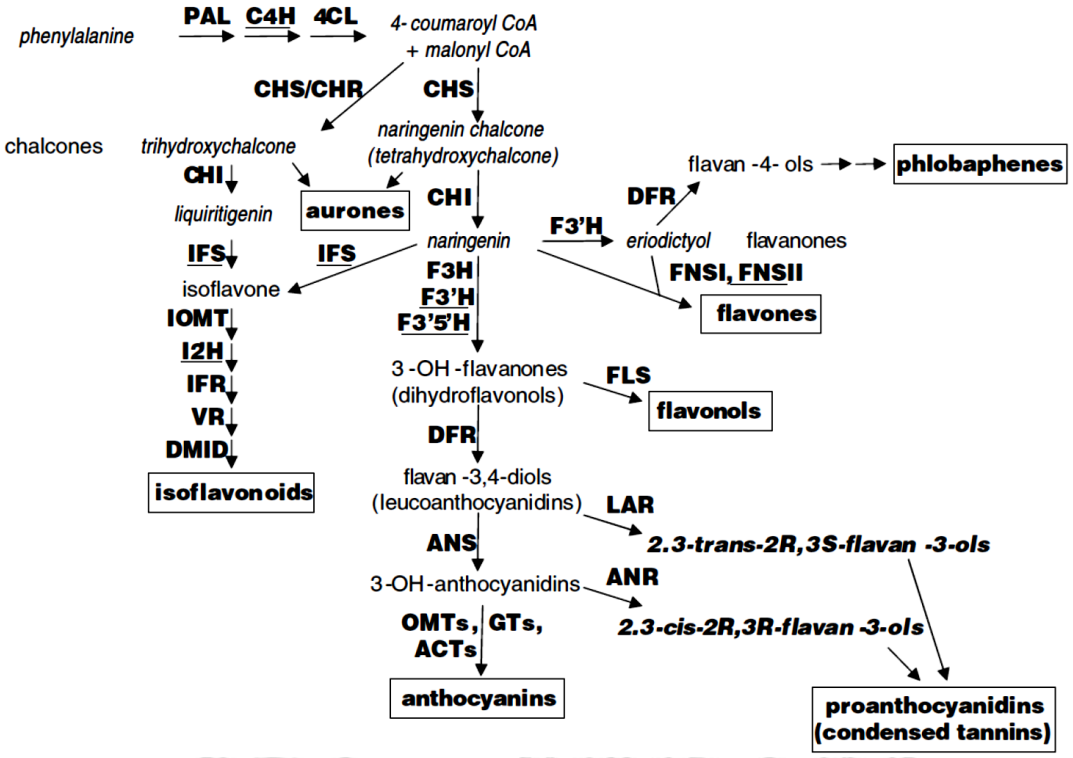

Figure 1.3 Biosynthetic pathway of flavonoid[18]

Abbreviations: ACTs, acetyl transferases; ANR, anthocyanidin reductase; ANS, anthocyanidin synthase; C4H, cinnamate-4-hydroxylase; CHI, chalcone isomerase; CHR, chalcone reductase; CHS,chalcone synthase; 4CL, 4-coumaroyl:CoA-ligase; DFR, dihydroflavonol 4-reductase; DMID, 7,2'-dihydroxy, 4'-methoxyisoflavanol dehydratase; F3H, flavanone 3-hydroxylase; FNSI and FNSII, flavone synthase I and II; F3'H and F3'5'H, flavonoid 3' and 3'5'hydroxylase; IOMT, isoflavone O-methyltransferase; IFR, isoflavone reductase; I2'H, isoflavone 2'-hydroxylase; IFS, isoflavone synthase; LAR, leucoanthocyanidin reductase; OMTs, O-methyltransferase; PAL, phenylalanine ammonia-lyase: GTs, glucosyl transferases; VR, vestitone reductase.

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The antioxidant activity of flavonoids is acting by chelating metal ion, inhibiting enzymes, interact with the other antioxidants and radical scavenging[16]. Flavonoids usually found in many sources such as vegetables, fruits, flowers, nuts, seeds, and also in beverages. Flavonoids have various biological properties such as antibacterial, anti-inflammation, antitumor, anti-allergic and antiviral properties.

1.3.9 *In vitro* antioxidant activity assay

Radical-scavenging is the principal mechanism by which antioxidant acts in foods. Numerous methods have been developed to evaluate the antioxidant activity. The basic methods usually use 2,2-diphynyl-1-picrylhydrazyl (DPPH) or 2,2'-azinobis (3-ethylbenzthiazoline-sulphonic acid) (ABTS) radicals [19].

For the DPPH assay, the scavenging of DPPH radicals is observed by using spectrophotometer to monitor the decreasing of absorbance at 517 nm due to the reduction by antioxidant or reaction with a radical species[19]. Fast reaction of DPPH radicals exposes with some phenolics e.g. α-tocopherol. Many reports in which the DPPH method has been used presented that the scavenging occurred after 15 or 30 minutes reaction time. The radical scavenging activity is generally reported in the term of EC_{50}. EC_{50} is the concentration of antioxidant desired for 50 % scavenging DPPH radical in the specified time period[19].

The ABTS radical cation is more reactive than the DPPH radical. Therefore, the antioxidant reaction of the ABTS radical cation can be completed within 1 minute. Since the method was first described, the generation of the radical cations had been changed several times. The most recent method is to use potassium persulphate to oxidize ABTS in order to generate the radical

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cations. The radical scavenging activity which assessed by the ABTS method can express as the trolox equivalent antioxidant capacity (TEAC)[19].

The FRAP assay was initially developed by Benzie and Strain to determine the reducing power in plasma. Determining the antioxidant activity by FRAP assay in natural products can be used by modifyng method. The FRAP assay measures the reaction of ferric 2,4,6-tripyridyl-s-triazine (TPTZ) reduce to a blue colored product. The reaction detects compounds with redox potentials of <0.7 volt, thus FRAP assay is a suitable screening method for detecting redox status in tissues or cells. The degree of hydroxylation and extent of conjugation in polyphenol are related to the reducing power. Nevertheless, the FRAP assay cannot detect antioxidant compounds that act by radical quenching (H transfer), especially protein and thiols[20, 21].

1.3.10 Extraction method

For traditional uses, decoction is one of the technique of extraction to prepare water extract (solution) from a traditional formula include Mahoog formula. Decoction is the method of choice for extraction sticky tissue, barks, roots and fibrous plants. Therefore, this study will use decoction and soxhlet's apparatus to extract the plant materials. Soxhlet's extraction is one of the most commonly used methods for extraction of active compounds from the plants. The advantage of soxhlet's extraction is that large amounts of plant materials can be extracted with a much smaller quantity of solvent, which tremendously saves time, energy and budgets[22].

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1.3.11 Structure identification[23, 24]

In spectroscopic identification of organic compounds, the important spectroscopic and analytical techniques that used for structure elucidation included Ultraviolet/Visible Spectroscopy, Infrared Spectroscopy, Nuclear Magnetic Resonance Spectroscopy and Mass Spectrometry the detail is described as follows:

1) Ultraviolet/Visible Spectroscopy: UV/VIS spectroscopy measure the absorption of ultraviolet/visible light by a molecule causing the promotion of an electron from a ground state to an excited state. The types of bonds in a molecule and chromophore within a molecule are correlated with the wavelengths of absorption peaks.

2) Infrared Spectroscopy: Infrared spectroscopy is one of the most general spectroscopic techniques used in organic and inorganic compound research. This technique measures the absorption at different IR frequencies. The purpose of IR spectroscopic analysis is to determine the functional groups in the compound. Different functional groups are represented the characteristic frequencies of IR radiation. IR spectrophotometer can be used with various kinds of sample such as liquids, gases and solids. Thus, IR spectroscopy is a favorite and necessary tool for structure elucidation and compound identification.

3) Nuclear Magnetic Resonance Spectroscopy: Nuclear magnetic resonance spectroscopy (NMR) is a useful technique based on the magnetic properties of the atomic in the radio-frequency region for determining organic structure. ^{1}H and ^{13}C are the common nuclei which are used to study. In ^{1}H NMR spectra shows the chemical shifts in the range +14 to -4 ppm and the NMR signal such as: number, location, intensity and splitting pattern depend on their chemical environment. ^{13}C NMR is similar to ^{1}H NMR and it can be used to identify carbon atoms in organic compound similar to a ^{1}H NMR being used to identify hydrogen atoms.

4) Mass Spectrometry: Mass spectrometry (MS) is an important technique for structural elucidation of natural product. The principle concept of MS is when a sample is loaded into the MS instrument, the components of sample are converted to ions by ionization method and then they are excited to undergo fragmentations. Mass to charge ratio of fragmentation ions are determined, and the result displays on mass

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spectrums. Data obtained from mass spectrums can be interpreted to the molecular weight and the structure of the compounds.

The structural elucidation starts by gathering the information from the molecular ion peak in mass spectra for deriving the molecular formula by using the "Rule of thirteen" and then calculated the index of hydrogen deficiency which can be used to predict the sum of the number of ring and of double and triple bonds. After that assigned diagnostic bands, peaks, protons and carbons in the IR, UV/VIS, ^{1}H NMR and ^{13}C NMR spectrums, respectively. Data obtained from the previous information can be the proposed structure of the compounds.

1.3.12 Medicinal plants used in the present study

1) **Scientific name:** *Millingtonia hortensis* L.f.

Family name: Bignoniaceae

Common name: Indian cork tree

Local name: ปีบ

Lanna name: กาซะลอง

Part used: stem

Botanical description from Flora of China:

Evergreen trees, 8-25 m tall. Leaves 40-100 cm; leaflets elliptic, ovate, or ovate-oblong, glabrous, base rounded, oblique, margin entire, apex acuminate. Cymose-paniculate inflorescences, pedicels and peduncle pale yellow pubescent; bracts and bractlets deciduous, pedicel slender, calyx small. Corolla white, tube 3-7 cm, 2-3 mm in diameter at base. Ovary glabrous; ovules numerous. Seeds discoid-oblong, compressed, including wing and surrounded by membranous and transparent wings.[25]

Distribution: widely distributed in South Asia and South East Asia

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Figure 1.4 *Millingtonia hortensis* L.f.

2) **Scientific name:** *Caesalpinia sappan* L.

Family name: Caesalpineaceae

Common name: Sappan tree

Local name: ฝาง

Lanna name: -

Part used: heartwood

Botanical description from Flora of China:

Shrubby tree, 4-8(-10) m tall. Branches with dense, conspicupus lenticels. Leaves 30-45 cm; pinnae 7-13 pairs, opposite; leaflets 10-17 pairs, sessile, oblong to oblong-rhombic, both surfaces glabrous or sparsely hair. Panicles terminal or axillary, as long as leaves; bracts lanceolate, large. Peduncles puberulent. Receptacle shallowly campanulate. Petals yellow, broadly obovate, uppermost one entire at apex, tinged pink at base, clawed. Stamens slightly exserted; filaments densely, hairly; stigma truncate. Legume reddish brown. Seeds 3 or 4, light brown, slightly compressed, oblong.[26]

Distribution: Cambodia, India, Laos, Malaysia, Myanmar, Sri Lanka, Vietnam, Africa, America

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Figure 1.5 *Caesalpinia sappan* L.

3) **Scientific name:** *Sindora siamensis* Teijsm. & Miq.

Family name: Caesalpineaceae

Common name: -

Local name: มะค่าแต้

Lanna name: มะค่าหนาม

Part used: stem

Botanical description from Mangrove guidebook for Southeast Asia:

Leaves alternate, with 3(-5) pairs of opposite leaflets; leaflets oblong-ovate, rounded tip or with a slight notch at the tip. Upper surface of leaflet is dull, the veins very thinly velvety, faint net-like lines on both surfaces. Flowers densely clustered in a compound terminal panicle, stalks golden colored, finely hairy. Sepals green, ovate, outside hairy, often warty, with a few spines on the ends. Petals 1, boat-shaped, variable in color from light yellow to red or brown, woolly outside, smooth inside. Stamens 10 (9+1), pink, fused unevenly, with curved filaments, pink; 5 stigmas. Fruit consists of a pod, which is flat, irregularly round or ovate, rather diffusely spiny; stalks are very short. Seeds ovate, 10-15 mm.[27]

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Distribution: widely in Indochina and the Malay Peninsula and all regions in Thailand

4) **Scientific name:** *Celastrus paniculatus* Willd.

Family name: Celastraceae

Common name: -

Local name: กระทุงลาย

Lanna name: มะแตก

Part used: stem

Botanical description from Flora of China:

Large deciduous twining shrubs; bark pale brown, rough and cracked, exfoliating in small scales; branchlets pubescent or glabrous, with prominent elliptic lenticels. Leaves blade elliptic, oblong, rectangular, ovate, or obovate to suborbicular, glabrous, base cuneate, margin serrate, apex mucronate to acuminate. Flowers greenish, 5-merous, dioecious; sepals free, imbricate, semiorbicular, ciliate; petals oblong to obovate-rectangular. Disk membranous, cupulate, slightly 5-lobed. Stamens inserted on margin of disk. Ovary globose. Capsule depressed, globose, 3-valved, bright yellow, 3-6-seeded. Seeds elliptic; aril orange-red.[28]

Distribution: widely in India and Thailand.

Figure 1.6 *Celastrus paniculatus* Willd.

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5) **Scientific name:** *Combretum quadrangulare* Kurz

Family name: Combretaceae

Common name: -

Local name: สะแกนา

Lanna name: แพ่ง

Part used: stem

Botanical description from PROSEA:

A shrub or tree up to 12 m tall, branches quadrangular; leaves usually opposite, obovate, base acute, apex obtuse or rounded, densely scaly, soon glabrescent; inflorescence an axillary and terminal spike, flowers mostly 4-merous, densely scaly, subsessile, receptacle stipitate above ovary, abruptly dilated into the cup-shaped calyx-limb, petals broadly ovate, easily shed, yellowish; pseudocarp thinly 4-winged; seed fusiform.[29]

Distribution: widely in Southeast Asia

Figure 1.7 *Combretum quadrangulare* Kurz

6) **Scientific name:** *Terminalia bellerica* (Gaertn.) Roxb.

Family name: Combretaceae

Common name: Beleric myrobalan

Local name: สมอพิเภก

Lanna name: แหนต้น

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Part used: stem

Botanical description from Flora of China:

Trees deciduous, to 35 m tall. Bark gray, longitudinally ridged. Branchlets with conspicuous, spirally ascending leaf scars. Leaves spiraled, crowded into pseudowhorls at apices of branchlets; petiole glabrous; leaf blade glossy, obovate, both surfaces glabrous except ferruginous tomentose when young, base obtuserounded or attenuate, apex obtuse or mucronate; lateral veins in 5-8 pairs. Inflorescences axillary, simple spikes, often grouped at branchlet apex and forming a panicle; axis densely ferruginous tomentose. Calyx tube distally shallowly cupular, abaxially tomentose, adaxially long villous; lobes 5. Stamens 10, exserted. Fruit shortly stipitate, subglobose to broadly ellipsoid or ovoid, weakly to strongly 5-ridged, densely and finely velutinous or sericeous.[30]

Distribution: widely in Southeast Asia, Sri Lanka, Bangladesh, Bhutan, China, Nepal and Pakistan

Figure 1.8 *Terminalia bellerica* (Gaertn.) Roxb.

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7) **Scientific name:** *Combretum deciduum* Collet & Hemsl.

Family name: Combretaceae

Common name: -

Local name: -

Lanna name: แหนเครือ

Part used: stem

Botanical description: -

Distribution: -

8) **Scientific name:** *Shorea obtusa* Wall. ex Blume

Family name: Dipterocarpaceae

Common name: -

Lanna name: แงะ

Part used: stem

Botanical description:

Deciduous tropical tree, 10-30 m tall. Leaves oblong. Flower white, fragrant.[31]

Distribution: -

Figure 1.9 *Shorea obtusa* Wall. ex Blume

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9) **Scientific name:** *Erythoxylum cuneatum* (Miq.) Kurz

Family name: Erythoxylaceae

Common name: -

Local name: ไกรทอง

Lanna name: มะห้านก

Part used: root, stem

Botanical description from Flora of the Philippines and PROSEA: Small to large tree or a shrub, 8-40 m tall. Leaves very variable in size and shape, even on the same twig, mostly obovate, elliptic or oblong; dark green to greenish brown often shining above, dull light green beneath, shortly acuminate or rounded with a more or less emarginate, mostly mucronate tip, base attenuate or cuneate; midrib nearly always sunken above, very prominent beneath; nerves on both sides equally distinct, often almost horizontal and close together giving a dense nervation, venation delicate; areolation often distinct; petiole 2-7(-9) mm. Stipules triangular to lanceolate, mostly as long as the petiole, not divided, entire, distinctly bicarinate c. 2-7(-9) mm, top mostly curved. Flowers in clusters of 1-8, mostly in pairs, faintly scented. Bracteoles deltoid, scarious, 1-nerved. Pedicels thickened towards the calyx. Calyx tube; lobes triangular, acuminate with a bluntish tip. Petals white, whitish green to light green and yellow, oblong or oblong-elliptic, convex; ligule 3-lobed, half as long as the blade; claw often distinctly narrowing towards the base. Flowers dimorphous, both types either with equal or unequal stamens. Drupe oblong-ovoid, often somewhat curved, red, when dry obtusely trigonous, distinctly furrowed, top pointed; fertile cell as large as or smaller than sterile cell, bilaterally compressed, sterile cells distinct and large, on both sides of the fertile cell. Seed flattened often curved, with distinct furrows.[32, 33]

Distribution: Burma and Indochina to New Guinea.

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Figure 1.10 *Erythoxylum cuneatum* (Miq.) Kurz

10) **Scientific name:** *Trigonostemon reidioides* (Kurz) Craib

Family name: Euphorbiaceae

Common name: -

Local name: โลดทะนง

Lanna name: มะโหกโตน

Part used: root

Botanical description from Flora of Thailand:

Shrub, up to 1.5 m tall; branchlets pubescent, glabrescent. Stipules triangular. Leaves: petiole 0.8-1.9 cm long, sparsely hairy; blade narrowly or broadly oblong, oblanceolate or ovate lanceolate, chartaceous, hairly on both side, base obtuse, margin glandular serrulate, apex acute or acumunate, nerves in 8-12 pairs, trinerved at base. Inflorescences racemose. Staminate flowers: pedicel 1-2 cm long; sepals obovate, hairly outside; petals oblanceolate or obovate, dark red; disc cupular, undulate; stamens 3, staminal column. Pistillate flowers: pedicel 0.8-1.5 mm long; sepals 5, oblong, sparsely hairly outside; petals 5, obvate, dark red, ovate; disc cupular; ovary pubescent. Fruits capsule globose, pubescent. Seed globose.[34]

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Distribution: Indochina

Figure 1.11 *Trigonostemon reidioides* (Kurz) Craib

11) Scientific name: *Croton crassifolius* Geiseler

Family name: Euphorbiaceae

Common name: -

Local name: พังคี

Lanna name: ปังคี

Part used: root

Botanical description from Flora of China:

Shrubs 20-50 cm tall; indumentum stellate-tomentose; older branches subglabrous. Stipules subulate, caducous. Petiole apex or base of midrib with 2 stalked and copular glands; leaf blade ovate, ovate-elliptic, or oblong, adaxial hairs gradually deciduous, but persistent hairs rugged, base rotund to slightly cordate, margins obscurely serrulate, sometimes glandular between teeth, apex obtuse to shortly acuminate; basal veins 3(-5), lateral veins (3 or)4 or 5. Inflorescence terminal, bracts linear, margins linear-lacerate, glandular-serrate. Male flowers: sepals stellate-tomentose outside; petals oblong, about as long as sepals, margins woolly; stamens 14-20. Female flowers: sepals as in male; ovary densely yellow-tomentose; styles 4- parted, lobes linear. Capsule subglobose. Seeds ellipsoidal.[28]

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Distribution: Laos, Myanmar, Thailand and Vietnam

12) **Scientific name:** *Leea rubra* Blume ex Spreng.

Family name: Leeaceae

Common name: -

Local name: กะตังใบแดง

Lanna name: เขืองแข้งม้า

Part used: root, stem

Botanical description from PROSEA:

A small semi-herbaceous shrub, up to 3 m tall; leaves 2-4 pinnate, leaflets numerous, rachis, stipules a narrow wing, leaflets ovate to ovate-oblong or elliptical to elliptical-lanceolate, base rounded to acute, apex acute to shortly acuminate, margin crenate to shallowly serrate, pearl-glands apparently absent; cyme generally compact, rusty pubescent, bracts deltoid-triangular, inconspicuous; flowers bright red, calyx glabrous, lobes shallowly retuse or cleft, sinuses deep, ovary 4-6-celled; berry 8-10 mm in diameter, dark red, 6-seeded; seed 4 mm x 4 mm.[35]

Distribution: India, Burma (Myanmar) throughout South-East Asia, to northern Australia.

Figure 1.12 *Leea rubra* Blume ex Spreng.

13) **Scientific name:** *Leea indica* (Burm.f.) Merr.

Family name: Leeaceae

Common name: -

Local name: กะตังใบ

Lanna name: เขืองแข้งม้าขาว

Part used: root, stem

Botanical description from PROSEA:

Shrub, tree or small tree 2-10 m tall, many- or single-stemmed, frequently stilt-rooted, stems glabrous to pubescent; leaves (1-)2-3-pinnate, leaflets 7-numerous, stipules obovate, early caducous, usually glabrous, leaflets ovate-oblong to ovatelanceolate or elliptical to elliptical-lanceolate, base cuneate to rounded, apex acute to acuminate, margin serrate to shallowly dentate, pearl-glands small, inconspicuous, rapidly caducous; cyme usually lax, sometimes compact, glabrous to pubescent, bracts deltoid to narrowly triangular; flowers greenish-white, calyx glabrous to pubescent, staminodial tube, lobes shallowly retuse, notched or cleft, sinuses shallow, ovary (4-)6(-8)-celled; berry 5-10(-15) mm in diameter, purple-black, 6-seeded; seed 5 mm x 4 mm.[36]

Distribution: India, Sri Lanka, throughout South-East Asia, to northern Australia, Solomon Islands, New Hebrides and Fiji.

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Figure 1.13 *Leea indica* (Burm.f.) Merr.

14) Scientific name: *Aganosma marginata* (Roxburgh) G. Don

Family name: Apocynaceae

Common name: -

Local name: -

Lanna name: เดื่อดิน

Part used: stem

Botanical description from Flora of China:

Lianas to 8 m. Stems and branches lenticellate. Petiole ca. 1 cm; leaf blade oblong, abaxially pubescent especially along veins, base acute to rounded, apex acuminate or caudate; lateral veins 12-15 pairs, elevated abaxially. Cymes axillary, 3-branched; peduncle puberulent; bracts and bracteoles sublinear. Pedicel puberulent. Calyx with a continuous row of numerous basal glands inside; sepals sublinear, puberulent outside. Corolla white or yellowish, tube 8-10 mm, densely villous inside; lobes very narrowly elliptic. Stamens inserted below middle of corolla tube; disc ringlike, shorter than ovary. Ovary glabrous. Follicles 2, cylindric. Seeds oblong, flat.[37]

Distribution: Cambodia, India, Indonesia, Laos, Malaysia, Philippines, Thailand and Vietnam.

15) Scientific name: *Pterocarpus macrocarpus* Kurz

Family name: Papilionaceae

Common name: -

Local name: ประดู่

Lanna name: ดู่ป่า

Part used: stem

Botanical description from Cambodian Tree Species:

Deciduous tree, 25-30 tall. Leaves compound, alternate, bi-pinnate, with densely hairy on the petiole. Leaves shed during the dry season**.** Flowers small, bright yellow, fragrant. Fruits with orbicular wing.[38]

Distribution: Southeast Asia, Northeast India.

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Figure 1.14 *Pterocarpus macrocarpus* Kurz

16) **Scientific name:** *Thunbergia laurifolia* Lindl.

Family name: Acanthaceae

Common name: Blue trumpet vine, purple allamanda, laurel-leaved thunbergia, laurel clock vine

Local name: รางจืด

Lanna name: ฮางจืด

Part used: stem

Botanical description from U.S. Geological Survey :

Woody climbers. Leaves ovate-oblong or sublanceolate subentire to slightly crenate leaves, obtuse or subcordate, acute-acuminate, pinnately nerved, glabrous; bracteoles persistent; calyx truncate; 2 corolla blue-violet to white.[39]

Distribution: -

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Figure 1.15 *Thunbergia laurifolia* Lindl.

17) Scientific name: *Derris scandens* (Roxb.) Benth.

Family name: Papilionaceae

Common name: -

Local name: เถาวัลย์เปรียง

Lanna name: -

Part used: stem

Botanical description from PROSEA:

Climber up to 20 m long or scandent shrub with drooping branches, young branches finely pubescent; leaflets (7-)9-13(-19), puberulous beneath; inflorescence axillary; flowers with pubescent purplish calyx and whitish or pinkish corolla, standard without basal callosities, glabrous or hairy on the back; fruit narrowly oblong or strap-shaped, with a broad wing along one side.[40]

Distribution: India, Burma, Thailand, Malaysia and Northern Australia.

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Figure 1.16 *Derris scandens* (Roxb.) Benth.

18) Scientific name: *Piper sp.*

Family name: Piperaceae

Common name: -

Local name: -

Lanna name: สะค้านแดง

Part used: stem

Botanical description:

Small trees, shrubs, subshrubs, or rarely herbs, erect or reclining, glabrous or pubescent.

Distribution: -

19) Scientific name: *Ventilago denticulata* Willd.

Family name: Rhamnaceae

Common name: -

Local name: รางแดง

Lanna name: ก้องแกบแดง

Part used: stem

Botanical description:

Woody climber shrub. Leaves alternate, stipulate, elliptic, crenate-serrate. Flowers numerous in panicles, greenish-yellow. Ovary half-inferior. Fruit winged.[41]

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Distribution: -

Figure 1.17 *Ventilago denticulata* Willd.

20) Scientific name: *Ziziphus mauritiana* Lam.

Family name: Rhamnaceae

Common name: -

Local name: พุทรา

Lanna name: ตันแต้

Part used: stem

Botanical description from Flora of China:

Evergreen trees or shrubs, to 15 m tall. Young branches densely yellow-gray tomentose; old branches purple-red. Stipular spines 2, one oblique and hooklike recurved; petiole densely gray-yellow tomentose; leaf blade adaxially dark green, shiny, ovate or oblong-elliptic, rarely subrounded, papery to thickly papery, abaxially yellow or gray-white tomentose, adaxially glabrous, 3-veined from base, veins conspicuously reticulate abaxially, impressed or ± prominent adaxially, base subrounded, slightly oblique, margin serrulate, apex rounded, rarely acute. Flowers green-yellow, few to 10 in subsessile or shortly pedunculate, axillary dichotomous cymes. Pedicel gray-yellow tomentose. Sepals ovatetriangular, abaxially hairy, apex acute. Petals oblong-spatulate, clawed at base. Stamens subequaling petals.

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Disk thick, fleshy, 10-lobed, concave at middle. Ovary globose, glabrous; style 2-fid or branched to half. Drupe orange or red, turning black at maturity, oblong or globose, with persistent tube at base; fruiting pedicel, pilose, 2-loculed, 1- or 2-seeded; mesocarp corky; endocarp thick, thickly leathery. Seeds red-brown, broad and compressed.[42]

Distribution: Afghanistan, Bhutan, India, Indonesia, Malaysia, Myanmar, Nepal, Sri Lanka, Thailand, Vietnam; Africa and Australia.

21) Scientific name: *Ziziphus oenoplia* (L.) Mill.

Family name: Rhamnaceae

Common name: -

Local name: เล็บเหยี่ยว

Lanna name: ตันขอ

Part used: stem

Botanical description from Flora of China:

Shrubs erect or scandent, spinose. Young branches densely ferruginous or yellow-brown pubescent; bark gray or gray-brown. Stipular spines 1, sometimes 2, one recurved and one erect; petiole densely yellow-brown pubescent; leaf blade ovate-oblong or ovatelanceolate, papery, abaxially appressed pubescent to nearly villous, adaxially veins sparsely pubescent or glabrescent, 3-veined at base, veins prominent abaxially, conspicuously impressed adaxially, base usually ± asymmetric, subrounded, margin inconspicuously crenate, apex acute or acuminate. Flowers greenish yellow, few to 10 in axillary shortly pedunculate cymes. Pedicel pilose. Sepals ovate-triangular, abaxially sparsely pilose to pubescent, adaxially glabrous, apex acute. Petals spatulate, clawed, enfolding stamens. Stamens slightly shorter than petals. Disk pentagonous, thick, fleshy, often 5-lobed. Ovary globose, glabrous, immersed in disk; style 2-branched. Drupe black, shiny, globose or obovoid-globose, small, base with persistent calyx tube, apex mucronulate; fruiting pilose; endocarp

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cartilaginous, ; stone 1- or 2-seeded. Seeds shiny, globose.[42]

Distribution: India, Indonesia, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand; Australia.

Figure 1.18 *Ziziphus oenoplia* (L.) Mill.

22) Scientific name: *Ziziphus cambodiana* Pierre

Family name: Rhamnaceae

Common name: -

Local name: ตะครอง

Lanna name: หมากมา

Part used: stem

Botanical description:

Shrub, 10 m tall. Leaves alternatively, oval or oblong. Flowers pale yellow. Fruit drupe. Seeds round or oval shaped.[43]

Distribution: -

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Figure 1.19 *Ziziphus cambodiana* Pierre

23) Scientific name: *Oxyceros horridus* Lour.

Family name: Rubiaceae

Common name: -

Local name: คัดเค้าเครือ

Lanna name: เก็ดเก๊า

Part used: stem

Botanical description:

Shrub. Leaves opposite. Flowers white, fragrant.

Distribution: -

Figure 1.20 *Oxyceros horridus* Lour.

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24) Scientific name: *Anomianthus dulcis* (Dunn) J.Sinclair

Family name: Annonaceae

Common name: -

Local name: นมวัว

Lanna name: นมวัว

Part used: stem

Botanical description from PROSEA:

Woody climber, up to 30 m long. Flowers pale yellow. Fruit with numerous separate ripe carpels which are berrylike, globose to cylindrical, up to 2.5 cm long, red. In forests, thickets and woody grasslands; not very common.[44]

Distribution: Thailand, Indo-China, Peninsular Malaysia, Indonesia

Figure 1.21 *Anomianthus dulcis* (Dunn) J.Sinclair

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25) Scientific name: *Schleichera oleosa* (Lour.) Oken

Family name: Sapindaceae

Common name: Ceylon oak

Local name: ตะคร้อ

Lanna name: มะโจ้ก

Part used: stem

Botanical description from PROSEA:

Dioecious, deciduous tree, up to 40 m tall. Bark smooth, grey. Branches terete, with sparse, short fulvous sericeous hairs. Leaves paripinnate; leaflets elliptical to obovate, chartaceous to coriaceous, dark brown or greyishgreen above, lighter brown to greenish beneath, deep purple when young, base subacute to cuneate, often oblique, margin entire to repandous, apex obtuse or emarginate, sometimes shortly acuminate, veins in 12-15 pairs, looped and joined near the margin. Inflorescence situated in the defoliated part of branchlets above leaf scars, sometimes axillary, consisting of a few simple (female) or sparsely branched (male) thyrses, the basal part with scattered, many-flowered fascicles, the upper part spicate, sparsely hairy; flowers functionally unisexual, pale yellow or pale green; sepals 4-5, connate at base, lobes ovate to deltoid, obtuse to acute, with thin hairs on both sides, margin ciliate and sometimes glandular, deciduous in fruit; disk uninterrupted, patelliform, sinuate; petals absent; stamens 5-9, filaments sparsely hairy, much reduced in female flowers; ovary ovoid, slightly 3-angular and indistinctly 3-sulcate, style rather thick, pistil much reduced in male flowers. Fruit a broadly ovoid, ellipsoid to subglobular berry.[45]

Distribution: Sri Lanka and Indochina

Figure 1.22 *Schleichera oleosa* (Lour.) Oken

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26) Scientific name: *Holoptelea integrifolia* Planch.

Family name: Ulmaceae

Common name: -

Local name: กระเชา

Lanna name: ขะจาว

Part used: stem

Botanical description from Kumar D, *et al*.:

Large deciduous trees, 18 m tall. Bark gray, peeling in corky scales on old trees. Leaves simple, alternate, elliptic-ovate; leaf base rounded or heart shaped; stipules lance-shaped. Flowers greenish-yellow to brownish, pubescent, borne in short racemes or fascicles at the scars of fallen leaves. Sepals velvety, often four. Fruit circular samara, net veined wings, and flat seeds.[46]

Distribution: -

Figure 1.23 *Holoptelea integrifolia* Planch.

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1.3.13 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula

The previous reports of chemical constituents isolated from medicinal plants containing in the Mahoog formula and their biological activities are shown in Table 1.3.

Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula

No.	Scientific name	Part used	Chemical constituents	Biological activities
1	*M. hortensis*	flower	acteoside[47], cirsimaritin[48], cornoside[47], galactoside[49, 50] β-D-glucosyl isoeugenol[47], hortensin[48], isorengyol[47], millingtonine[51], pectolinarigenin[48], rengyol[47, 58, 59] , rengyolone[47], rengyside A-B[47], scutellarein[49, 50] and scutellarein-5-salidroside[47]	antimicrobial[52], antimutagenicity[53], antioxidant[52], antiproliferation[52] and larvicidal[54]
		leaf	crude	antimicrobial[55]
		stem bark	crude	antibacterial[56] and antioxidant[57]
2	*C. sappan*	heart wood	brazilin[58], brazilide A[59], brazilein[60-62],	anti-inflammatory[63], antimicrobial[64-67],

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
			caeasalpin J[58], caesappanin A and B[69], homoisoflavonoids[70], 4,4′-dihydroxy-2′-methoxychalcone[70], 8-methoxybonducellin[70], quercetin[70], ombuin[70], hematoxylin[71], protosappanin A[58, 60, 62], protosappanin B[60, 62], 3'-deoxy-4-O-methylepisappanol[60] sappanchalcone[60], sappanone B[60], palmitic acid[60], (+)-(8S,8'S)-bisdihydrosiringenin[60], 4-O-methylsappanol[58], rhamnetin[70], 4-*O*-methylsappanol[60]3-deoxysappanchalcone[60], (+)-lyoniresinol[60], 3-deoxysappanone B[60], isoprotosappanin B[60], 3'-O-methylbrazilin[60], 5-hydroxy-1,4-naphthoquinone[65] and neosappanone A[72]	antioxidant[68], immunomodulation[73] immunosuppressive[61, 74] hepatoprotective[75] vasorelaxant[71]
		seed	phanginin A–K[76]	cytotoxicity[76]

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
3	*S. siamensis*	NS	NS	NS
4	*C. paniculatus*	seed	celapagin[77], celapanin[77], celapanigin[77], fatty acid[78], 1β,9α-dibenzoyloxy-4α-hydroxy-6α-acetoxy-β-dihydroagarofuran[79], and 1β, 6α,9α-tribenzoyloxyl-4α- β-dihydroagarofuran[80],	antioxidant[78, 81, 82], antispermatogenic[83], antiprotozoal[84], amnesic[77], antianxiety[85], nootropic[86], antispasmodic[87], muscle relaxant[79], analgesic[88], anti-inflammatory[88] and neuroprotective[89]
5	*C. quadrangulare*	leaf	betulinic acid[90], 24-epiquadrangularic acid G and L-M[91], quadrangularic acid F-M[91], 7β-hydroxy-23-deoxojessic acid[90, 91], norquadrangularic acid A[91], kumatakenin[90, 92], isokaempferide[90, 92], cycloartane triterpenes[92], methyl quadrangularates A-D and N-P[90], quadragularols A-B[90] β-sitosterol[90], methyl 24-epiquadrangularate C[90], quadrangularic acid E[90], 1-O-acetyl-23-	cytotoxicity[93]

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
			deoxojessic acid[90], methyl 23-deoxojessate[90], norquadrangularic acids B-C[90], 5,7,49-trihydroxy-3,39-dimethoxyflavone[90] and 5,49-dihydroxy-3,7,39-trimethoxyflavone[90]	
		seed	arjunglucoside II[94], arjunetin[94], arjungenin[94], arjunglucoside I[94], (+)-catechin[94], chebuloside II[94], combreglucoside[94], quadranosides I-V[95] quadranosides VI-XI[94], rosamutin[94], 28-O-β-D-glucopyranosyl-6β,23-dihydroxytormentic acid[94], vitexin[94], (-)-epigallocatechin[94], 6β-hydroxyhovenic acid[96], 6β-hydroxyarjunic acid[96], 2α,6β-dihydroxybetulinic acid[96], 19α-hydroxyasiatic acid[96],	antibacterial[97] hepatoprotective[96]

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
			nigaichigoside F1[96], pinfaensin[96], 2α,3β,23-trihydroxyurs-12,19-dien-28-oic acid β-D-glucopyranosyl[96], 5-methoxy-(-)-isolariciresinol[96], 5-methoxy-9-β-xylopyranosyl-(-)-isolariciresinol[96], (+)-gallocatechin[96], (-)-epicatechin[96], β-sitosterol glucoside[96], gallic acid[96] and methyl gallate[96]	-
6	*T. bellerica*	fruit	termilignan[98], thannilignan[98], 7-hydroxy-3',4'-(methylenedioxy) flavan[98], anolignan B[98], and gallic acid[99]	antispasmodic[100], bronchodilatory[100], anti-HIV-1[98], antimalarial[98], antimicrobial[98, 101], antihyperlipidemic[102] and antioxidant[101]
		seed	cannogenol 3-O-β-D-galactopyranosyl-(1→4)-O-α-L-rhamnopyranoside[103]	NS

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
7	*C. deciduum*	NS	NS	NS
8	*S. obtusa*	root	crude extract	antimicrobial[104]
9	*E. cuneatum*	leaf and branch	(+)-Catechin, citroside A, quercetin 3-O-alpha-L-rhamnoside, apocynol B, (6S,9R)-roseoside, inamoside and vomifoliol 9-O-alpha-larabinofuranosyl (1→6)-beta-D-glucopyranoside [105]	anticancer[106], cytotoxicity[107],
10	*T. reidioides*	root	afzelechin-(4α→8)-afzelechin[108], lotthanongine[108] , rediocides A-G[109, 110], scopoletin[110], (+)-syringaresinol[110], stigmasterol[110] and tomentin[110]	anticandidal[111] and cytotoxic[110]
11	*C. crassifolius*	root	9-[2-(2(5H)-furanone-4-yl) ethyl]-4,8,9-trimethyl-1,2,3,4,5,6,7,8-octahydronaph-thalene-4-carboxylic acid[112],	-

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
			methyl 9-[2-(2(5H)-furanone-4-yl)ethyl]-4,8,9-trimethyl-1,2,3,4,5,6,7,8-octahydronaphthalene-4-carboxylic ester[112] and crassifoliusin[113]	
12	*L. rubra*	leaf	gallic acid[114], myrecitol 3-rhamnoside[114], p-hydroxybenzoic acid[114] and syringic acid[114]	-
		root	-	anti-inflammatory, antinociceptive and antipyretic[115]
13	*L. indica*	leaf	phthalic acid, palmitic acid, 1-eicosanol, solanesol, farnesol, gallic acid, lupeol, beta-sitosterol and ursolic acid[116]	anticancer[117], antimicrobial[118], antioxidant[119, 120], cytotoxic[119] and phosphodiesterase inhibitory[121]
14	*A. marginata*	NS	NS	NS
15	*P. macrocarpus*	ND	crude extract	antioxidant[122]
16	*T. laurifolia*	-	-	-

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
17	*D. scandens*	stem	genistein[123], genistein-7- O-α-rhamno(1→6)-β-glucosyl glycoside[123], 3'-γ,γ-dimethylallyl-weighteone[123], 2',2''-dihydroxy-4'-methoxy-4'',5''-methylenedioxy-benzil[124], 3'-formyl-4',5-dihydroxy-2'',2''-dimethylchromeno-[6,7:5'',6''] isoflavone[124], derriscandenosides A-E[125], scandenal[124], scandenin[123], scanderone[124], isoscandinone[126], scandenin A and B[126], scandenone[126], scandinone[126] and 4', 5', 7-trihydroxybiprenyl isoflavone[126]	anti-inflammatory[127], antibacterial[124, 128] and radical scavenging[124, 126]
		root	derrisdione A[129]	antifeedant[129]
18	*Piper sp.*	NS	NS	NS
19	*V. denticulata*	ND	crude extract	anti-herpes simplex virus type 1[130]

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
20	*Z. mauritiana*	leaf	mucilages and polysaccharides[131]	antioxidant[132]
		fruit	crude extract	antioxidant[133]
		seed	crude extract	anticancer[134]
		root	mauritine L and M[135], nummularines H and B[135] and hemsine A[135]	antiplasmodial[135]
		bark	crude extract	antioxidant, anti-inflammatory and adipocyte differentiation inhibitory[136]
21	*Z. oenoplia*	root	ziziphine N, O, P and Q[137]	hepatoprotective[138], antiplasmodial[137] and antiulcer[137]
		leaf and bark	crude extract	antibacterial, antifungal, and β-glucuronidase inhibitory[139]
22	*Z. cambodiana*	root bark	3-O-(4-hydroxy-3-methoxybenzoyl) ceanothic acid (3-O-vanillylceanothic acid), lupeol, betulinaldehyde, betulinic acid, 2-O-E-p-coumaroyl alphitolic acid, alphitolic acid,	antiplasmodial and antimycobacterial[140]

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
			zizyberanalic acid, and ceanothic acid[140]	
		-	colubrinic acid, betulinic acid and alphitolic acid[141]	Hedgehog/GLI-mediated transcriptional inhibitors[141]
23	*O. horridus*	root	30-hydroxy ursolic acid[142] , D-mannitol, sterol mixture, oleanolic acid acetate, oleanolic acid-3-α-L-arabinoside and mesembryanthemoi-digenic acid[143]	
		-	pseudoginsenoside-RP1[144]	antinociceptive[144]
24	*A. dulcis*	leaf	*p*-coumaroyl-*β*-phenethylamine, 2′,3′-dihydroxy-4′,6′-dimethoxydihydro-chalcone, chrysin, pinocembrin, 5,7-dimethoxy-8-hydroxyflavanone and 2′,3′-dihydroxy-4′,6′-dimethoxy-chalcone[145]	
25	*S. oleosa*	seed oil	fatty acid[146]	
		stem bark	schleicherastatins 1-7 and schleicheols 1-2[147]	antiulcer[148], cytotoxic[149] and hydroxyl radical scavenging[149]

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Table 1.3 Chemical constituents and biological activities of medicinal plants containing in Mahoog formula (continued)

No.	Scientific name	Part used	Chemical constituents	Biological activities
15	*H. integrifolia*	stem bark, heart wood and leaf	friedelin[46], friedelin-3-β-ol[46], β-sitosterol[150], hederagenin[150], hexacosanol[46], fatty acid esters[46], holoptelin A and B[46] and β-amyrin[46]	antioxidant, anti-inflammatory and antimicrobial[8]

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