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นางสาวขนมกมล อุบลนุช

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CHEMICAL COMPOSITION AND ANTIMICROBIAL ACTIVITY OF ESSENTIAL OILS FROM THAI LAURACEOUS PLANTS

MISS CHOMKAMON UBONNUCH

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จากการศึกษาพืชในวงศ์ Lauraceae ของไทย จำนวน 15 ต้น ในแง่ของปริมาณและชนิดขององค์ประกอบของน้ำมันระเหย โดยใช้วิธีการกลั่นด้วยไอน้ำและเทคนิคทางโครมาโทกราฟี/แมสสเปกโทเมตรี ผลการศึกษาพบว่ามีความหลากหลายขององค์ประกอบทางเคมีและปริมาณโดยพบว่าองค์ประกอบส่วนใหญ่อยู่ในกลุ่มออกซิจิเนเตดโมโนเทอร์ปีนและในแง่ปริมาณจะอยู่ในช่วงร้อยละ 0.08-3.0 นอกจากนี้ยังได้ทำการศึกษาพืชต่างประเทศในวงศ์ Lauraceae ที่นำมาปลูกในไทยอีกจำนวน 1 ต้น ซึ่งได้ทำการเปรียบเทียบในด้านปริมาณและองค์ประกอบ พบว่าองค์ประกอบส่วนใหญ่ที่วิเคราะห์ได้ไม่มีความแตกต่างกันมากนักแต่ปริมาณจะต่ำกว่าและเมื่อนำน้ำมันระเหยไปทดสอบฤทธิ์ในการต้านจุลชีพต่อเชื้อ *Staphylococcus aureus* ATCC29213, *Enterococcus faecalis* ATCC29212, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC27853, *Bacillus subtilis* ATCC6633 *Candida albicans* ATCC10231 and *Microsporum gypseum* (clinical isolate) พบว่าน้ำมันระเหยส่วนใหญ่มีฤทธิ์ต้านแบคทีเรียและต้านเชื้อรา *Candida albicans.*

ภาควิชา ....เภสัชเวท....
สาขาวิชา ....เภสัชเวท....
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ลายมือชื่อนิสิต ....ชมกมล อุบลนุช....
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Content and composition of essential oils from fifteen species of Thai Lauraceous plants were investigated by hydrodistillation. The results obtained from GC/MS analysis showed diversity of their chemical components and their quantities. Oxygenated monoterpenes are most commonly found in essential oils of these particular species. The content of these compounds were found to be between 0.08 to 3.0 %. Essential oils of one species of Western Lauraceous plants cultivated in Thailand were also studied. Results have shown similarity of their constituents to previous report from western country, but with less amount. Screening for antimicrobial activity of essential oil from these plants against *Staphylococcus aureus* ATCC29213, *Enterococcus faecalis* ATCC29212, *Escherichia coli* ATCC25922, *Pseudomonas aeruginosa* ATCC27853, *Bacillus subtilis* ATCC6633 *Candida albicans* ATCC10231 and *Microsporum gypseum* (clinical isolate) was carried out, and it was found that most of the essential oils from Thai Lauraceae plants exhibited antibacterial activity and antifungal activity (*Candida albicans*).

ภาควิชา เภสัชเวท
สาขาวิชา เภสัชเวท
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ลายมือชื่อนิสิต ชมกมล อุบลนุช
ลายมือชื่ออาจารย์ที่ปรึกษา
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LIST OF ABBREVIATIONS

AOAC = Association of Official Analytical Chemists
cm = Centimeter
°C = Degree celsius
Fig = Figure
g = Gram
GC = Gas chromatography
GC-MS = Gas chromatography-Mass spectrometry
h = hour
HPLC = High performance liquid chromatography
i.d. = Internal diameter
m = Meter
MeOH = Methanol
mg = Milligram
min = Minute
µl = Microliter
ml = Milliliter
mm = Millimeter
MW = Molecular weight
No. = Number
RT = Retention time
sp = Species
v/w = Volume by weight
wt = Weight

CHAPTER I

INTRODUCTION

Lauraceae is a family belonging to order Laurales (Bentham and Hooker, 1967). The family includes about 40 genera and 13,000 species (Porter, 1967) of largely tropical parts and are most abundant in southeastern Asia and tropical America, while a few species can be found in warm temperate regions (Benson, 1959).

Mostly evergreen (deciduous in temperature regions), sometimes dioecious, trees or shrubs (except *Cassytha*, a twining parasitic perennial herb with leaves reduced or absent), bark and foliage usually aromatic ; leaves usually alternate, occasionally opposite or subopposite, simple, usually entire, mostly penninerved, usually punctate and coriaceous, exstipulate ; flowers in usually axillary, occasionally subterminal, panicles, spikes, racemes, or umbels ; generally bisexual, sometimes unisexual, actinomorphic, mostly 3-merous, small, greenish yellowish or white, the perianth biseriate, of usually 6 basally connate, usually undifferentiated sepallike segments, deciduous or persistant, the tube usually persisting as a cupule at base of fruit ; the androecium typically of 4 whorls of 3 stamens each, adnate to perianth tube, the innermost usually reduced to staminodes (sometimes only a single whorl remains functional and one or more whorls of staminodes may be absent), the filaments usually free, rarely those whorls united, the third whorl usually bearing a pair of usually sessile and distinct basal glandular protuberances (occasionally connate and disc-forming), the anthers basifixed, 2-celled or 4-celled at anthesis, those of the 2 outer whorls mostly introrse, the inner third whorl extrorse, dehiscing by flaplike valves opening upwards (when 4-celled, the valves superposed, except in *Nectandra* where the cells are arranged in an arc) ; pistil 1, the ovary usually superior, 1-loculed, the ovule solitary, anatropous, pendulous, the placentation parietal, the style 1, stigma 1, occasionally 2-3-lobed ; fruit a drupe or berry usually surrounded at base by enlarged and often persistent perianth tube seated on an enlarged receptacle or pedicel ; seed with large straight embryo, the endosperm absent (Lawrence, 1970).

Lauraceous Plants in Thailand

The occurrence of Lauraceous plants in Thailand as reported by Tem Smitinand (1980), includes various species as shown below about 18 genera and 69 species

Actinodaphne

A. angustifolia Nees.

Local name : กาทัด Kaathat (Rayong) , กาทิดหนู Kaathit nuu (Trat) **ร่มเข้า** Rom khao (Ranong)

A. henryi Gamble.

Local name : **ตองลาด** Tong laat (Chang Mai) , ตาถีบทอง Taa thaap thong (Nakhon Ratchasima) , แสนตะกละใหญ่ Saentaklayai (Sukhothai)

A. montana Gamble.

Local name : **แมแดซิกะ** Mae-dae si-ka (Malay-Pattani)

Alseodaphne

A. birmanica Kosterm.

Local name : **ขมิ้นต้น** Khaminton (Phetchabun)

Alsodeia = Rinorea

Alsomitra = Neoalsomitra

Alsophila = Cyathea

Beilschmiedia

B. assamica Maissn.

Local name : **จันทร์ดง** Chan dong , ตีด Teet (Trang)

B. *gammieana* King ex Hook. f.

Local name : **หน่วยนกงุม** Nuai nok ngum (Chiang Mai)

B. globularia Kurz.

local name : **มะเขือขื่น** Ma khuea khuen (Nakhon si Thammarat)

B. roxburghiana Nees.

Local name : ฝีหมอบ Fee mop (Nonthaburi) , **มะดูก** Maduuk (Trat)

Cinnamomum

C. bejolghota Sweet. (*C. obtusifolium* Nees ; *C. sintoc* Bl.)

Local name : ขนุนมะแวง Khanun mawaeng, เชียกใหญ่ Chiak yai (Trang),จวงดง Chuang dong (Nong kai), เฉียด Chiat, บริแวง Bori waeng (Ranong) , ฝนแสนห่า Fon saen haa ,สมุลแว้ง Samum lawaeng (Nakhon si Thammarat), พะแว Phawae, โมงหอม Mong homระแวง Rawaeng (Chon Buri), มหาปราบ Mahaapraap (Trat), มหาปราบตัวผู้ Mahaapraap tuaphuu (Chonthaburi), แลงแวง Laengwaaeng (pattani), **อบเชย** Op choei (Bangkok ,Uttaradit)

C. camphora Th. Fries.

Local name : พรมเส็ง Phrom-seng. (Shan-Northern) ; **อบเชยญวน** Opchoei yuan (General)

C. cinereum Gamble.

Local name : **ลูกข่า** Luuk Khaa (Chon Buri)

C. crenulicupulum Kosterm.

Local name : **ฮางแกง** Haang kaeng (Chiang Mai)

C. deschampsii Gamble.

Local name : **เชียดตัวเมีย** Chiet tua mia (Narathiwat); แตยอ Tae-yo (Malay-Narathiwat)

C. glaucescens Drury.

Local name : **กะเพราต้น** Kaphrao ton (Nakhon Ratchasima)

C. ilicioides Cheval (*C. siamense* Craib)

Local name : **ข่าต้น** Kha ton , ตะไคร้ต้น Takhrai ton (Chiang Mai) ; Cinnamom.

C. *iners* Bl.

Local name : กระแจะโมง Krachae mong ,กะเชียด Kachait, กะทังนั้น Kathang nan (Yala) ; กระดังงา Kradangngaa (Kanchanaburi) ;กระพัง

หัน Kapang han ,โกเล่ Ko-le เนอม้า Noe-maa (Karen-Kanchanaburi) ; เขียด, เคียด Khiat , เฉียด Chiat ,ชะนุต้น Chanu ton (Peninsular) , **เชียด** Chiat , มหาปราบตัวผู้ Mahaapraap tua phuu, อบเชย Opchoei, อบเชยต้น Opchoei ton (Central) ; ดิ๊กซี่สอ Dik-see-so (Karen-Chieng Mai) ; บอกคอก Bok Khok (Lampang); ฝักดาบ Fak daap (pitsanulok) ; พญาปราบ Phayaa praap (Nakhan Ratchasima) , สะวง Sawong (Prachin Buri)

C. kerrii Kosterm

Local name : **ละมุดละแม้ง** Lamunlamaeng (Loei)

C. mollissimum Bl.

Local name : **เชียดใบใหญ่** Chiatbaiyai (Yala)

C. porrectum Kosterm (*C. glanduliferum* Nees. ; *C. pathenoxylon* Nees.)

Local name : จวง Chuang ,จวงหอม Chuang hom (Peninsular); จะไคต้น Cha Khai ton , จะไคหอม Cha Khai hom (Northern) ; **เทพทาโร** Thepthaaro (Central, Chanthaburi , Suratthani) ; พลูต้นขาว Phluu ton khaao (Chiang Mai) ; มือแดกะมาจิง Mue-dae-ka-maa-nging (Malay-Pattani)

C. puberulum Ridl.

Local name : เชียดตัวผู้ Chiat tua phuu (Narathiwat) ; แตยอย่าแต Tae-yo-yaa-tae, ยอยแต Yo-yaa-tae (Malay-Narathiwat)

C. *subavenium* Mig. (*C. burmannii* Bl.)

Local name : ชะเอม Cha em , ชะเอมเครือ Cha-em Khruea (loei) ; **สุรามะริด** Suraamarit (Nakhon Ratchasima) ; เส่กอเล Se-ko-le (Kalen-Chiang-Mai)

C. tamala Th. Fries. (*C. cassia* Bl.)

Local name : **แกง** Kaeng (Chiang Mai)

C. tavoyanum Meissn.

Local name : **ปอยเลื่อม** Poi lueam (Northern)

C. zeylanicum Linn.

Local name : **การบูร** Kaarabuun (Bangkok) Cinnamon tree

Cryptocarya

C. pallens Kosterm.

Local name : หมากขี้อ้าย Maak khee aai (Lampang)

Dehaasia

D. candolleana Kosterm.

Local name : ทำมัง Thammang (Surat Thani) ; สิไหรใบใหญ่ Sirai bai yai (Yala)

D. kerrii Kosterm.

Local name : แหลช่อ Lae cho (Trang)

D. suborbicularis Kosterm.

Local name : กระตืด Kratuet (Khmer-Chanthaburi)

Endiandra

E. maingayi Hook fern.

Local name : ดันหมีใบเล็ก Dan mee bai lek (Trang)

Lindera

L. meissneri Hook. fern.

Local name : แส่ลู่เบาะ Sae luu-boh (Karen-Chiang Mai)

L. oxyphylla Hook. fern.

Local name : เลือดควาย Lueat khwaai (Surat Thani)

Litsea

L. baviensis Lec.

Local name : สุรามะริด Suraa-marit (Lampang)

L. cubeba Pers.

Local name : จะไค้ต้น Chakhai ton (Chiang mai); ตะไคร้ Takhrai (Kanchanaburi); ตะไคร้ต้น Takhrai ton (Loei)

L. elliptica Boerl.

Local name : ทำมัง Thammang (Surat Thani)

L. euosma W.W. Smith.

Local name : ซะไคร้ต้น Sakhraiton (Chiang Mai) ; **เมียดต้น** Miat ton (Loai)

L. glutinosa C.B. Robinson. (*L. chinensis* Lamk. ; *L. sebifera* Bl.)

Local name : กำปรนบาย Kam-pron-baai (Chong-Chanthaburi) ,ดอกจุ่ม Dok chum (Lampang) ตังสีไพร Tang see phrai (Phitsanulok) ; ทังบวน Thang buan (Pattani) ; มะเย้อ Ma yoe, ยุบเหยา Yup yao, **หมีเหม็น** Mee men (Northern Chon Buri) ; มือเบาะ Mue-boh (Malay-Yala); มัน Mon (Trang) ; หมี Mee (Ubon Thani, Lampang) ; หมูทะลวง Muu thaluang (Chanthaburi) ; หมูเหม็น Muu men (Phrae); เส่บียชู้ Se-pui-khuu (Karen Mae Hong Son) ; อีเหม็น Ee men (Kanchanaburi, Ratchburi)

L. grandis Hook. f.

Local name : กะทัง Ka thang, **กะทังใบใหญ่** Ka thang bai yai (Peninsular) ; กะตา Ka-taa, กะยูกะตา Kaa-yuu ka-taa, มือแด Mue-dae, มือแด็ง Mue-daeng(Malay-Narathiwat) ; กายมือแด Kaa-yuu mue-daa, มือแต Mue-tae (Malay-Pattani) ; ทังทอง Thang thong (Surat Thani) ; มะดัง Ma Dang (Narathiwat) ; สังตัง Sangtong (Yala)

L. johorensis Gamble.

Local name : **แปงู** Pae nguu (Pattani)

L. lancifolia Hook. f.

Local name : **หมอรัด** Mo rat (Surat Thani)

L. leiantha Hook. f.

Local name : **ทำมัง** Thammang (Surat Thani)

L. megacarpa Gamble.

Local name : **ทังช่อ** Thang cho (Surat Thani)

L. monopetala Pers. (*L. polyantha* Juss.)

Local name : **กะทัง** Ka thang (Peninsular); พอครา Pho khraa (Na khon Si Thammarat) ; โพหน่วย Phonuai, มุหมู Mu-muu (Karen-Kanchanaburi) ; เมาะโม Moh-mo (Karen-Mae Hong son) ; ยุ๊กเอา YuK yao (Phrae) ; สะหมี่ Sa mee (Chaiyaphum) ; หมี Mee

(Chanthaburi) ; หมีตุ้ม Mee tum , หมีโป่ง Mee pong (Chiang Mai) ; อีเหมี่น Ee men (Northern)

L. myristicaefolia Hook. f.

Local name : จามจุรี Chamchuree (Trat); **ตริด** Trit (Trang) , ตะไคร้ Ta Khrai (Chanthaburi)

L. parakensis Gamble.

Local name : **ตารีด** Taareet (Trang)

L. petiolata Hook. f.

Local name : **ทำมัง** Thammang (Penisular)

L. pierrei Lec.

Local name : **ตานหก** Taan hok (Prachin Buri)

L. resinosa Bl.

Local name : **ทำมังพอกรง** Thammang phokrong (Nakhon Si Thammarat)

L. semecarpifolia Hook. f.

Local name : **ช่อข้าวสุก** Cho khaao suk (Chiang Mai)

L. umbellata Merr. (*L. amara* Bl.)

Local name : **ฟันปลา** Fan plaa , สลด Salot (Chanthaburi) ; เมนตรือ Men-true (Khmer-Chanthaburi); สะเตื้อ Sa tuea (Trat)

Neocinnamomum

N. caudatum Kosterm. (*C. caudatum* Nees.)

Local name : ***จวงหอม*** *Chuanghom (Chiang Mai)*

Neolitsea

N. casiaefolia Merr.

Local name : **พิกุลป่า** Phikun paa (Chon Buri); เฮียน Hian (Songkhla)

N. cuipala Kostel.

Local name : **กีบตอง** Keep tong (Lampang)

N. siamensis Kostel.

Local name : **ตาทิบทอง** Taa thip thong, ตาทิบหิน (Taa thip hin) (Nakhon Ratchasima)

N. zeylanica Merr.

Local name : **เอียน** Ian (Peninsular)

Nothaphoebe

N. umbelliflora Bl.

Local name : **ทังใบช่อ** Thang bai cho (Satun)

Persea

P. americana Mill.

Local name : **อะโวคาโด** Awokhaado (Bangkok); Avocado, Alligator Pear.

P. gamblei Kosterm.

Local name : **อินทวา** Inthawaa (Loei)

P. kurzii Kosterm.

Local name : **ยางบง** ยางโบง Yaang bong (Nakhon Phanom, Nakhon Ratchasima)

P. membranacea Kosterm.

Local name : **เอียน** Ian (Songkhla)

P. pauhoi Kanehira

Local name : **ล่าเต๋า** Laa-tao (Chinese-Bangkok) ; Bandoline wood.

Phoebe

P. attenuata Nees.

Local name : ทังสิ่ไหร Thang sirai (Yala) ; แหลขี้ควาย Lae khee khwaai, แหลขี้ควาย Lae khee khwaai, **แหลคางคก** Lae Khaang khok, แหลทบ Lae Thop (Trang)

P. declinata Nees.

Local name : จันทิต Chan thit, **แหลบุก** Lae buk (Suratthani) ; พังตาลเขา Phangtaan Khao, แหลช่อ Laecho, แหลทอบ Lae thop (Trang) ; รังกะแท Rang ka thae (Chanthaburi)

P. excelsa Nees.

Local name : **พังตานเขา** Phang Taan khao (Trang)

P. grandis Merr.

Local name : ทังบอน Thang bon (Pattani) ; **มุ้นเขา** Mun Khao (Nakhon Si Thammarat)

P. lanceolata Nees.

Local name : ไก่ทัด Kai hat, ตกสืบ Tok suep, ตองหอม Tong hom, ปีตอง Pee tong (Chieng Mai) ; ตั่งนี Tang Nee (Lampang, Phrae) ; ท๊อป Thop, สิไหรคางคก Sirai Khaang khok (Pattani) ; สิแกซาเต๊าะ Si-kaa-saa-toh (Malay-Narathiwat), **แหลบุก** Lae buk (Peninsular)

P. opaca Bl.

Local name : **มุ้นเขา** Mun khao (Peninsular)

P. peniculata Nees.

Local name : กอหิน Ko hin (Loei) ; กะทิต Ka thit (Trat) ; กะทิต ใบพลวง Ka thit bai phluang (Chanthaburi) ; คางคก Khaang khok (Lampang, Phrae) ; จันทิพ Chan thip (Na khon Si Thammarat) ; เชโกรโบ Se-kro-bo (Karen-Chiang Mai) ; ตองแข็ง Tong Khaeng, มะดูกดง Ma duuk dong (Chiang Mai) ; ตะนมบังกรวย Ta-nom bang-kruai (khmer-Chanthaburi) ; ทบ Thop (Chum-phon, Nakhon-Si-Thammarat) ; ทัน Than (Surat Thani) ; **สะทิบ** Sa thip (Uttaradit)

P. tavoyana Hook. f.

Local name : กอหิน Ko hin (Loei) , **ทัน** Than (General)

Temmodaphne

T. thailandica Kosterm.

Local name : **สมุลแว้ง** Samun lawaeng (Trat)

Description and uses of plants selected for this study

Cinnamomum camphora Th. Fries.

A large handsome evergreen tree, native of China, Japan, and Formosa, and introduced into, and cultivated in many other countries including India, either as an ornamental plant or as a source of camphor. In its natural habitat it attains a height aromatic. The fruits are dark green, ovoid, rather dry, globole and about 0.3 inch in diameter. (Council of Scientific and Industrial Research , 1950).

Every part of *C. camphora* is credited with sedative, anodyne, antispasmodic, diaphoretic, and anthelmintic properties. Internally the plant is used in colds, chills, and in diarrhoea from cold ; externally it is applied to cases of inflammations, bruises and sprain. The essential oil from the tree and pure camphor are quite ineffective as anthelmintics (Blatter, Caius and Mhaskar, 1935).

Cinnamomum iners Bl.

Tree, about 12 m. tall, with a short thick stem and large bushy top ; branchlets glabrous. Leaves coriaceous, when young white, then red, finally deep green, elliptic or elliptic-oblong, variable, 12.5-18 cm. long, 3.8-7.5 cm. wide ; nerves 3, nervules and reticulations almost or quite invisible ; glabrous beneath ; petioles 5 mm. long. Panicles about 15 cm. long, lax. Flowers and pedicels silky, yellow within, 2.5 mm. long, foetid tube very short ; sepals ovate, subacute. Fruits ellipsoid, black, pulpy, blunt, 1-1.5 cm. long, cupule very short (Backer and Van Den Brink, 1963)

The seed, bruised and mixed with honey or sugar, are given to children in dysentery and coughs, and combined with other ingredients in fevers. The oil from the inner bark is effective as an anthelmintic (Blatter, Caius and Mhaskar, 1935).

Cinnamomum porrectum Kosterm

Lofty tree 9-30 m. tall with whitish rough bark. Leaves red when young, adult subcoriaceous dark green, glaucous beneath, elliptic-ovate, acute or acuminate, base acute or round ; nerves pinnate, slender, 3 pairs from the midrib ; 5-10 cm. long, 2.5-4.5 cm. wide ; petioles slender, 2.5-3.2 cm. long. Panicles numerous, slender, glabrous ; peduncle 2.5-5 cm. long ; branches 1.3 cm. long, cymose at the top. Flowers few on each, 2.5 mm. across, light yellow. Perianth-tube funnel-shaped, glabrous, lobes oblong, villous inside. Drupe globose, 7 mm. across ; perianth-tube enlarged, 4.5 mm. across, tube funnel-shaped, 5 mm. long (Blatter, Caius and Mhaskar, 1935).

The fruit yields an oil used in rheumatic affections. An infusion of the root is also employed as a substitute for *Sassafras* (Burkill, 1935).

Litsea cubeba Pers.

A deciduous aromatic shurb or small tree found in eastern Himalayas, Assam and Manipur up to an altitude of 2,700 m. Bark greenish, warty ; leaves lanceolate or ovate-lanceolate, somewhat inequilateral, membraneous ; flowers in umbels or corymbs ; fruits globose. Most parts of the plant are aromatic and yield volatile oils. The fruit is edible. It is aromatic and carminative and is reported to be used in Indo-China for headache, dizziness, hysteria, paralysis and loss of memory. It is also used as a preservative for fish. In Indonesia, the fruits are used as a substitute for cubeb pepper (*Piper cubeba* Linn.) (Council of Scientific and Industrial Research, 1962).

Litsea glutinosa C. B. Robinson.

An evergreen shrub or tree, up to 25 m. in height and 1.5 m. in girth , with a clean bole 6.0 m. long, found throughout India, ascending up to an altitude of 1,350 m. in the outer Himalayas. Bark brownish grey, somewhat corky, viscid inside ; leaves very variable in size and shape, elliptic-ovate or oblong-lanceolate, pubescent, aromatic ; flowers in umbellate heads, yellowish ; fruit globose , black or purple (Council of Scientific and Industrial Research, 1962).

The bark of *L. glutinosa* constitutes the common demulcent drug sold in Indian bazaars under the name Maida Lakri or Maida Lakadi. It is available in the form of broken quills or pieces, a few inches in length. It is mucilaginous, feebly balsamic and mildly astringent. It is used in diarrhoea and dysentery. Ground and pasted material is used as an emoellient application for sprains, bruises and rheumatic and gout joints ; it is also used as a styptic dressing for wounds. The leaves are mucilaginous and considered emoelient and antispasmodic. They are used in infusion or as poultice for bruises and wounds ; flower buds are credited with similar properties. In parts of India, the leaves are used as cattle fodder. The fruit is edible. It is a rich source of lauric acid and may be utilized for the preparation of lauryl compounds used as detergents. The root is sweetish bitter, astringent and tonic. In Philippines, a decoction of the root is used as emmenagogue (Blatter, Caius and Mhaskar, 1935).

Litsea petiolata Hook.f.

Branches and leaves glabrous, leaves 4-5 in., alternate, long-petioled, penninerved, coriaceous, pale brown when dry, elliptic or oblong, obtuse or subacute, smooth above, beneath minutely reticulate with 5-6 pairs of slender nerves, umbels below the leaves clustered very shortly pedicelled 5-fold., bracts 5, outer glabrous, sepals 6 with long lax hairs, stamens 9-10, filaments long, slender, villous (Hooker, 1885).

It's stem bark is used for mixing in "Nam Prik" (Thai-chilli sauce) in order to release the smell that similar to the giant water bug's smell as well as stem wood is used as pestel for preparing Nam Prik. Young leaf is used for eating with "Nam Prik Kaeng Num Kai" (Thai-southern chilli sauce) and "Khanom Cheen" (Thai Rice Noodle) Its pharmacological properties is carminative activity, antiflatulence, stomach discomfortability. (ลั่นทม จอนจวบทรง, 2537)

There are several essential oil containing plants of the family Lauraceae in the rain forests of Thailand which have never been investigated, including plant species in the two genera of *Litsea* and *Cinnamomum*.

The main objectives of this investigation are as follows :

1. to screen for new essential oils from Thai Lauraceous plants.
2. to study the antimicrobial activity of these essential oils.

Additionally, this work also includes a western Lauraceous plant cultivated in Chiang Mai by the Royal Project Foundation, namely, *Laurus nobilis* L. The aim is to analyze its chemical composition and percentage of the oil and compare these with the imported material available in the market.

CHAPTER II

HISTORICAL

1. Chemical Constituents of Essential Oil in Lauraceae Family

The Lauraceae family comprises many species and has a worldwide distribution. They are known to possess characteristic aromatic constituents. The essential oils of some Lauraceae species (belonging to the genus *Cinnamomum* and *Litsea*) could be useful natural resources for terpenes, which are commercially important chemicals in the flavor, fragrance and pharmaceutical industries. Essential oils are usually chemically complex mixture. Only few groups of naturally occurring products contain as many compounds as essential oils. The following review focuses only on Thai Lauraceae plants of which the chemical composition of their essential oils have been previously worked on. The list of these compounds are shown below.

Table 1 Chemical constituents of essential oils from some Lauraceous plants

Plant part	Chemical constituents	References
Leaves	*Cinnamomum camphora* Nees.et. Eberm. **Monoterpene** sabinene, myrcene, *(Z)*-β-ocimene, *trans*-sabinene hydrate, α-thujene, *(+,-)*camphene, *p*-cymene, terpinene, dipentene, fenchene, geranial, neral, phellandrene, *(α,β)*-pinene, *(α,γ)*-terpinolene, **Oxygenated monoterpene** *(α,δ)*-terpineol, borneol, borneol, camphor, carvacrol, *1,8*-cineole,	Medici, Pieretti and Salvatore, 1992 ; Duke, 1992 ; Pe'lissier *et al.,* 1995 ; Baruah and Bhagat, 1975

Table 1 (continue)

Plant part	Chemical constituents	References
	citronellol, *p*-cymol, gerniol, geranyl acetate, hotrienol, nerol, neryl acetate, *(cis,trans)*-ocimene, α-terpinyl acetate, α-terpineol, terpinin-*1*-ol, terpinen-*4*-ol, orthodene, piperitone **Diterpenoid** camphorene **Sesquiterpene** *(*β,δ*)*-elemene, α-cubebene, cubenol, α-copaene, *(*α,β*)*-santalene, *cis*-α-bergamotene, *epi*-β-santalene, *(E)*-β-farnesene, *(Z)-(E)*-α-farnesene, bicyclogermacrene, α-muurolene, *(E,E)*-α-farnesene, calamenene, calacorene, bisabolene, cadinadiene, *(*α-δ*)*-cadinene, α-calacorene, cadinene, β-elemene, α-humulene, β-caryophyllene, caryophyllene, epicampheronol, limonene, junenol, germacrene B, epicubenol, myrcene, humulene, nerolidol, β-selinene, **Oxygenated sesquiterpene** spathulenol, caryophyllene oxide, humulene oxide, β-eudesmol, *(*α,β*)*-bisabolol, cadinenol, cadineol, *trans*-cadinol, α-cadinol, campherenol, campherenone, linallool, *(-)*-linalool, *cis*-linalool oxide, linalyl acetate,	

Table 1 (continued)

Plant part	Chemical constituents	References
	trans-muurolol, nerolidol, **Phenylpropanoid** dihydroeugenol, cuminalcohol, cuminaldehyde, dihydrocuminyl alcohol, eugenol, methyl eugenol, safrole, **Aliphatic alcohol** acetaldehyde, cinnamonol, azulene, camphoracene, camphazulene, camphorenone, caprinaldehyde, capronaldehyde, *3,7*-dimethylocta-*1,7*-dien-*3,6*-diol, *3,7*-dimethylocta-*1,5*-dien-*3,7*-diol, *3,5*-dimethyl-*4,6*-di-*o*-methylphloracetophenone, dimethylsecoisolariciresinol, *5*-dodecanyl-*4*-hydroxy-*4*-methyl-*2*-cyclopentenone, ethyl phenol, *(α,β)*-hexanal, *n*-hexanol, *cis*-*3*-hexenol, *n*-hexylaldehyde, isovaleraldehyde, mesityloxide, methyl-isobutyl ketone, methyl-vinyl ketone, furfural, tragetonol, myristinaldehyde, pentenylaldehyde, propionaldehyde, sterinaldehyde, piperonal, suvenol, secoisosolariciresinol-dim-ethyl-ether **Benzenoid** vanillin	

Table 1 (continued)

Plant part	Chemical constituents	References
	Long chain hydrocarbon *cis-2,6,6*-trimethyl-2-vinyl-5-hydroxytetrahydrofuran, decane, tridecane, salvene	
Arial part	*Cinnamomum camphora* Th. Fries. **Monoterpene** α-thujene, *(α,β)*-pinene, camphene, sabinene, myrcene, α-phellandrene, *p*-cymene, limonene, *(Z)*-β-ocimene, γ-terpinene, *trans*-sabinene hydrate **Oxygenated monoterpene** *1,8*-cineole, linalool, δ-terpineol, γ-terpineol, camphor **Sesquiterpene** *(β,δ)*-elemene, α-cubebene, α-copaene, β-caryophyllene, α-santalene, *cis*-α-bergamotene, *epi*-β-santalene, α-humulene, *(E)*-β-farnesene, bicyclogermacrene, α-muurolene, β-santalene, *(Z,E)*-α-farnesene, bicyclogermacrene, α-muurolene, *(E,E)*-α-farnesene, calamenene, *(α,δ)*-cadinene, calacorene, germacrene B **Oxygenated sesquiterpene** spathelenol, caryophyllene oxide, humulene oxide, *trans*-cadinol, β-eudesmol, α-cadinol	Tisserand and Balancs, 1995 ; Pe'lissier *et al.*, 1995

Table 1 (continued)

Plant part	Chemical constituents	References
	Phenylpropanoid safrole, eugenol **Long chain hydrocarbon** decane, tridecane	
Leaves	*Cinnamomum porrectum* Kosterm **Monoterpene** α-thujene, *(α,β)*-pinene, camphene, sabinene, α-phellandrene, *p*-cymene, limenene, δ-*3*-carene, *(E)*-ocimene, sabinene hydrate, terpinolene, *allo*-ocimene **Oxygenated monoterpene** *1,4*-cineol, *1,8*-cineol, linalool, citronellol, borneol, terpinen-4-ol, α-terpineol, citronellal, geraniol, geranial, methyl geranate, bornyl acetate, methyl citronellate **Sesquiterpene** *(δ,β,γ)*-elemene, β-caryophyllene, *(α,β)*-humulene, β-selinene, α-farnesene, α-muurolene, (δ,*γ)*-cadinene, **Oxygenated sesquiterpene** elemol, viridiflorol, α-guaiol, farnesol, δ-cadinol, eudesmol **Long chain hydrocarbon** octanal, *2,6*-dimethyl-*5*-heptenol	Tai, Ting and Nie, 1964 ; Tai, Ting and Nie, 1965 ; Essential Oil Research Group, 1975 ; Ding, 1994

Table 1 (continued)

Plant part	Chemical constituents	References
Root bark	**Phenylpropanoid** *(E)*-methyl cinnamate *Cinnamomum porrectum* Kosterm **Sesquiterpene** α-cubebene, α-copaene, β-elemene, α-gurjunene, α-humulene, *allo*-aromadendrene, germacrene D, β-selinene, valencene, α-muurolene, β-bisabolene, (γ,δ)-cadinene, calamenene **Oxygenated sesquiterpene** aromadendrene epoxide, epiglobulol, spathulenol, caryophyllene oxide, globulol, viridiflorol, *(α,δ)*-cadinol, guaiazulene **Long chain hydrocarbon** tetradecanal **Benzanoid** benzaldehyde, benzyl benzoate **Phenylpropanoid** safrole, elemicin	Center for Education, 1995
Wood	*Cinnamomum porrectum* Kosterm **Sesquiterpene** α-cubebene, calamenene **Oxygenated sesquiterpene** *(δ,α)*-cadinol, cadalene **Benzanoid** benzaldehyde, piperonal, *2,4*-dimethyl benzoic acid, *2,3*-dimethyl	Yacob, Zakaria and Ramli, 1990

Table 1 (continued)

Plant part	Chemical constituents	References
	benzoic acid, benzyl benzoate **Long chain hydrocarbon** tetradecanal **Phenylpropanoid** safrole, methyl eugenol, elemicin	
Arial part	*Litsea cubeba* Pers. **Oxygenated monoterpene** *1,8*-cineole, linalool, citronellal, isopulegol, citronellol, neral, geraniol **Long chain hydrocarbon** methyl-heptenone	Nath, Hazarida and Buruan, 1996
Fruits	*Litsea cubeba* Pers. **Monoterpene** limonene **Oxygenated monoterpene** linalool, neral, geranial	Gogoi, Baruah and Nath, 1997
Leaves	*Laurus nobilis* L. **Hemiterpenoid** *2*-methyl-butanal, *3*-methylbutanal, *3*-methyl-butanol **Monoterpene** camphene, δ-*3*-carene, *p*-cymene, limonene, phellandral, α-thujene, *(α,β)*-phellandrene, *(α,β)*-pinene, sabinene, *(cis,trans)*-sabinene hydrate, *(α,γ)*-terpinene, terpinolene, **Oxygenated monoterpene** borneol, bornyl acetate, camphor,	Guenther, 1972 ; Council of Scientific and Industrial Research, 1962 ; Akgul *et al.*, 1989 ; Duke, 1992 ; Muller-Riebau *et al.*, 1995

Table 1 (continued)

Plant part	Chemical constituents	References
	trans-carveol, carvone, *1,8*-cineole, cineole, dehydro-*1,8*-cineole, geraniol, geranyl acetate, linalool, terpinen-*4*-ol, α-terpineol, α-terpinyl acetate, α-terpinyl formate, thuj-*2*-en-*4*-ol, **Sesquiterpene** α-amorphene, *allo*-aromadendrene, artemorin, bicyclogermacrene, bicyclosesquiphellandrene, *cis*-α-bisabolene, β-bisabolene, cubebene, calamenene, α-bourbonene, *(α,γ,δ)*-cardinene, cadina-*3,5*-diene, cadina-*1 (6),5*-diene, caryophyllene, ledene, β-caryophyllene, α-copaene, *(α-β)*-cubebene, cyclosativene, myrcene, *1*-epibicyclosesquiphellandrene, β-eudesmol, α-guaiene, α-gurjunene, laurenobiolide, *(α,γ)*-muurolene, myrtenol, myrtenal, neryl acetate, *(cis,trans)*-ocimene, neral, nerol, santamarine, *(α,β)*-selinene, reynosin, tulipinolide, verlotorin, α-ylangene, *(β,γ)*-elemene **Oxygenated sesquiterpene** caryophyllene oxide, perillylalcohol, viridiflorol **Phenylpropanoid** eugenol acetate, acetoeugenol, elimicin, cinnamyl acetate, cuminyl	

Table 1 (continued)

Plant part	Chemical constituents	References
	alcohol, eugenol eugenyl acetate, methyl cinnamate, methyl eugenol, trans-methyl eugenol **Aliphatic alcohol** acetone, *8*-acetoxycarvotanacetone, benzaldehyde, butanol, butanal, hexanol, hexanal, *cis*-*3*-hexanol, *trans*-*2*-hexanal, *cis*-*3*-hexenol, kaempferol, *cis*-*p*-menth-*2*-en-*1*-ol, *cis*-*p*-mentha-*2,8*-dien-*1*-ol, methyl heptenone, *2*-methylpropanol, pentanol, pentanal, *1*-penten-*3*-ol, methanol, **Long chain hydrocarbon** ethyl-pentanoate, methylpropionate, *2*-methylpropyl acetate, tridecane, *2*-methylpropyl-*2*-methylpropionate, pentyl acetate, tetradecane, toluene, hexadecane	

CHAPTER III

MATERIALS AND METHODS

3.1 Plant Materials

The plant materials were collected from various locations in Thailand and at different periods of time as shown in Table 2. Authentication was achieved through comparison with herbarium specimen at the Botany Section, Technical Division, Department of Agriculture, Ministry of Agriculture and Cooperative, Thailand.

Table 2 Investigating locations of collected plants and harvest time.

Number	Name	Place	Harvest time
1	*Cinnamomum camphora* Th. Fries. (leaves)	Bangkok	July 1997
2	*Cinnamomum camphora* Th. Fries. (leaves)	Rayong	January 1998
3	*Cinnamomum iners* Bl. (leaves)	Bangkok	November 1998
4	*Cinnamomum porrectum* Kosterm (leaves)	Phatthalung	May 1998
5	*Cinnamomum porrectum* Kosterm (bark)	Phatthalung	May 1998
6	*Litsea cubeba* Pers (leaves)	Chiang Mai	October, 1997
7	*Litsea glutinosa* C.B. Robinson. (fruits)	Ratchaburi	July 1997
8	*Litsea petiolata* Hook. f. (leaves)	Krabi	April 1998
9	*Litsea petiolata* Hook. f. (bark)	Krabi	June 1998
10	*Cinnamomum* sp.1 (leaves)	Rayong	April 1998
11	*Cinnamomum* sp.2 (leaves)	Rayong	April 1998
12	*Cinnamomum* sp.3 (leaves)	Khon Kaen	October 1998
13	*Cinnamomum* sp.4 (leaves)	Khon Kaen	October 1998

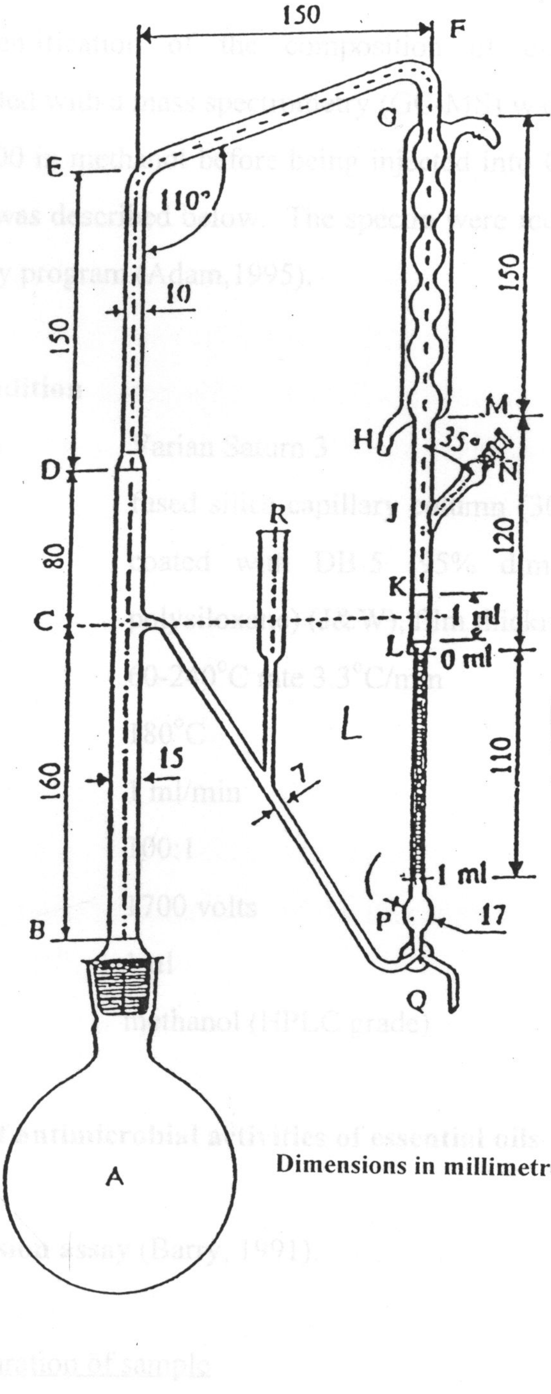
Table 2 (continued)

Number	**Name**	**Place**	**Harvest time**
14	*Cinnamomum* sp.5 (leaves)	Bangkok	November 1998
15	*Cinnamomum* sp.6 (leaves)	Bangkok	November 1998
16	*Cinnamomum* sp.7 (leaves)	Bangkok	November 1998
17	*Cinnamomum* sp.8 (leaves)	Bangkok	November 1998
18	*Cinnamomum* sp.9 (leaves)	Bangkok	December 1997
19	*Laurus nobilis* L. (leaves)	Chiang Mai	November 1997

3.2 Essential oil content and composition

3.2.1 Essential oil content determination

Essential oil was determined by the method described in the Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC, method 962.17) (Helrich, 1990). One hundred and fifty grams of each sample were put into a 1000 ml round bottom flask. The tridistilled water were added into the flask to about half full. The flask was connected to the apparatus for the determination of volatile oil (Fig. 1). The content of the flask was distilled until two consecutive reading taken at one hour interval showed no change in oil content. After cooling, the oil volume was measured, calculated and expressed as millilitre of the oil per one hundred grams of sample. The essential oil obtained was then collected and stored at 4°C until being analyzed for its chemical composition by GC-MS.



Dimensions in millimetres

Figure 1 Apparatus for essential oil content determination

3.2.2 Gas chromatography-mass spectrometry

For the identification of the composition of essential oils, a gas chromatography-coupled with a mass spectrometry (GC-MS) was used. The essential oil was diluted to 1:100 in methanol before being injected into GC-MS system. The condition of GC-MS was described below. The spectra were recorded and compared with the terpene library program (Adam,1995).

GC-MS Condition

Instrument model	Varian Saturn 3
Column	fused silica capillary column (30 m x 0.25 mm i.d.) coated with DB-5 (95% dimethyl 5% diphenyl polysiloxane) (J&W), film thickness 0.25 μm
Column programming	60-240°C rate 3.3°C/min
Injector temperature	180°C
Helium carrier gas	1 ml/min
Split ratio	100:1
Accelerating voltage	1700 volts
Sample size	1 μl
Solvent	methanol (HPLC grade)

3.3 Determination of antimicrobial activities of essential oils

3.3.1 Agar diffusion assay (Barry, 1991).

3.3.1.1 Preparation of sample

The essential oils were diluted to a final concentration of 10% in 0.1% sterile Tween 80.

3.3.1.2 Preparation of the inoculum

The bacterial strains used were as follows :

- *Staphylococcus aureus* ATCC29213
- *Enterococcus faecalis* ATCC29212
- *Bacillus subtilis* ATCC6633
- *Escherichia coli* ATCC25922
- *Pseudomonas aeruginosa* ATCC27853

Preparations of bacterial inocula were done according to the standard method. Each bacterial strain was cultured overnight on trypticase soy agar (TSA) plate at 37°C. Four well isolated colonies of the overnight grown culture were inoculated into a 5 ml trypticase soy broth (TSB) and incubated at 37°C for 2-3 h. The turbidity of inoculum was adjusted with sterile broth to match a 0.5 turbidity standard of McFarland No 1.

The fungal strains used were as follows :

- *Candida albicans* ATCC10231
- *Microsporum gypseum* (clinical isolate)

Candida albicans ATCC10231 was grown on Sabouraud dextrose agar (SDA) slant at 30°C for 24 h. The inoculum was prepared by suspending the culture in sterile normal saline solution and turbidity of the inoculum was adjusted to match a 0.5 turbidity standard of McFarland No 1.

Spores of *Microsporum gypseum* grown on SDA slant at 30°C for 4 days were washed from the slant culture with sterile 0.05% Tween 80. The turbidity of the spore suspension was adjusted to match 0.5 turbidity standard of McFarland No 1

3.3.1.3 Preparation of test plates

- For testing bacteria :

Mueller Hinton agar (MHA) was melted and allowed to cool at 45 - 50°C in a water bath. Then 25 ml of the melted agar medium was dispensed into sterile glass petri dishes, with internal diameters of 9 cm, to yield a uniform depth of 4 mm. The agar was allowed to harden on a flat level surface. The plates were dried for 1 h at 37 °C.

- For testing fungi :

Sabouraud dextrose agar (SDA) was used and prepared as described above.

3.3.1.4 Inoculation of agar plates

A sterile cotton swab was dipped in each inoculum and the excess was removed by rotating the swab several times against the inside wall of the tube above the fluid level. The entire surfaces of the MHA plate and the SDA plate for testing bacteria and fungi, respectively, were inoculated by streaking with the swab for 3 times and each time the plate was rotated 60 degree.

3.3.1.5 Assay procedure

A 50 μl of each 10% oil sample or diluent (0.1% sterile Tween 80) was delivered to each hole (6 mm diameter) in the inoculated medium. This was done in triplicate. After maintaining at room termperature for 1 h, the bacterial and fungal plates were incubated at 37°C overnight and 30°C for 48-72 h, respectively. The oil samples showing inhibition zone were examined further for their minimal inhibitory concentrations (MIC).

3.3.2 Determination of minimal inhibitory concentration (MIC).

Determination of the MIC of essential oil was done by the broth microdilution test (Barry, 1991 ; Woods and Washington, 1995 ; Espinel-Ingroff and Pfaller, 1995).

3.3.2.1 Preparation of the inoculum

- For testing bacteria :

The inoculum was prepared as described in section 3.3.1.2. The turbidity of the 0.5 McFarland turbidity standard No 1 provides approximately 1×10^8 CFU(colony forming unit)/ml. The inoculum was further diluted to 1:100 in Mueller Hinton broth.

- For testing fungi :

The inoculum was prepared as described in section 3.3.1.2. This produced a fungal suspension containing 1x 10^6 to 5 x 10^6 organisms per ml. The inoculum was further diluted to 1:100 in Sabouraud dextrose broth.

3.3.2.2 Preparation of the essential oil dilutions (Mann and Markham, 1998).

- For testing bacteria :

The oil samples were mixed with equal volume of 0.5% tween 80 and diluted with MHB containing 0.1% agar in a two-fold dilution to give the concentrations ranging from 10% to 0.039% v/v

- For testing fungi :

Sabouraud dextrose broth (SDB) was used instead of Mueller Hinton broth (MHB) and prepared as above.

3.3.2.3 Assay procedure

A 50 μl volume of each concentration of the essential oil was dispensed to the corresponding well of sterile multiwell microdilution plate (96-Flat-shaped wells). Another 50 μl volume of diluted inoculum was added into each well. After incubating the tray at 37°C for 24 h, the lowest concentration of oil sample that showed growth inhibition was considered as the MIC. This determination was done in duplicate. The corresponding concentrations of oil in diluent were used as turbidity control. Inhibitory effect of oil was examined by measurement of culture turbidity in each well using microplate reader (Bio-Rad, model 450).

CHAPTER IV

RESULTS

4.1 Chemical Composition of the Essential Oils from Thai Lauraceous Plants

4.1.1. Essential Oil Composition of *Cinnamomum camphora* Th. Fries. collected from Bangkok

The leaves of *Cinnamomum camphora* collected in Bangkok were found to contain essential oil at 0.38 % (v/w) of the fresh weight. GC/MS analysis showed at least 34 peaks in its GC chromatogram (Fig. 2). These peaks were identified as 14 monoterpenes, 4 oxygenated monoterpenes, 10 sesquiterpenes and 1 phenylpropane and 1 long chain hydrocarbon (Table 3). Among these, the major components were found to be camphor (55.43 %) , limonene (11.58 %) and α-pinene (10.59 %).

In terms of relative amount, the oxygenated monoterpenes appeared to be the major terpenoid group, accounting for 57.75 % of the essential oil. Monoterpenes and sesquiterpenes were present in lesser amount, at 39.98 % and 1.39 %, respectively (Fig. 3).

In terms of structure, the major components, camphor belongs to the oxygenated monoterpenoid group of camphane, whereas α-pinene and limonene belong to the monoterpenoid groups of pinane and menthane, respectively.

camphor
(camphane)

limonene
(menthane)

α-pinene
(pinane)

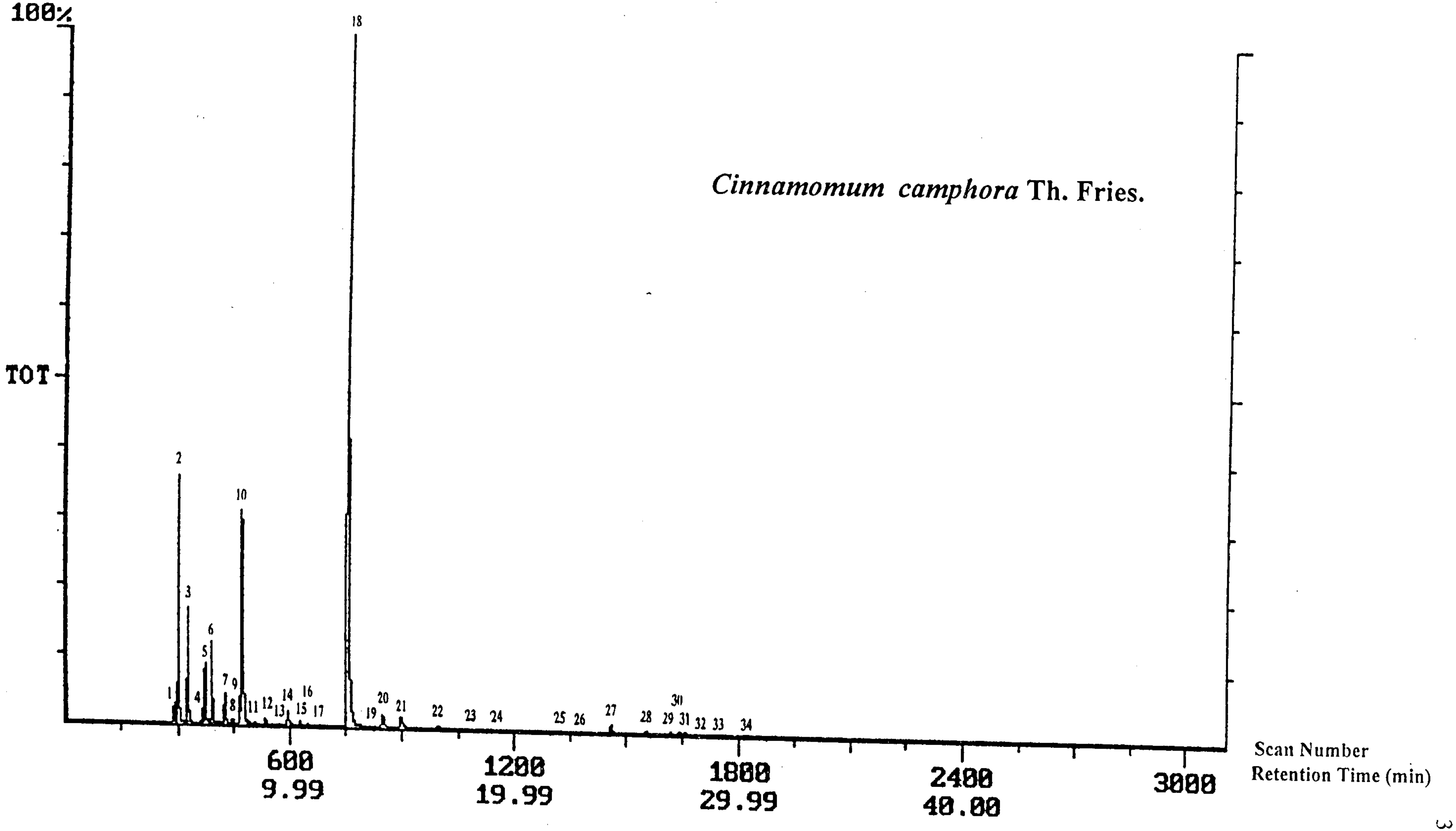


Figure 2 GC chromatogram of the essential oil from *Cinnamomum camphora* Th. Fries. Leaves (Bangkok)

Table 3 Essential oil composition of *Cinnamomum camphora* leaves (Bangkok)

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.87
2	α-pinene	5.03	10.59
3	camphene	5.48	5.22
4	sabinene	6.08	0.60
5	β-phellandrene	6.23	2.87
6	β-pinene	6.54	3.72
7	α-phellandrene	7.11	1.62
8	δ-*2*-carene	7.44	0.17
9	verbenene	7.78	1.44
10	limonene	7.88	11.58
11	*(E)*-β-ocimene	8.48	0.04
12	γ-terpinene	8.91	0.37
13	trans-sabinene hydrate	9.61	0.05
14	terpinolene	9.93	0.84
	Oxygenated monoterpene		
18	camphor	12.54	55.43
19	borneol	13.99	0.06
20	terpin-*4-ol*	14.16	1.13
21	α-terpineol	14.98	1.13
	Sesquiterpene		
25	α-copaene	22.38	0.07
26	β-elemene	23.09	0.03
27	*(E)*-caryophyllene	24.33	0.59
28	α-humulene	25.89	0.18
29	γ-muurolene	26.99	0.08
30	β-selinene	27.34	0.22
31	α-selinene	27.63	0.14
32	germacrene A	28.11	0.03
33	*trans*-β-guaiene	28.59	0.02
34	germacerne B	30.19	0.03
	Phenylpropanoid		
24	*(Z)*-isosafrole	18.99	0.07
	Long chain hydrocarbon		
15	*n*-heneicosane	10.44	0.14
	Miscellaneous		
16	unknown	10.83	0.09
17	unknown	11.79	0.30

Table 3 (continued)

Peak No	Compound	Retention time (min)	%Area
22	unknown	16.61	0.15
23	unknown	17.98	0.11

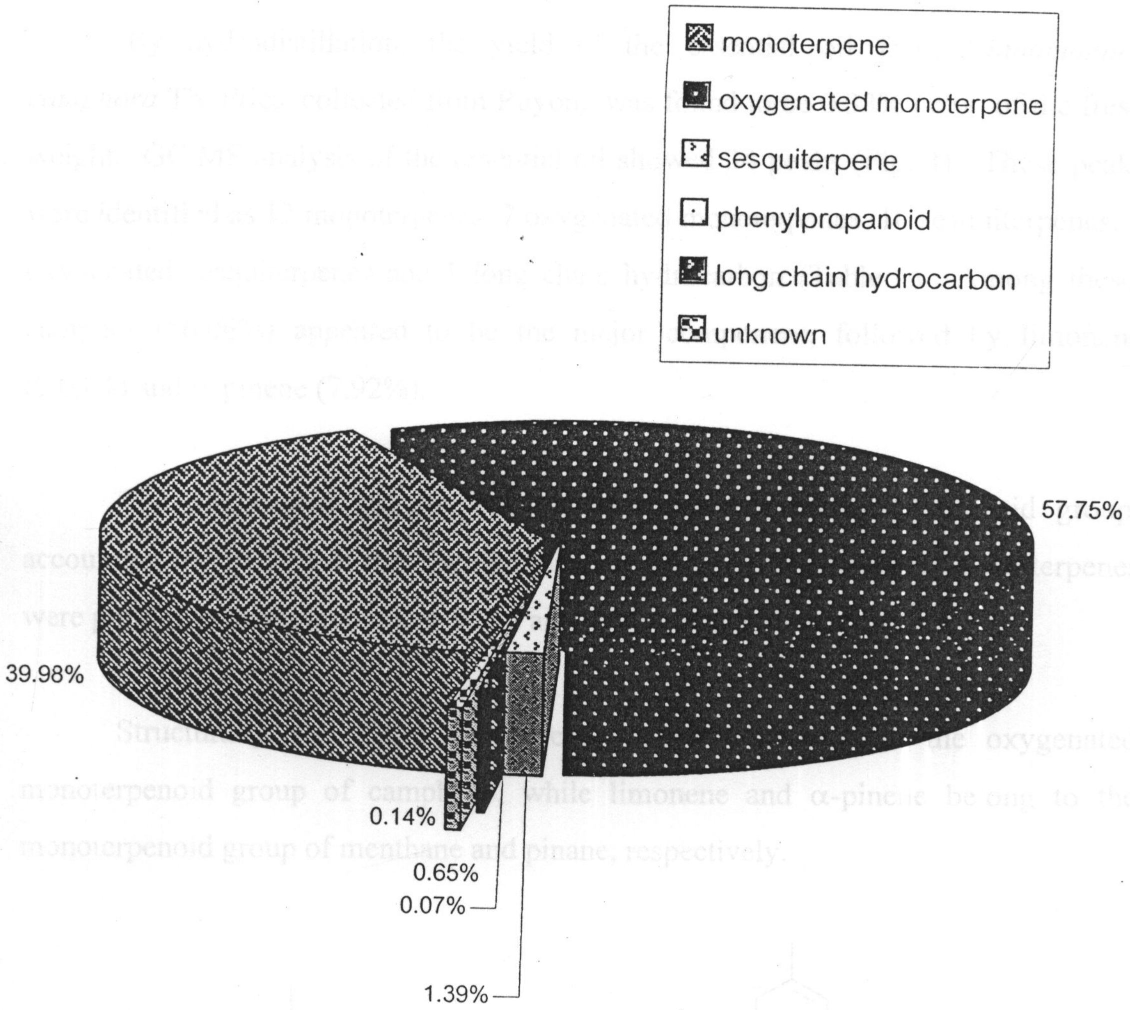


Figure 3 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum camphora* Th. Fries. Leaves (Bangkok)

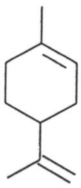
4.1.2. Essential Oil Composition of *Cinnamomum camphora* Th. Fries. collected from Rayong

By hydrodistillation, the yield of the essential oil from *Cinnamomum camphora* Th. Fries. collected from Rayong was found to be 0.33% (v/w) of the fresh weight. GC/MS analysis of the essential oil showed 34 peaks (Fig. 4). These peaks were identified as 13 monoterpenes, 7 oxygenated monoterpenes, 10 sesquiterpenes, 3 oxygenated sesquiterpenes and 1 long chain hydrocarbon (Table 4). Among these, camphor (56.06%) appeared to be the major component, followed by limonene (9.03%) and α-pinene (7.92%).

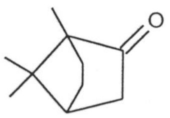
The oxygenated monoterpene appeared to be the major terpenoid group, accounting for 58.61% of the essential oil (Fig. 5). Monoterpenes and sesquiterpenes were present in lesser amount, at 30.35 and 9.67%, respectively.

Structurally, the major components, camphor belongs to the oxygenated monoterpenoid group of camphene, while limonene and α-pinene belong to the monoterpenoid group of menthane and pinane, respectively.

α-pinene
(pinane)



limonene
(menthane)



camphor
(camphane)

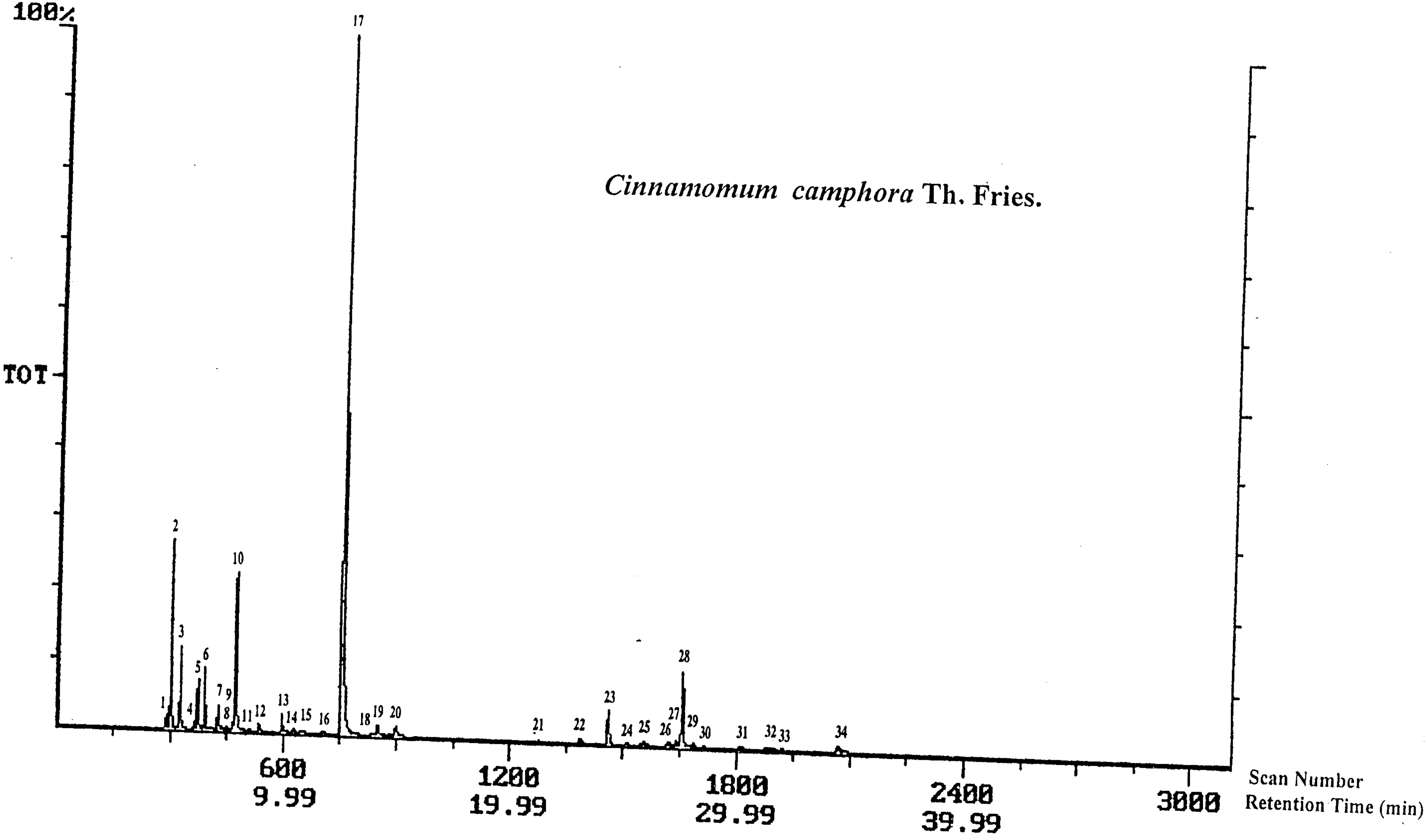


Figure 4 GC chromatogram of the essential oil from *Cinnamomum camphora* Th. Fries. Leaves (Rayong)

Table 4 Essential oil composition of *Cinnamomum camphora* leaves (Rayong)

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.53
2	α-pinene	5.03	7.92
3	camphene	5.48	3.79
4	sabinene	6.08	0.37
5	β-phellandrene	6.23	2.40
6	β-pinene	6.54	3.03
7	α-phellandrene	7.11	1.22
8	δ-*2*-carene	7.44	0.15
9	verbenene	7.78	0.45
10	limonene	7.88	9.03
11	*(E)*-β-ocimene	8.48	0.09
12	γ-terpinene	8.91	0.42
13	terpinolene	9.93	0.95
	Oxygenated monoterpene		
15	linalool	10.81	0.32
16	α-campholenal	11.73	0.13
17	camphor	12.54	56.06
18	borneol	13.99	0.12
19	terpin-*4-ol*	14.16	0.95
20	α-terpineol	14.98	0.97
21	α-terpinyl acetate	19.79	0.06
	Sesquiterpene		
22	β-elemene	23.09	0.21
23	*(E)*-caryophyllene	24.33	2.49
24	longifolene	25.11	0.06
25	α-humulene	25.89	0.21
26	γ-muurolene	26.99	0.33
27	β-selinene	27.34	0.36
28	bicyclogermacrene	27.59	5.58
29	germacrene A	28.11	0.17
30	*trans*-β-quaiene	28.59	0.10
31	germacrene B	30.19	0.16
	Oxygenated sesquiterpene		
32	spathulenol	31.29	0.27
33	α-eudesmol acetate	31.59	0.06
34	α-eudesmol	34.48	0.78
	Long chain hydrocarbon		
14	*n*-heneicosane	10.44	0.21

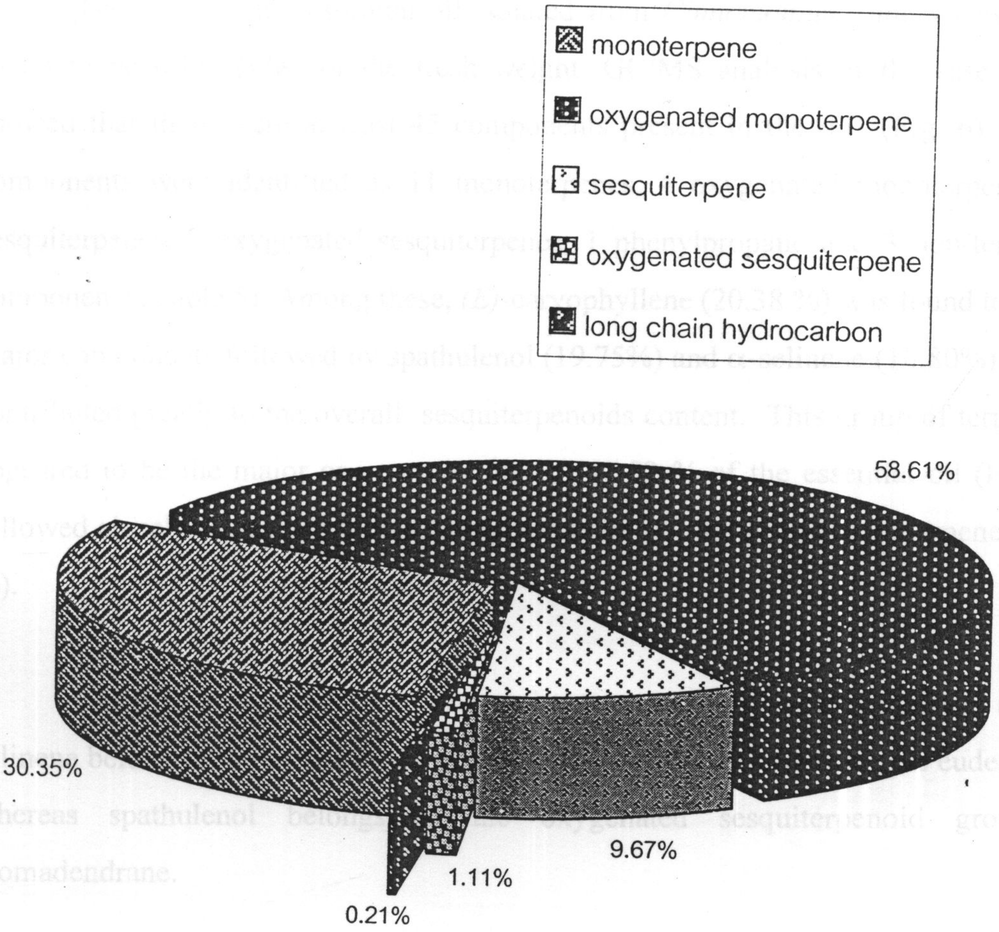
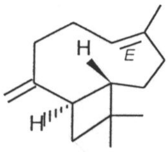


Figure 5 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum camphora* Th. Fries. Leaves (Rayong)

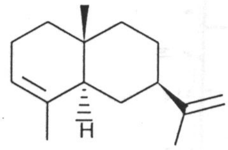
4.1.3. Essential Oil Composition of *Cinnamomum iners* Bl.

The yield of the essential oil isolated from *Cinnamomum inners* leaves was found to be 0.1% (v/w) of the fresh weight. GC/MS analysis of the essential oil showed that there were at least 45 components present in the oil (Fig. 6). These components were identified as 11 monoterpenes, 4 oxygenated monoterpenes, 17 sesquiterpenes, 9 oxygenated sesquiterpenes, 1 phenylpropane and 3 non-terpenoid components (Table 5). Among these, *(E)*-caryophyllene (20.38 %) was found to be the major components followed by spathulenol (19.75%) and α-selinene (10.80%), which contributed greatly to the overall sesquiterpenoids content. This group of terpenoids appeared to be the major one, accounting for 47.92 % of the essential oil (Fig. 7),. followed closely by the oxygenated sesquiterpenes (47.48 %) and monoterpenes (2.42 %).

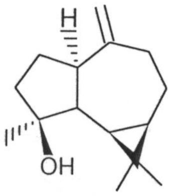
In terms of structure type, the major component, *(E)*-caryophyllene and α-selinene belong to the sesquiterpenoid group of caryophyllane and simple eudesmane, whereas spathulenol belongs to the oxygenated sesquiterpenoid group of aromadendrane.



(E)-caryophyllene
(*caryophyllane*)



α-selinene
(simple eudesmane)



spathulenol
(aromadendrane)

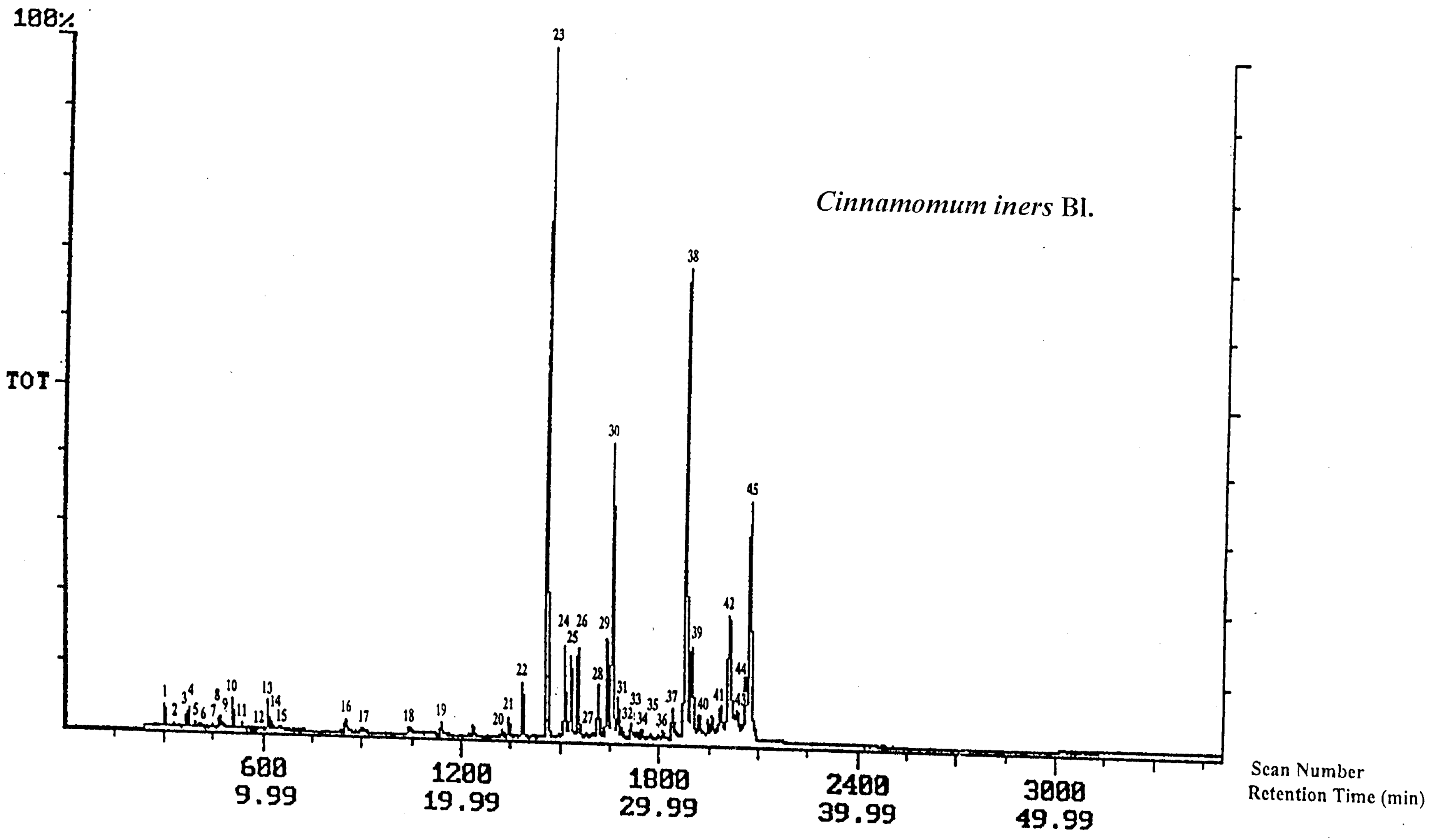


Figure 6 GC chromatogram of the essential oil from *Cinnamomum iners* Bl. leaves

Table 5 Essential oil composition of *Cinnamomum iners* leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-pinene	5.03	0.42
2	camphene	5.48	0.04
3	sabinene	6.08	0.21
4	β-phellandrene	6.23	0.39
5	β-pinene	6.54	0.11
7	δ-*2*-carene	7.44	0.05
8	verbenene	7.78	0.21
9	limonene	7.88	0.23
10	*(E)*-β-ocimene	8.48	0.59
11	γ-terpinene	8.91	0.13
12	terpinolene	9.93	0.04
	Oxygenated monoterpene		
15	linalool	10.81	0.13
16	terpin-*4-ol*	14.16	0.39
17	α-terpineol	14.98	0.17
18	geraniol	17.38	0.24
	Sesquiterpene		
19	δ-elemene	20.63	0.25
21	α-copaene	22.38	0.48
22	β-elemene	23.09	1.45
23	*(E)*-caryophyllene	24.33	20.38
24	α-gerjunene	25.23	2.10
25	cyperene	25.54	2.15
26	α-humulene	25.89	2.58
27	β-patchoulene	26.61	0.25
28	α-muurolene	26.89	1.60
29	β-selinene	27.34	3.35
30	α-selinene	27.63	10.80
31	β-gurjunene	27.88	1.42
32	germacrene A	28.11	0.35
33	*trans*-β-guaiene	28.59	0.28
34	selina-*3,7(11)*-diene	28.91	0.18
35	α-calacorene	29.61	0.11
36	germacrene B	30.19	0.19
	Oxygenated sesquiterpene		
37	*(E)*-nerolidol	30.66	0.88
38	spathulenol	31.29	19.75
39	α-eudesmol acetate	31.59	3.98

Table 5 (continued)

Peak No	Compound	Retention time (min)	%Area
40	hinesol acetate	31.96	0.71
41	juniper camphor acetate	33.08	1.73
42	bicyclovetivenol	33.54	7.32
43	α-muurolol	33.93	1.04
44	himachalol	34.36	2.07
45	selin-*11*-en-*4*-*alpha*-ol	34.58	10.00
	Phenylpropananoid		
20	*(Z)*-isoeugenol	22.10	0.16
	Long chain hydrocarbon		
6	*n*-decane	6.83	0.07
13	*2*-nonanone	10.23	0.73
14	*n*-heneicosane	10.44	0.16

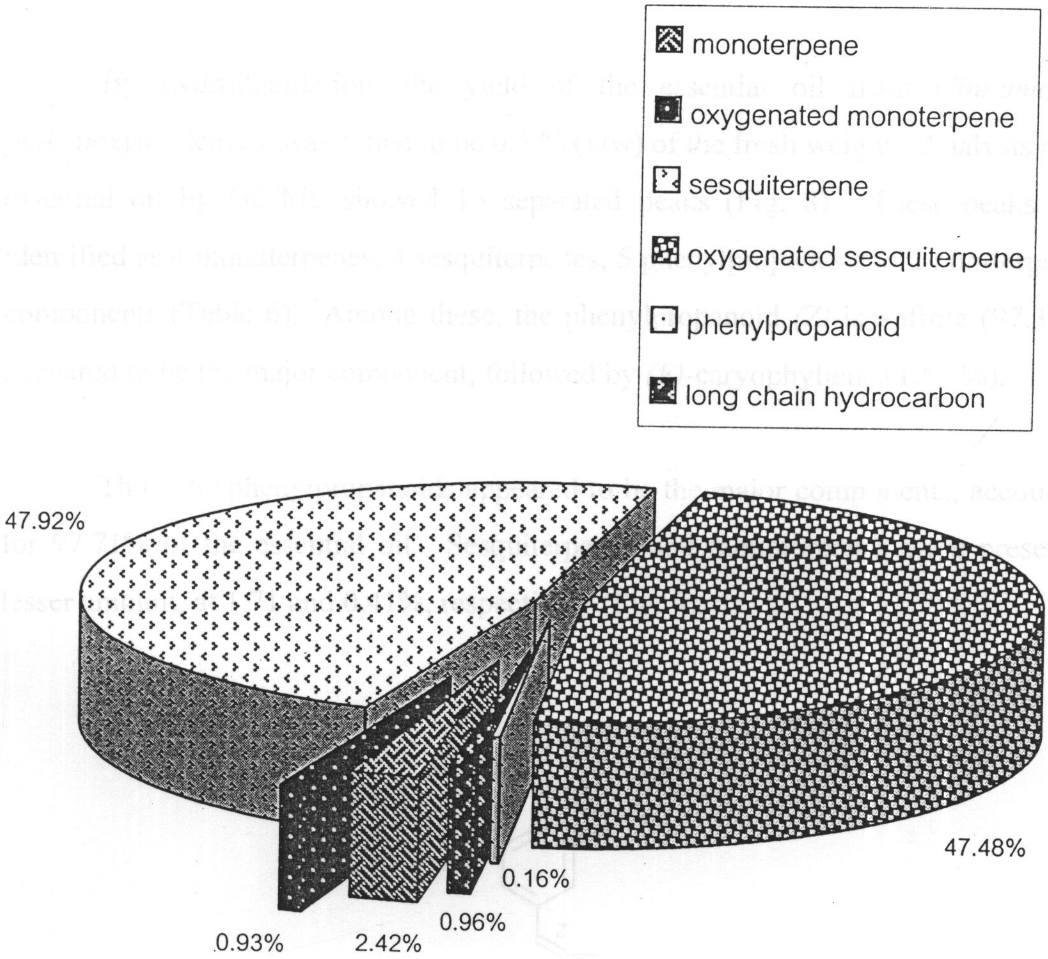
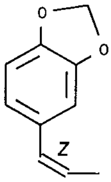


Figure 7 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum iners* Bl. leaves

4.1.4. Essential Oil Composition of *Cinnamomum porrectum* Kosterm leaves

By hydrodistillation, the yield of the essential oil from *Cinnamomum pathenoxylon* leaves was found to be 0.5 % (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 15 separated peaks (Fig. 8). These peaks were identified as 4 monoterpenes, 4 sesquiterpenes, 5 phenylpropanes and 2 non-terpenoid components (Table 6). Among these, the phenylpropanoid *(Z)*-isosafrole (97.30 %) appeared to be the major component, followed by *(E)*-caryophyllene (1.51 %).

Thus, the phenylpropanoids appeared to be the major components, accounting for 97.71% of the essential oil. Sesquiterpenes and monoterpenes were present in lesser amount, at 1.71 and 0.41%, respectively (Fig. 9).



(Z)-isosafrole
(phenylpropane)

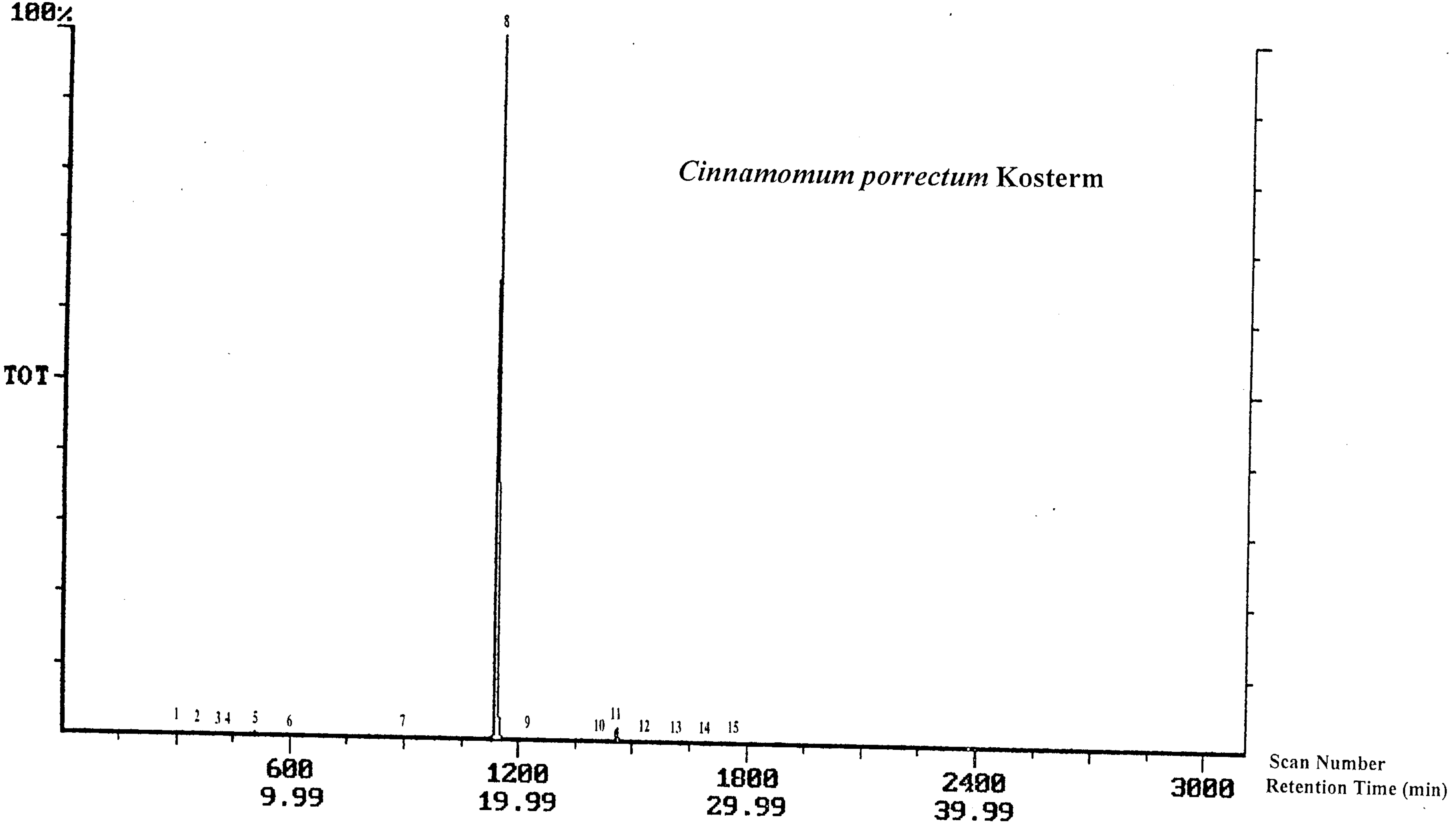


Figure 8 GC chromatogram of the essential oil from *Cinnamomum porrectum* Kosterm leaves

Table 6 Essential oil composition of *Cinnamomum porrectum* leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-pinene	5.03	0.06
2	sabinene	6.08	0.08
3	β-phellandrene	6.23	0.12
5	*(E)*-β-ocimene	8.48	0.15
	Sesquiterpene		
11	*(E)*-caryophyllene	24.33	1.51
12	α-humulene	25.89	0.14
13	γ-muurolene	26.99	0.06
14	*trans*-β-guaiene	28.59	0.02
	Phenylpropananoid		
7	*n*-methyl chavical	14.88	0.19
8	*(Z)*-isosafrole	18.99	97.30
9	*(E)*-isosafrole	23.04	0.03
10	methyl eugenol	23.18	0.16
15	myristicin	30.15	0.03
	Long chain hydrocarbon		
4	*2*-nonanone	10.23	0.04
6	*n*-heneicosane	10.44	0.09

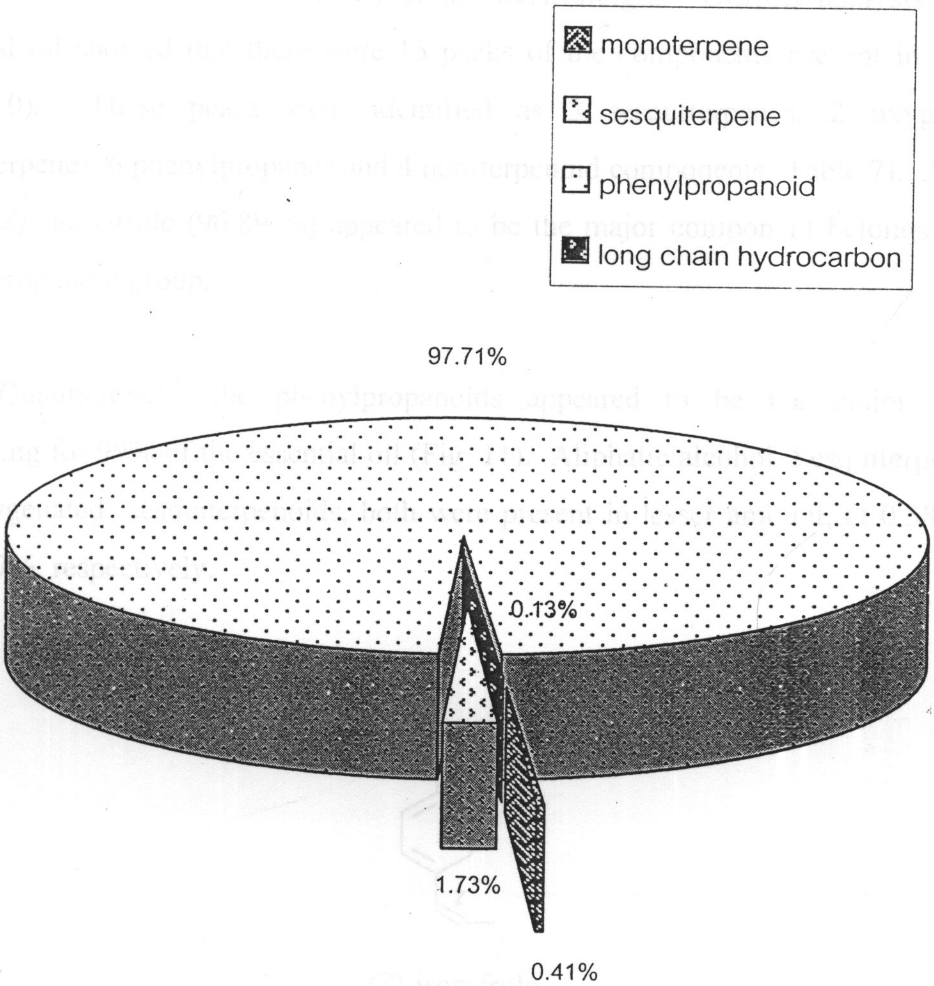
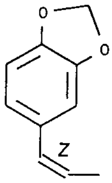


Figure 9 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum porrectum* Kosterm leaves

4.1.5. Essential Oil Composition of *Cinnamomum porrectum* Kosterm bark

The yield of the essential oil isolated from *Cinnamomum pathenoxylon* Nees. bark was found to be 0.1 % (v/w) of the fresh weight. GC/MS analysis of the essential oil showed that there were 15 peaks of the components present in the oil (Fig. 10). These peaks were identified as 3 sesquiterpenes, 2 oxygenated sesquiterpenes, 6 phenylpropanes and 4 non-terpenoid components (Table 7). Among these, *(Z)*- isosafrole (96.89 %) appeared to be the major component belongs to the phenylpropanoid group.

Quantitatively, the phenylpropanoids appeared to be the major group, accounting for 99% of the essential oil (Fig. 11). Aliphatic alcohol, Sesquiterpenoids and oxygenated sesquiterpenoids, both were present in lesser amount, at 0.38, 0.17 and 0.17%, respectively.



(Z)-isosafrole
(phenylpropane)

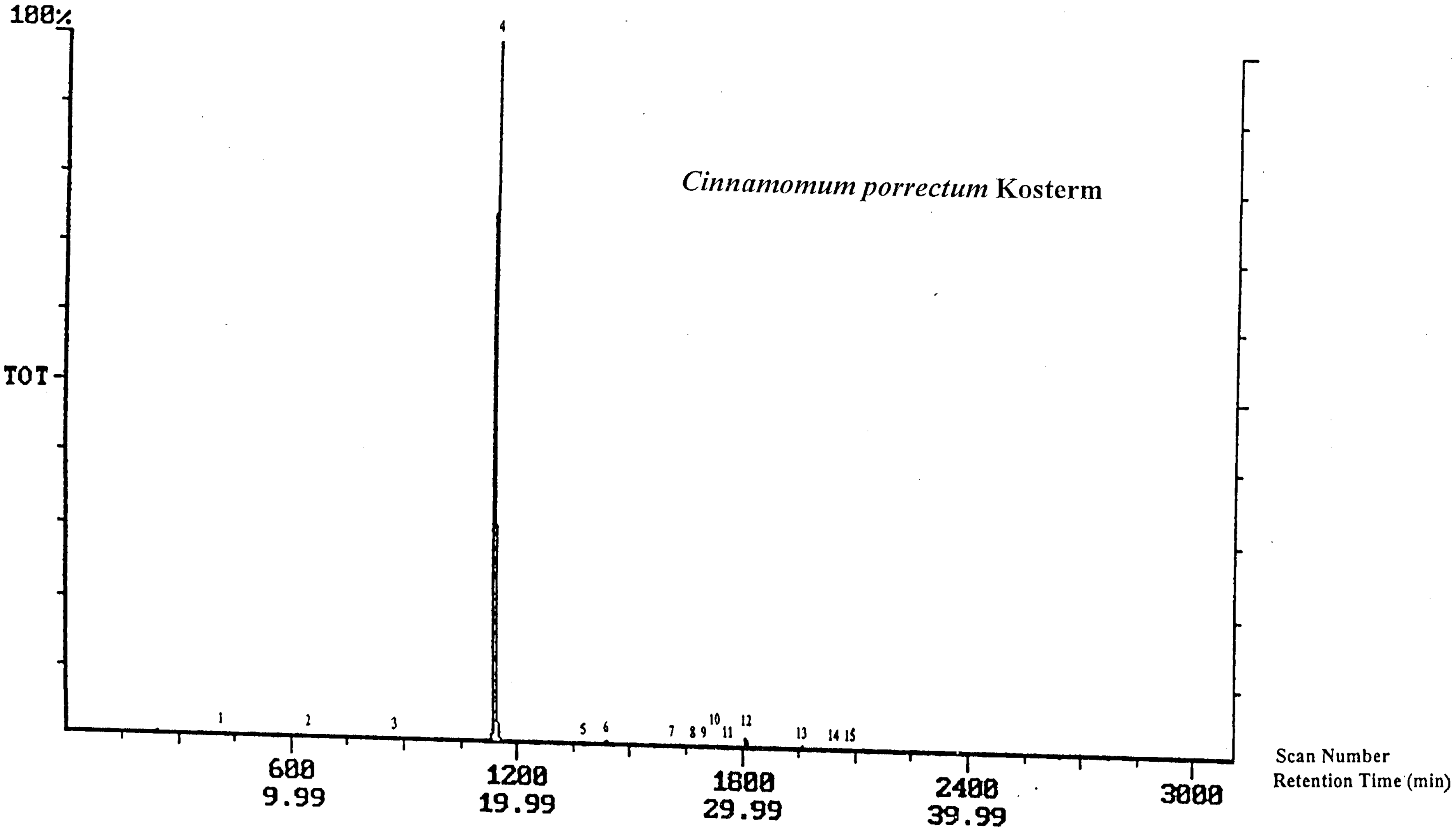


Figure 10 GC chromatogram of the essential oil from *Cinnamomum porrectum* Kosterm bark

Table 7 Essential oil composition of *Cinnamomum porrcetum* bark

Peak No	Compound	Retention time (min)	%Area
	Sesquiterpene		
7	γ-cadinene	26.75	0.03
8	*cis*-muurola-*4(14),5*-diene	28.39	0.02
10	*cis*-calamenene	28.78	0.12
	Oxygenated sesquiterpene		
14	*epi*-α-muurolol	33.98	0.05
15	α-cadinol	34.49	0.12
	Phenylpropanoid		
3	methyl chavical	14.88	0.20
4	*(Z)*-isosafrole	18.99	96.85
5	*(E)*-isosafrole	34.04	0.15
6	methyl eugenol	23.18	0.51
11	myristicin	30.15	0.04
12	elemicin	32.64	1.25
	Aliphatic alcohol		
13	dodecanal	32.64	0.38
	Long chain hydrocarbon		
1	*n*-decane	6.83	0.05
2	*n*-heneicosane	10.44	0.11
	Miscellaneous		
9	unknown	28.48	0.08

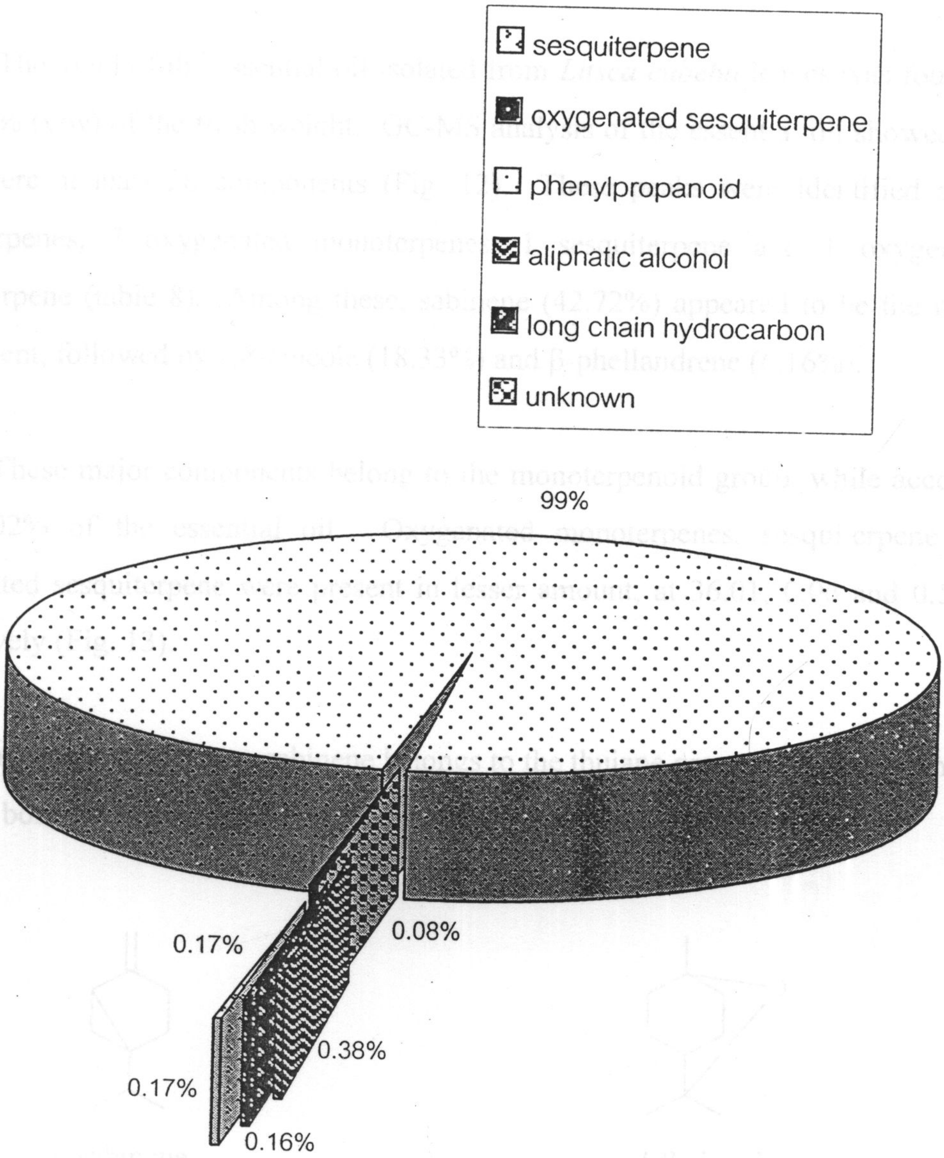


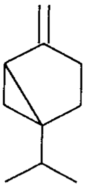
Figure 11 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum porrectum* Kosterm bark

4.1.6. Essential Oil Composition of *Litsea cubeba* Pers.

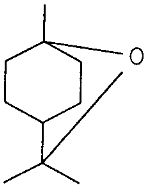
The yield of the essential oil isolated from *Litsea cubeba* leaves was found to be 0.48% (v/w) of the fresh weight. GC-MS analysis of the essential oil showed that there were at least 26 components (Fig. 12). These peaks were identified as 15 monoterpenes, 7 oxygenated monoterpenes, 1 sesquiterpene and 1 oxygenated sesquiterpene (table 8). Among these, sabinene (42.72%) appeared to be the major component, followed by *1,8*-cineole (18.33%) and β-phellandrene (6.16%).

These major components belong to the monoterpenoid group, while accounts for 63.02% of the essential oil. Oxygenated monoterpenes, sesquiterpene and oxygenated sesquiterpene were present in lesser amount, at 36.01, 0.06 and 0.50%, respectively (Fig. 13).

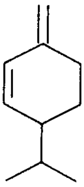
In terms of structure, sabinene belongs to the thujane group of monoterpenoids whereas both *1,8*-cineol and β-phellandrene belong to the menthane group.



sabinene
(thujane)



1,8-cineol
(menthane)



β-phellandrene
(menthane)

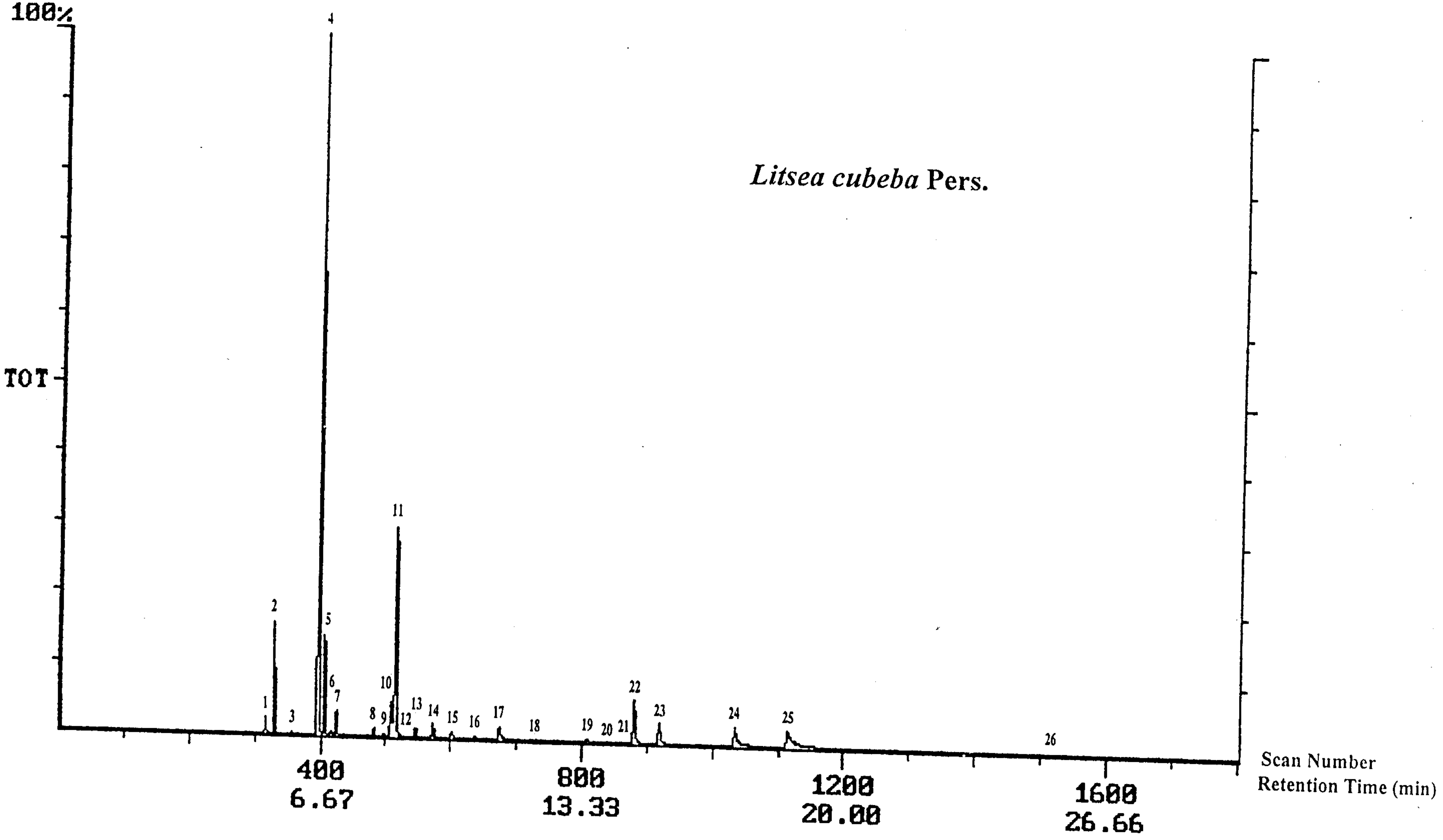


Figure 12 GC chromatogram of the essential oil from *Litsea cubeba* Per. leaves

Table 8 Essential oil composition of *Litsea cubeba* leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.82
2	tricyclene	4.98	5.39
3	camphene	5.48	0.11
4	sabinene	6.08	42.72
5	β-phellandrene	6.23	6.16
7	β-pinene	6.54	1.67
8	δ-*2*-carene	7.44	0.53
9	*o*-cymene	7.59	0.21
10	limonene	7.88	2.56
12	*(Z)*-β-ocimene	8.13	0.18
13	*(E)*-β-ocimene	8.48	0.67
14	γ-terpinene	8.91	1.08
15	*trans*-sabinene hydrate	9.61	0.70
16	terpinolene	9.93	0.22
	Oxygenated monoterpene		
11	*1,8*-cineole	7.98	18.33
17	linalool acetate	10.81	1.75
19	citronellal	12.76	0.47
22	terpin-*4-ol*	14.16	4.24
23	α-terpineol	14.98	2.56
24	*cis*-carveol	17.23	3.49
25	geranial	18.77	5.17
	Sesquiterpene		
26	*(E)*-caryophyllene	24.33	0.06
	Oxygenated sesquiterpene		
6	*6*-methyl-*5*-hepten-*2-one*	6.37	0.50
	Miscellaneous		
18	unknown	12.25	0.13
20	unknown	13.84	0.10
21	unknown	14.23	0.17

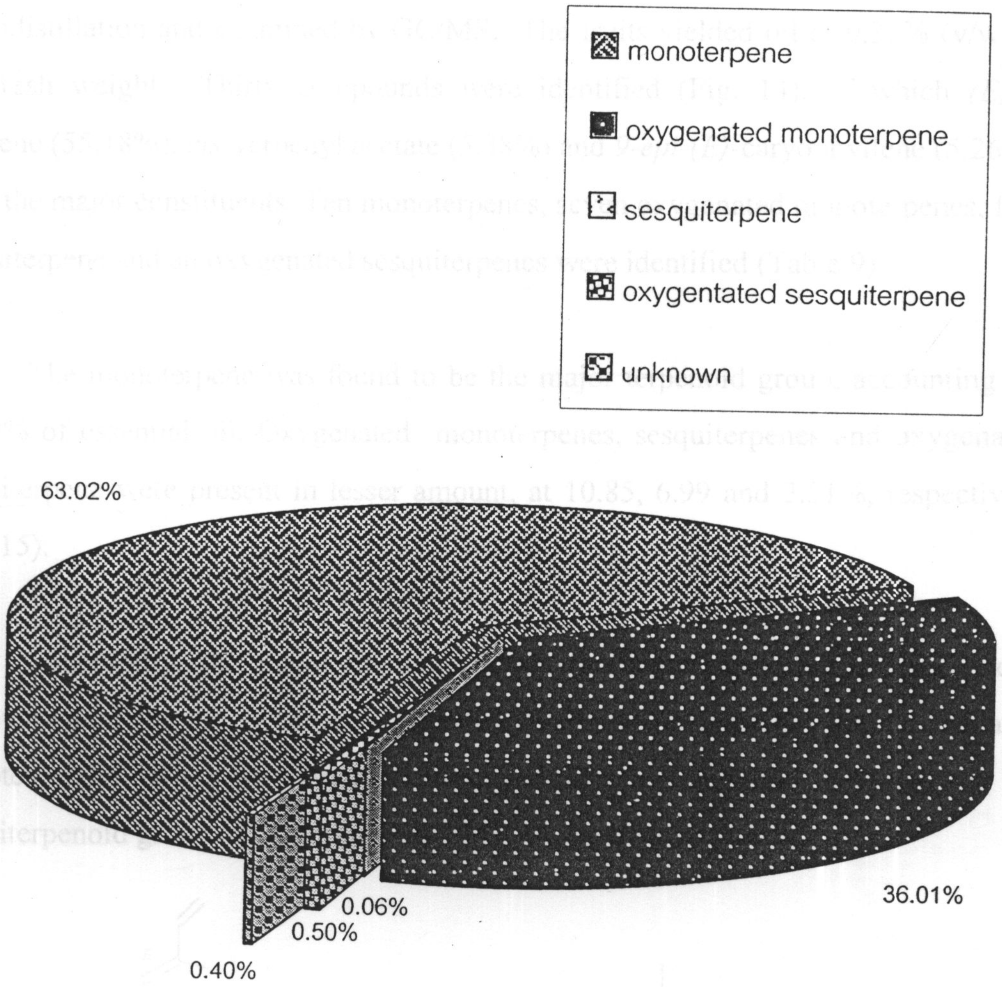


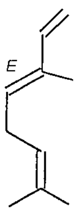
Figure 13 The percentage of various terpenoid groups found in the essential oil of *Litsea cubeba* Pers. leaves

4.1.7. Essential Oil Composition of *Litsea glutinosa* C.B. Robinson.

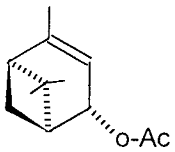
The essential oil from the fruits of *Litsea glutinosa* was isolated by hydrodistillation and examined by GC/MS. The fruits yielded oil at 0.37% (v/w) of the fresh weight. Thirty compounds were identified (Fig. 14), of which *(E)*-β-ocimene (55.18%), *cis*-verbenyl acetate (5.38%) and *9-epi-(E)*-caryophyllene (5.26%), were the major constituents. Ten monoterpenes, seven oxygenated monoterpenes, four sesquiterpene and an oxygenated sesquiterpenes were identified (Table 9).

The monoterpene was found to be the major terpenoid group, accounting for 69.69% of essential oil. Oxygenated monoterpenes, sesquiterpenes and oxygenated sesquiterpene were present in lesser amount, at 10.85, 6.99 and 2.51%, respectively (Fig. 15).

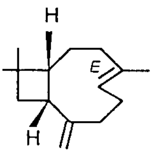
Structurally, the major component, *(E)*-β-ocimene, belongs to the acyclic monoterpenoid group, whereas *cis*-verbenyl acetate belong to the oxygenated monoterpenoid group of pinanes and *9-epi-(E)*-caryophyllene belongs to the sesquiterpenoid group of caryophyllane.



(E)-β-ocimene
(acyclic monoterpenoid)



cis-verbenyl acetate
(pinane)



9-epi-(E)-caryophyllene
(caryophyllane)

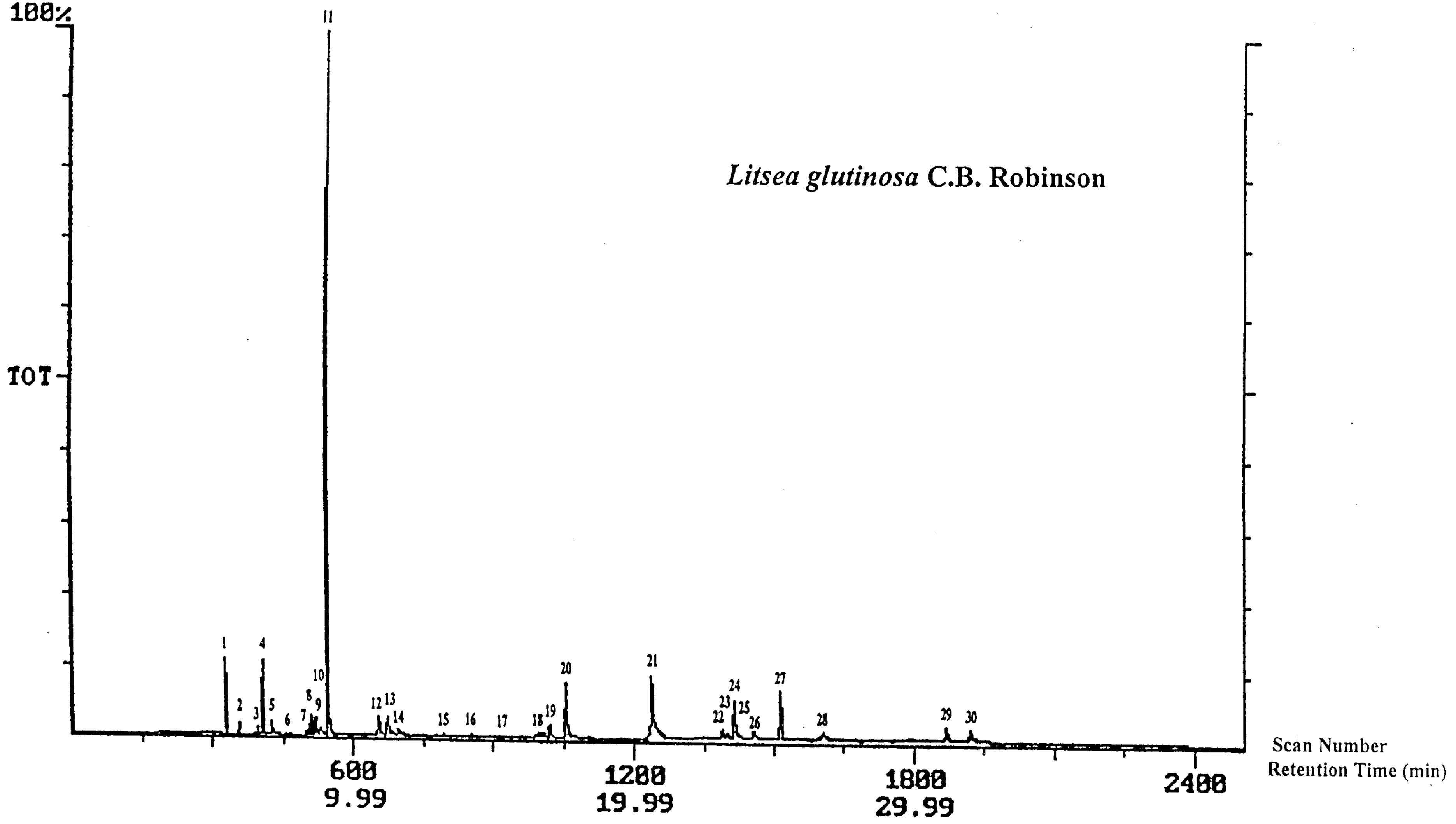


Figure 14 GC chromatogram of the essential oil from *Litsea glutinosa* C.B. Robinson fruits

Table 9 Essential oil composition of *Litsea glutinosa* fruits

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	tricyclene	4.98	3.83
2	camphene	5.48	0.62
3	sabinene	6.08	0.56
4	β-pinene	6.54	4.02
5	δ-*3*-carene	7.16	0.45
6	δ-*2*-carene	7.44	0.12
7	*o*-cymene	7.59	0.30
8	limenene	7.88	1.21
10	*(Z)*-β-ocimene	8.13	1.03
11	*(E)*-β-ocimene	8.48	46.13
	Oxygenated monoterpene		
9	*1,8*-cineole	7.98	1.02
12	verbenone	10.35	2.13
15	camphor	12.54	0.19
16	terpin-*4*-ol	14.16	0.12
17	α-terpineol	14.98	0.12
24	*cis*-verbenyl acetate	23.01	4.50
26	cumin aldehyde	24.20	0.98
	Sesquiterpene		
23	α-copaene	22.38	0.47
25	elemene	23.09	0.19
27	*9-epi*-caryophyllene	25.07	4.40
28	*(Z)*-α-bisabolene	25.44	0.79
	Oxygenated sesquiterpene		
29	caryophyllene oxide	31.32	2.10
	Miscellaneous		
13	unknown	11.26	2.24
14	unknown	11.61	1.25
18	unknown	15.54	0.76
19	unknown	17.60	1.30
20	unknown	19.83	6.35
21	unknown	20.02	10.05
22	unknown	21.65	1.09
30	unknown	31.89	1.67

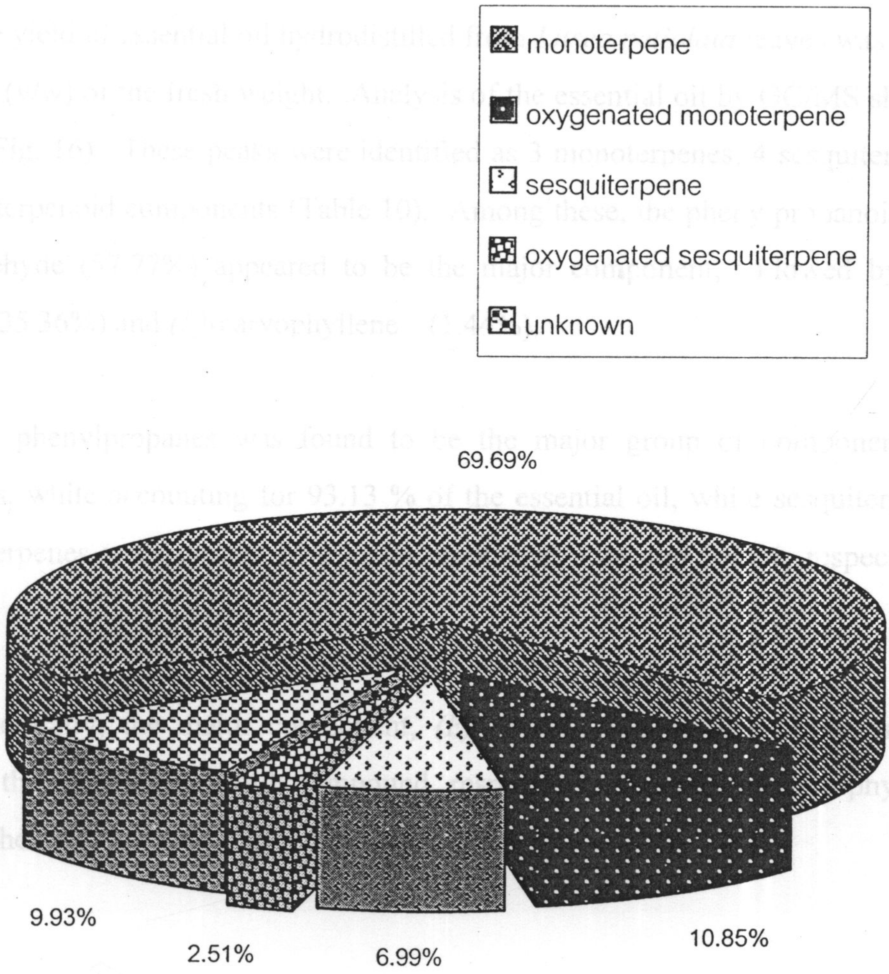


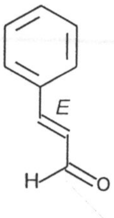
Figure 15 The percentage of various terpenoid groups found in the essential oil of *Litsea glutinosa* C.B.Robinson fruits

4.1.8. Essential Oil Composition of *Litsea petiolata* Hook.f. leaves

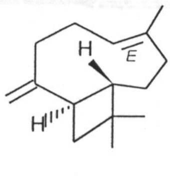
The yield of essential oil hydrodistilled from *Litsea petiolata* leaves was found to be 2.1% (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 15 peaks (Fig. 16). These peaks were identified as 3 monoterpenes, 4 sesquiterpenes and 3 non-terpenoid components (Table 10). Among these, the phenylpropanoid *(E)*-cinnamaldehyde (57.77%) appeared to be the major component, followed by *(Z)*-isosafrole (35.36%) and *(E)*-caryophyllene (1.44%).

The phenylpropanes was found to be the major group of components of components, while accounting for 93.13 % of the essential oil, while sesquiterpenes and monoterpenes were present in a lesser amount at 3.04 and 0.46%, respectively (Fig.17).

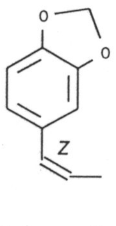
Structurally, the major component, *(E)*-cinnamaldehyde and *(Z)*-isosafrole, belong to the phenylpropanoid compound respectively, while *(E)*-caryophyllene belongs to the sesquiterpenoid group of caryophilane.



(E)-cinnamaldehyde
(phenylpropane)



(E)-caryophyllene
(*caryophilane*)



(Z)-isosafrole
(phenylpropane)

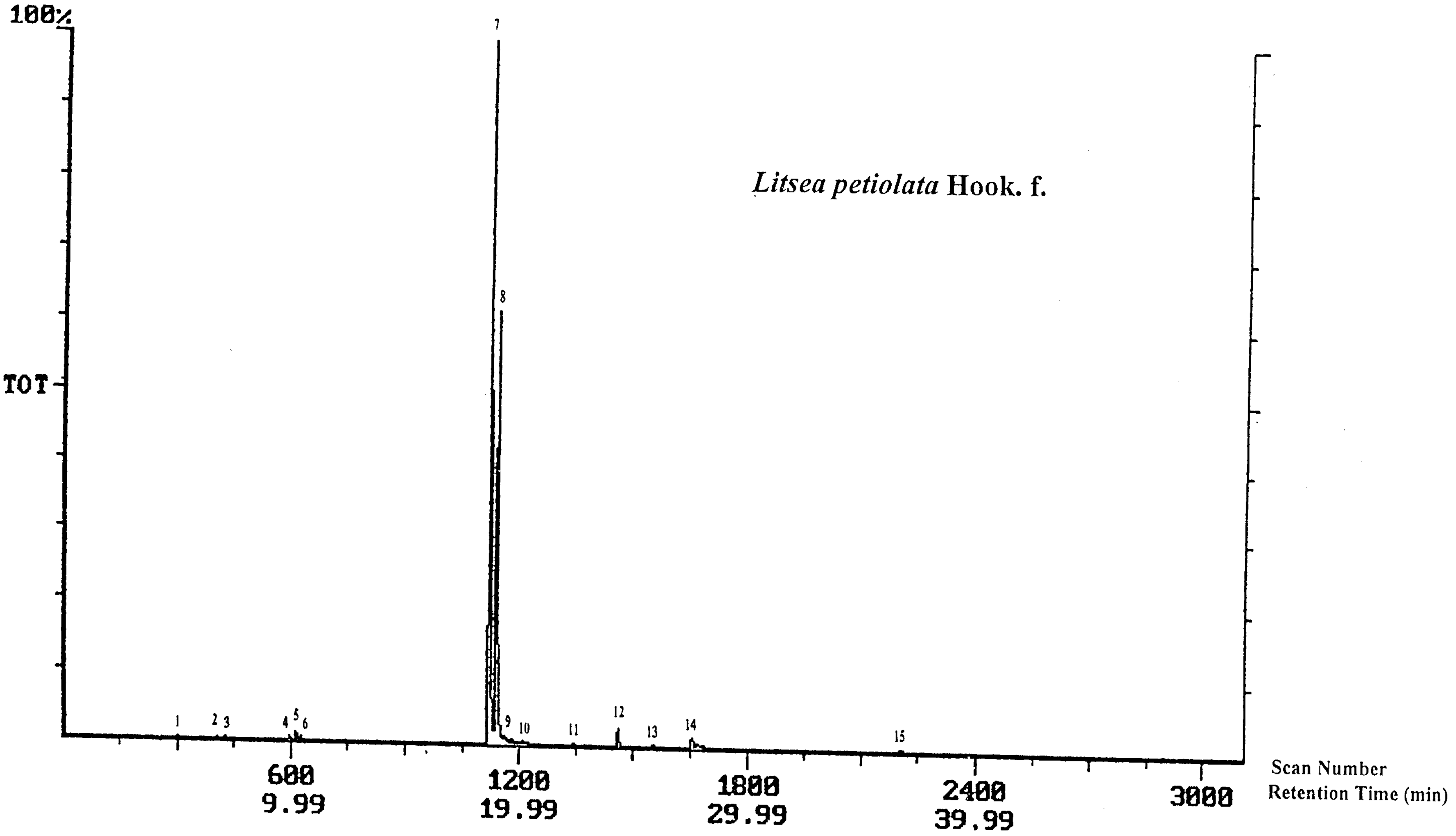


Figure 16 GC chromatogram of the essential oil from *Litsea petiolata* Hook. f. leaves

Table 10 Essential oil composition of *Litsea petiolata* Hook.f. leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-pinene	5.03	0.05
3	phellandrene	6.23	0.18
4	terpinolene	9.93	0.23
	Sesquiterpene		
11	α-copaene	22.38	0.16
12	*(E)*-caryophyllene	24.33	1.44
13	α-humulene	25.89	0.10
14	bicyclogermacrene	27.59	1.34
	Phenylpropanoid		
7	*(E)*-cinnamaldehyde	18.68	57.77
8	*(Z)*-isosafrole	18.99	35.36
	Long chain hydrocarbon		
2	*n*-decane	6.83	0.08
16	*2*-nonanone	10.23	0.63
17	*n*-heneicosane	10.44	0.25
	Miscellaneous		
9	unknown	19.34	1.42
10	unknown	19.66	0.73
15	unknown	36.76	0.21

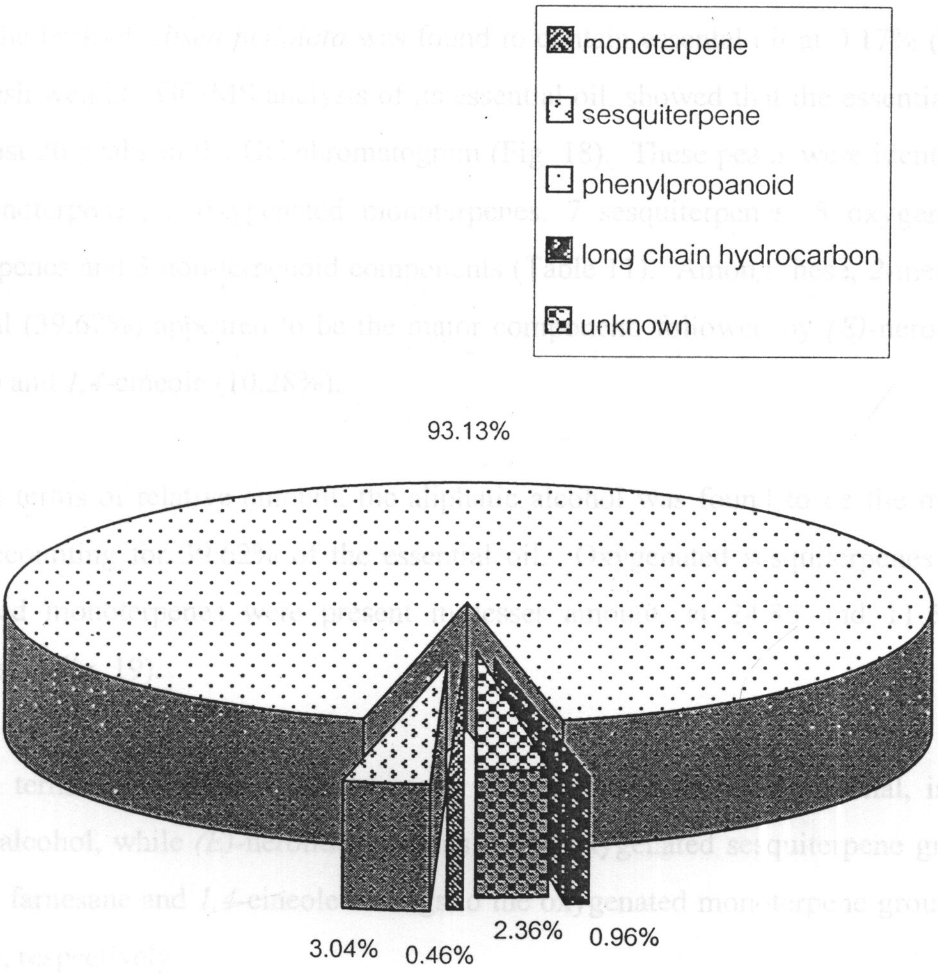


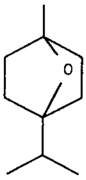
Figure 17 The percentage of various terpenoid groups found in the essential oil of *Litsea petiolata* Hook.f. leaves

4.1.9. Essential Oil Composition of *Litsea petiolata* Hook.f. bark

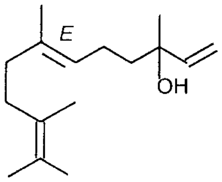
The bark of *Litsea petiolata* was found to contain essental oil at 0.17% (v/w) of the fresh weight. GC/MS analysis of its essential oil, showed that the essential oil has at least 26 peaks in the GC chromatogram (Fig. 18). These peaks were identified as 6 monoterpenes, 2 oxygenated monoterpenes, 7 sesquiterpenes, 5 oxygenated sesquiterpenes and 3 non-terpenoid components (Table 11). Among these, *2*-methyl-undecanal (39.62%) appeared to be the major component, followed by *(E)*-nerolidol (22.67%) and *1,4*-cineole (10.28%).

In terms of relative amount, the aliphatic alcohol was found to be the major group, accounting for 39.62% of the essential oil. Oxygenated sesquiterpenes and oxygenated monoterpenes were present in lesser amount, at 24.86 and 11.51%, respectively (Fig. 19).

In terms of structure type, the major component, *2*-methyl-undacanal, is an aliphatic alcohol, while *(E)*-nerolidol belongs to the oxygenated sesquiterpene group of simple farnesane and *1,4*-cineole belongs to the oxygenated monoterpene group of menthane, respectively.



1,4-cineole
(menthane)



(E)-nerolidol
(simple farnesane)

$CH_3(CH_2)_8CHCH_3COH$

2-methyl-undacanal
(aliphatic alcohol)

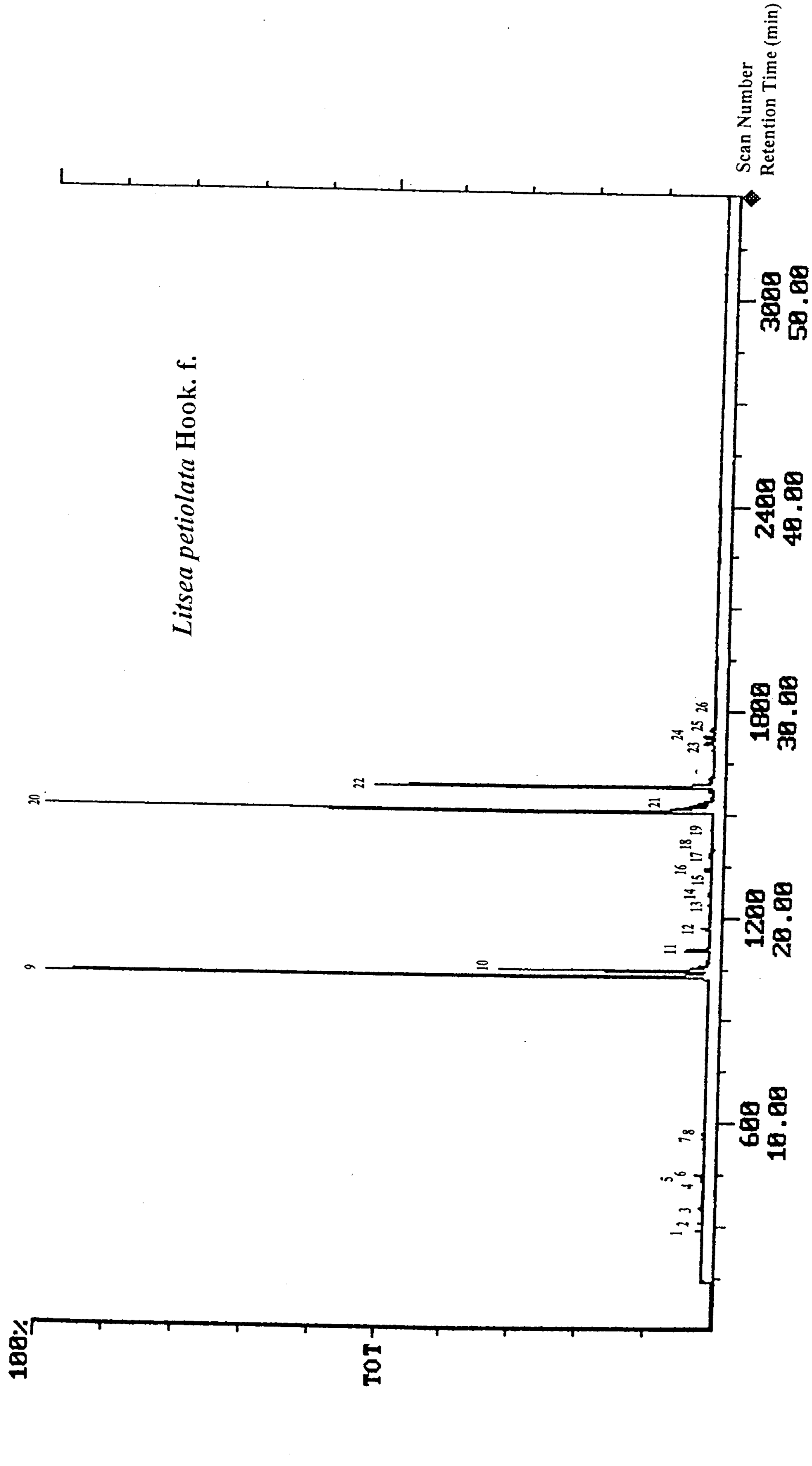


Figure 18 GC chromatogram of the essential oil from *Litsea petiolata* Hook. f. bark

Table 11 Essential oil composition of *Litsea petiolata* Hook.f. bark

Number of peak	Compound	Retention time (min)	%Area
	Monoterpene		
1	tricyclene	4.98	1.09
2	camphene	5.48	1.37
3	β-phellandrene	6.23	0.86
4	*o*-cymene	7.59	0.80
5	limonene	7.88	0.67
7	α-terpinene	9.76	0.06
	Oxygenated monoterpene		
6	*1,8*-cineole	7.98	1.23
9	*1,4*-cineole	10.27	10.28
	Sesquiterpene		
12	α-copaene	22.38	0.12
14	germacrene D	22.93	0.17
15	*cis*-β-guaiene	23.71	0.07
16	*9-epi-(E)*-caryophyllene	25.07	0.53
18	longifolene	25.11	0.25
19	α-humulene	25.89	0.73
21	bicyclogermacrene	27.59	3.06
	Oxygenated sesquiterpene		
22	*(E)*-nerolidol	30.66	22.67
23	spathulenol	31.29	1.03
24	globulol	31.47	0.84
25	β-eudesmol acetate	31.63	0.23
26	cubenol	33.38	0.09
	Aliphatic alcohol		
20	*2*-methyl-undecanal	26.92	39.62
	Long chain hydrocarbon		
8	*2*-nonanone	10.23	0.09
10	*2*-undecanone	18.50	11.84
	Miscellaneous		
11	unknown	18.80	1.97
13	unknown	22.56	0.17
17	unknown	25.09	0.14

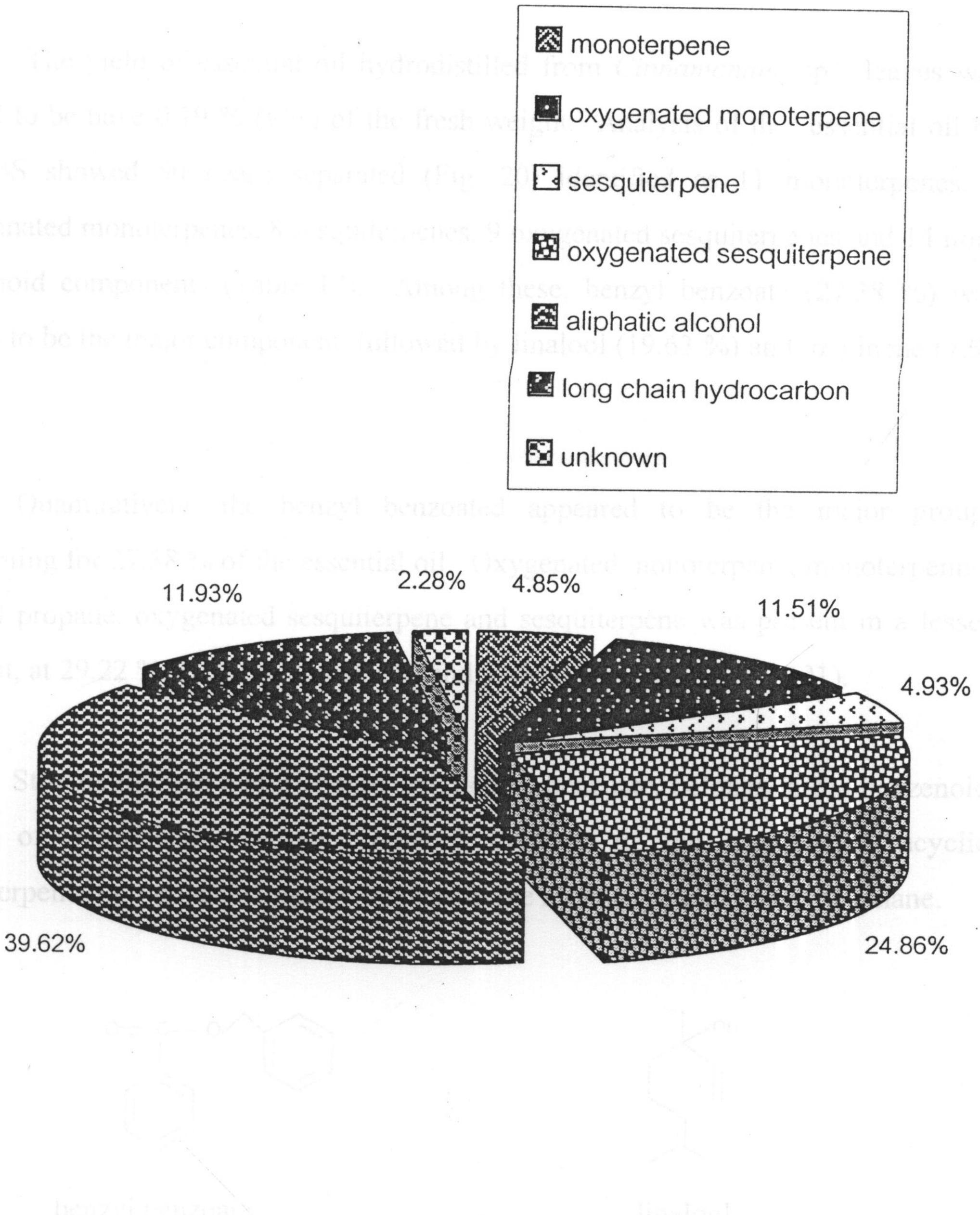


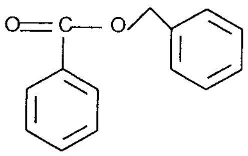
Figure 19 The percentage of various terpenoid groups found in the essential oil of *Litsea petiolata* Hook.f. bark

4.1.10. Essential Oil Composition of *Cinnamomum* sp.1

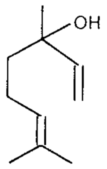
The yield of essential oil hydrodistilled from *Cinnamomum* sp1. leaves was found to be have 0.19 % (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 50 peaks separated (Fig. 20) identified as 11 monoterpenes, 8 oxygenated monoterpenes, 8 sesquiterpenes, 9 oxygenated sesquiterpenes and 14 non-terpenoid components (Table 12). Among these, benzyl benzoate (27.38 %) was found to be the major component, followed by linalool (19.63 %) and α-pinene (7.95 %).

Quantitatively, the benzyl benzoated appeared to be the major group, accounting for 27.38 % of the essential oil. Oxygenated monoterpene, monoterpenne, phenyl propane, oxygenated sesquiterpene and sesquiterpene was present in a lesser amount, at 29.22 %, 19.66%, 8.08%, 8% and 4.03%, respectively (Fig. 21).

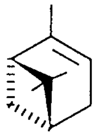
Structurally, the major component, benzyl benzoate, belongs to the benzenoid group of compounds, whereas linalool belongs to the oxygenated acyclic monoterpenoid group and α-pinene belongs to the monoterpenoid group of pinane.



benzyl benzoate
(benzoid)



linalool
(acyclic monoterpenoid)



α-pinene
(pinane)

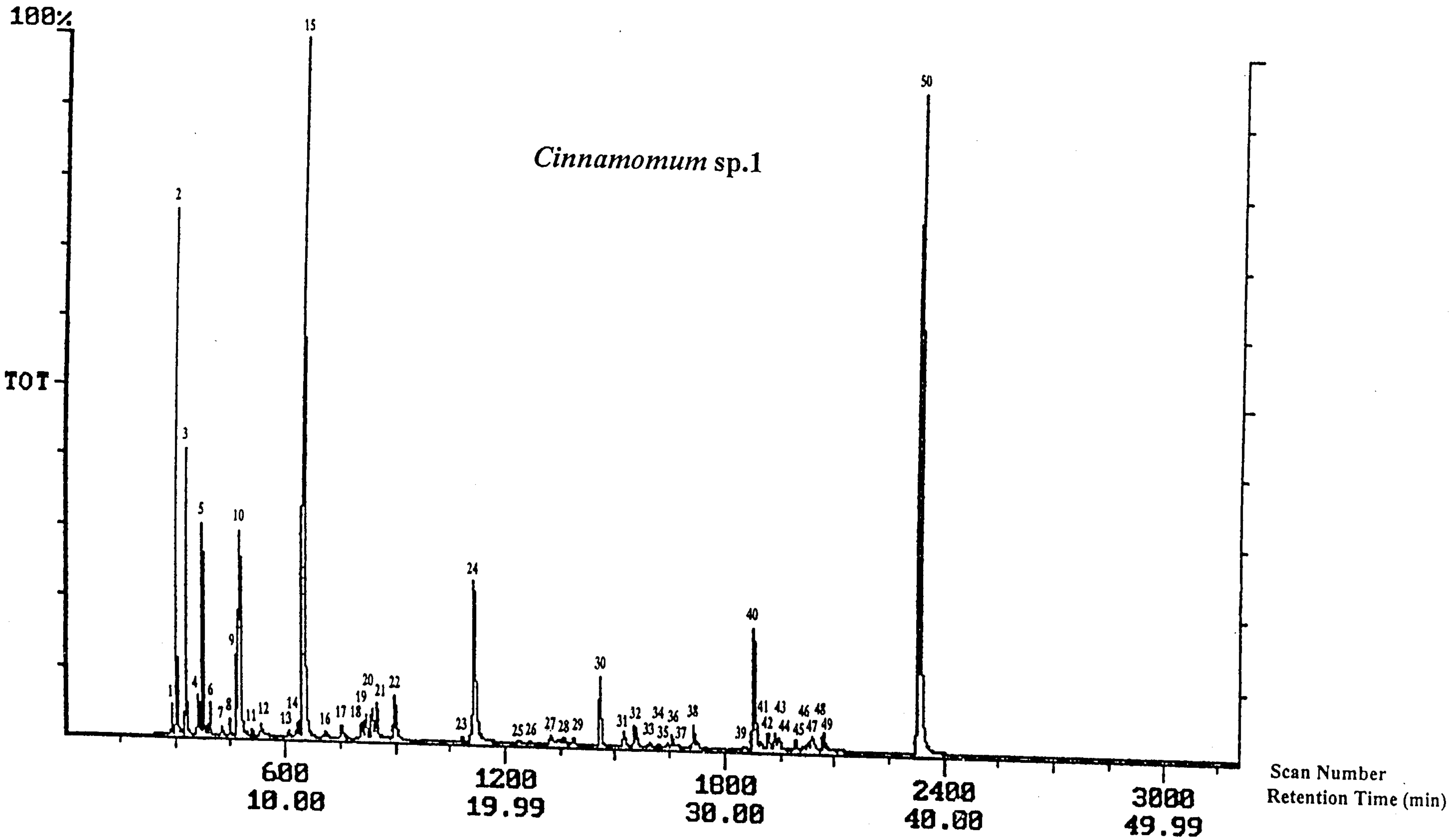


Figure 20 GC chromatogram of the essential oil from *Cinnamomum* sp.1 leaves

Table 12 Essential oil composition of *Cinnamomum* sp.1 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.47
2	α-pinene	5.03	7.95
3	camphene	5.48	4.59
5	β-phellandrene	6.23	3.54
6	β-pinene	6.54	0.55
7	α-phellandrene	7.11	0.21
8	δ-2-carene	7.44	0.26
9	verbenene	7.78	1.45
11	*(E)*-β-ocimene	8.48	0.13
12	γ-terpinene	8.91	0.44
13	terpinolene	9.93	0.07
	Oxygenated monoterpene		
10	*trans*-sabinene hydrate acetate	7.94	4.83
14	*trans*-linalool oxide	10.13	0.15
15	linalool	10.81	19.63
16	*trans*-*para*-menth-*2*-en-*1*-ol	11.81	0.18
17	camphor	12.54	0.44
20	isoborneol	13.93	1.17
21	terpin-*4*-ol	14.16	1.21
22	α-terpineol	14.98	1.61
	Sesquiterpene		
26	β-cubebene	21.13	0.03
28	α-copaene	22.38	0.24
30	*(E)*-caryophyllene	24.33	1.87
32	α-humulene	25.89	0.79
33	δ-cadinene	26.58	0.09
34	γ-muurolene	26.99	0.04
36	bicyclogermacrene	27.59	0.38
38	trans-β-guaiene	28.59	0.59
	Oxygenated sesquiterpene		
37	*epi*-cubebol	27.84	0.10
40	spathulenol	31.29	4.29
41	α-eudesmol acetate	31.59	0.39
42	hinesol acetate	31.96	0.55
43	longiborneol acetate	32.26	0.46
44	humulene epoxide II	32.44	0.35
45	*1*-*epi*-cubebol	33.19	0.33
48	*epi*-α-muurolol	33.96	0.85

Table 12 (continued)

Peak No	Compound	Retention time (min)	%Area
49	α-cadinol	34.49	0.68
	Phenylpropanoid		
18	*(Z)*-cinnamyl alcohol	13.46	0.51
24	*(E)*-cinnamaldehyde	18.61	7.16
27	*(Z)*-isoeugenol	22.10	0.41
	Benzenoid		
4	bebzaldehyde	6.01	1.28
19	ethyl benzoate	13.66	0.75
23	*n*-pentyl benzoate	18.04	0.11
29	*n*-hexyl benzoate	22.66	0.27
31	*(Z)*-methyl butyl benzoate	25.41	0.40
50	benzyl benzoate	38.86	27.38
	Miscellaneous		
25	unknown	20.63	0.07
35	unknown	27.41	0.08
39	unknown	30.88	0.11
46	unknown	33.59	0.17
47	unknown	33.78	0.26

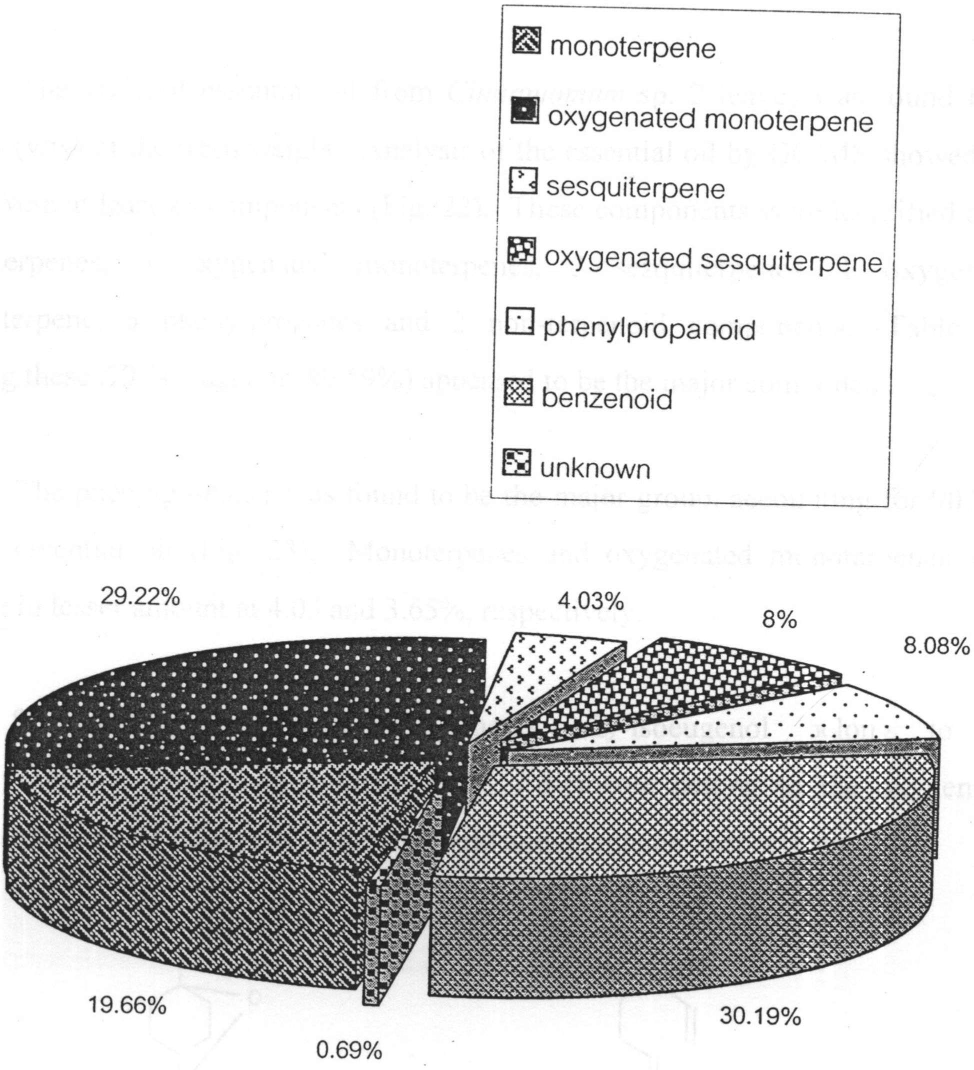


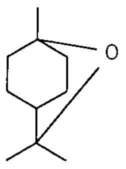
Figure 21 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.1 leaves

4.1.11. Essential Oil Composition of *Cinnamomum* sp. 2

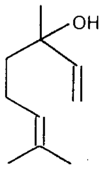
The yield of essential oil from *Cinnamomum* sp. 2 leaves was found to be 0.32% (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed that there were at least 28 components (Fig. 22). These components were identified as 11 monoterpenes, 5 oxygenated monoterpenes, 3 sesquiterpenes, 1 oxygenated sesquiterpene, 3 phenylpropanes and 2 non-terpenoid components. (Table 13). Among these *(Z)*-isoeugenol (89.59%) appeared to be the major component.

The phenylpropanes was found to be the major group, accounting for 90.29% of the essential oil (Fig. 23). Monoterpenes and oxygenated monoterpenes were present in lesser amount at 4.03 and 3.65%, respectively.

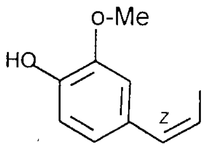
Structurally, the major components, *(Z)*-isoeugenol belong to the phenylpropanoid group, while linalool and *1,8*-cineole belong to the oxygenated monoterpene group of acyclic monoterpenoid and menthane, respectively.



1,8-cineole
(menthane)



linalool
(acyclic monoterpenoid)



(Z)-isoeugenol
(phenylpropanoid)

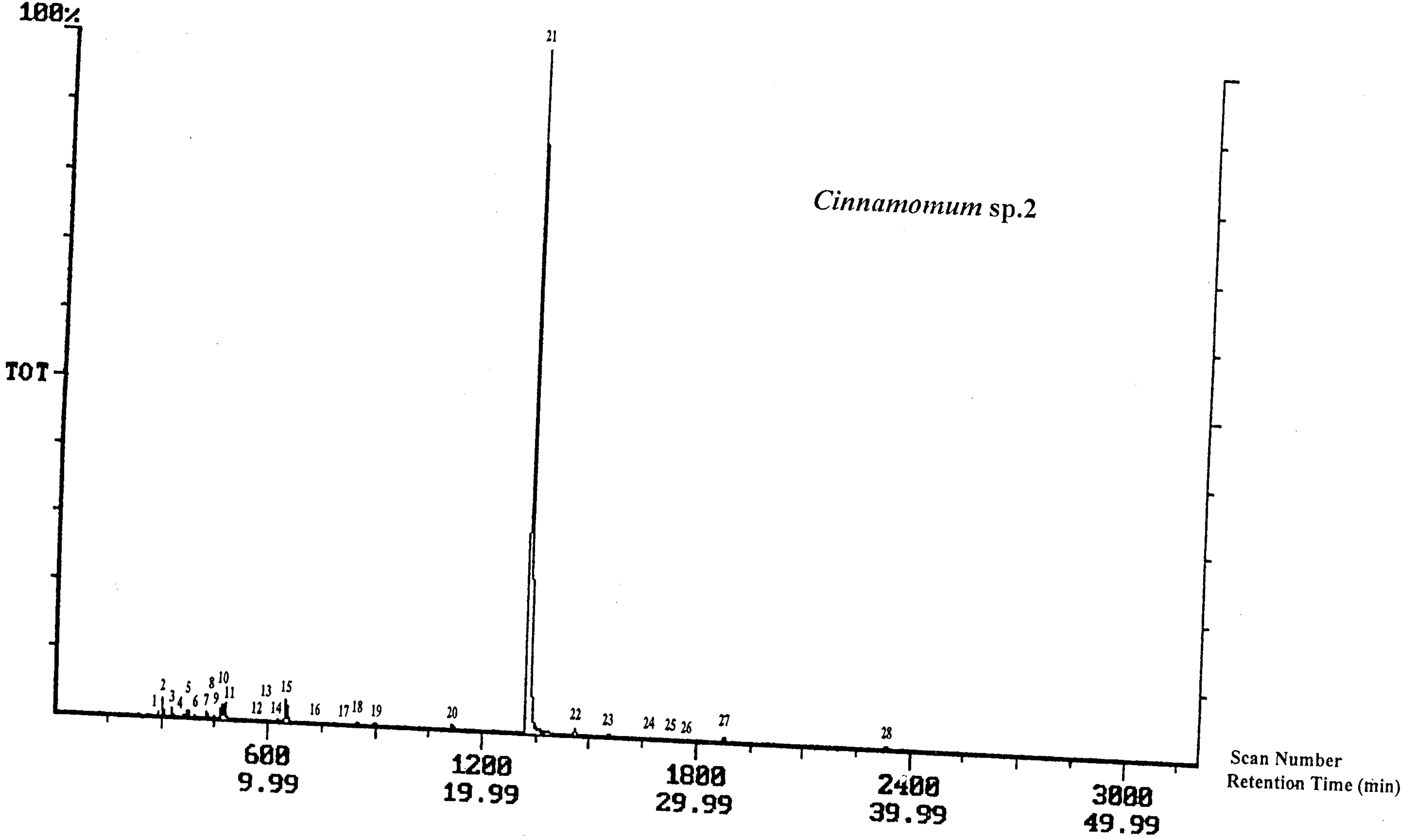


Figure 22 GC chromatogram of the essential oil from *Cinnamomum* sp.2 leaves

Table 13 Essential oil composition of *Cinnamomum* sp.2 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.15
2	α-pinene	5.03	0.94
3	camphene	5.48	0.44
5	β-phellandrene	6.23	0.39
6	β-pinene	6.54	0.07
7	*a*-phellandrene	7.11	0.33
8	*2*-δ-carene	7.44	0.14
9	verbenene	7.78	0.85
10	limonene	7.88	0.44
12	γ-terpinene	8.91	0.15
13	terpinolene	9.93	0.13
	Oxygenated monoterpene		
11	*1,8*-cineole	7.98	1.16
15	linalool	10.81	2.06
17	isoborneol	13.93	0.05
18	terpin-*4*-ol	14.16	0.18
19	α-terpineol	14.98	0.20
	Sesquiterpene		
22	*(E)*-caryophyllene	24.33	0.50
24	bicyclogermacrene	27.59	0.05
25	*trans*-β-guaiene	28.59	0.03
	Oxygenated sesquiterpene		
27	spathulenol	31.29	0.50
	Phenylpropanoid		
20	*(E)*-cinnamaldehyde	18.61	0.61
21	*(Z)*-isoeugenol	22.10	89.59
26	eugenyl acetate	28.84	0.09
	Benzenoid		
28	benzyl benzoate	38.86	0.27
	Long chain hydrocarbon		
14	*n*-heneicocane	10.44	0.15
	Miscellaneous		
4	unknown	6.04	0.12
16	unknown	11.83	0.08
23	unknown	25.91	0.28

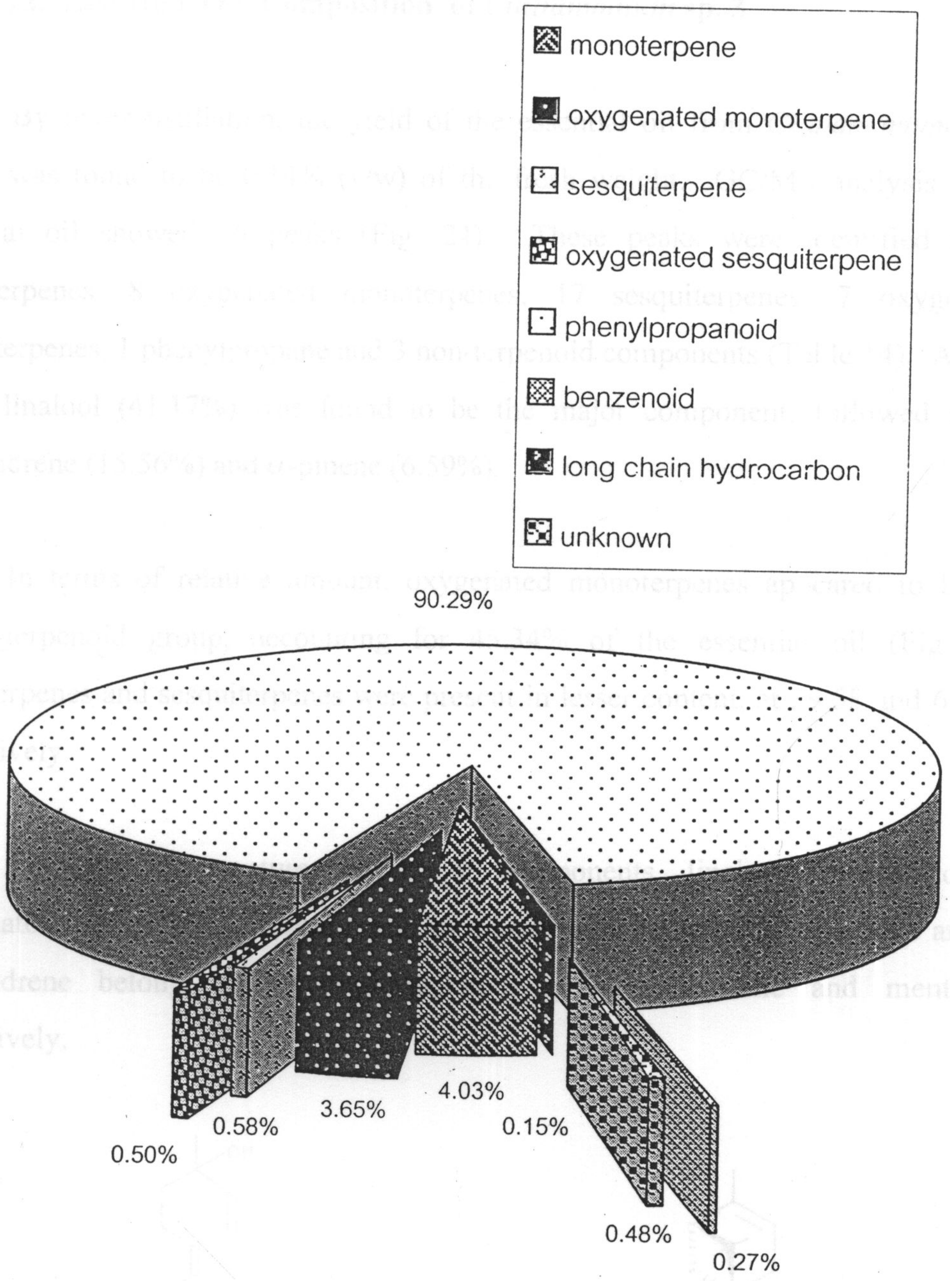


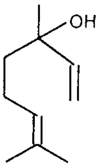
Figure 23 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.2 leaves

4.1.12. Essential Oil Composition of *Cinnamomum* sp. 3

By hydrodistillation, the yield of the essential oil from *Cinnamomum* sp. 3 leaves was found to be 0.14% (v/w) of the fresh weight. GC/MS analysis of the essential oil showed 56 peaks (Fig. 24). These peaks were identified as 14 monoterpenes, 8 oxygenated monoterpenes, 17 sesquiterpenes, 7 oxygenated sesquiterpenes, 1 phenylpropane and 3 non-terpenoid components (Table 14). Among these, linalool (41.17%) was found to be the major component, followed by α-phellandrene (15.56%) and α-pinene (6.59%).

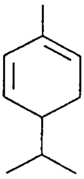
In terms of relative amount, oxygenated monoterpenes appeared to be the major terpenoid group, accounting for 45.34% of the essential oil (Fig. 25). Monoterpenes and sesquiterpenes were present in lesser content, at 39.58 and 6.94%, respectively.

In terms of structure, the major components, linalool, belong to the oxygenated monoterpene group of acyclic monoterpenoids whereas α-pinene and α-phellandrene belong to the monoterpenoid group of pinane and menthane, respectively.



linalool
(acyclic monoterpenoid)

α-pinene
(pinane)



α-phellandrene
(menthane)

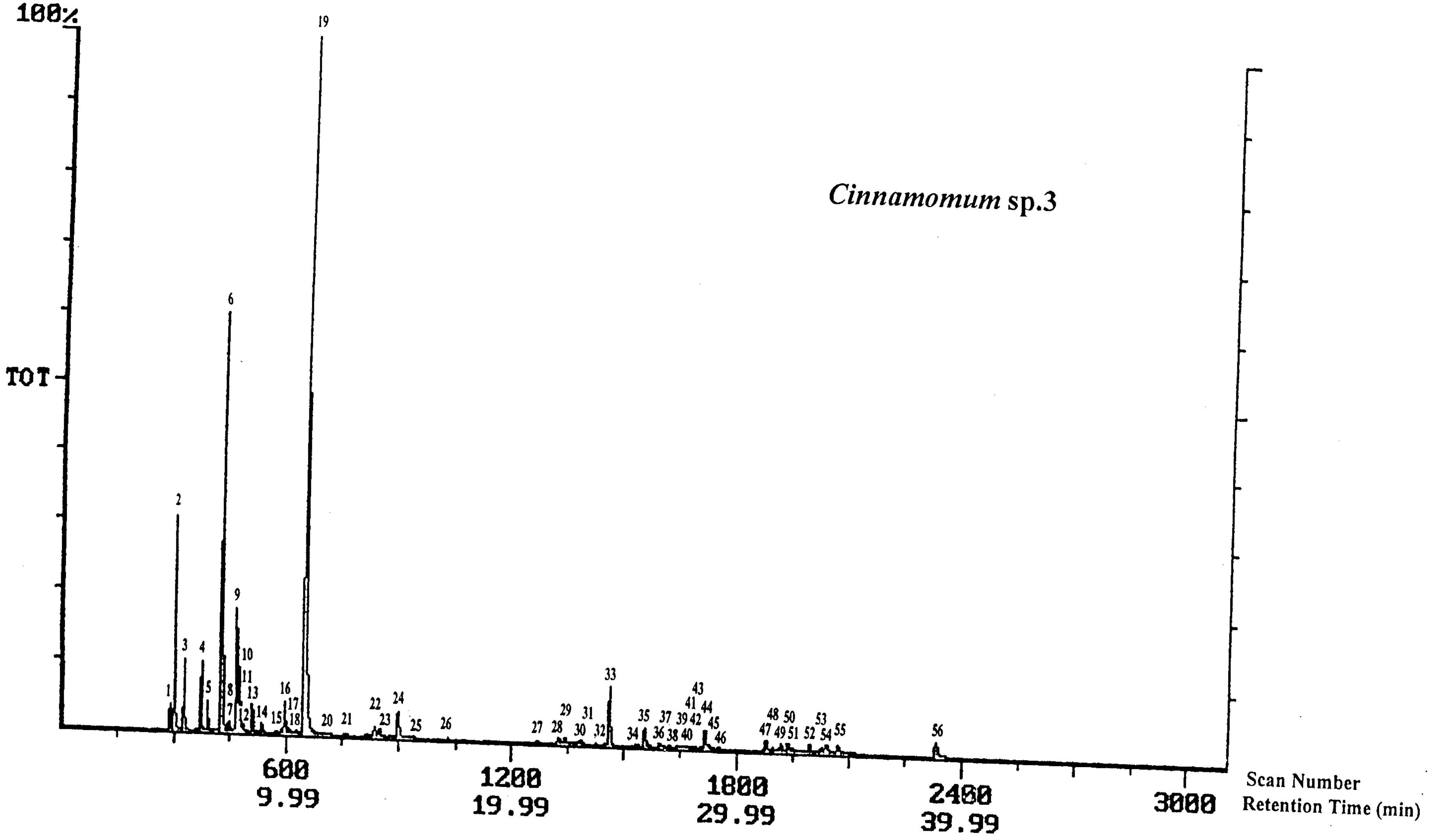


Figure 24 GC chromatogram of the essential oil from *Cinnamomum* sp.3 leaves

Table 14 Essential oil composition of *Cinnamomum* sp.3 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.08
2	α-pinene	5.03	6.59
3	camphene	5.48	2.55
4	β-phellandrene	6.23	2.32
5	β-pinene	6.54	1.02
6	α-phellandrene	7.11	15.56
7	δ-*2*-carene	7.44	0.31
8	*o*-cymene	7.59	0.12
9	verbenene	7.78	4.73
10	limonene	7.88	2.78
13	*(E)*-β-ocimene	8.48	1.02
14	γ-terpinene	8.91	0.40
15	α-terpinene	9.76	0.09
16	terpinolene	9.93	1.29
	Oxygenated monoterpene		
12	terpin-*4-ol* acetate	8.09	0.26
17	*trans*-linalool oxide	10.13	0.26
19	linalool	10.81	41.17
20	*trans-para*-menth-*2*-en-*1*-ol	11.81	0.09
22	borneol	13.93	0.70
23	terpin-*4*-ol	14.16	0.55
24	α-terpineol	14.98	1.90
26	bornyl acetate	18.44	0.41
	Sesquiterpene		
27	β-cubebene	21.13	0.06
29	α-copaene	22.38	0.29
30	germacrene D	22.93	0.07
31	β-elemene	23.09	0.16
33	*(E)*-caryophyllene	24.33	3.20
34	*trans*-calamenene	25.58	0.07
35	α-humulene	25.89	1.00
36	δ-cadinene	26.58	0.18
37	γ-cadinene	26.75	0.05
38	γ-muurolene	26.99	0.11
39	isoledene	27.43	0.17
40	bicyclogermacrene	27.59	0.14
42	germacrene A	28.11	0.17
43	*cis*-muurola-*4(14),5*-diene	28.39	0.04
44	*trans*-β-guaiene	28.59	1.04

Table 14 (continued)

Peak No	Compound	Retention time (min)	%Area
45	α-cadinene	28.76	0.22
46	cadina-*1,4*-diene	29.19	0.07
	Oxygenated sesquiterpene		
41	*epi*-cubebol	27.84	0.12
47	spathulenol	31.29	0.61
48	α-eudesmol acetate	31.63	0.19
49	hinesol acetate	31.96	0.56
52	*1-epi*-cubenol	33.19	0.44
54	*epi*-α-muurolol	33.98	0.86
55	α-cadinol	34.49	0.56
	Phenylpropanoid		
28	*(Z)*-isoeugenol	22.10	0.48
	Benzenoid		
56	benzyl benzoate	38.86	1.33
	Aliphatic alcohol		
32	tetradecanal	24.16	0.09
	Long chain hydrocarbon		
18	*n*-heneicosane	10.44	0.12
	Miscellaneous		
11	unknown	7.96	1.47
21	unknown	12.61	0.10
25	unknown	15.36	0.09
50	unknown	32.28	0.55
51	unknown	32.44	0.14
52	unknown	33.79	0.26

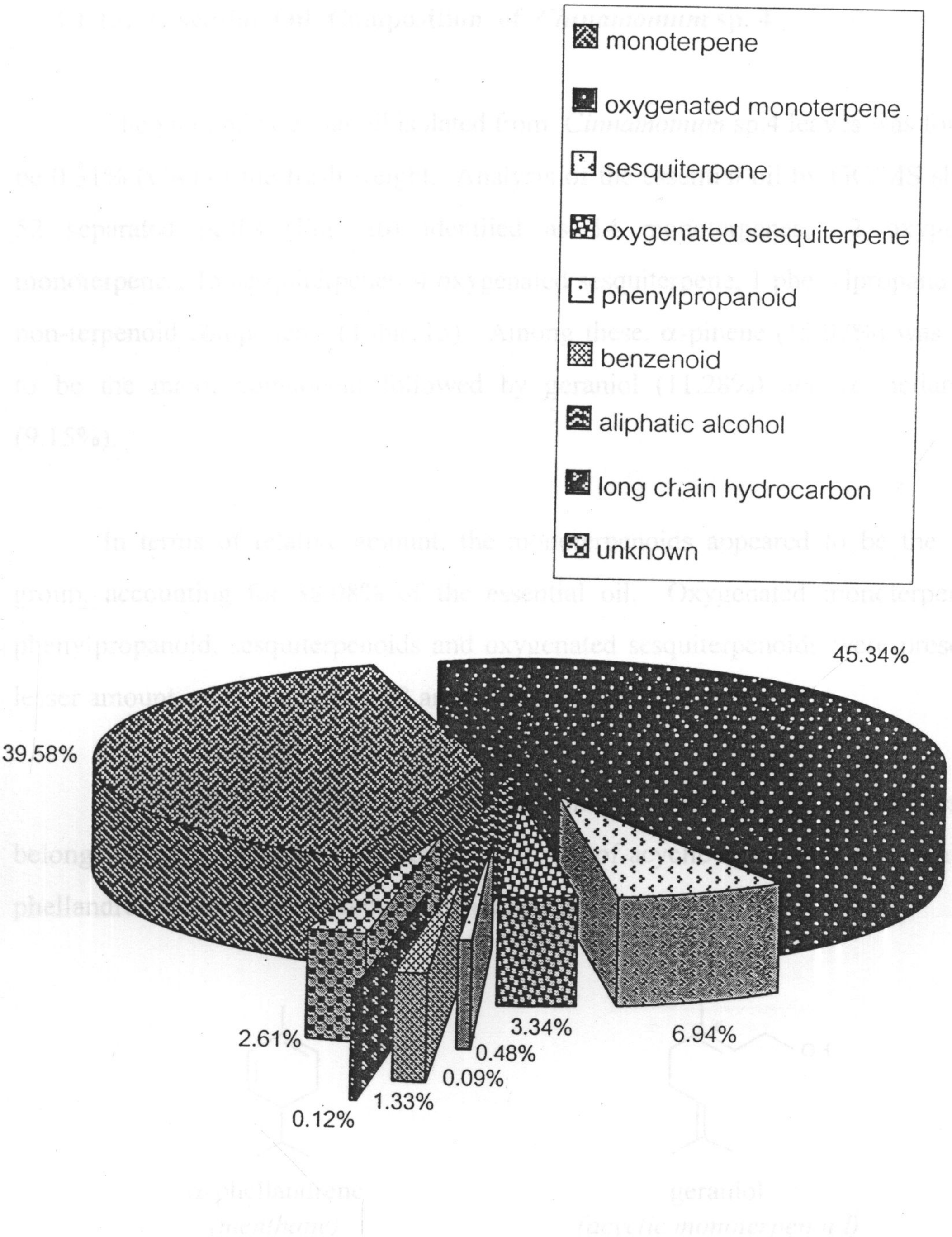


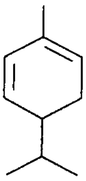
Figure 25 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.3 leaves

4.1.13. Essential Oil Composition of *Cinnamomum* sp. 4

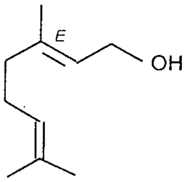
The yield of essential oil isolated from *Cinnamomum* sp.4 leaves was found to be 0.31% (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 52 separated peaks (Fig. 26) identiied as 14 monoterpenes, 12 oxygenated monoterpenes, 15 sesquiterpenes, 4 oxygenated sesquiterpene, 1 phenylpropane and 2 non-terpenoid components (Table 15). Among these, α-pinene (15.07%) was found to be the major component followed by geraniol (11.28%) and α-phellandrene (9.15%).

In terms of relative amount, the monoterpenoids appeared to be the major group, accounting for 38.08% of the essential oil. Oxygenated monoterpenoids, phenylpropanoid, sesquiterpenoids and oxygenated sesquiterpenoids were present in lesser amount, at 33.95, 8.75, 8.33 and 3.88%, respectively (Fig. 27).

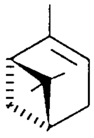
Structurally, α-pinene is a monoterpenoid of the pinane group, geraniol belongs to the oxygenated monoterpenoid group of acyclic monoterpenoid, while α-phellandrene belongs to the monoterpenoid group of menthane.



α-phellandrene
(menthane)



geraniol
(acyclic monoterpenoid)



α-pinene
(pinane)

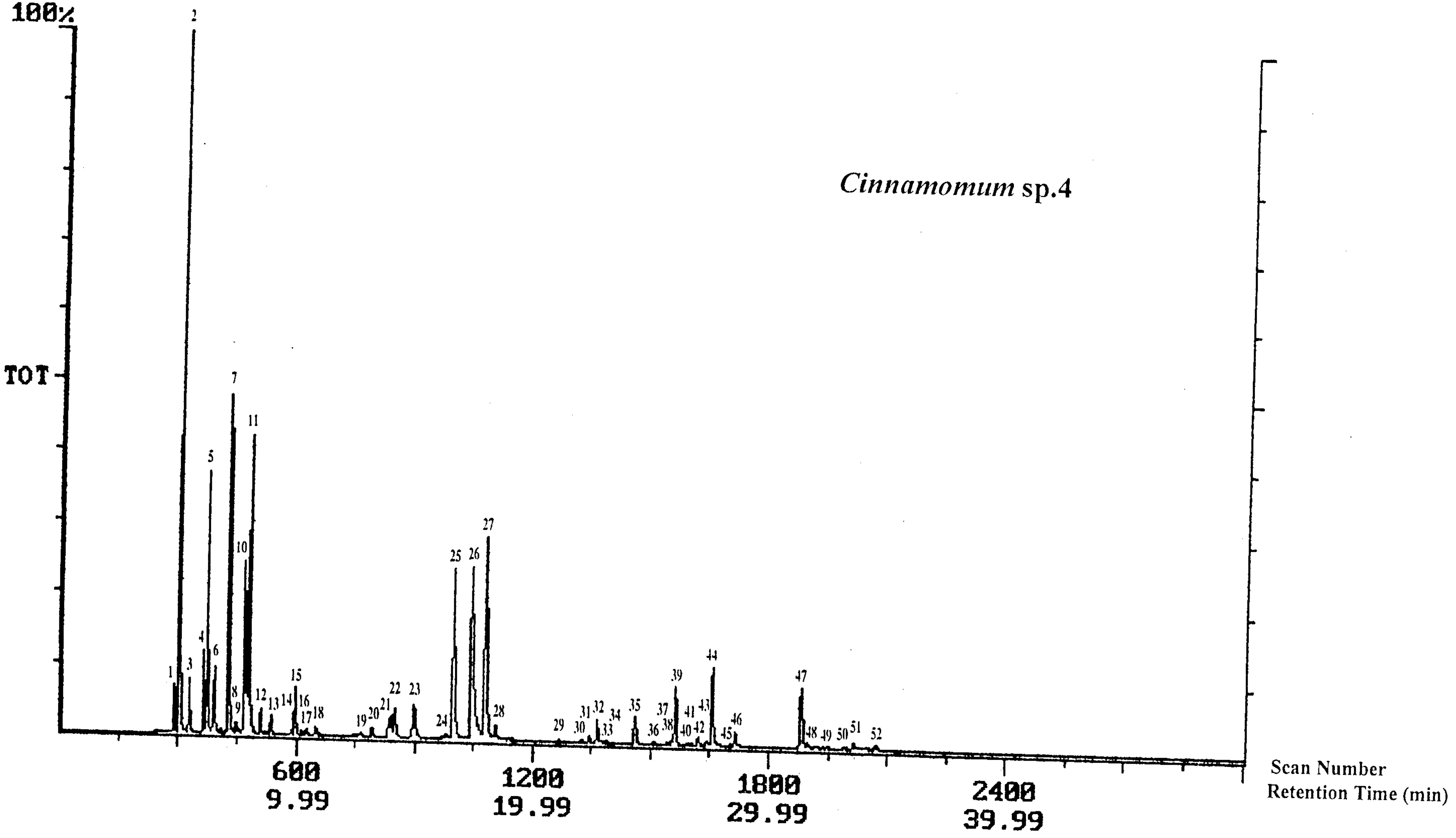


Figure 26 GC chromatogram of the essential oil from *Cinnamomum* sp.4 leaves

Table 15 Essential oil composition of *Cinnamomum* sp.4 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	1.03
2	α-pinene	5.03	15.07
3	camphene	5.48	1.38
4	sabinene	6.08	1.91
5	β-phellandrene	6.23	6.28
6	β-pinene	6.54	1.88
7	α-phellandrene	7.11	9.15
8	δ-2-carene	7.44	0.24
9	*o*-cymene	7.59	0.11
10	verbenene	7.78	4.36
12	*(E)*-β-ocimene	8.48	0.62
13	γ-terpinene	8.91	0.51
14	α-terpinene	9.76	0.13
15	terpinolene	9.93	1.41
	Oxygenated monoterpene		
11	*1,8*-cineol	7.98	8.84
18	linalool	10.81	0.40
19	citronellal	12.76	0.15
20	*cis*-limonene oxide	13.19	0.33
21	borneol	13.99	1.19
22	terpin-*4*-ol	14.16	1.40
23	α-terpineol	14.98	1.79
24	citronellol	16.34	0.42
25	neral	16.63	6.84
26	geraniol	17.38	11.28
28	isobornyl acetate	18.46	0.37
32	geranyl acetate	22.73	0.88
	Sesquiterpene		
29	β-cubebene	21.13	0.04
31	α-copaene	22.38	0.21
33	germacrene D	22.93	0.06
34	β-elemene	23.09	0.07
35	*E*-caryophyllene	24.33	1.06
36	longifolene	25.11	0.06
37	*cis*-β-guaiene	25.73	0.02
38	α-humulene	25.89	0.17
39	valencene	26.03	2.15
41	γ-cadinene	26.75	0.21
42	γ-muurolene	26.99	0.34

Table 15 (continued)

Peak No	Compound	Retention time (min)	%Area
43	viridiflorene	27.38	0.22
44	bicyclogermacrene	27.59	3.09
45	*cis*-muurola-*4(14),5*-diene	28.39	0.06
46	trans-β-guaiene	28.59	0.57
	Oxygenated sesquiterpene		
47	spathulenol	31.29	3.09
48	α-eudesmol acetate	31.59	0.35
49	hinesol acetate	31.96	0.12
52	α-cadinol	34.49	0.32
	Phenylpropane		
27	*(Z)*-methyl cinnamate	17.94	8.75
	Long chain hydrocarbon		
16	*2*-nonanone	10.23	0.16
17	*n*-heneicosane	10.44	0.17
	Miscellaneous		
30	unknown	22.09	0.09
40	unknown	26.56	0.16
50	unknown	33.21	0.10
51	unknown	33.59	0.36

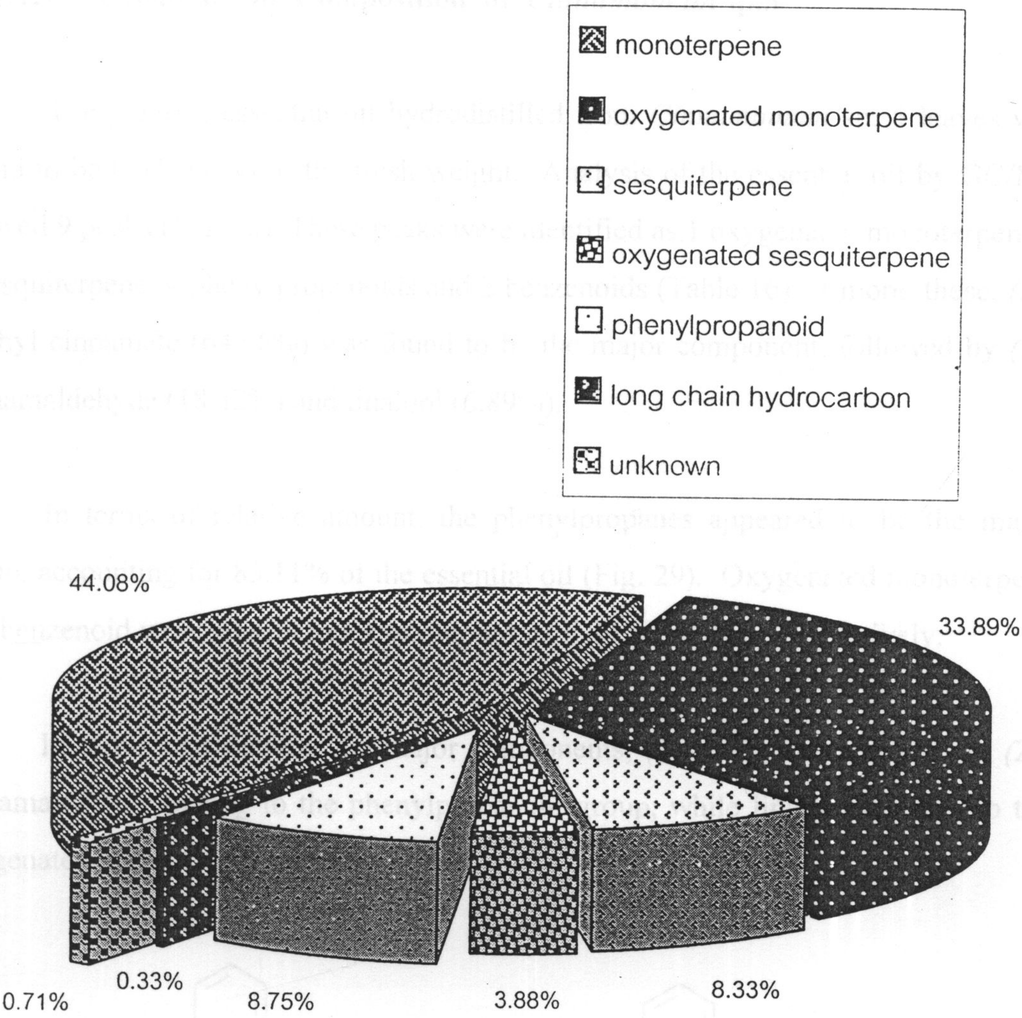


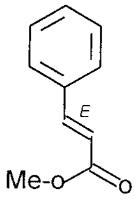
Figure 27 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.4 leaves

4.1.14. Essential Oil Composition of *Cinnamomum* sp.5

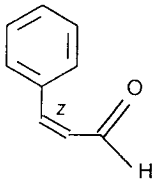
The yield of essential oil hydrodistilled from *Cinnamomum* sp. 5 leaves was found to be 0.6% (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 9 peaks (Fig. 28). These peaks were identified as 1 oxygenated monoterpene, 1 sesquiterpene, 4 phenylpropanoids and 2 benzenoids (Table 16). Among these, *(E)*-methyl cinnamate (64.66%) was found to be the major component, followed by *(Z)*-cinnamaldehyde (18.42%) and linalool (6.89%).

In terms of relative amount, the phenylpropanes appeared to be the major group, accounting for 85.11% of the essential oil (Fig. 29). Oxygenated monoterpene and benzenoid were present in lesser amount, at 6.89 and 0.84%, respectively.

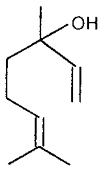
In terms of structure, the major components, *(E)*-methyl cinnamate and *(Z)*-cinnamaldehyde belong to the phenylpropanoid group, while linalool belongs to the oxygenated acyclic monoterpenoid group.



(E)-methyl cinnamate
(phenylpropane)



(Z)-cinnamaldehyde
(phenylpropane)



linalool
(acyclic monoterpenoid)

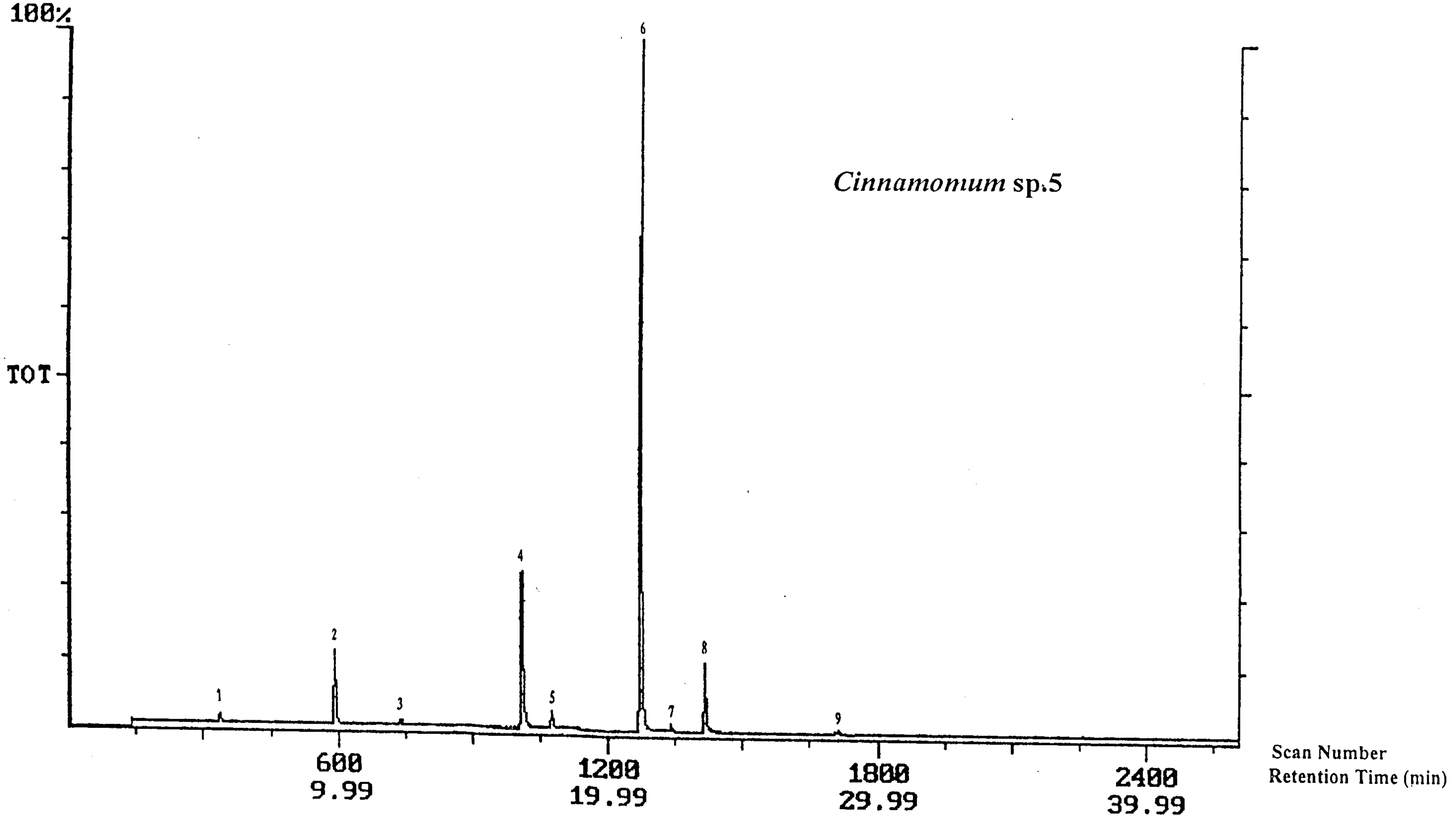


Figure 28 GC chromatogram of the essential oil from *Cinnamomum* sp.5 leaves

Table 16 Essential oil composition of *Cinnamomum* sp.5 leaves

Peak No	Compound	Retention time (min)	%Area
	Oxygenated monoterpene		
2	linalool	10.81	6.89
	Sesquiterpene		
7	*(E)*-caryophyllene	24.33	0.58
	Phenylpropanoid		
3	*(Z)*-cinnamyl alcohol	13.46	0.47
4	*(Z)*-cinnamaldehyde	16.81	18.42
5	*(Z)*-methyl cinnamate	17.94	1.56
6	*(E)*-methyl cinnamate	21.21	64.66
8	*(Z)*-cinnamyl acetate	24.89	6.42
	Benzenoid		
1	benzaldehyde	6.01	0.84
	Miscellaneous		
9	unknown	28.54	0.14

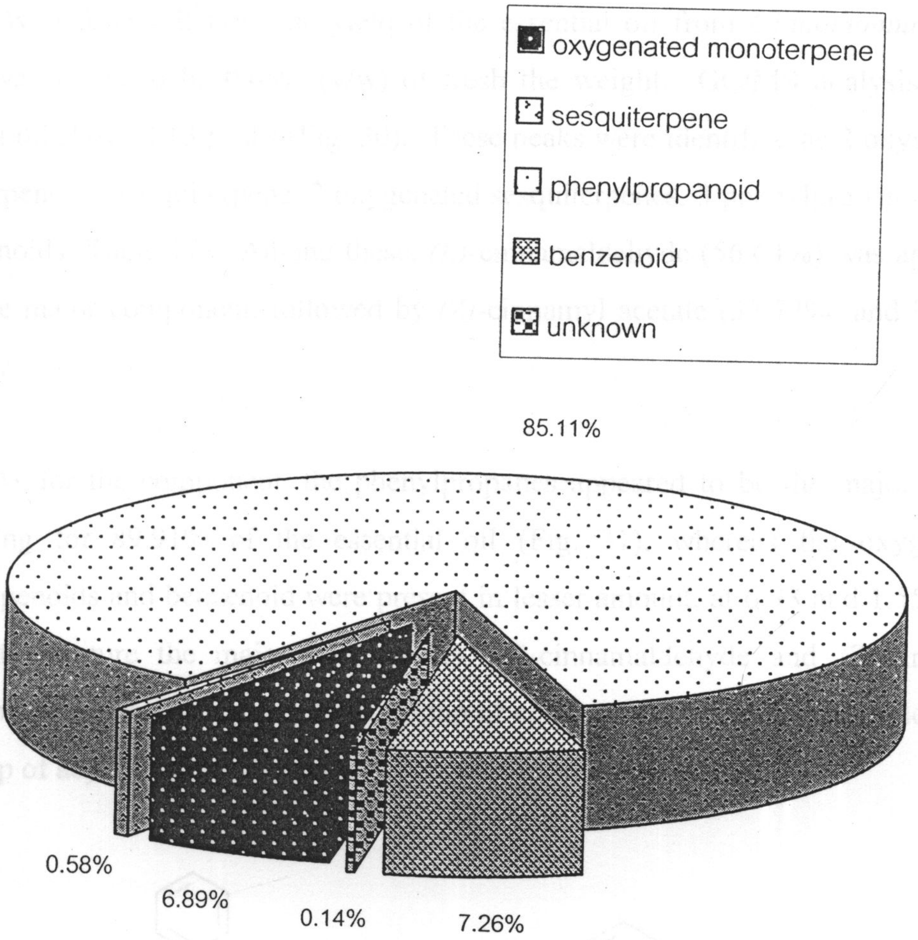
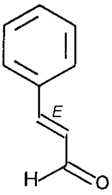


Figure 29 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.5 leaves

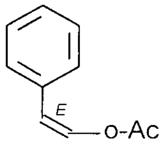
4.1.15. Essential Oil Composition of *Cinnamomum* sp. 6

By hydrodistillation, the yield of the essential oil from *Cinnamomum* sp. 6 leaves was found to be 0.66% (v/w) of fresh the weight. GC/MS analysis of the essential oil showed 13 peaks (Fig. 30). These peaks were identified as 2 oxygenated monoterpenes, 1 sesquiterpene, 2 oxygenated sesquiterpenes, 3 phenylpropanoids and 3 benzenoids (Table 17). Among these, *(E)*-cinnamaldehyde (56.64%) was appeared to be the major component, followed by *(Z)*-cinnamyl acetate (32.72%) and linalool (6.73%).

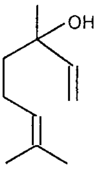
As for the component, the phenylpropanes appeared to be the major group, accounting for 89.91% of the essential oil (Fig. 31), whereas the oxygenated monoterpenoids and benzenoid were present in lesser amount, at 6.98 and 1.55%. In terms of structure the major components, *(E)*-cinnamaldehyde and *(Z)*-cinnamyl acetate belong to the phenylpropanoid group of compounds, while linalool belongs to the group of acyclic monoterpenoids.



(E)-cinnamaldehyde
(phenylpropane)



(Z)-cinnamyl acetate
(phenylpropane)



linalool
(acyclic monoterpenoid)

Table 17 Essential oil composition of *Cinnamomum* sp.6 leaves

Peak No	Compound	Retention time (min)	%Area
	Oxygenated monoterpene		
2	*1,8*-cineole	7.98	0.25
3	linalool	10.81	6.73
	Sesquiterpene		
9	α-cubebene	20.17	0.07
	Oxygenated sesquiterpene		
12	*(E)*-nerolidol	30.66	0.33
13	caryophyllene oxide	31.32	0.67
	Phenylpropanoid		
6	*(Z)*-cinnamaldehyde	16.81	0.45
8	(E)-cinnamaldehyde	18.61	56.64
10	*(E)*-methyl cinnamate	21.21	0.10
11	*(Z)*-cinnamyl acetate	24.89	32.72
	Benzenoid		
1	benzaldehyde	6.01	1.39
5	acetophenone	13.25	0.16
	Miscellaneous		
4	unknown	12.31	0.21
7	unknown	15.89	0.25

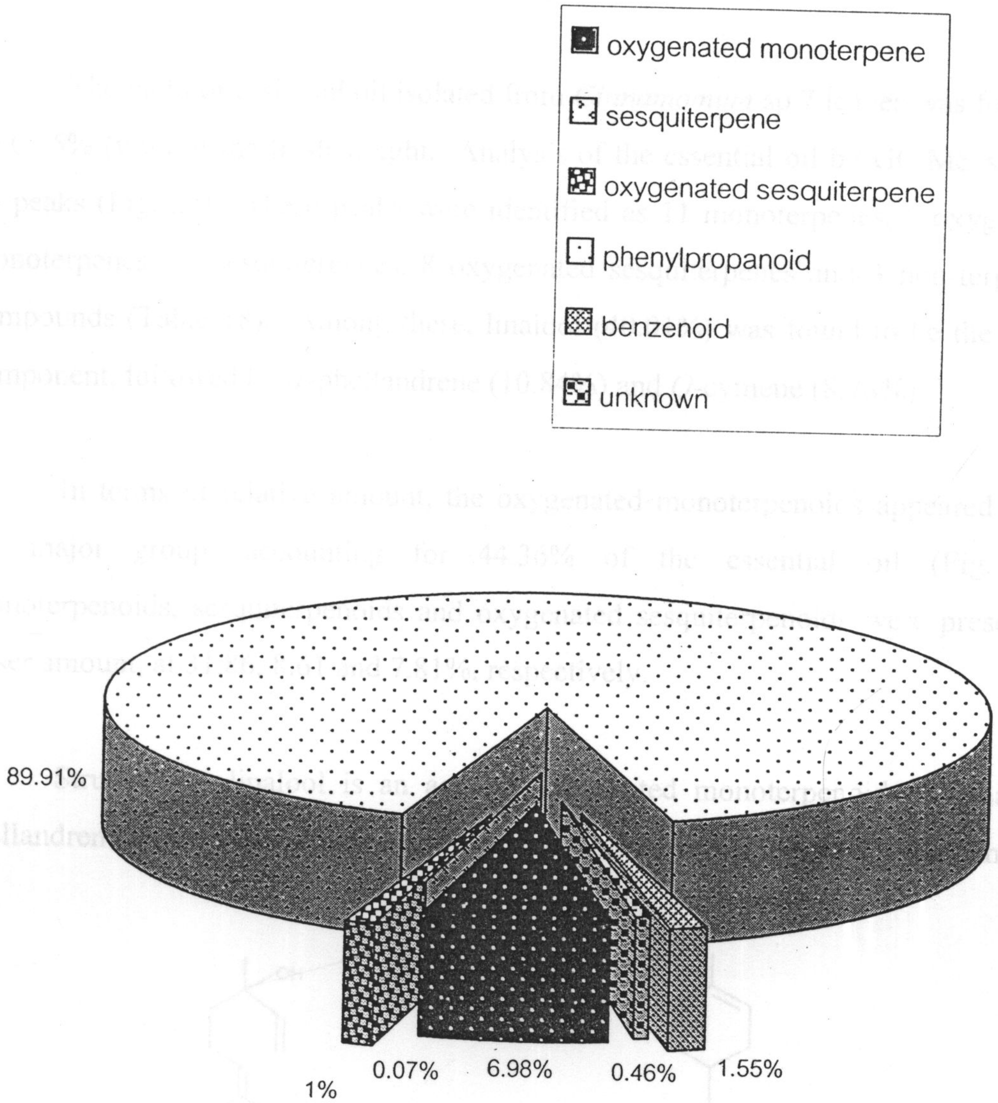


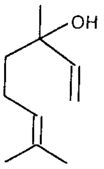
Figure 31 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.6 leaves

4.1.16. Essential Oil Composition of *Cinnamomum* sp.7

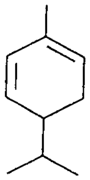
The yield of essential oil isolated from *Cinnamomum* sp.7 leaves was found to be 0.15% (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 46 peaks (Fig. 32). These peaks were identified as 11 monoterpenes, 5 oxygenated monoterpenes, 13 sesquiterpenes, 8 oxygenated sesquiterpenes and 3 non-terpenoid compounds (Table 18). Among these, linalool (40.01%) was found to be the major component, followed by α-phellandrene (10.84%) and *O*-cymene (8.78%).

In terms of relative amount, the oxygenated monoterpenoids appeared to be the major group, accounting for 44.36% of the essential oil (Fig. 33). Monoterpenoids, sesquiterpenoids and oxygenated sesquiterpenoids were present in lesser amount, at 31.86, 8.61 and 7.81%, respectively.

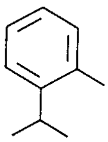
Structurally, linalool is an acyclic oxygenated monoterpenoid, whereas α-phellandrene and *o*-cymene both belongs to the monoterpenoid group of menthane.



linalool
(acyclic monoterpenoid)



α-phellandrene
(menthane)



o-cymene
(menthane)

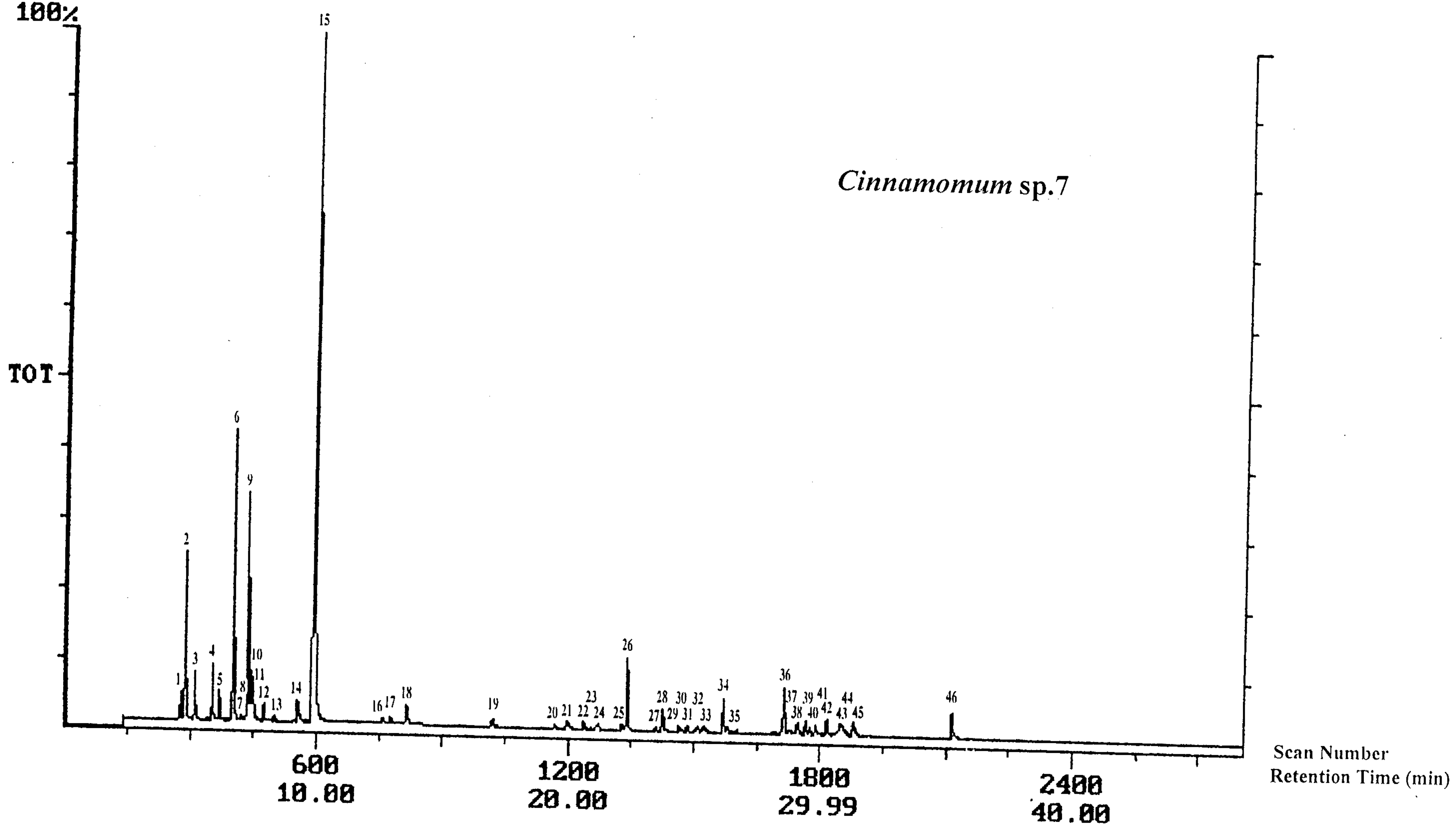


Figure 32 GC chromatogram of the essential oil from *Cinnamomum* sp.7 leaves

Table 18 Essential oil composition of *Cinnamomum* sp.7 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.08
2	tricyclene	4.98	5.27
3	sylvestrene	5.98	1.61
4	sabinene	6.08	1.94
5	myrcene	6.11	1.08
6	α-phellandrene	7.11	10.84
7	δ-*2*-carene	7.44	0.13
9	*o*-cymene	7.59	8.78
12	*(E)*-β-ocimene	8.48	0.61
13	γ-terpinene	8.91	0.22
14	terpinolene	9.93	0.58
	Oxygenated monoterpene		
11	*1,8*-cineole	7.98	1.99
15	linalool	10.81	40.01
16	borneol	13.99	0.47
18	α-terpineol	14.98	1.45
19	bornyl acetate	18.44	0.44
	Sesquiterpene		
20	α-cubebene	20.17	0.14
22	α-copaene	22.38	0.37
23	germacrene D	22.93	0.16
24	α-bulnesene	24.10	0.30
26	*9-epi-(E)*-caryophyllene	25.07	3.63
27	seychellene	25.37	0.14
28	*(Z)*-α-bisabolene	25.44	1.13
29	*allo*-aromadendrene	25.56	0.13
30	*trans*-calamenene	25.58	0.26
31	γ-cardinene	26.75	0.28
32	γ-muurolene	26.99	0.28
34	*trans*-β-guaiene	28.59	1.67
35	cadina-*1,4*-diene	29.19	0.12
	Oxygenated sesquiterpene		
33	*epi*-cubebol	27.84	0.51
36	caryophyllene oxide	31.32	2.62
38	globulol	31.47	0.74
40	humulene epoxide II	32.44	0.46
42	*1-epi*-cubenol	33.19	0.90
43	cubenol	33.68	0.84

Table 18 (continued)

Peak No	Compound	Retention time (min)	%Area
44	*epi*-α-muurolol	33.98	0.71
45	α-cadinol	34.49	1.03
	Phenylpropanoid		
21	*(E)*-isoeugenol	21.02	0.61
	Benzenoid		
46	benzyl benzoate	38.85	1.88
	Aliphatic alcohol		
25	tetradecanal	24.16	0.29
	Miscellaneous		
8	unknown	7.48	0.13
10	unknown	7.85	2.21
17	unknown	14.05	0.43
37	unknown	31.40	0.33
39	unknown	31.95	0.77
41	unknown	33.01	0.58

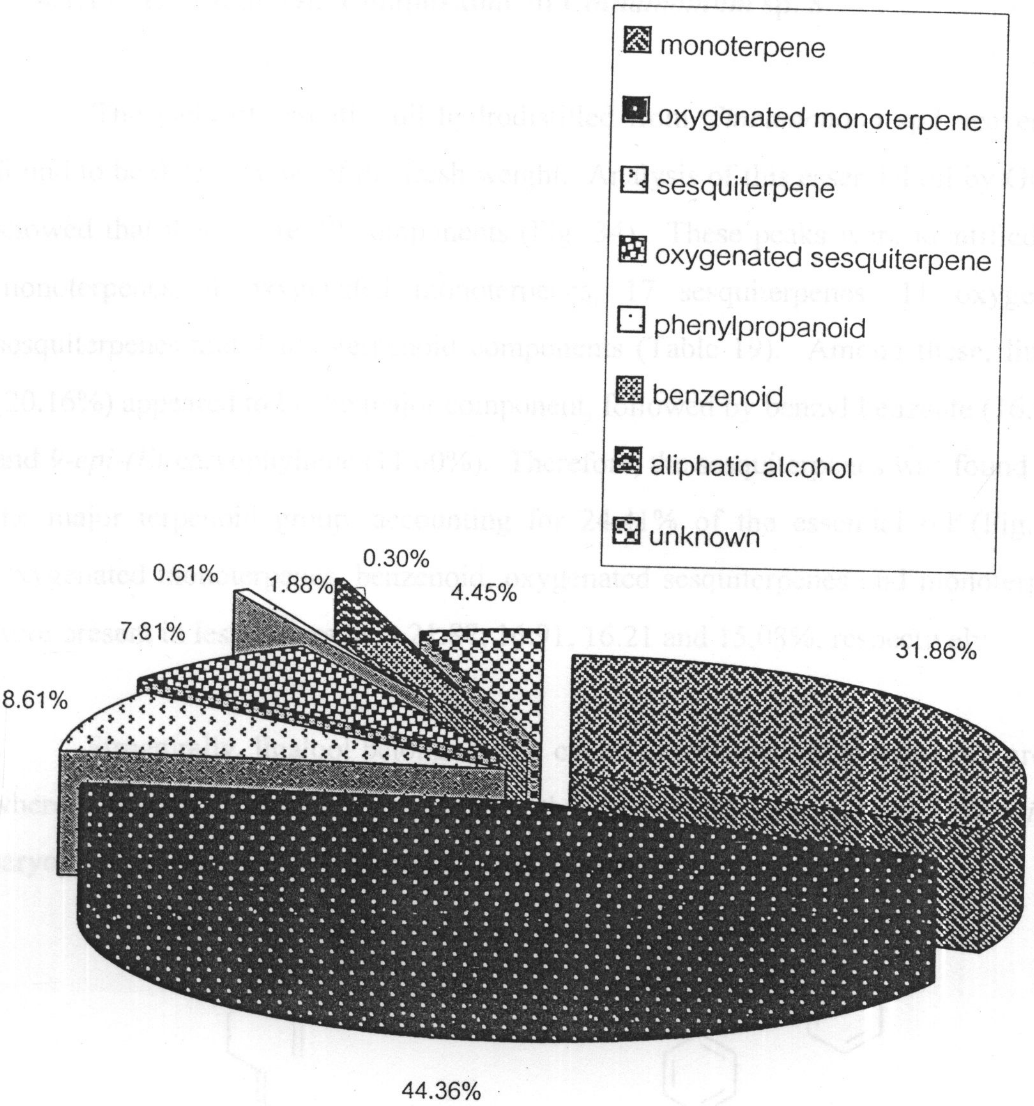
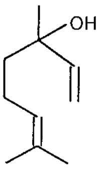


Figure 33 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.7 leaves

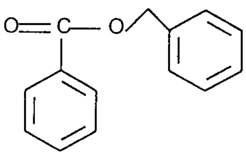
4.1.17. Essential Oil Composition of *Cinnamomum* sp. 8

The yield of essential oil hydrodistilled from *Cinnamomum* sp.8 leaves was found to be 0.08% (v/w) of the fresh weight. Analysis of this essential oil by GC/MS showed that there were 49 components (Fig. 34). These peaks were identified as 8 monoterpenes, 4 oxygenated monoterpenes, 17 sesquiterpenes, 11 oxygenated sesquiterpenes and 4 non-terpenoid components (Table 19). Among these, linalool (20.16%) appeared to be the major component, followed by benzyl benzoate (16.91%) and *9-epi-(E)*-caryophyllene (11.60%). Therefore, the sesquiterpenes was found to be the major terpenoid group, accounting for 24.41% of the essential oil (Fig. 35). Oxygenated monoterpenes, benzenoid, oxygenated sesquiterpenes and monoterpenes were present in lesser amount at 21.87, 16.91, 16.21 and 15.08%, respectively.

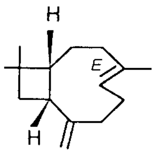
Structurally, linalool belongs to the cyclic oxygenated monoterpenoid group , whereas benzyl benzoate belongs to the benzenoid group, and *9-epi-(E)*-caryophyllene belongs to the sesquiterpenoid group of caryophyllane.



linalool
(acyclic monoterpenoid)



benzyl benzoate
(benzenoid)



9-epi-(E)-caryophyllene
(caryophyllane)

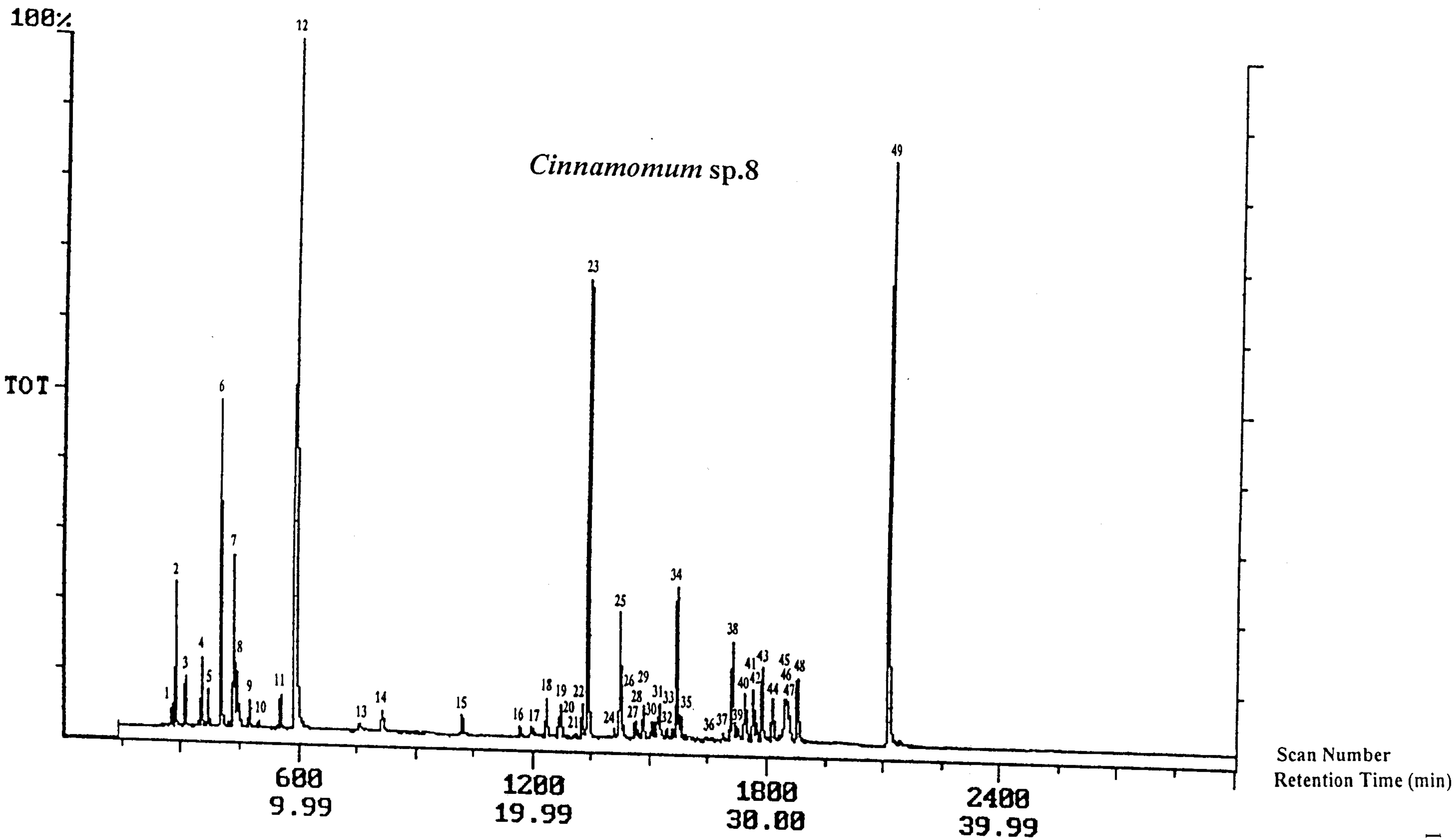


Figure 34 GC chromatogram of the essential oil from *Cinnamomum* sp.8 leaves

Table 19 Essential oil composition of *Cinnamomum* sp.8 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.27
2	tricyclene	4.98	1.97
3	camphene	5.48	0.79
4	sabinene	6.08	1.01
6	α-phellandrene	7.11	6.40
7	*o*-cymene	7.59	3.46
9	*(E)*-β-ocimene	8.48	0.51
11	terpinolene	9.93	0.67
	Oxygenated monoterpene		
12	linalool	10.81	20.16
13	borneol	13.99	0.43
14	α-terpineol	14.98	0.80
15	bornyl acetate	18.44	0.48
	Sesquiterpene		
16	α-cubebene	20.17	0.21
18	β-cubebene	21.13	0.95
19	α-copane	22.38	0.49
20	β-elemene	23.09	0.82
21	*cis*-β-guaiene	23.71	0.10
23	*9-epi-(E)*-caryophyllene	25.07	11.60
24	seychellene	25.37	0.15
25	*(Z)*-α-bisabolene	25.44	3.10
26	*allo*-aromadendrene	25.56	0.26
27	*trans*-calamenene	25.58	0.42
28	γ-cadinene	26.75	0.21
29	γ-muurolene	26.99	0.83
30	isoledene	27.43	0.54
32	germacrene A	28.11	0.32
33	*cis*-muurola-*4(14),5*-diene	28.39	0.27
34	α-cadinene	28.76	3.86
35	cadina-*1,4*-diene	29.19	0.28
	Oxygenated sesquiterpene		
31	*epi*-cubebol	27.84	1.53
38	caryophyllene oxide	31.32	3.16
39	globulol	31.47	0.69
40	β-eudesmol acetate	31.63	1.59
41	ledol	32.30	1.43
42	humulene epoxide II	32.44	0.54

Table 19 (continued)

Peak No	Compound	Retention time (min)	%Area
45	cubenol	33.68	1.78
46	α-muurolol	33.93	1.12
47	*epi*-α-muurolol	33.98	0.90
48	α-cadinol	34.49	2.29
	Phenylpropanoid		
17	*(E)*-isoeugenol	21.02	0.42
	Benzenoid		
49	benzyl benzoate	38.86	16.91
	Aliphatic alcohol		
22	tetracecanal	24.16	0.76
43	decanal	32.64	1.80
	Miscellaneous		
5	unknown	6.14	0.61
8	unknown	8.20	1.35
10	unknown	9.11	0.14
36	unknown	29.65	0.08
37	unknown	30.13	0.20

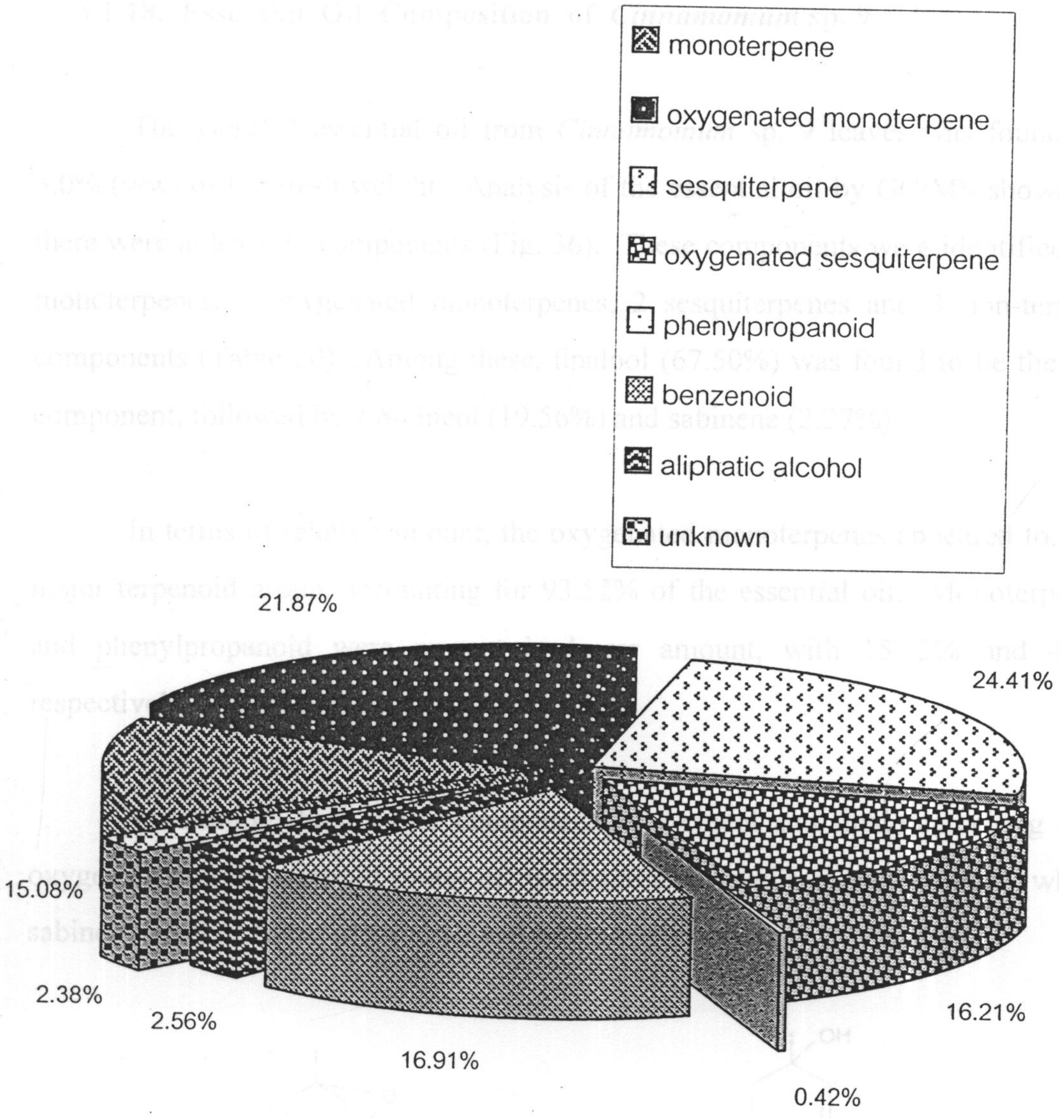


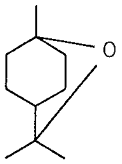
Figure 35 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.8 leaves

4.1.18. Essential Oil Composition of *Cinnamomum* sp. 9

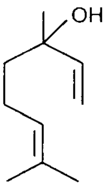
The yield of essential oil from *Cinnamomum* sp. 9 leaves was found to be 3.0% (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed that there were at least 27 components (Fig. 36). These components were identified as 10 monoterpenes, 7 oxygenated monoterpenes, 2 sesquiterpenes and 3 non-terpenoid components (Table 20). Among these, linalool (67.50%) was found to be the major component, followed by *1,8*-cineol (19.56%) and sabinene (2.27%).

In terms of relative amount, the oxygenated monoterpenes appeared to be the major terpenoid group, accounting for 93.52% of the essential oil. Monoterpenoids and phenylpropanoid were present in lesser amount, with 15.53% and 4.55%, respectively (Fig. 37).

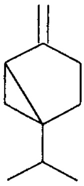
Structurally, both major components, *1,8*-cineol and linalool, belong to the oxygenated monoterpenoid group of menthane and acyclic monoterpenoid, whereas sabinene belongs to the monoterpenoid group of thujane.



1,8-cineol
(menthane)



linalool
(acyclic monoterpenoid)



sabinene
(thujane)

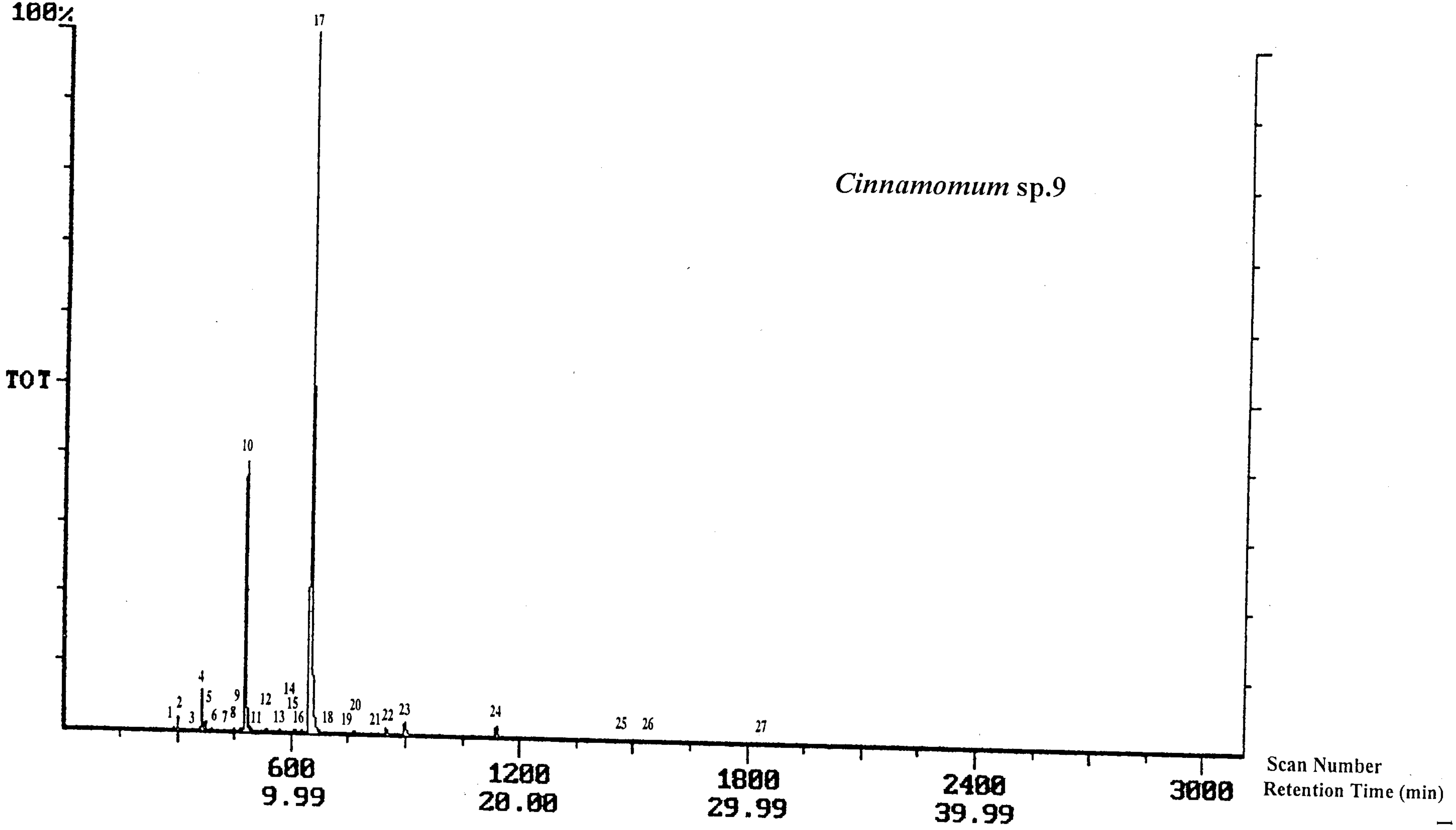


Figure 36 GC chromatogram of the essential oil from *Cinnamomum* sp.9 leaves

Table 20 Essential oil composition of *Cinnamomum* sp.9 leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.15
2	α-pinene	5.03	0.64
3	camphene	5.48	0.04
4	sabinene	6.08	2.27
5	β-phellandrene	6.23	0.61
6	β-pinene	6.54	0.20
8	δ-*2*-carene	7.44	0.11
9	verbenene	7.78	0.24
12	γ-terpinene	8.91	0.19
14	terpinolene	9.93	0.05
	Oxygenated monoterpene		
10	*1,8*-cineole	7.79	19.56
13	*cis*-linalool oxide	9.51	0.21
15	*trans*-linalool oxide	10.13	0.25
17	linalool	10.81	71.09
21	satolina alcohol	13.88	0.10
22	terpin-*4-ol*	14.16	0.68
23	α-terpineol	14.98	1.63
	Sesquiterpene		
25	*(E)*-caryophyllene	24.33	0.06
26	α-humulene	25.89	0.04
	Phenylpropanoid		
24	*(Z)*-isosafrole	18.99	1.32
	Long chain hydrocarbon		
7	*n*-decane	6.83	0.06
16	*n*-heneicosane	25.89	0.13
	Miscellaneous		
11	unknown	8.48	0.05
18	unknown	11.79	0.04
19	unknown	12.59	0.03
20	unknown	12.78	0.21
27	unknown	31.26	0.03

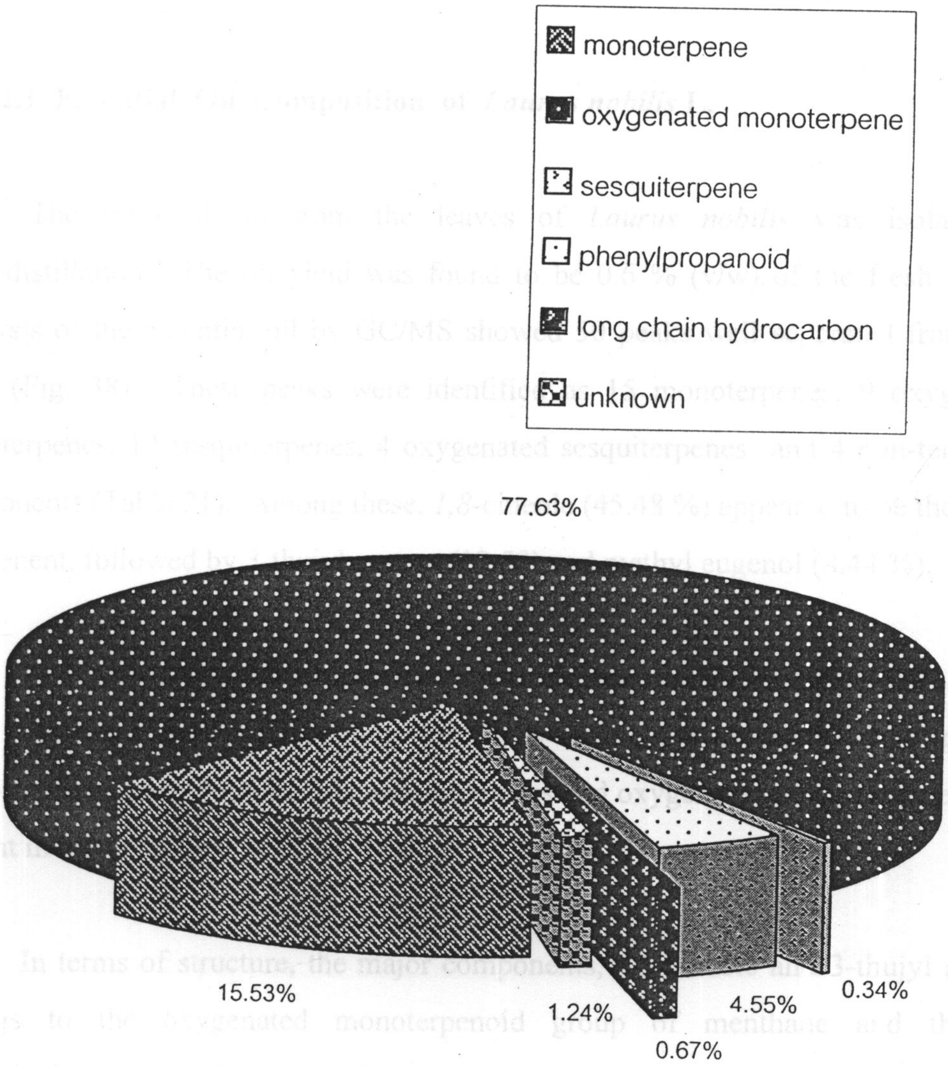


Figure 37 The percentage of various terpenoid groups found in the essential oil of *Cinnamomum* sp.9 leaves

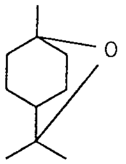
4.2 Chemical Composition of Essential Oil from Western Country in Thailand

4.2.1 Essential Oil Composition of *Laurus nobilis* L.

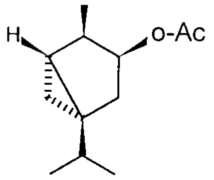
The essential oil from the leaves of *Laurus nobilis* was isolated by hydrodistillation. The oil yield was found to be 0.6 % (v/w) of the fresh weight. Analysis of the essential oil by GC/MS showed 50 peaks well separated from each other (Fig. 38). These peaks were identified as 15 monoterpenes, 9 oxygenated monoterpenes, 12 sesquiterpenes, 4 oxygenated sesquiterpenes and 4 non-terpenoid components (Table 21). Among these, *1,8*-cineole (45.48 %) appeared to be the major compenent, followed by *3*-thujyl acetate (12.58) and methyl eugenol (8.44 %).

In terms of relative amount, the oxygenated monoterpenes appeared to be the major terpenoid group, accounting for 63.23 % of the essential oil (Fig. 39). Monoterpenes, phenylpropanoids, sesquiterpenes and oxygenated sesquiterpenes were present in lesser amount at 12.39, 11.01, 2.52 and 2.36% , respectively.

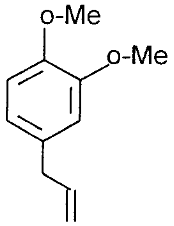
In terms of structure, the major components, *1,8*-cineole and 3-thujyl acetate belongs to the oxygenated monoterpenoid group of menthane and thujane, respectively, while methyl eugenol belongs to the phenylpropanoid group.



1,8-cineole
(*menthane)*



3-thujyl acetate
(thujane)



methyl eugenol
(phenylpropane)

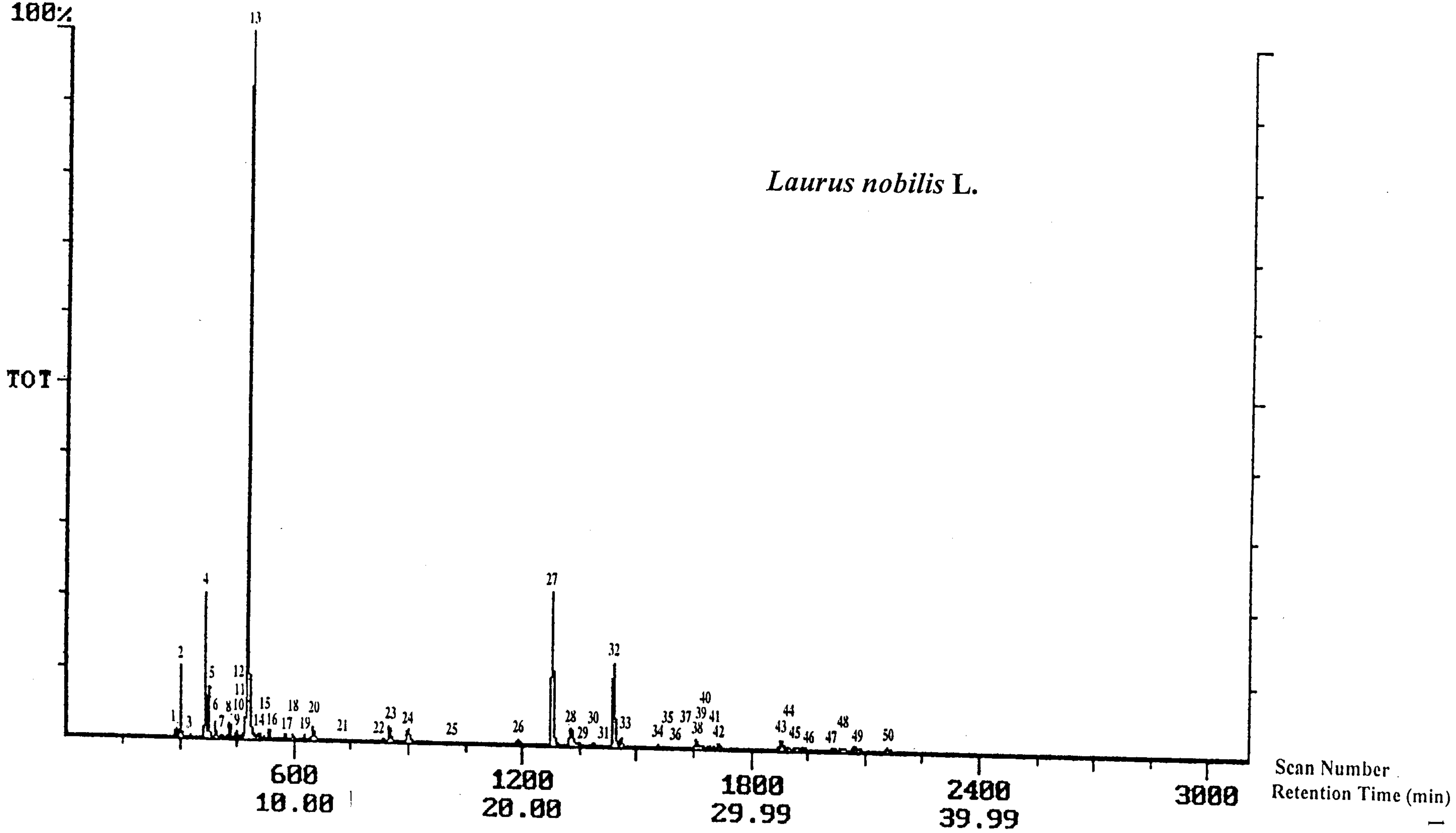


Figure 38 GC chromatogram of the essential oil from *Laurus nobilis* L. leaves

Table 21 Essential oil composition of *Laurus nobilis* L. leaves

Peak No	Compound	Retention time (min)	%Area
	Monoterpene		
1	α-thujene	4.83	0.41
2	α-pinene	5.03	3.35
3	camphene	5.48	0.36
4	sabinene	6.08	7.39
5	β-phellandrene	6.23	2.88
6	β-pinene	6.54	0.84
8	δ-3-carene	7.16	0.96
9	δ-2-carene	7.44	0.30
10	*o*-cymene	7.59	0.14
11	verbenene	7.78	0.29
12	limonene	7.88	0.97
14	*(E)*-β-ocimene	8.48	0.33
16	γ-terpinene	8.91	0.55
17	*trans*-sabinene hydrate	9.61	0.38
18	terpinolene	9.93	0.24
	Oxygenated monoterpene		
13	*1,8*-cineol	7.98	45.48
20	linalool	10.81	1.46
21	*trans*-*para*-menth-*2*-en-*1*-ol	11.81	0.06
22	santolina alcohol	13.88	0.23
23	terpin-*4-ol*	14.16	1.47
24	α-terpineol	14.98	1.54
25	isobornyl acetate	18.46	0.04
26	α-terpinyl acetate	19.79	0.37
27	*3*-thujyl acetate	21.29	12.58
	Sesquiterpene		
30	β-elemene	23.09	0.09
31	*cis*-β-guaiene	25.73	0.04
33	*(E)*-caryophyllene	24.33	0.69
34	α-humulene	25.89	0.06
35	valencene	26.03	0.04
36	γ-muurolene	26.99	0.07
37	β-selinene	27.34	0.06
38	bicyclogermacrene	27.59	0.78
39	β-gurjunene	27.88	0.17
40	germacrene A	28.11	0.15
41	*cis*-muurola-*4(14),5*-diene	28.39	0.07
42	trans-β-guaiene	28.59	0.30

Table 21 (continued)

Peak No	Compound	Retention time (min)	%Area
	Oxygenated sesquiterpene		
43	spathulenol	31.29	1.22
45	hinesol acetate	31.96	0.29
47	*epi*-α-muurolol	33.98	0.20
48	α-cadinol	34.49	0.65
	Phenylpropanoid		
28	*(Z)*-isoeugenol	22.10	2.57
32	methyl eugenol	23.98	8.44
	Long chain hydrocarbon		
7	*n*-decane	6.83	0.08
19	*n*-heneicosane	10.44	0.17
	Miscellaneous		
15	unknown	8.71	0.06
29	unknown	22.74	0.06
44	unknown	31.62	0.24
46	unknown	32.28	0.16
49	unknown	34.78	0.16
50	unknown	35.99	0.43

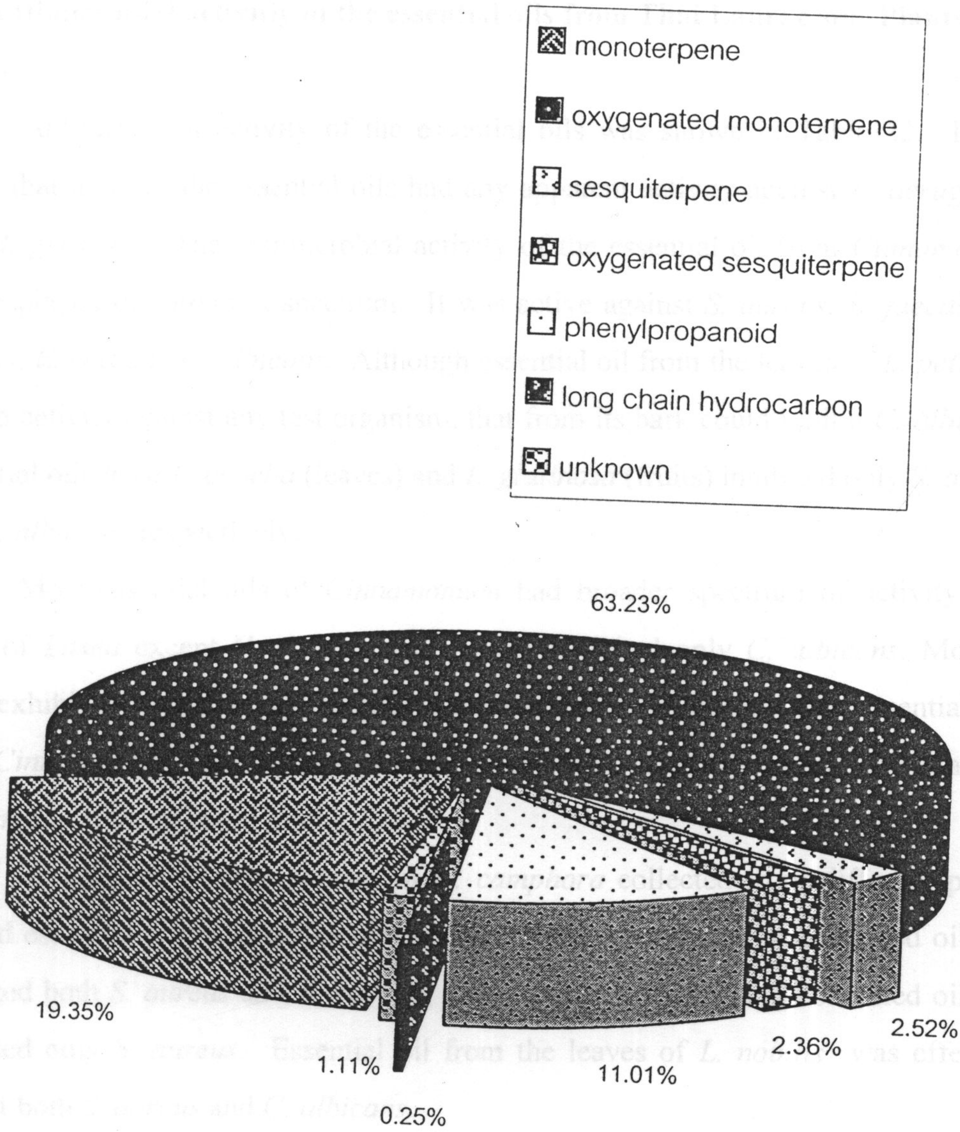


Figure 39 The percentage of various terpenoid groups found in the essential oil of *Laurus nobilis* L. leaves

4.3 Antimicrobial activitiy of the essential oils from Thai Lauraceous Plants

Antimicrobial activity of the essential oils was shown in Table 22. It was found that none of the essential oils had any apparent activity against *P. aeruginosa* and *M. gypseum.* The antimicrobial activity of the essential oil from *Cinnamomum* sp7 displayed the broadest spectrum. It was active against *S. aureus*, *E. faecalis*, *B. subtilis*, *E. coli* and *C. albicans*. Although essential oil from the leaves of *L. petiolata* had no activity against any test organism, that from its bark could inhibit *C. albicans.* Essential oils *from L. cubeba* (leaves) and *L. glutinosa* (fruits) inhibited only *S. aureus* and *C. albicans*, respectively.

Most essential oils of *Cinnamomum* had broader spectrum of activity than those of *Litsea* except *C. pathenoxylon* which inhibited only *C. albicans*. Most of them exhibited activities against both *S. aureus* and *C. albicans*. The essential oils from *Cinnamomum.* sp5 and sp6 had the lowest MIC (0.019%). Most essential oils of *Cinnamomum.* sp could inhibit *E. coli.*

In terms of location, leaves of *C. camphora* collected from different places yielded essential oils with different activities. That from Bangkok contained oil that inhibited both *S. aureus* and *B. subtilis*, whereas that from Rayong contained oil that inhibited only *S. aureus*. Essential oil from the leaves of *L. nobilis* was effective against both *S. aureus* and *C. albicans*.

Table 22 Antimicrobial activitity of essential oils from Thai Lauraceous plants

Plant	*Staphylococcus aureus* ATCC 29213		*Excherichia coli* ATCC 25922		*Bacillus subtilis* ATCC 6633		*Enterococcus faecalis* ATCC 29212		*Pseudomonas aeruginosa* ATCC 27853		*Candida albicans* ATCC 10231		*Microsporum gypseum* (clinical isolate)	
	mm± SD[a]	MIC (%)	mm± SD[a]	MIC (%)	mm± SD[a]	MIC (%)	mm± SD[a]	MIC (%)	mm± SD[a]	MIC (%)	mm± SD[a]	MIC (%)	mm± SD[a]	MIC (%)
1. *Cinnamomum camphora* Th. Fries. (leaves;Bangkok)	8.20 ± 1.40	0.63	0	ND[b]	9.3 ± 0.99	1.25	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]
2. *Cinnamomum camphora* Th. Fries. (leaves ; Rayong)	9.03 ± 0.99	2.5	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]
3. *Cinnamomum inner* Bl.(leaves)	11.0 ± 2.42	0.312	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	9.7 ± 3.14	0.078	0	ND[b]
4. *Cinnamomum porrectum* Kosterm. (leaves)	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	11.9 ± 1.91	0.078	0	ND[b]
5. *Litsea cubeba* Pers (leaves)	10.3 ± 2.42	0.312	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]
6. *Litsea glutinosa* C.B. Robinson. (fruits)	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	13.65± 0.45	1.25	0	ND[b]
7. *Litsea petiolata* Hook. f. (leaves)	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]
8. *Litsea petiolata* Hook. f. (bark)	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	19.60± 3.96	0.078	0	ND[b]
9. *Cinnamomum* sp.1 (leaves)	7.73 ± 2.07	0.63	6.10 ± 3.78	1.25	7.7 ± 3.11	0.63	0	ND[b]	0	ND[b]	23.2 ± 3.12	0.312	0	ND[b]
10.*Cinnamomum* sp.2 (leaves)	10.0 ± 3.79	0.63	7.43 ± 3.21	0.63	0	ND[b]	0	ND[b]	0	ND[b]	20.8 ± 4.15	0.312	0	ND[b]
11.*Cinnamomum* sp.3 (leaves)	8.3 ± 1.23	0.63	19.6 ± 3.36	1.25	20.26± 0.63	1.25	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]
12.*Cinnamomum* sp.4 (leaves)	16.3 ± 4.44	0.156	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	11.8 ± 2.76	0.312	0	ND[b]
13.*Cinnamomum* sp.5 (leaves)	9.73 ± 0.81	0.156	6.8 ± 0.78	0.63	0	ND[b]	0	ND[b]	0	ND[b]	17.20± 2.89	0.019	0	ND[b]
14.*Cinnamomum* sp.6 (leaves)	0	ND[b]	7.9 ± 3.37	0.156	0	ND[b]	0	ND[b]	0	ND[b]	23.0 ± 4.12	0.019	0	ND[b]
15.*Cinnamomum* sp.7 (leaves)	14.7 ± 3.26	0.63	6.86 ± 0.31	1.25	12.2 ± 2.96	1.25	16.3 ± 2.86	1.25	0	ND[b]	9.83 ± 2.10	0.078	0	ND[b]
16.*Cinnamomum* sp.8 (leaves)	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	9.85 ± 2.17	0.156	0	ND[b]
17.*Cinnamomum* sp.9 (leaves)	6.3 ± 0.98	0.63	7.23 ± 1.30	0.63	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]
18.*Laurus nobilis* L. (leaves)	11.8 ± 1.07	1.25	0	ND[b]	0	ND[b]	0	ND[b]	0	ND[b]	16.4 ± 1.96	ND[b]	0	ND[b]

[a] inhibiton zone diameter resulted from 10% oil in 0.1% tween 80

[b] not determined

CHAPTER V

DISCUSSION

Testing and evaluation of the chemical composition and antimicrobial activity of essential oil is difficult because of their volatility, their water solubility, and their complexity (Jansen, Scheffer and Baerheim-Svendsen, 1987).

The leaves of *Cinnamomum camphora* was gathered at two locations, Bangkok (Middle parts of Thailand) and Rayong (Eastern part of Thailand). Both of them had the same major constituents in comparable quantities, as shown in Table 23, they were camphor, limonene and α-pinene. This was in agreement with the result previously reported (Pe'lissier *et al*, 1995).

Oil yields obtained from the leaves and the stem bark of *Cinnamomum porrectum* were different, 0.5% and 0.1%, respectively. It was evident that both of them contained sesquiterpene and phenylpropanoid. Interestingly, monoterpene was found only in leaf, whereas oxygenated sesquiterpene and aliphatic alcohol (dodecanal) were found only in bark oil. The amounts of safrole, the major components in both oil, were very high (leaves, 97.3% ; stem bark 96.85%). This major component was in agreement with that previously reported (Dung *et al.*, 1995). Safrole was an important raw material in the synthesis of heliotropin. In addition to sassafras oils (Lauraceae) (Grieve and Leyel,1975), *C. porrectum* oil might be another source of safrole in commercial. Many species from which safrole could be obtained were members of the Lauraceae family (Lawrence, 1992).

Previous studies reported two types of *L. cubeba* leaf oil linalool type and cineol type (Nath *et al*, 1996). However, there was no report on the occurrence of sabinene as the major component.

The oil obtained from leaves and stem bark *of Litsea petiolata* were 2.1% and 0.17%, respectively. Each oil was found to be pale yellow to almost colorless, the occurrence of cinnamaldehyde and *(Z)*-isosafrole in the leaf oil up to 57.7 % and 35.36%, respectively, whereas these compounds were absent in the stem bark oil.

When comparing the chemical constituents in essential oils from three species of *Litsea*, it was found that the major component was present specifically in individual species. They were sabinene in *L. cubeba*, *(E)*-β-ocimene in *L. glutinosa*, *(E)*-cinnamaldehyde and *2*-methyl-undecanal in *L. petiolata*. These major components might potentially be used as the marker for identification of these individuals.

Nine unidentified speices were investigated from three provinces of Thailand (Rayong, Khon-Kaen, Bangkok). The leaf oil yield of some *Cinnamomum* sp. were around 0.08-3.0% (v/w).

Laurus nobilis (True bay), an evergreen shrub from western country, was cultivated from the northern parts of Thailand. It was found that *1,8*-cineole (45.48%), *3*-thujyl acetate (12.58%), methyl eugenol (8.44%) and sabinene (7.39%) were the major component. The presence of cineole (30-50%) and eugenol as the major component were in agreement with the results from an earlier study (Guenther, 1972). True bay oil could be a useful natural resource of methyl eugenol. It showed a significant anti-inflammatory effect and moderate analgesic action (Moretti, Peana and Satta, 1997).

In screening for antimicrobial activity, the agar diffusion techinque was used in order to determine antimicrobial activity of essential oil, the diameter of clear zone more than 6 mm indicated the inhibition activity. As shown in Table 22, all sample had no activities against *P. aeruginosa* and *M. gypseum*. The antimicrobial effectiveness of a compound is often described in term of its minimum inhibitory concentration (MIC). Results in Table 22 showed that there was no direct correlation between the inhibition zone diameter and the MIC. This might be resulted from the difference in physical properties of oil such as solubility and partition coefficient which affected the inhibition zone diameter.

The differences in antimicrobial activities, as shown in Table 22, of the essential oils hydrodistilled from plants grown in different locations (*C. camphora* grown in Bangkok and Rayong) and from different parts of plant (leaves and bark of *L. petiolata*) implied that location and part of plant were the important factors. This suggested that not only the major constituents but also the minor constituents might account for the antimicrobial activities of essential oils. Essential oils of *Cinnamomum* sp1-9 had broader spectrum of activity than those of identified species. These might be resulted from the activities of cineol (Ross et al,1980 ; Muller-Riebau, Berger and Yegen, 1995 ; Carta, Moretti and Peana, 1996), linalool (Morris, Khettry and Seitz, 1979 ; Ross et al, 1980 ; Muller-Riebau, Berger and Yegen, 1995 ; Carson and Riley, 1995), camphor (Muller-Riebau, Berger and Yegen, 1995 ; Carta, Moretti and Peana, 1996), thymal, carvacol (Muller-Riebau, Berger and Yegen, 1995 ; Adams, Kunz and Weidenborner, 1996 ; Sophon *et al*, 2540) terpin-4-ol (Carson and Riley, 1995), cinnamaldehyde (Sophon *et al*, 2540), eugenol (Morris, Khettry and Seitz ,1970 ; Adams, Kunz and Weidenborner, 1996) and *n*-dodecanal (Janssen *et al*, 1985). These compounds had been previously reported as having antimicrobial activities.

C. porrectum leaf oil showed antifungal activity (*C. albicans*), it might be the effect of its major constituent (97%), isosaffrole. However, there was no report on antifungal activity of isosaffrole. It was used in combination with guaiacum or saraparilla for chronic rheumatism, syphilis and skin disease (Grieve, 1975). To conform its effect on *C. albicans,* isosaffrole should be tested.

Litsea cubeba leaf oil showed antibacterial effect against gram-positive bacteria (*S. aureus*) but it had no activity against gram-negative bacteria, yeast and mold. The effect on gram-positive bacteria agreed with previous report (Gogoi *et al.*, 1997) but its effect on fungal pathogen was different.

Essential oil from fruit of *L. glutinosa* and stem bark of *L. petiolata* showed effect on *C. albicans*. This is the first report on their antimicrobial activity. Leaf oil of *L. petiolata* had no antimicrobial activity despite the presence of cinnamaldehyde, its major component, which was previously reported on antimicrobial activity (Kurita and Koike, 1983). The reason underlying the negative result of this oil might be that some constituents in the oil might interfere each other such as antagonistic effect. However, the precise antimicrobial mechanisms of individual essential oil components have not yet been fully elucidated on the molecular basis.

CHAPTER VI

CONCLUSION

The present investigation deals with the determination of chemical components and antimicrobial activity of essential oils isolated from selected Thai Lauraceous plant. Thai Lauraceous plants representing 2 genera (*Cinnamomum* and *Litsea*), have been investigated. Comparison among 3 *Litsea* species was made. Additionally, one species of western Lauraceous plants cultivated in Thailand were also studied. Its major constituents corresponded with previous report but the amounts were lower. In addition, it was found that certain essential oils showed antimicrobial activity against Gram-positive bacteria, Gram-negative bacteria and yeast. Although the antimicrobial properties of the essential oils in this study were much lower than those of currently used antibiotics, the present study indicates the possibility of using some essential oils as natural antimicrobial agents.

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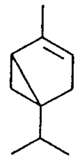
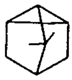
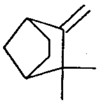
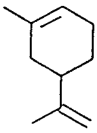
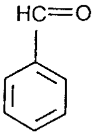
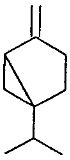
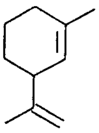
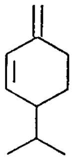
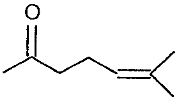
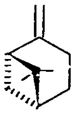
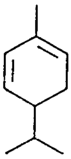
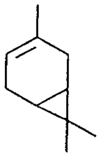
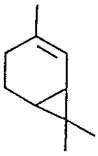
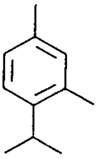
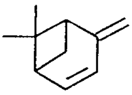
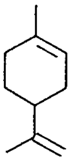
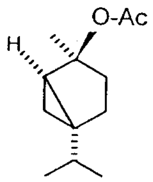
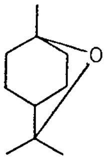
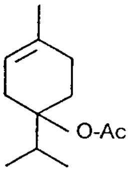
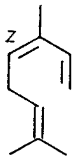
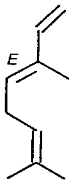
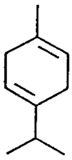
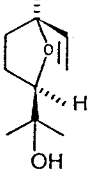
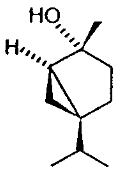
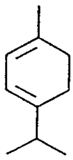
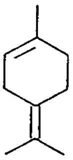
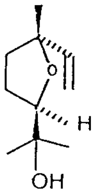
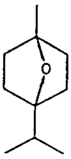
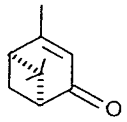
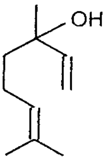
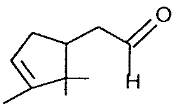
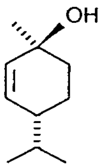
APPENDICES

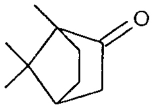
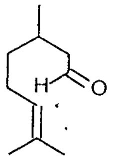
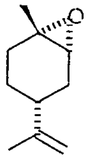
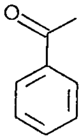
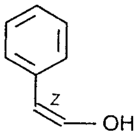
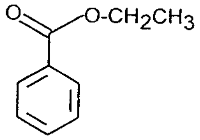
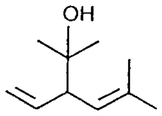
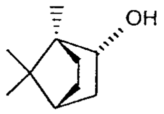
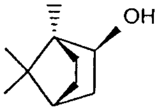
A. The chemical components of essential oil isolated from selected Lauraceous Plants

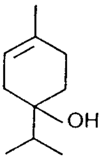
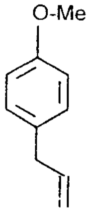
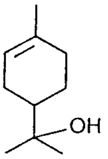
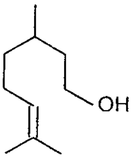
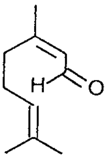
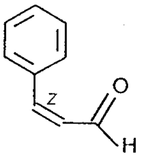
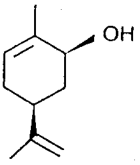
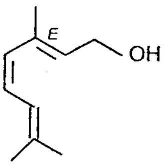
Retention time (min)	Compound	Structure
4.38	α-thujene	
4.98	tricyclene	
5.03	α-pinene	
5.48	camphene	
5.98	sylvestrene	
6.01	benzaldehyde	
6.08	sabinene	
6.09	isosylvestrene	
6.11	myrcene	

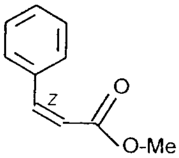
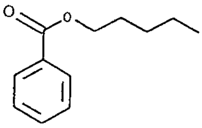
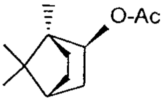
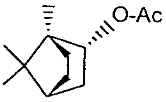
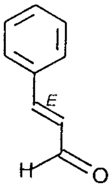
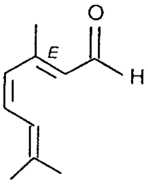
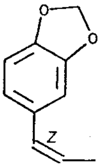
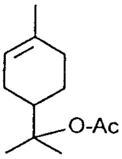
Retention time (min)	**Compound**	**Structure**
6.23	β-phellandrene	
6.37	*6*-methyl-*5*-hepten-*2*-one	
6.54	β-pinene	
6.83	*n*-decane	$CH_3(CH_2)_8CH_3$
7.11	α-phellandrene	
7.16	δ-*3*-carene	
7.44	δ-*2*-carene	
7.59	*o*-cymene	
7.78	verbenene	
7.88	limonene	

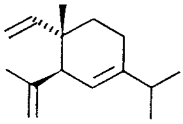
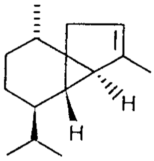
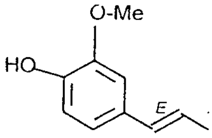
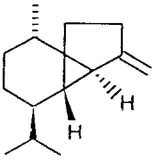
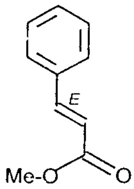
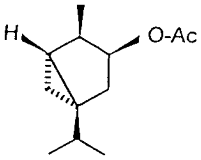
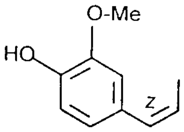
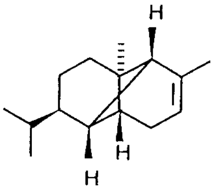
Retention time (min)	**Compound**	**Structure**
7.94	*trans*-sabinene hydrate acetate	
7.98	*1,8*-cineole	
8.09	terpin-*4*-ol-acetate	
8.13	*(Z)*-β-ocimene	
8.48	*(E)*-β-ocimene	
8.91	γ-terpinene	
9.51	*cis*-linalool oxide	
9.61	*trans*-sabinene hydrate	

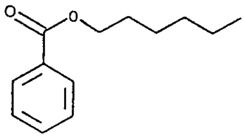
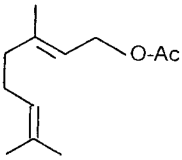
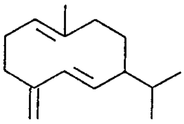
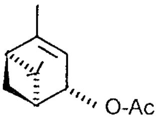
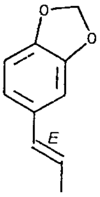
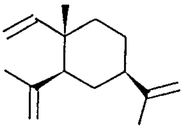
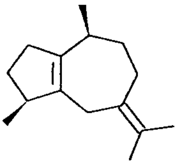
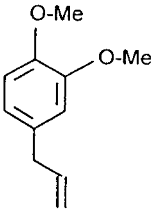
Retention time (min)	**Compound**	**Structure**
9.76	α-terpinene	
9.93	terpinolene	
10.13	*trans*-linalool oxide	
10.23	*2*-nonanone	$CH_3CO(CH_2)_6CH_3$
10.27	*1,4*-cineole	
10.35	verbenone	
10.44	*n*-heneicosane	$CH_3(CH_2)_{19}CH_3$
10.81	linalool	
11.73	α-campholenal	
11.81	*trans*-*para*-menth-*2*-en-*1*-ol	

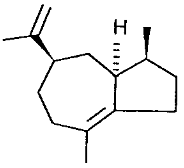
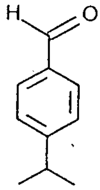
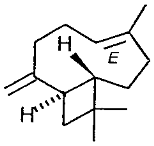
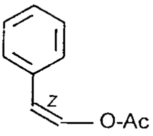
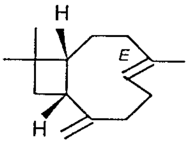
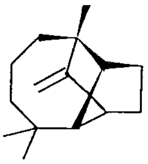
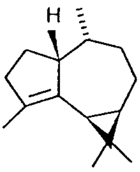
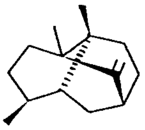
Retention time (min)	Compound	Structure
12.54	camphor	
12.76	citronellal	
13.19	*cis*-limonene oxide	
13.25	acetophenone	
13.46	*(Z)*-cinnamyl alcohol	
13.66	ethyl benzoate	
13.88	santolina alcohol	
13.93	isoborneol	
13.99	borneol	

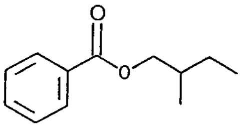
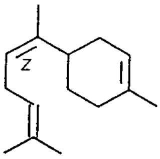
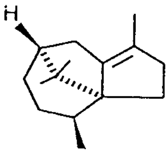
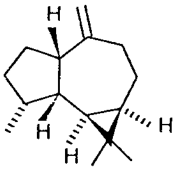
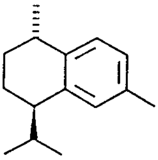
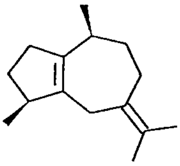
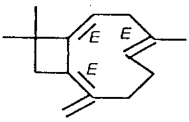
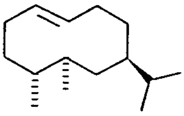
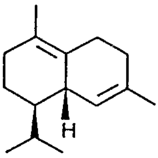
Retention time (min)	Compound	Structure
14.16	terpin-*4*-ol	
14.88	methyl chavicol	
14.98	α-terpineol	
16.34	citronellol	
16.63	neral	
16.81	*(Z)*-cinnamaldehyde	
17.23	*cis*-carveol	
17.38	geraniol	

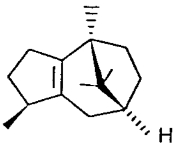
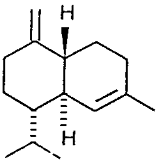
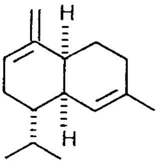
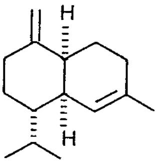
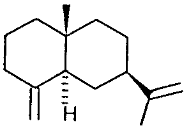
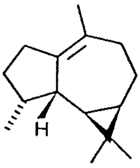
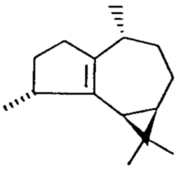
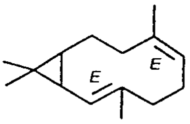
Retention time (min)	**Compound**	**Structure**
17.94	*(Z)*-methyl cinnamate	
18.04	*n*-pentyl benzoate	
18.44	bornyl acetate	
18.46	isobornyl acetate	
18.50	2-undecanone	$CH_3CO(CH_2)_8CH_3$
18.61	*(E)*-cinnamaldehyde	
18.77	geranial	
18.99	*(Z)*-isosafrole	
19.79	α-terpinyl acetate	

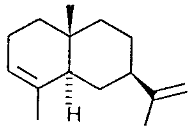
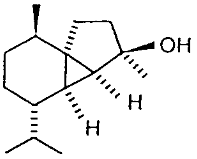
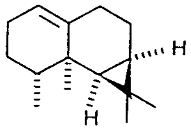
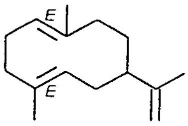
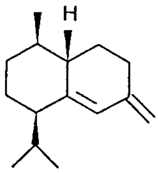
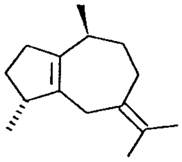
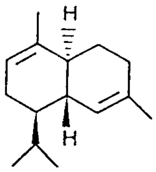
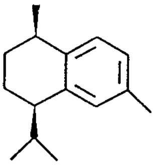
Retention time (min)	Compound	Structure
20.63	δ-elemene	
20.17	α-cubebene	
21.02	*(E)*-isoeugenol	
21.13	β-cubebene	
21.21	*(E)*-methyl cinnamate	
21.29	*3*-thujyl acetate	
22.10	*(Z)*-isoeugenol	
22.38	α-copaene	

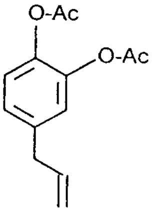
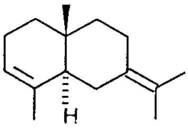
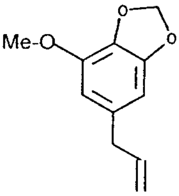
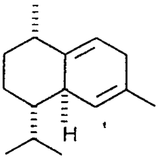
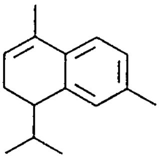
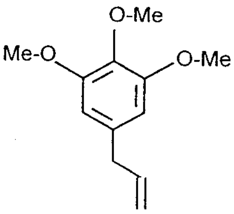
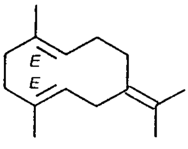
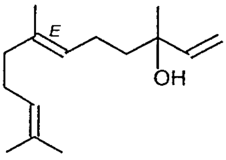
Retention time (min)	Compound	Structure
22.66	*n*-hexyl benzoate	
22.73	geranyl acetate	
22.93	germacrene D	
23.01	*cis*-verbenyl acetate	
23.04	*(E)*-isosafrole	
23.09	β-elemene	
23.71	*cis*-β-guiene	
23.98	methyl eugenol	

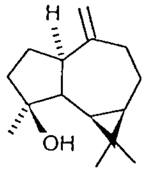
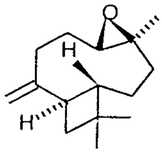
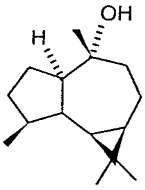
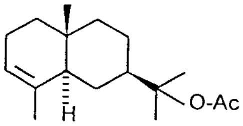
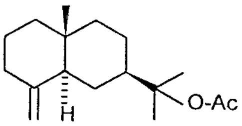
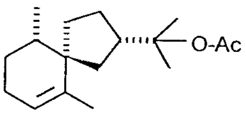
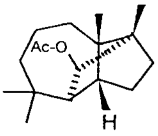
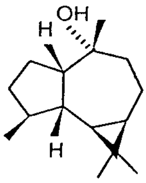
Retention time (min)	Compound	Structure
24.10	α-bulnesene	
24.16	tetradecanal	$CH_3(CH_2)_{12}COH$
24.20	cumin aldehyde	
24.33	*(E)*-caryophyllene	
24.89	*(Z)*-cinnamyl acetate	
25.07	*9-epi-(E)*-caryophyllene	
25.11	longifolene	
25.23	α-gurjunene	
25.37	seychellene	

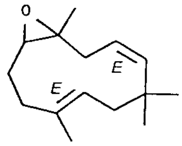
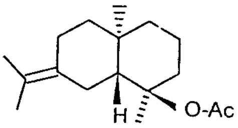
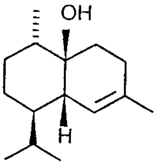
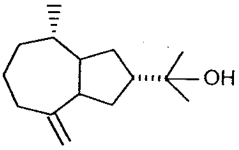
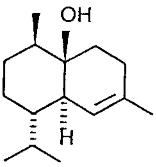
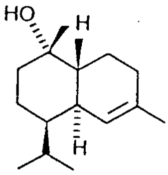
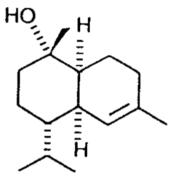
Retention time (min)	Compound	Structure
25.41	*(Z)*-methyl-butyl-benzoate	
25.44	*(Z)*-α-bisabolene	
25.54	cyperene	
25.56	*allo*-aromadendrene	
25.58	*trans*-calamenene	
25.73	*cis*-β-guaiene	
25.89	α-humulene	
26.03	valencene	
26.58	δ-cadinene	

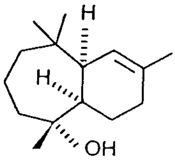
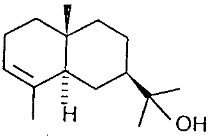
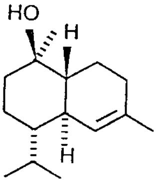
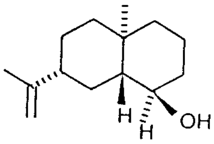
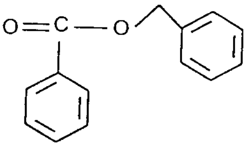
Retention time (min)	Compound	Structure
26.61	β-patchoulene	
26.75	γ-cadinene	
26.89	α-muurolene	
26.92	2-methyl-undecanal	$CH_3(CH_2)_8CH(CH_3)COH$
26.99	γ-muurolene	
27.34	β-selinene	
27.38	viridiflorene	
27.43	isoledene	
27.59	bicyclogermacrene	

Retention time (min)	Compound	Structure
27.63	α-selinene	
27.84	*epi*-cubebol	
27.88	β-gurjunene	
28.11	germacrene A	
28.39	*cis*-muurola-*4(14),5*-diene	
28.59	*trans*-β-guaiene	
28.76	α-cadinene	
28.78	*cis*-calamenene	

Retention time (min)	Compound	Structure
28.84	eugenyl acetate	
28.91	*3,7(11)*-selinadiene	
29.09	myristicin	
29.19	cadina-*1,4*-diene	
29.61	α-calacorene	
30.15	elemicin	
30.19	germacrene B	
30.66	*(E)*-nerolidol	

Retention time (min)	Compound	Structure
31.29	spathulenol	
31.32	caryophyllene oxide	
31.47	globulol	
31.59	α-eudesmol acetate	
31.63	β-eudesmol acetate	
31.96	hinesol acetate	
32.26	longiborneol acetate	
32.30	ledol	

Retention time (min)	**Compound**	**Structure**
32.44	humulene epoxide II	
32.64	dodecanal	$CH_3(CH_2)_{10}COH$
33.08	juniper camphor acetate	
33.19	*1-epi*-cubenol	
33.54	bicyclo-vetivenol	
33.68	cubenol	
33.93	α-muurolol	
33.98	*epi*-α-muurolol	

Retention time (min)	Compound	Structure
34.36	himachalol	
34.48	α-eudesmol	
34.49	α-cadinol	
34.58	selin-*11-en-4-alpha*-ol	
38.86	benzyl benzoate	

Note : **GC/MS Condition**

Instrument model : Varian Saturn 3

Column : fused silica capillary column (30 m X 0.25 mm i.d.) coated with DB-5 (J&w), film thickness 0.25 μm

Column programming : 60-240°C rate 3.3°C/min

Injector temperature : 180°C

Helium carrier gas : 1 ml/min

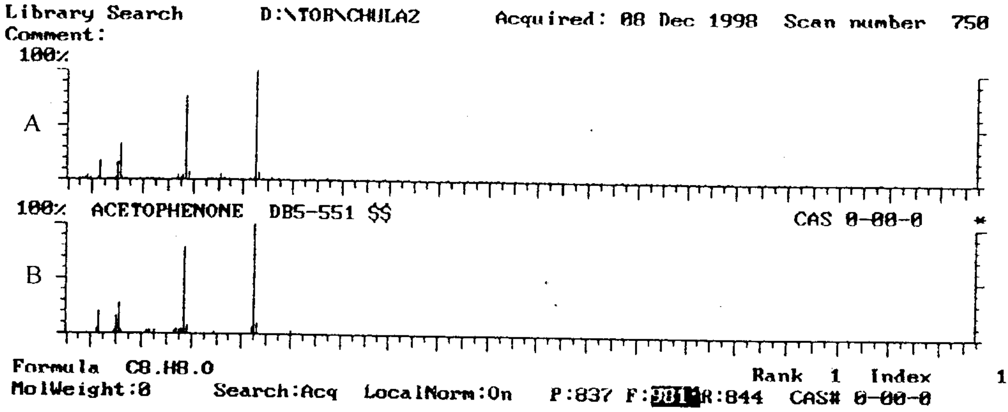
Split ratio : 100 : 1

Accelerating voltage : 1700 volts

Sample size : 1 μl

Solvent : methanol (HPLC grade)

B. Mass spectra of terpenoid and nonterpenoid compound.



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Library Search        D:\TOB\CHULA2        Acquired: 08 Dec 1998   Scan number   750
Comment:
100% ACETOPHENONE  DB5-551 $$                                  CAS 0-00-0        *
Formula   C8.H8.O                                             Rank   1   Index        13
MolWeight:0        Search:Acq   LocalNorm:On    P:837 F:981 R:844   CAS# 0-00-0
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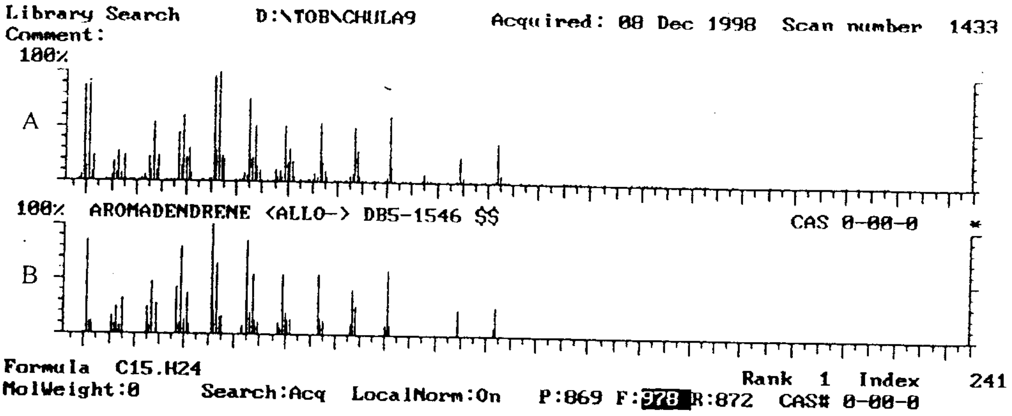
Figure 40 Mass spectra of acetophenone (A) and authentic acetophenone (B) by GC-MS



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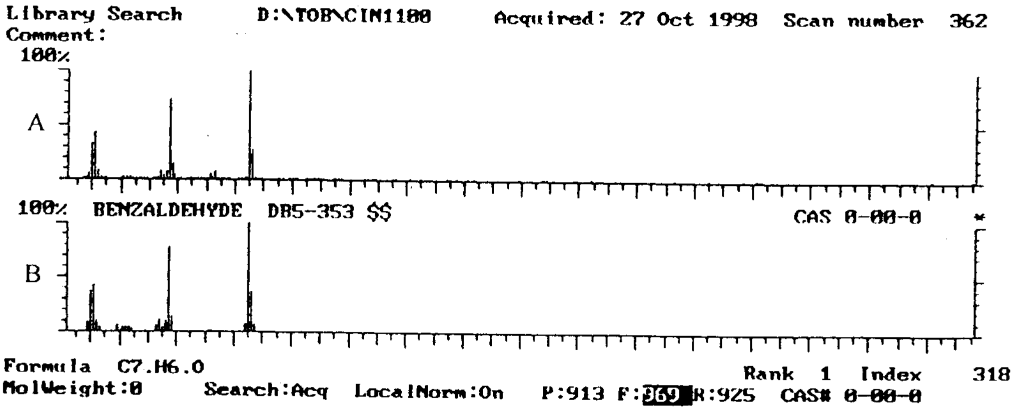
Library Search        D:\TOB\CHULA9        Acquired: 08 Dec 1998   Scan number   1433
Comment:
100% AROMADENDRENE <ALLO-> DB5-1546 $$                         CAS 0-00-0        *
Formula   C15.H24                                             Rank   1   Index       241
MolWeight:0        Search:Acq   LocalNorm:On    P:869 F:978 R:872   CAS# 0-00-0
```

Figure 41 Mass spectra of aromadendrene < *allo-*> (A) and authentic aromadendrene < *allo-*> (B) by GC-MS



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Library Search        D:\TOB\CIN1100       Acquired: 27 Oct 1998   Scan number   362
Comment:
100% BENZALDEHYDE  DB5-353 $$                                  CAS 0-00-0        *
Formula   C7.H6.O                                             Rank   1   Index       318
MolWeight:0        Search:Acq   LocalNorm:On    P:913 F:969 R:925   CAS# 0-00-0
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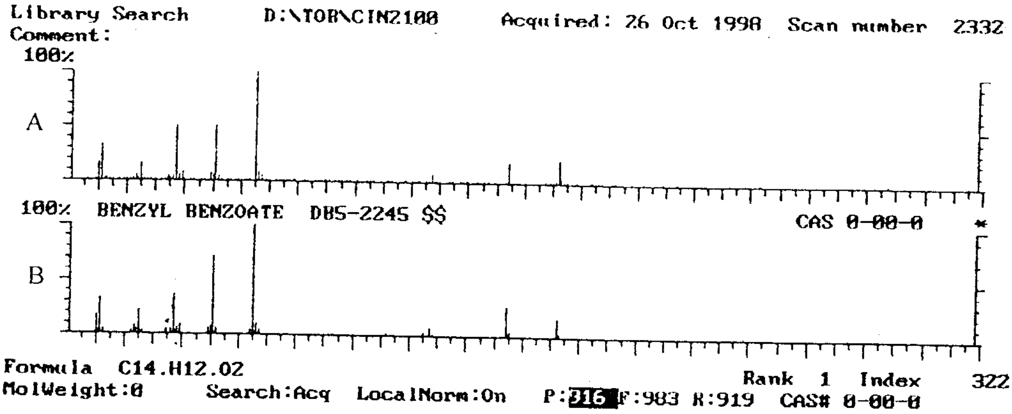
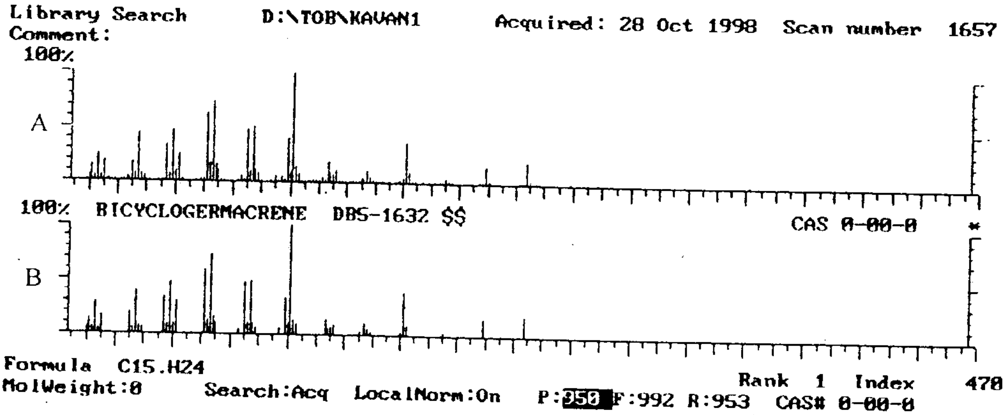
Figure 42 Mass spectra of benzaldehyde (A) and authentic benzaldehyde (B) by GC-MS



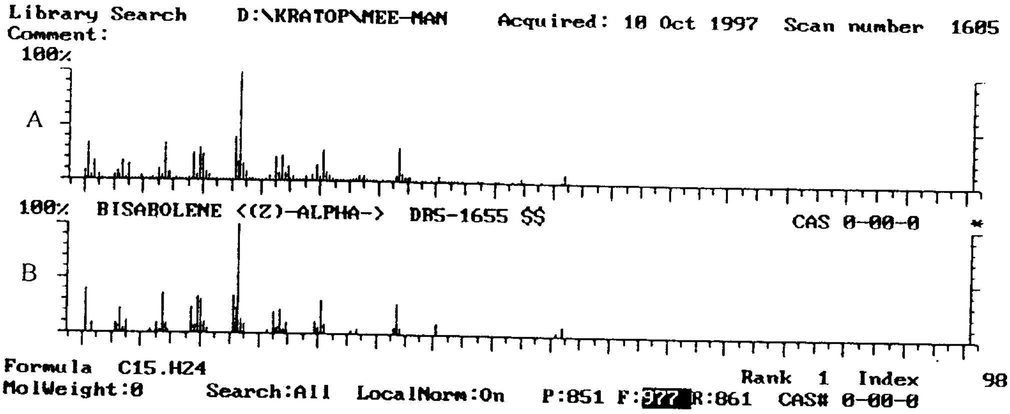
Library Search D:\TOB\CIN2100 Acquired: 26 Oct 1998 Scan number 2332
Comment:
100% BENZYL BENZOATE DBS-2245 $$ CAS 0-00-0 *
Formula C14.H12.O2 Rank 1 Index 322
MolWeight:0 Search:Acq LocalNorm:On P:916 F:983 R:919 CAS# 0-00-0

Figure 43 Mass spectra of benzyl benzoate (A) and authentic benzyl benzoate (B) by GC-MS



Library Search D:\TOB\KAVAN1 Acquired: 28 Oct 1998 Scan number 1657
Comment:
100% BICYCLOGERMACRENE DBS-1632 $$ CAS 0-00-0 *
Formula C15.H24 Rank 1 Index 470
MolWeight:0 Search:Acq LocalNorm:On P:950 F:992 R:953 CAS# 0-00-0

Figure 44 Mass spectra of bicyclogermacrene (A) and authentic bicyclogermacrene (B) by GC-MS



Library Search D:\KRATOP\MEE-MAN Acquired: 10 Oct 1997 Scan number 1605
Comment:
100% BISABOLENE <(Z)-ALPHA-> DBS-1655 $$ CAS 0-00-0 *
Formula C15.H24 Rank 1 Index 98
MolWeight:0 Search:All LocalNorm:On P:851 F:977 R:861 CAS# 0-00-0

Figure 45 Mass spectra of bisabolene <*(Z)*-α-> (A) and authentic bisabolene <*(Z)*-α-> (B) by GC-MS

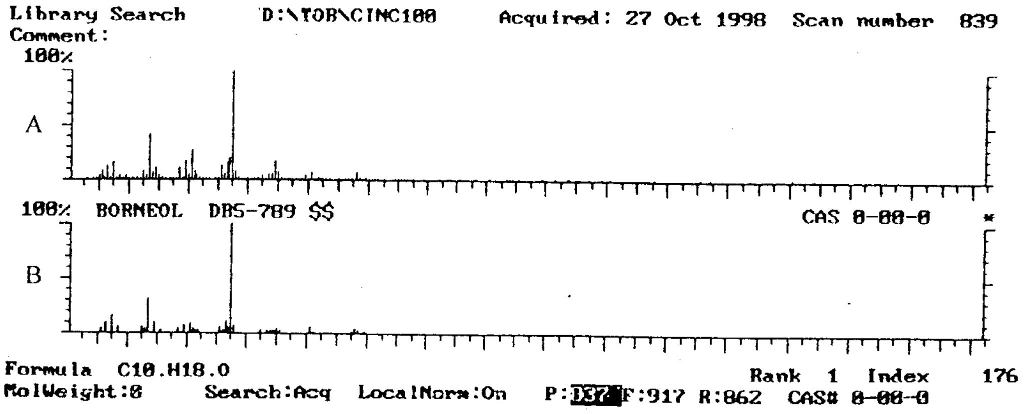


Figure 46 Mass spectra of borneol (A) and authentic borneol (B) by GC-MS

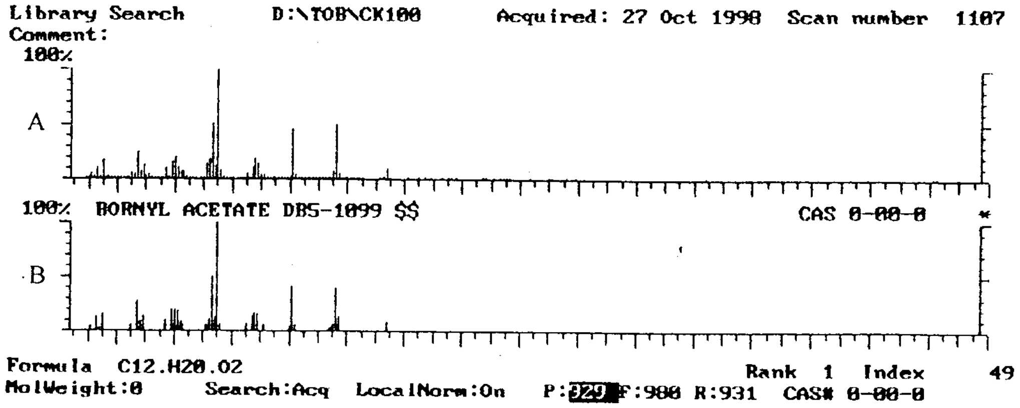


Figure 47 Mass spectra of bornyl acetate (A) and authentic bornyl acetate (B) by GC-MS

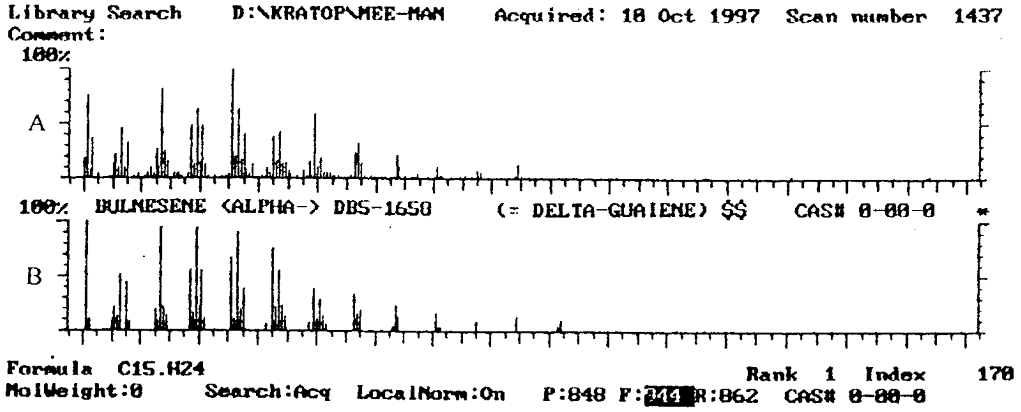


Figure 48 Mass spectra of bulnesene <α-> (A) and authentic bulnesene <α-> (B) by GC-MS

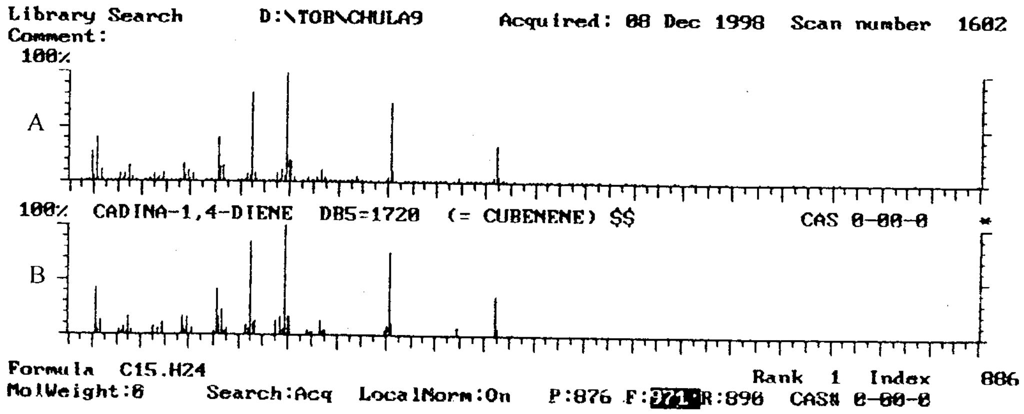


Figure 49 Mass spectra of cadina-*1,4-diene* (A) and authentic cadina-*1,4-diene* (B) by GC-MS

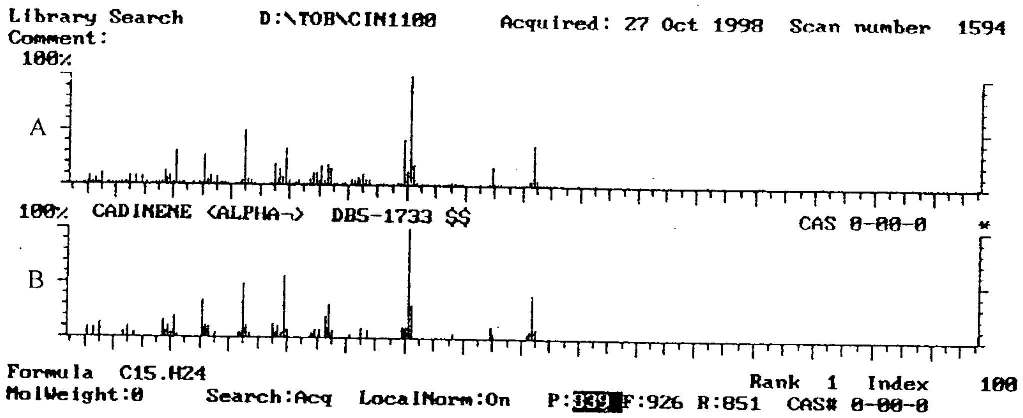


Figure 50 Mass spectra of cadinene <α-> (A) and authentic cadinene <α-> (B) by GC-MS

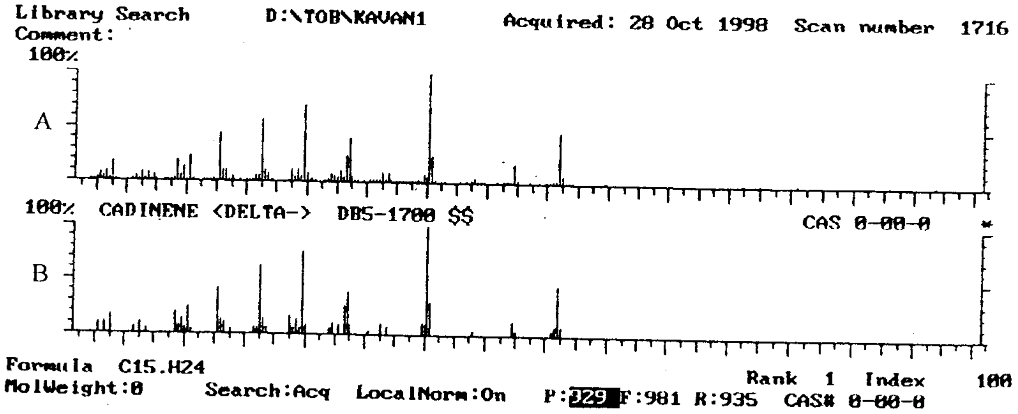
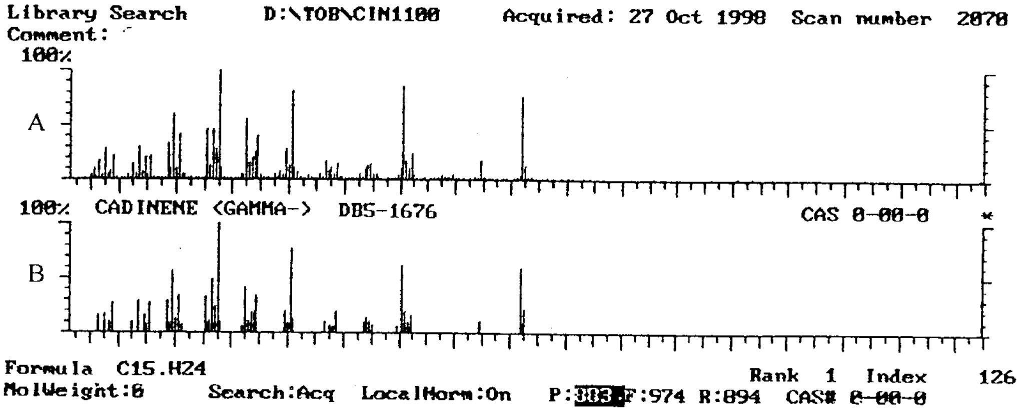


Figure 51 Mass spectra of cadinene <δ-> (A) and authentic cadinene <δ-> (B) by GC-MS



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Comment:
100%  CADINENE <GAMMA->  DB5-1676                             CAS 0-00-0     *
Formula  C15.H24                                          Rank  1  Index     126
MolWeight:0      Search:Acq   LocalNorm:On    P:383 F:974 R:894  CAS# 0-00-0
```
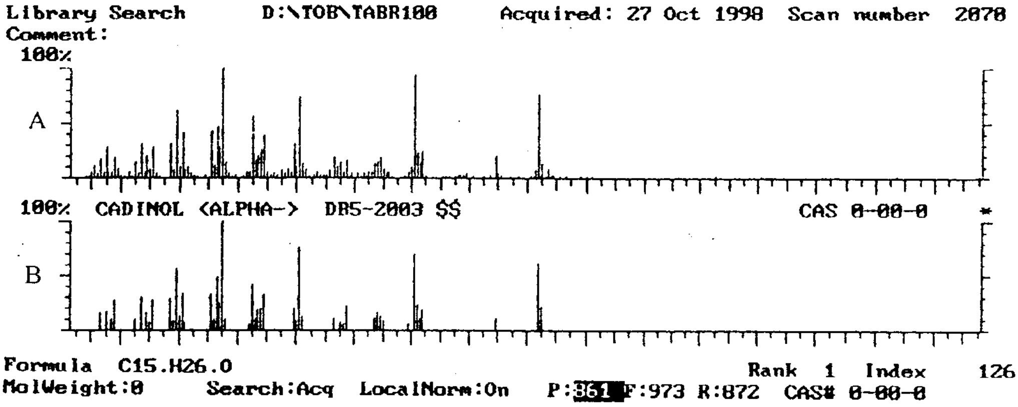

Figure 52 Mass spectra of cadinene <γ-> (A) and authentic cadinene <γ-> (B) by GC-MS



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Library Search      D:\TOB\TABR100      Acquired: 27 Oct 1998  Scan number  2070
Comment:
100%  CADINOL <ALPHA->  DB5-2003 $$                           CAS 0-00-0     *
Formula  C15.H26.O                                        Rank  1  Index     126
MolWeight:0      Search:Acq   LocalNorm:On    P:361 F:973 R:872  CAS# 0-00-0
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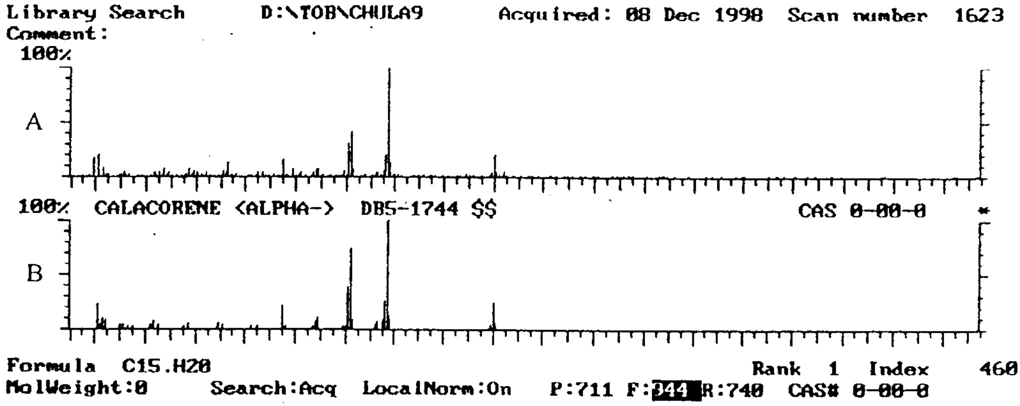
Figure 53 Mass spectra of cadinol <α-> (A) and authentic cadinol <α-> (B) by GC-MS



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Library Search      D:\TOB\CHULA9       Acquired: 08 Dec 1998  Scan number  1623
Comment:
100%  CALACORENE <ALPHA->  DB5-1744 $$                        CAS 0-00-0     *
Formula  C15.H20                                          Rank  1  Index     460
MolWeight:0      Search:Acq   LocalNorm:On    P:711 F:344 R:740  CAS# 0-00-0
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Figure 54 Mass spectra of calacorene <α-> (A) and authentic calacorene <α-> (B) by GC-MS

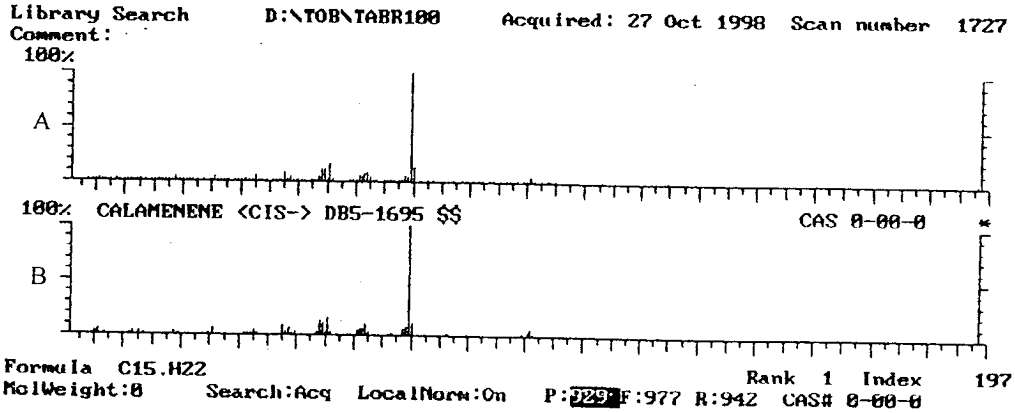


Figure 55 Mass spectra of calamenene < *cis*-> (A) and authentic calamenene <*cis*-> (B) by GC-MS

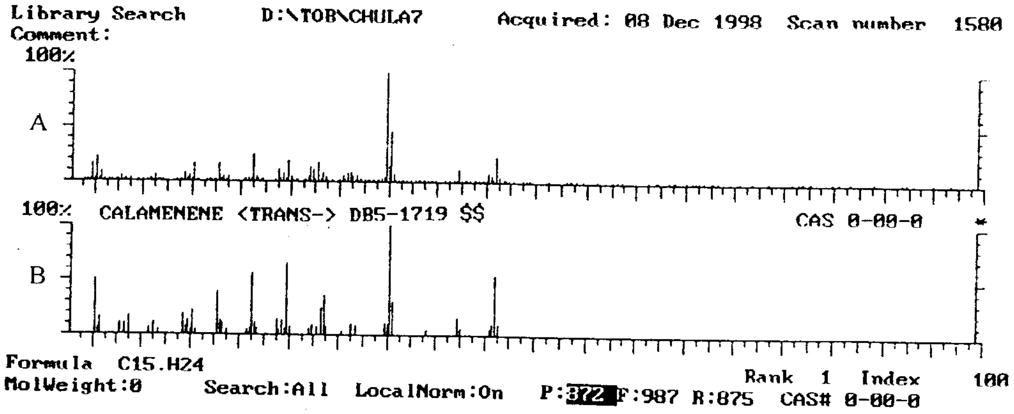


Figure 56 Mass spectra of calamenene < *trans*-> (A) and authentic calamenene <*trans*-> (B) by GC-MS

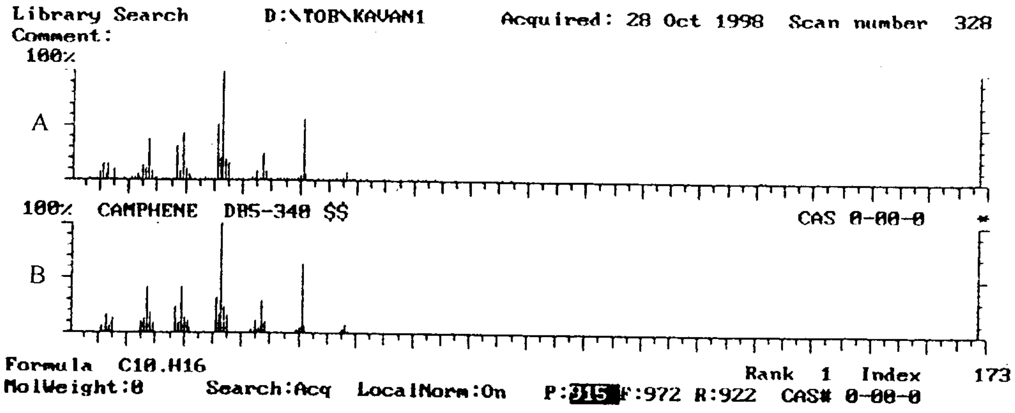


Figure 57 Mass spectra of camphene (A) and authentic camphene (B) by GC-MS

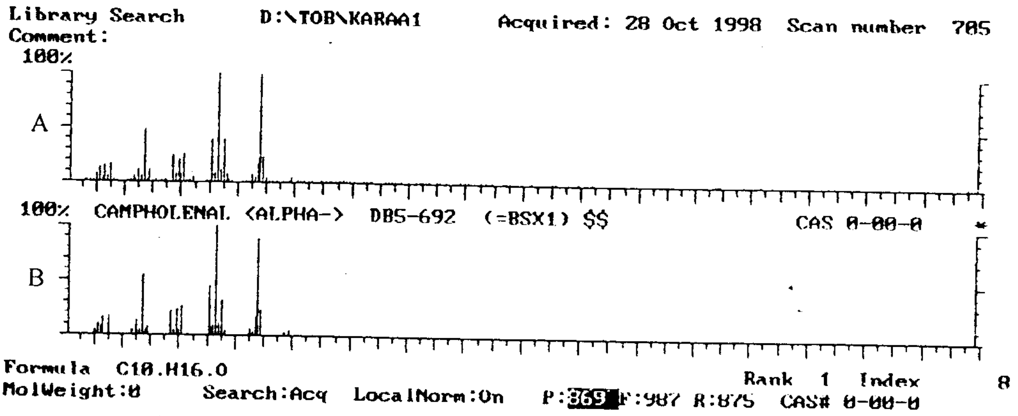


Figure 58 Mass spectra of campholenal <α-> (A) and authentic campholenal <α-> (B) by GC-MS

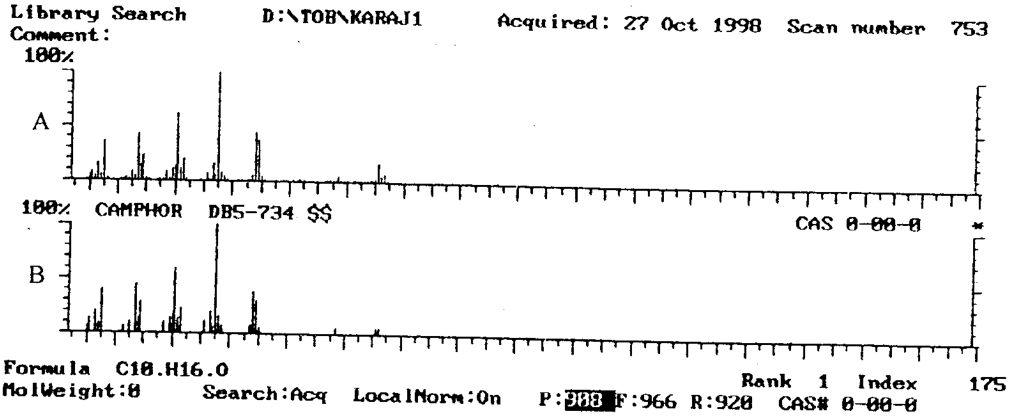


Figure 59 Mass spectra of camphor (A) and authentic camphor (B) by GC-MS

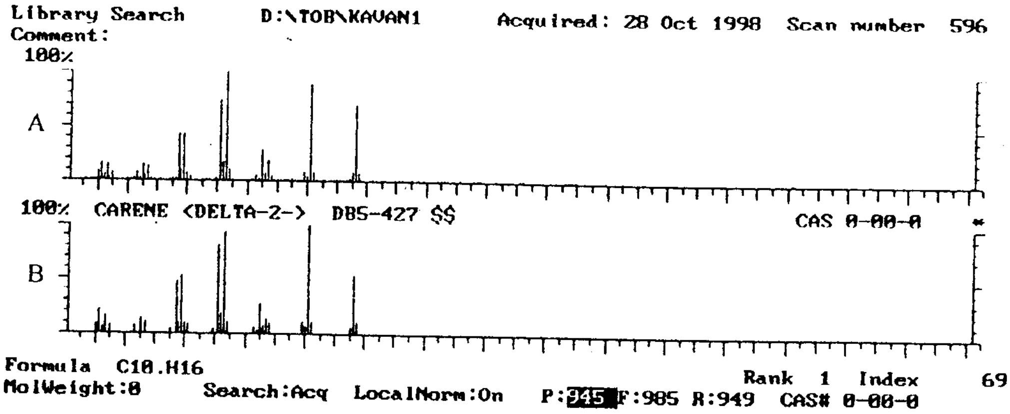


Figure 60 Mass spectra of carene < δ-2-> (A) and authentic carene < δ-2-> (B) by GC-MS

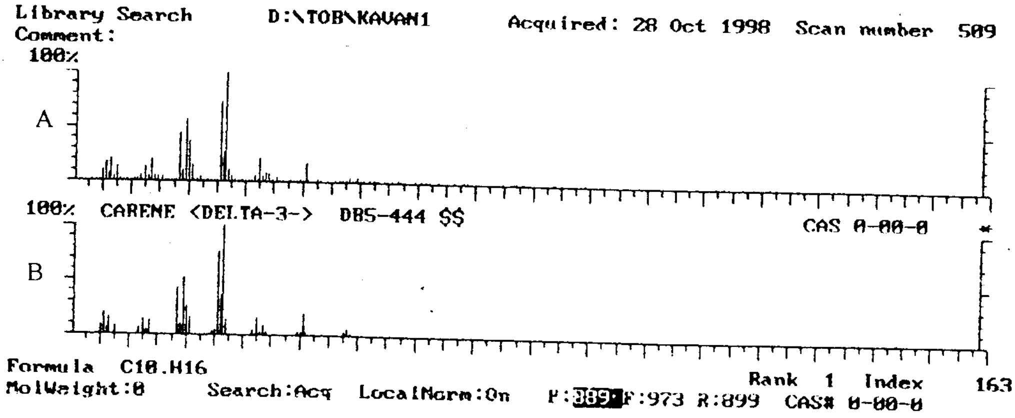


Figure 61 Mass spectra of carene < δ-*3*-> (A) and authentic carene < δ-*3*-> (B) by GC-MS

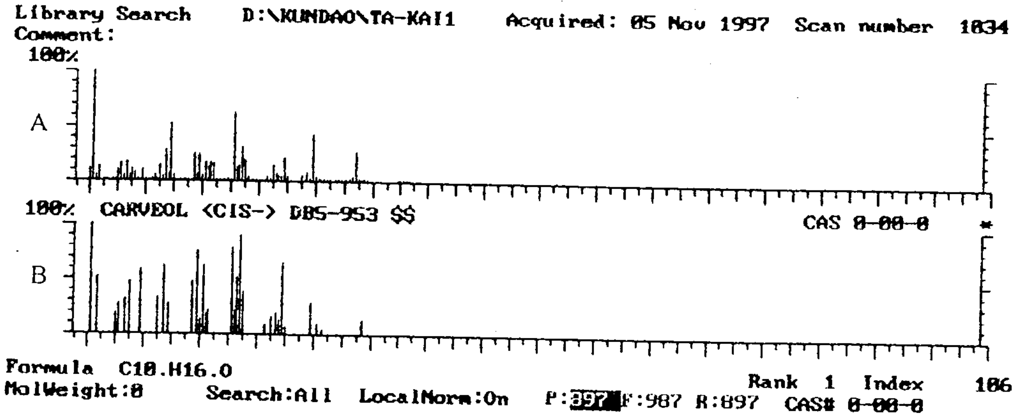


Figure 62 Mass spectra of carveol < *cis*-> (A) and authentic carveol < *cis*-> (B) by GC-MS

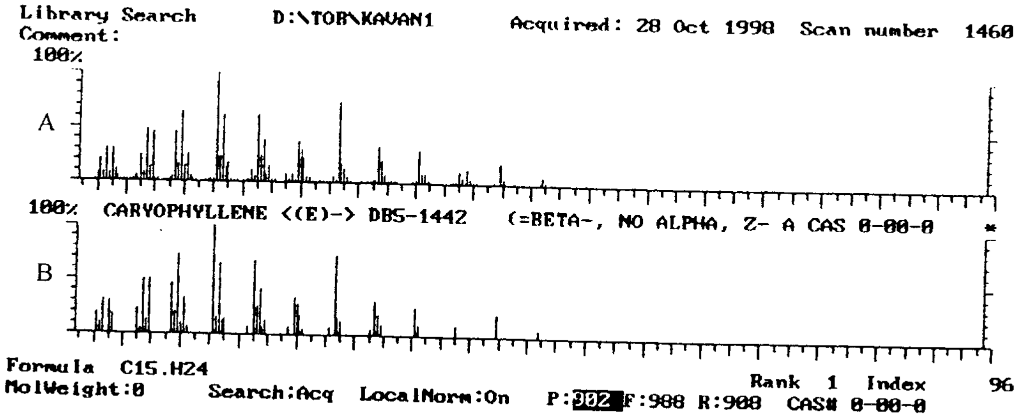


Figure 63 Mass spectra of caryophellene <*(E)*-> (A) and authentic caryophellene <*(E)*-> (B) by GC-MS

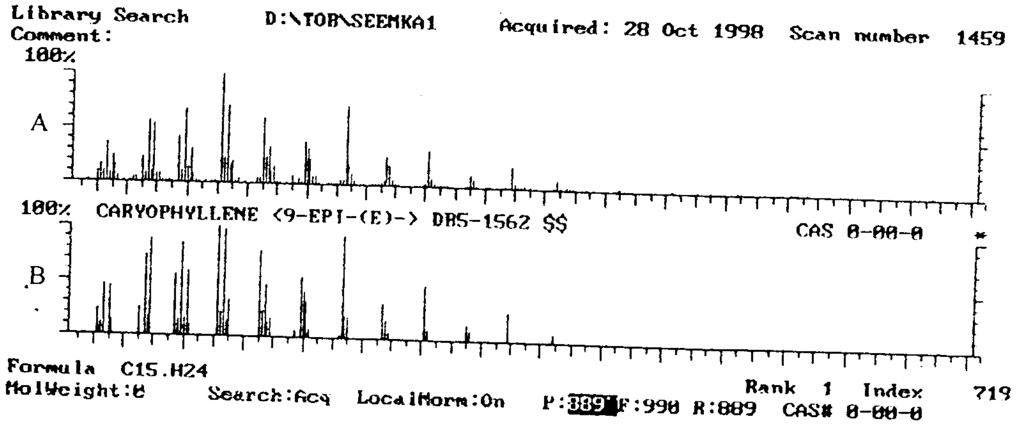


Figure 64 Mass spectra of caryophyllene *<9-epi-(E)->* (A) and authentic caryophyllene *<9-epi-(E)->* (B) by GC-MS

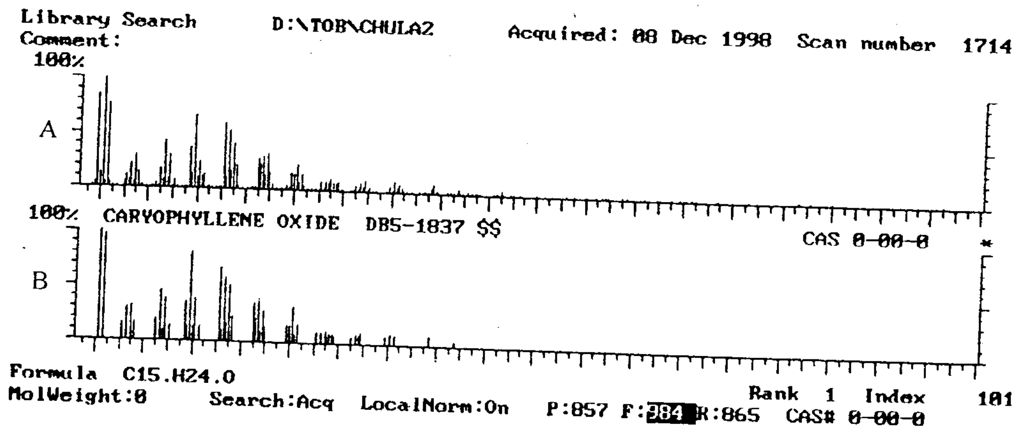


Figure 65 Mass spectra of caryophyllene oxide (A) and authentic caryophyllene oxide (B) by GC-MS

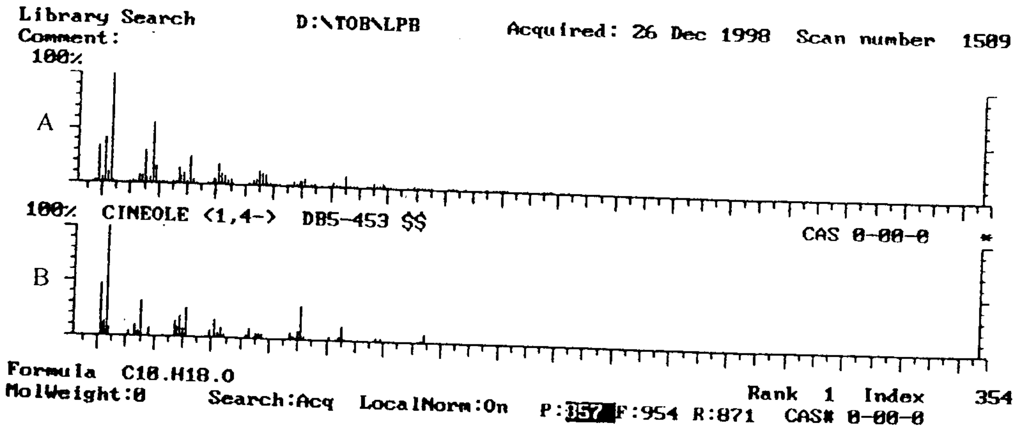
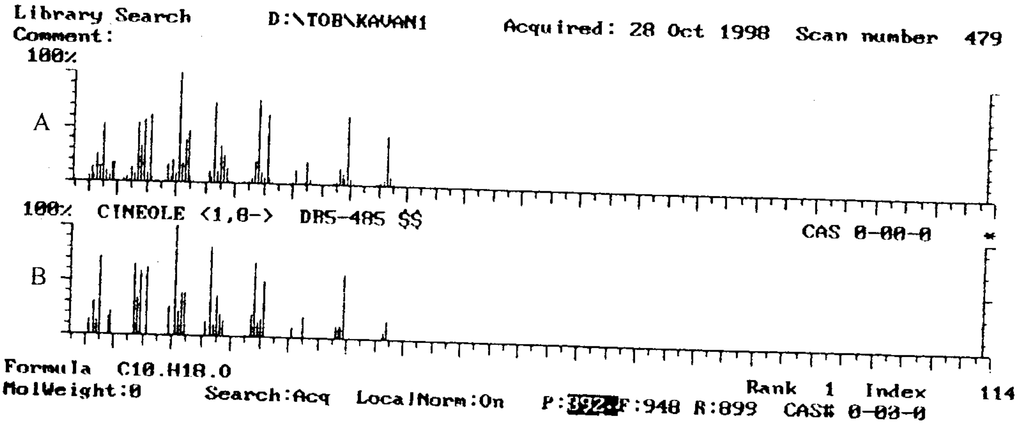
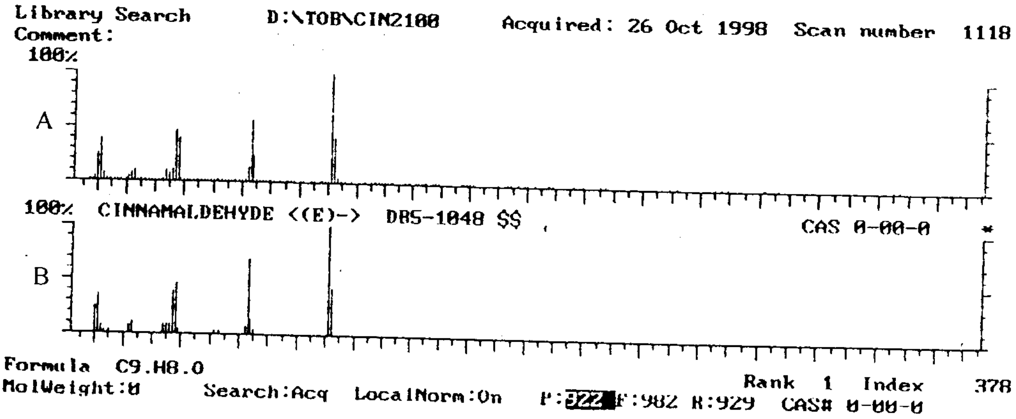


Figure 66 Mass spectra of cineole < *1,4->* (A) and authentic cineole < *1,4->* (B) by GC-MS



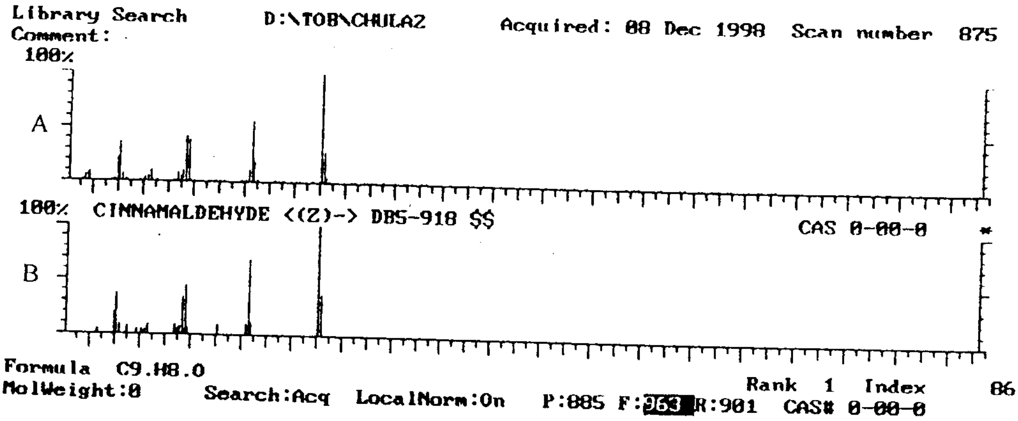
```
Library Search          D:\TOB\KAVAN1          Acquired: 28 Oct 1998  Scan number  479
Comment:
100%
A
100%  CINEOLE <1,8->  DBS-485 $$
                                                                   CAS 0-00-0      *
B
Formula  C10.H18.O
MolWeight:0        Search:Acq   LocalNorm:On     P:992 F:948 R:899   CAS# 0-00-0
                                                             Rank  1  Index        114
```

Figure 67 Mass spectra of cineole < *1,8*-> (A) and authentic cineole < *1,8*-> (B) by GC-MS



```
Library Search          D:\TOB\CIN2100         Acquired: 26 Oct 1998  Scan number  1118
Comment:
100%
A
100%  CINNAMALDEHYDE <(E)->  DBS-1048 $$
                                                                   CAS 0-00-0      *
B
Formula  C9.H8.O
MolWeight:0        Search:Acq   LocalNorm:On     P:922 F:982 R:929   CAS# 0-00-0
                                                             Rank  1  Index        378
```

Figure 68 Mass spectra of cinnamaldehyde < *(E)*-> (A) and authentic cinnamaldehyde < *(E)*-> (B) by GC-MS



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Library Search          D:\TOB\CHULA2          Acquired: 08 Dec 1998  Scan number  875
Comment:
100%
A
100%  CINNAMALDEHYDE <(Z)-> DBS-918 $$
                                                                   CAS 0-00-0      *
B
Formula  C9.H8.O
MolWeight:0        Search:Acq   LocalNorm:On     P:885 F:963 R:901   CAS# 0-00-0
                                                             Rank  1  Index        86
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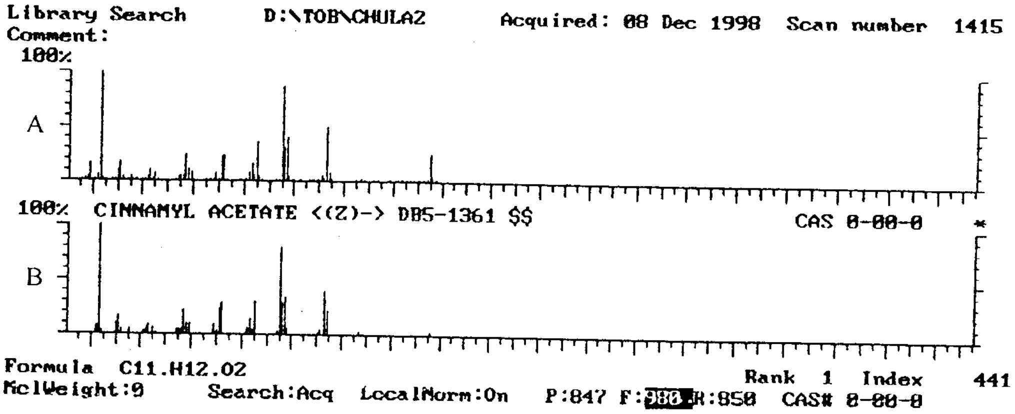
Figure 69 Mass spectra of cinnamaldehyde < *(Z)*-> (A) and authentic cinnamaldehyde < *(Z)*-> (B) by GC-MS



```
Library Search        D:\TOB\CHULA2        Acquired: 08 Dec 1998  Scan number  1415
Comment:
100%
100%  CINNAMYL ACETATE <(Z)-> DB5-1361 $$                               CAS 0-00-0     *
Formula   C11.H12.02                                              Rank  1  Index     441
MolWeight:0       Search:Acq   LocalNorm:On     P:847 F:980 R:850  CAS# 0-00-0
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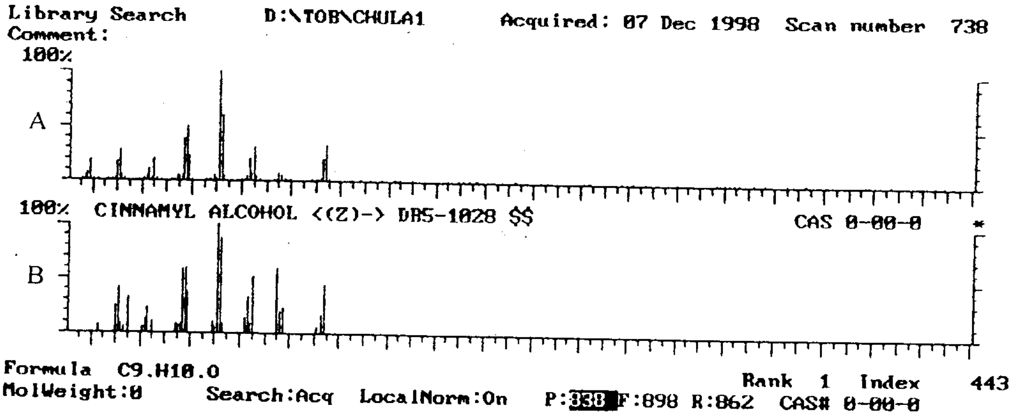
Figure 70 Mass spectra of cinnamyl acetate < *(Z)*-> (A) and authentic cinnamyl acetate < *(Z)*->(B) by GC-MS



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Library Search        D:\TOB\CHULA1        Acquired: 07 Dec 1998  Scan number  738
Comment:
100%
100%  CINNAMYL ALCOHOL <(Z)-> DB5-1028 $$                               CAS 0-00-0     *
Formula   C9.H10.0                                                Rank  1  Index     443
MolWeight:0       Search:Acq   LocalNorm:On     P:838 F:898 R:862  CAS# 0-00-0
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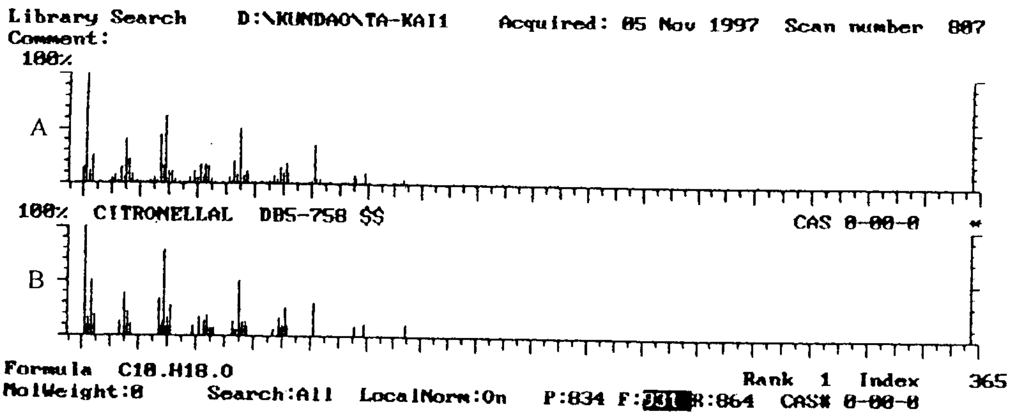
Figure 71 Mass spectra of cinnamyl alcohol < *(Z)*-> (A) and authentic cinnamyl alcohol < *(Z)*-> (B) by GC-MS



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Library Search        D:\KUNDAO\TA-KAI1     Acquired: 05 Nov 1997  Scan number  807
Comment:
100%
100%  CITRONELLAL   DB5-758 $$                                          CAS 0-00-0     *
Formula   C10.H18.0                                               Rank  1  Index     365
MolWeight:0       Search:All   LocalNorm:On     P:834 F:931 R:864  CAS# 0-00-0
```
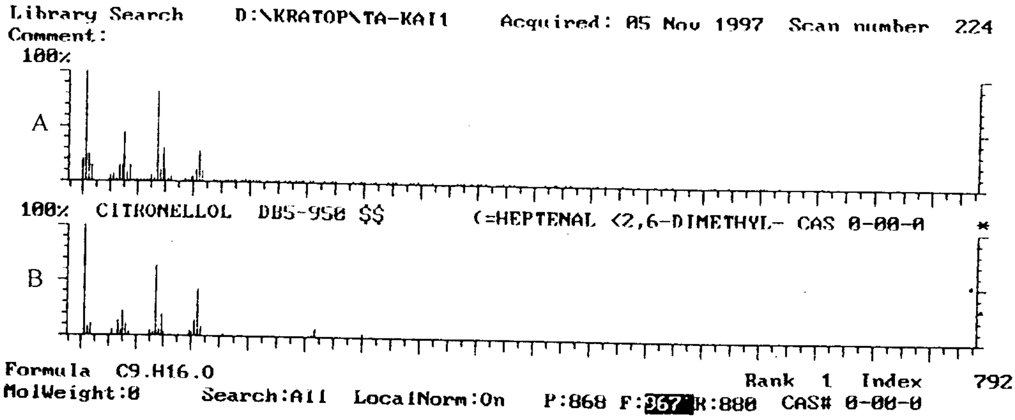
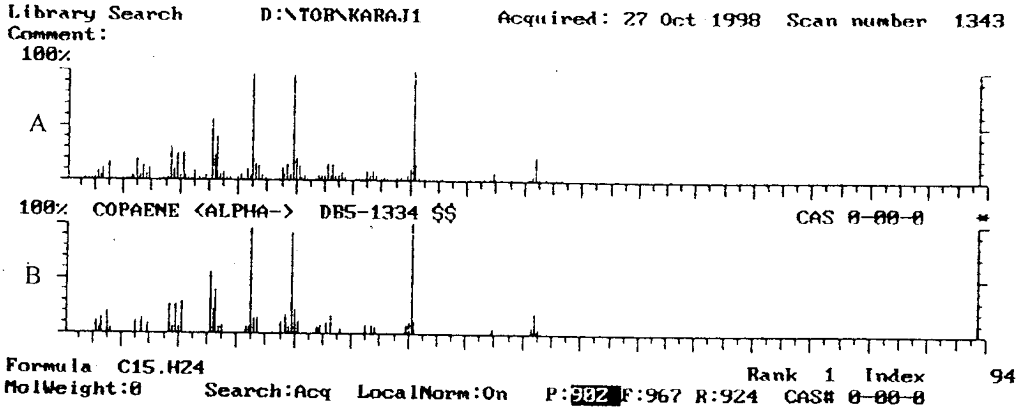

Figure 72 Mass spectra of citronellal (A) and authentic citronellal (B) by GC-MS



```
Library Search     D:\KRATOP\TA-KAI1     Acquired: 05 Nov 1997  Scan number  224
Comment:
100%
100%  CITRONELLOL  DB5-950 $$        (=HEPTENAL <2,6-DIMETHYL- CAS 0-00-0     *
Formula  C9.H16.0                                      Rank  1  Index      792
MolWeight:0      Search:All  LocalNorm:On   P:868 F:967 R:880  CAS# 0-00-0
```

Figure 73 Mass spectra of citronellol (A) and authentic citronellol (B) by GC-MS



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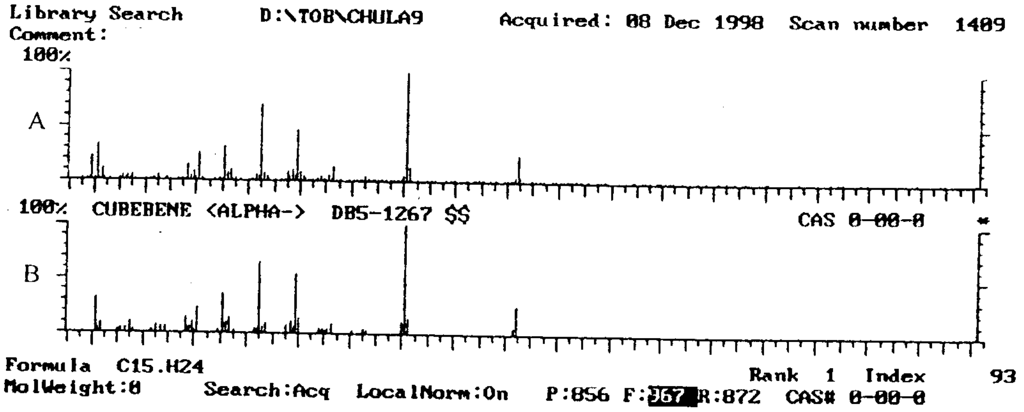
Library Search     D:\TOB\KARAJ1       Acquired: 27 Oct 1998  Scan number  1343
Comment:
100%
100%  COPAENE <ALPHA->  DB5-1334 $$                      CAS 0-00-0     *
Formula  C15.H24                                       Rank  1  Index       94
MolWeight:0      Search:Acq  LocalNorm:On   P:902 F:967 R:924  CAS# 0-00-0
```

Figure 74 Mass spectra of copaene < α-> (A) and authentic copaene < α-> (B) by GC-MS



```
Library Search     D:\TOB\CHULA9       Acquired: 08 Dec 1998  Scan number  1409
Comment:
100%
100%  CUBEBENE <ALPHA->  DB5-1267 $$                     CAS 0-00-0     *
Formula  C15.H24                                       Rank  1  Index       93
MolWeight:0      Search:Acq  LocalNorm:On   P:856 F:967 R:872  CAS# 0-00-0
```

Figure 75 Mass spectra of cubebene < α-> (A) and authentic cubebene < α-> (B) by GC-MS

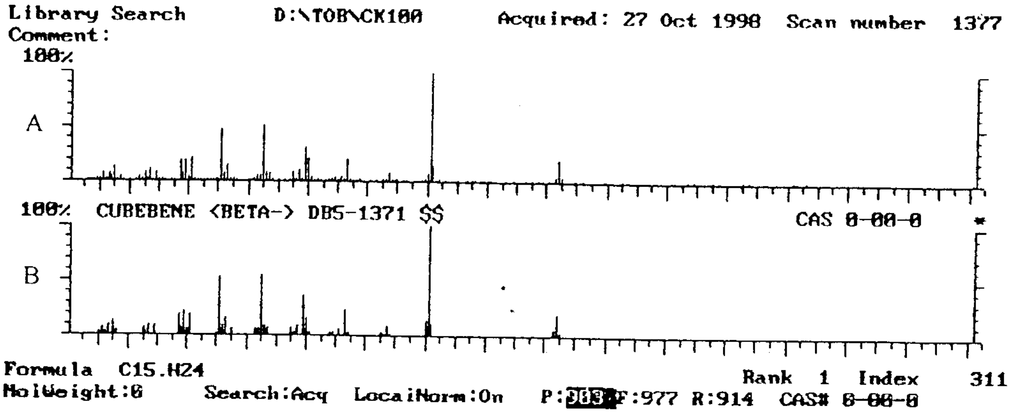

Library Search D:\TOB\CK100 Acquired: 27 Oct 1998 Scan number 1377
Comment:
CUBEBENE <BETA-> DBS-1371 $$ CAS 0-00-0
Formula C15.H24 Rank 1 Index 311
MolWeight:0 Search:Acq LocalNorm:On P:303 F:977 R:914 CAS# 0-00-0

Figure 76 Mass spectra of cubebene < β-> (A) and authentic cubebene < β-> (B) by GC-MS

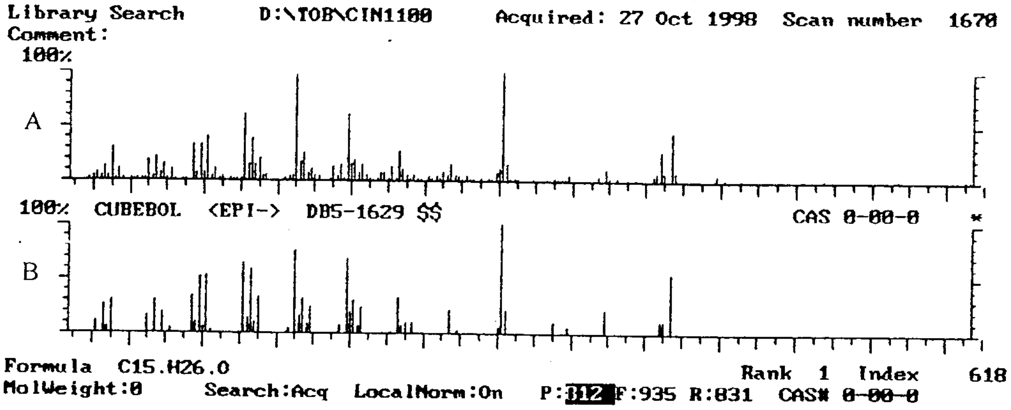

Library Search D:\TOB\CIN1100 Acquired: 27 Oct 1998 Scan number 1670
Comment:
CUBEBOL <EPI-> DBS-1629 $$ CAS 0-00-0
Formula C15.H26.O Rank 1 Index 618
MolWeight:0 Search:Acq LocalNorm:On P:312 F:935 R:831 CAS# 0-00-0

Figure 77 Mass spectra of cubebol < *epi*-> (A) and authentic cubebol < *epi*-> (B) by GC-MS

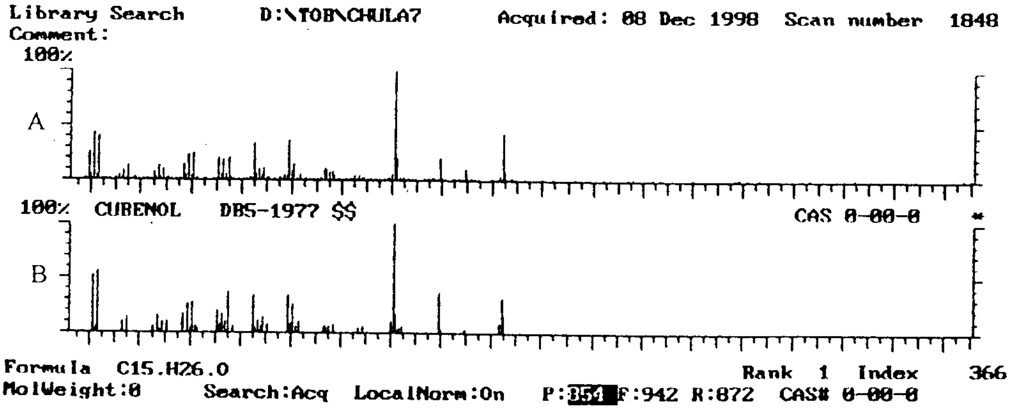
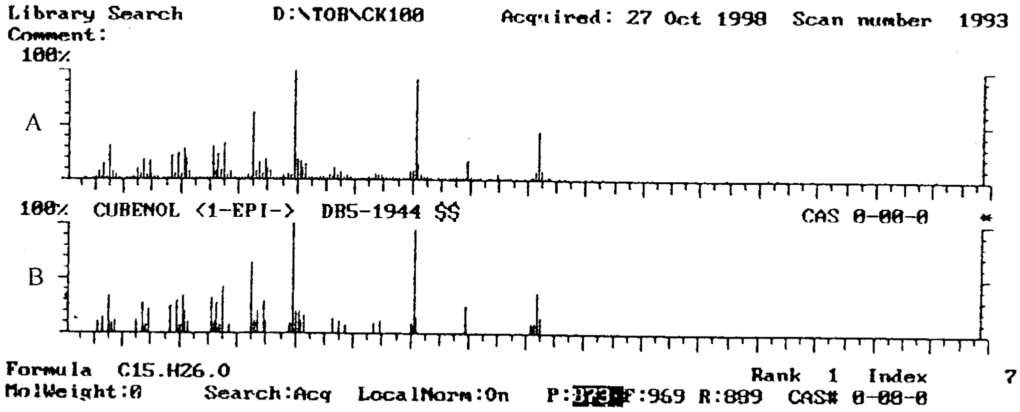
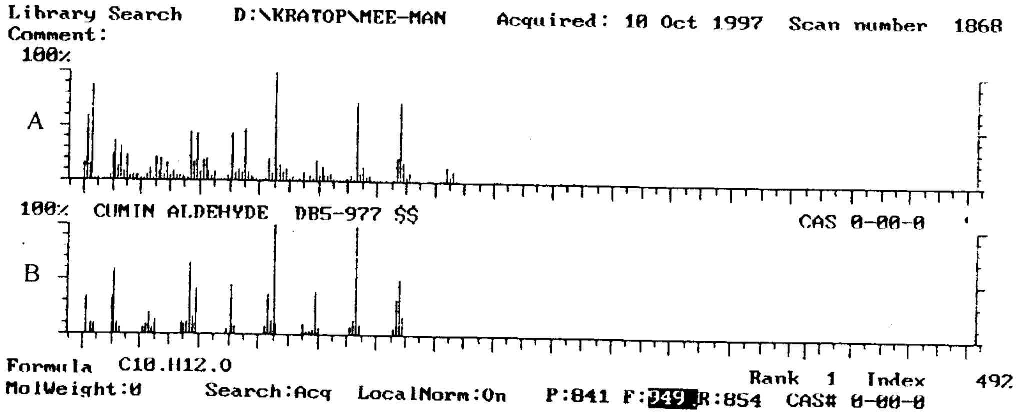

Library Search D:\TOB\CHULA7 Acquired: 08 Dec 1998 Scan number 1848
Comment:
CUBENOL DBS-1977 $$ CAS 0-00-0
Formula C15.H26.O Rank 1 Index 366
MolWeight:0 Search:Acq LocalNorm:On P:354 F:942 R:872 CAS# 0-00-0

Figure 78 Mass spectra of cubenol (A) and authentic cubenol (B) by GC-MS



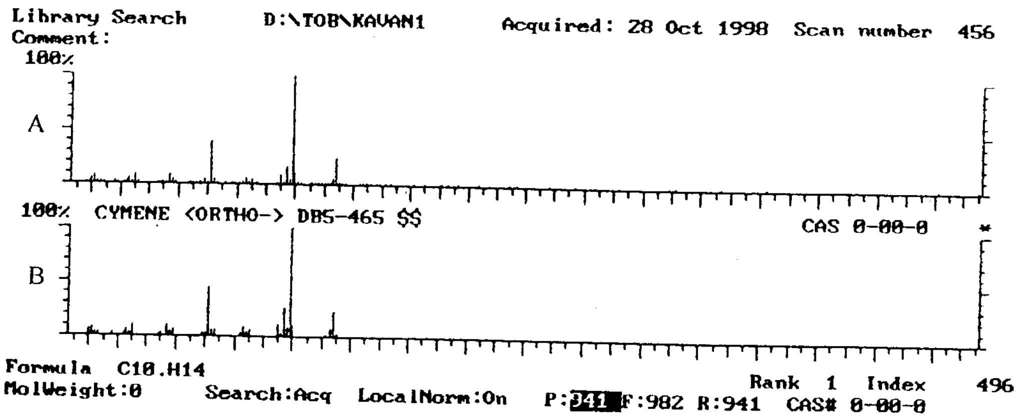
Library Search D:\TOB\CK100 Acquired: 27 Oct 1998 Scan number 1993
Comment:
CUBENOL <1-EPI-> DB5-1944 $$ CAS 0-00-0
Formula C15.H26.O Rank 1 Index 7
MolWeight:0 Search:Acq LocalNorm:On P:873 F:969 R:889 CAS# 0-00-0

Figure 79 Mass spectra of cubenol <*1-epi-*> (A) and authentic cubenol <*1-epi-*> (B) by GC-MS



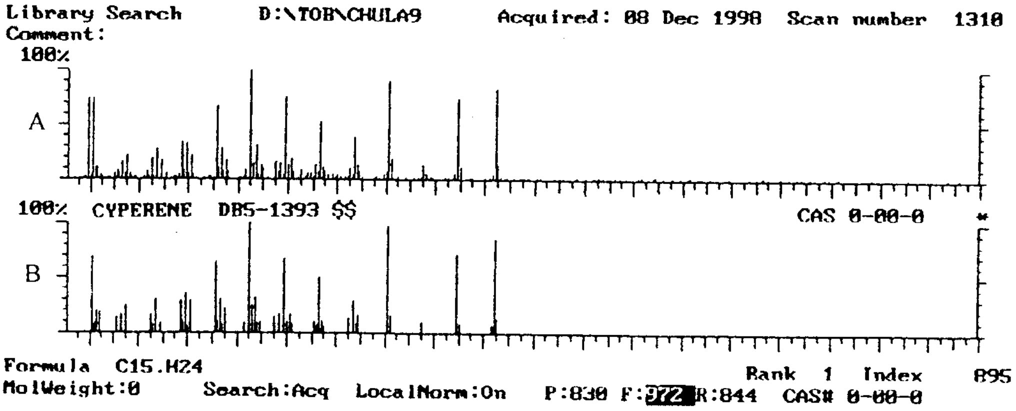
Library Search D:\KRATOP\MEE-MAN Acquired: 10 Oct 1997 Scan number 1868
Comment:
CUMIN ALDEHYDE DB5-977 $$ CAS 0-00-0
Formula C10.H12.O Rank 1 Index 492
MolWeight:0 Search:Acq LocalNorm:On P:841 F:949 R:854 CAS# 0-00-0

Figure 80 Mass spectra of cumin aldehyde (A) and authentic cumin aldehyde (B) by GC-MS



Library Search D:\TOB\KAVAN1 Acquired: 28 Oct 1998 Scan number 456
Comment:
CYMENE <ORTHO-> DB5-465 $$ CAS 0-00-0
Formula C10.H14 Rank 1 Index 496
MolWeight:0 Search:Acq LocalNorm:On P:941 F:982 R:941 CAS# 0-00-0

Figure 81 Mass spectra of cymene < *o*-> (A) and authentic cymene < *o*-> (B) by GC-MS



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Library Search        D:\TOB\CHULA9        Acquired: 08 Dec 1998   Scan number   1310
Comment:
100%
100%  CYPERENE  DBS-1393 $$                                          CAS 0-00-0     *
Formula  C15.H24                                                  Rank   1   Index      895
MolWeight:0        Search:Acq   LocalNorm:On     P:830 F:972 R:844   CAS# 0-00-0
```
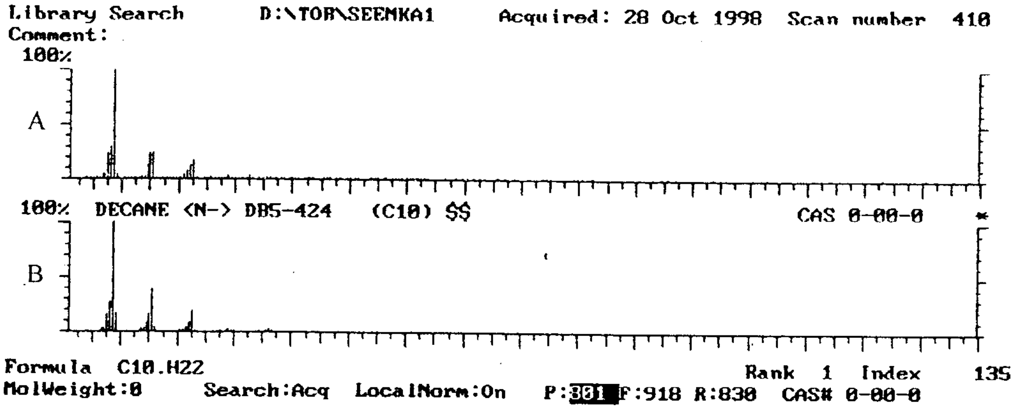

Figure 82 Mass spectra of cyperene (A) and authentic cyperene (B) by GC-MS



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Library Search        D:\TOB\SEEMKA1       Acquired: 28 Oct 1998   Scan number   410
Comment:
100%
100%  DECANE <N-> DBS-424   (C10) $$                                 CAS 0-00-0     *
Formula  C10.H22                                                  Rank   1   Index      135
MolWeight:0        Search:Acq   LocalNorm:On     P:301 F:918 R:830   CAS# 0-00-0
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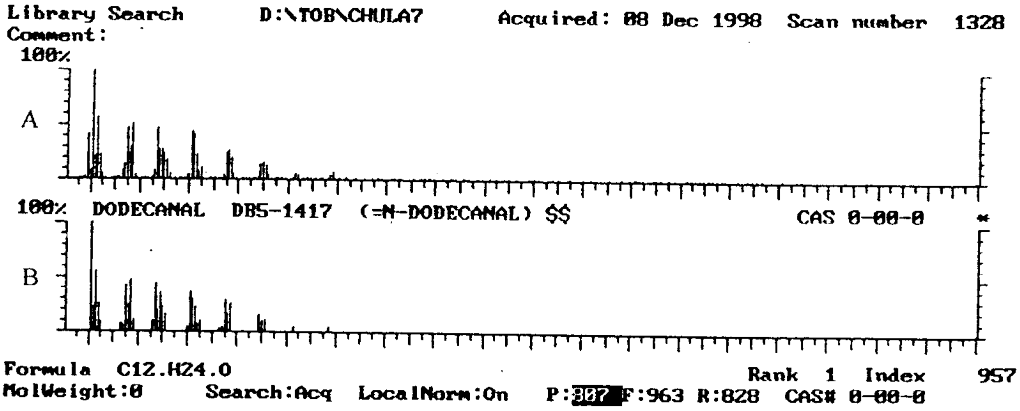
Figure 83 Mass spectra of decane < *n*-> (A) and authentic decane < *n*-> (B) by GC-MS



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Library Search        D:\TOB\CHULA7        Acquired: 08 Dec 1998   Scan number   1320
Comment:
100%
100%  DODECANAL   DBS-1417  (=N-DODECANAL) $$                        CAS 0-00-0     *
Formula  C12.H24.O                                                Rank   1   Index      957
MolWeight:0        Search:Acq   LocalNorm:On     P:307 F:963 R:828   CAS# 0-00-0
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Figure 84 Mass spectra of dodecanal (A) and authentic dodecanal (B) by GC-MS

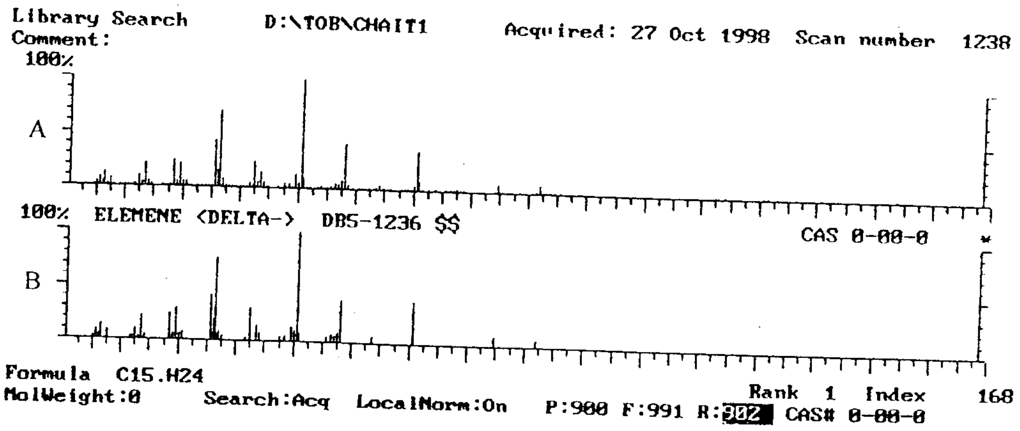


Figure 85 Mass spectra of elemene < δ-> (A) and authentic elemene < δ-> (B) by GC-MS

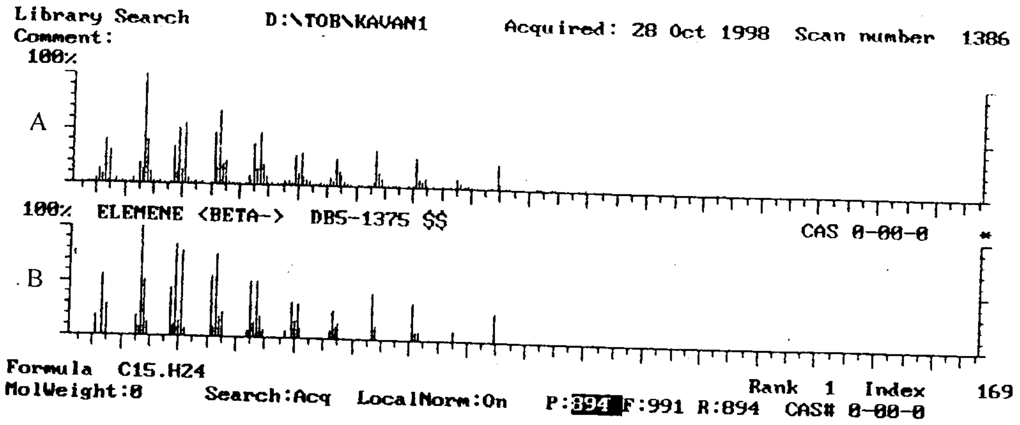


Figure 86 Mass spectra of elemene < β-> (A) and authentic elemene < β-> (B) by GC-MS

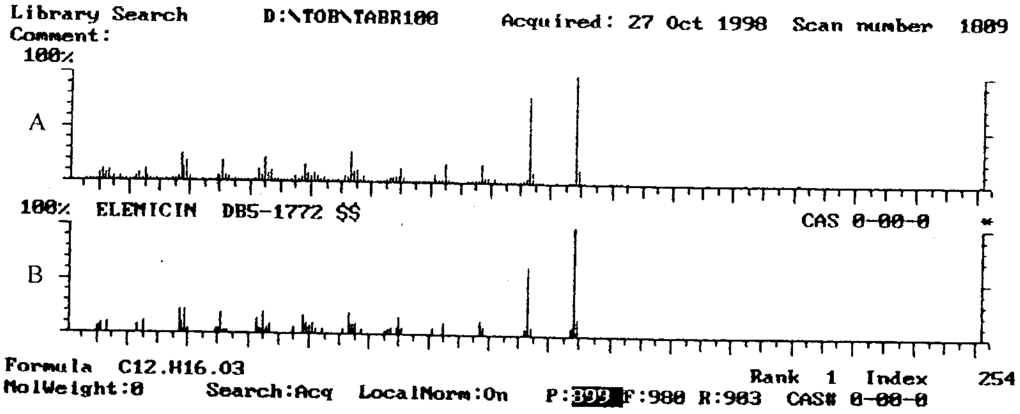


Figure 87 Mass spectra of elemicin (A) and authentic elemicin (B) by GC-MS

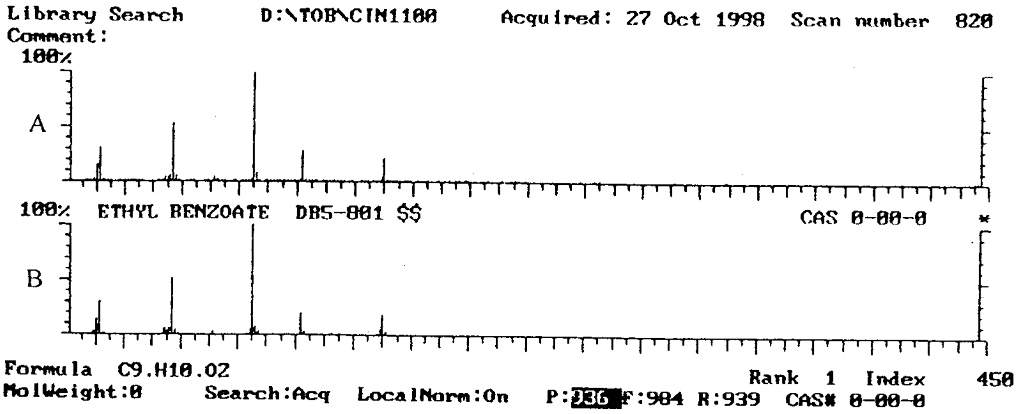


Figure 88 Mass spectra of ethyl benzoate (A) and authentic ethyl benzoate (B) by GC-MS

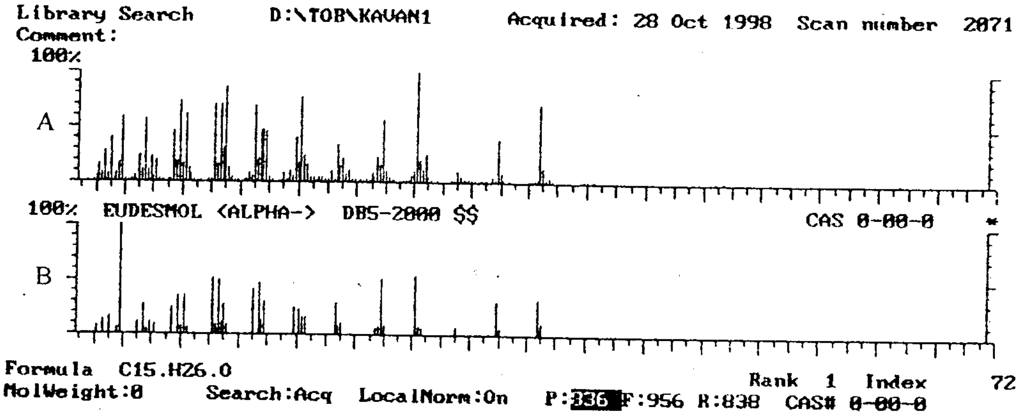


Figure 89 Mass spectra of eudesmol < α-> (A) and authentic eudesmol < α-> (B) by GC-MS

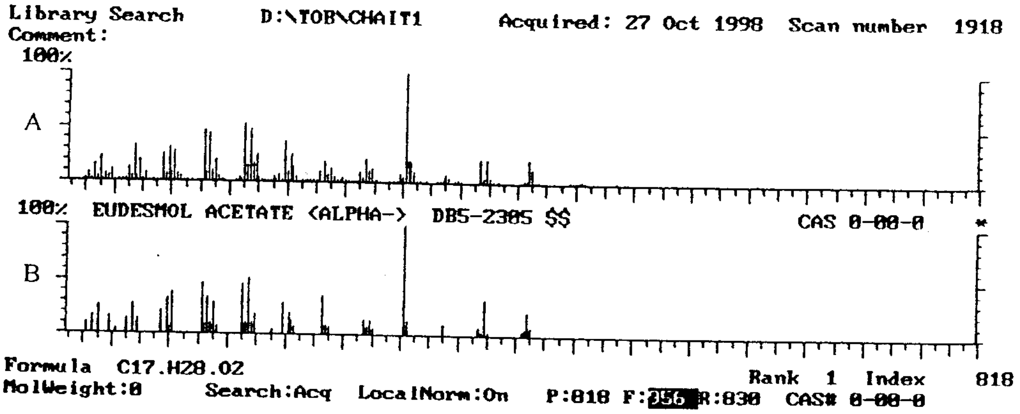
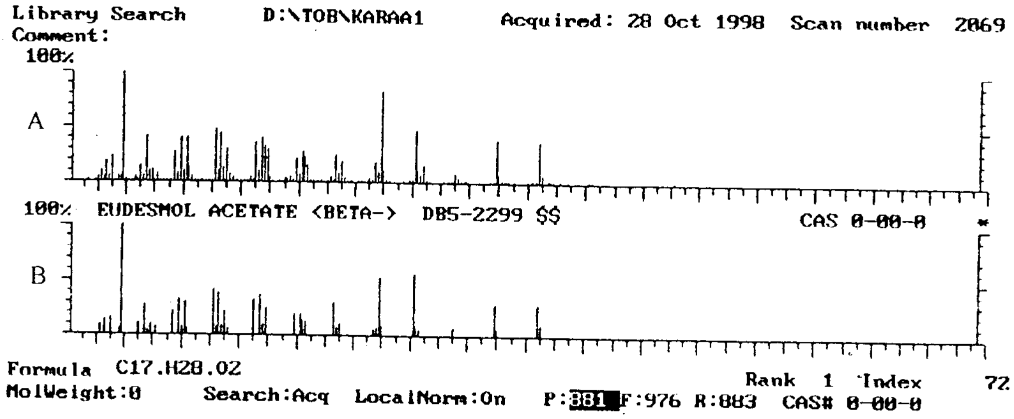


Figure 90 Mass spectra of eudesmol acetate < α-> (A) and authentic eudesmol acetate < α-> (B) by GC-MS



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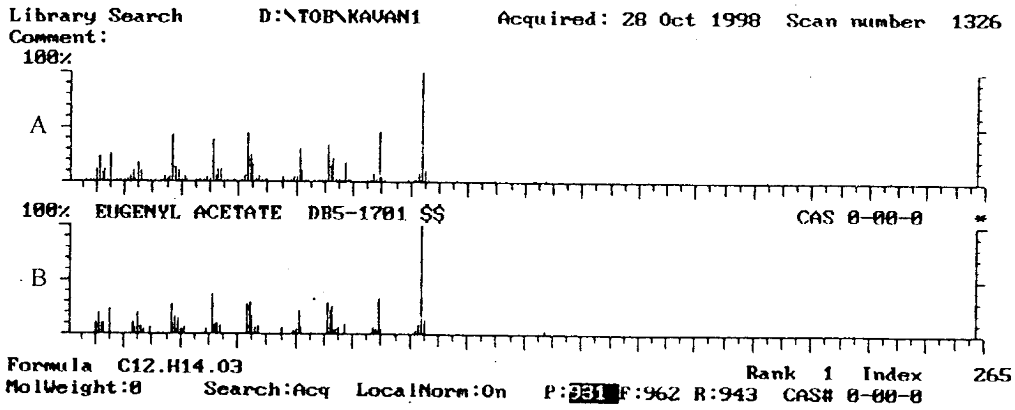
Library Search        D:\TOB\KARAA1        Acquired: 28 Oct 1998   Scan number  2069
Comment:
100%  EUDESMOL ACETATE <BETA->  DB5-2299 $$                         CAS 0-00-0     *
Formula  C17.H28.O2                                               Rank  1  Index     72
MolWeight:0      Search:Acq   LocalNorm:On    P:881 F:976 R:883   CAS# 0-00-0
```

Figure 91 Mass spectra of eudesmol acetate < β-> (A) and authentic eudesmol acetate < β-> (B) by GC-MS



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Library Search        D:\TOB\KAVAN1        Acquired: 28 Oct 1998   Scan number  1326
Comment:
100%  EUGENYL ACETATE   DB5-1701 $$                                CAS 0-00-0     *
Formula  C12.H14.O3                                               Rank  1  Index    265
MolWeight:0      Search:Acq   LocalNorm:On    P:931 F:962 R:943   CAS# 0-00-0
```
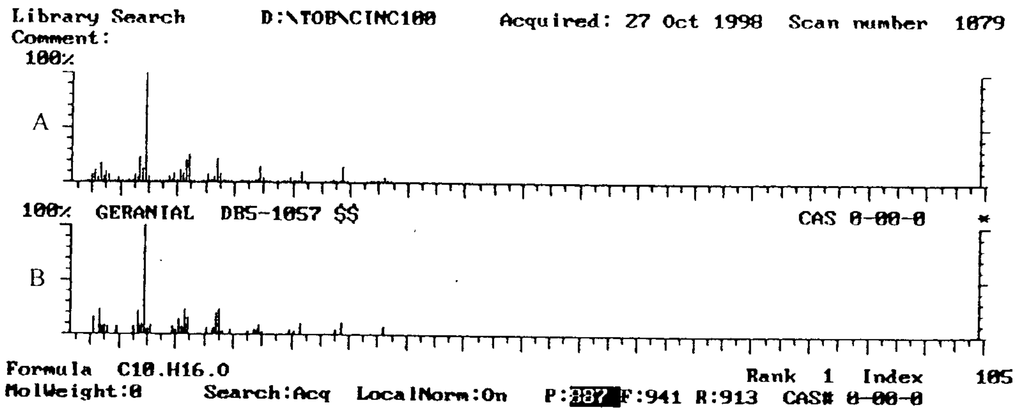

Figure 92 Mass spectra of eugenyl acetate (A) and authentic eugenyl acetate (B) by GC-MS



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Library Search        D:\TOB\CINC100       Acquired: 27 Oct 1998   Scan number  1079
Comment:
100%  GERANIAL   DB5-1057 $$                                       CAS 0-00-0     *
Formula  C10.H16.O                                                Rank  1  Index    105
MolWeight:0      Search:Acq   LocalNorm:On    P:887 F:941 R:913   CAS# 0-00-0
```

Figure 93 Mass spectra of geranial (A) and authentic geranial (B) by GC-MS

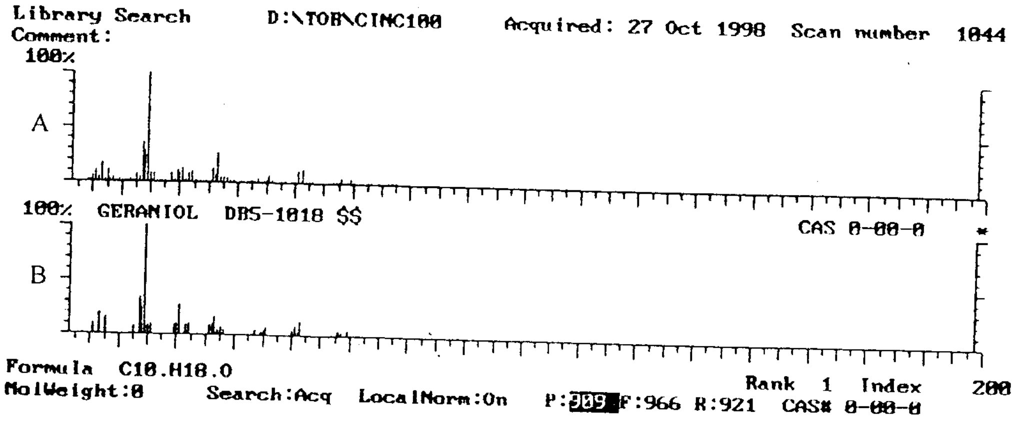


Figure 94 Mass spectra of geraniol (A) and authentic geraniol (B) by GC-MS

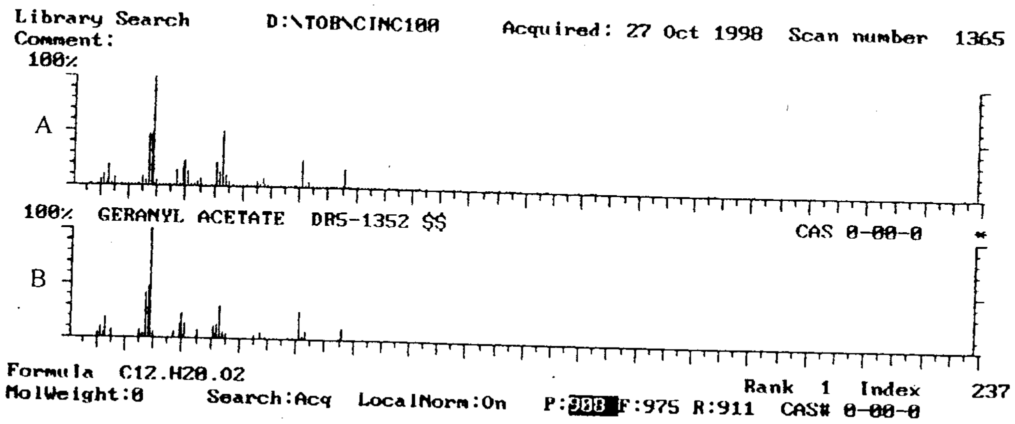


Figure 95 Mass spectra of geranyl acetate (A) and authentic geranyl acetate (B) by GC-MS

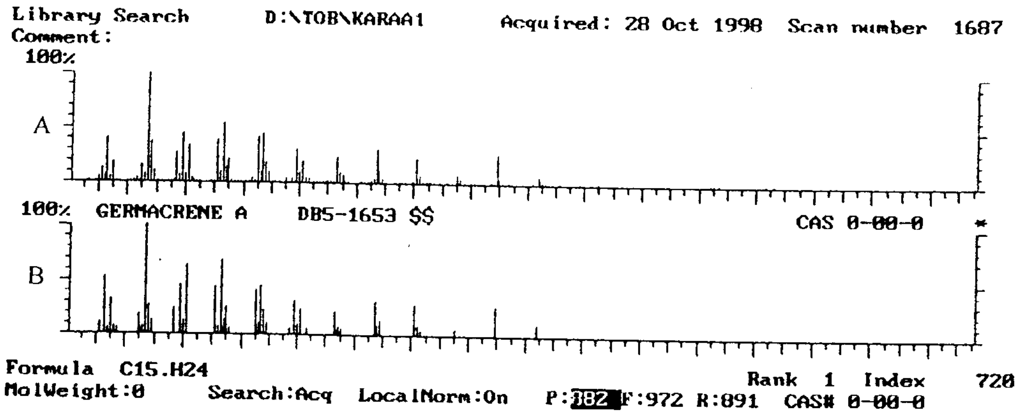


Figure 96 Mass spectra of germacrene A (A) and authentic germacrene A (B) by GC-MS

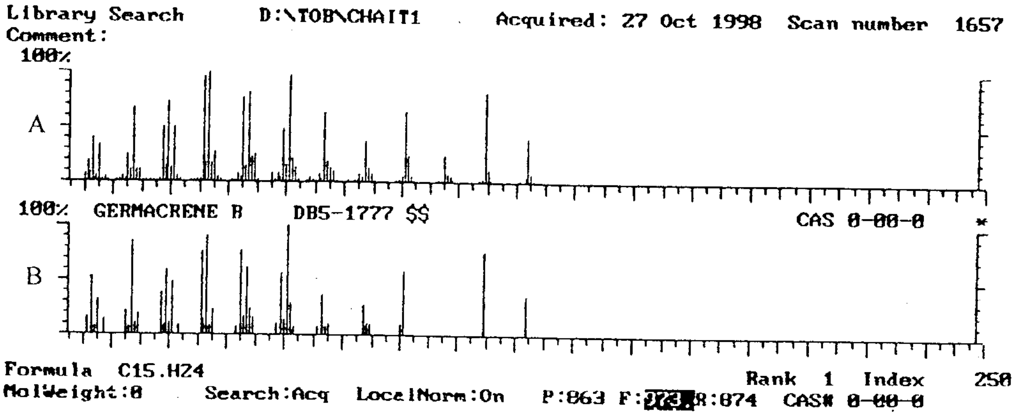


Figure 97 Mass spectra of germacrene B (A) and authentic germacrene B (B) by GC-MS

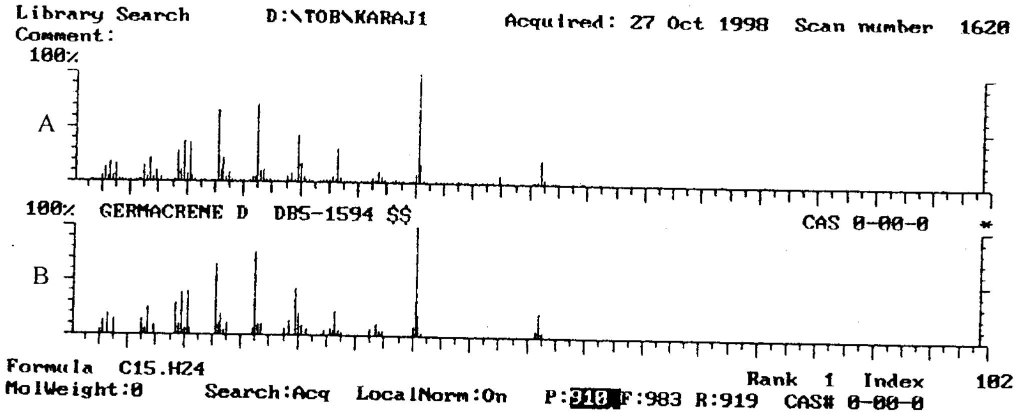


Figure 98 Mass spectra of germacrene D (A) and authentic germacrene D (B) by GC-MS

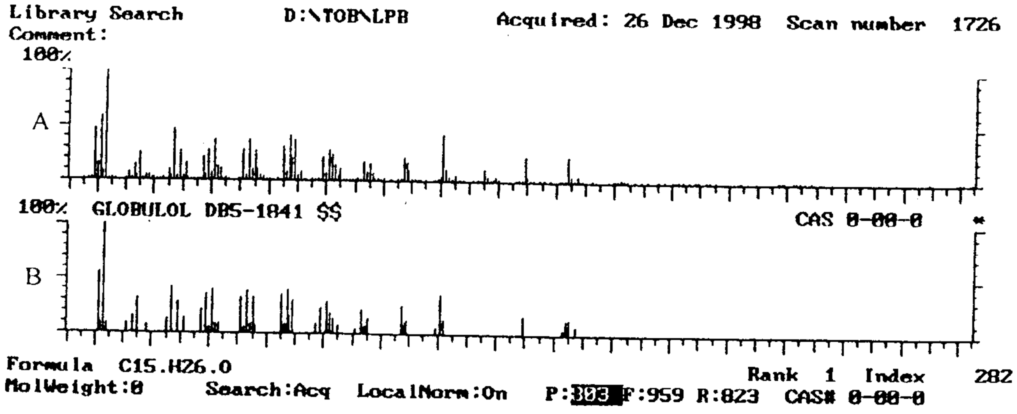


Figure 99 Mass spectra of globulol (A) and authentic globulol (B) by GC-MS

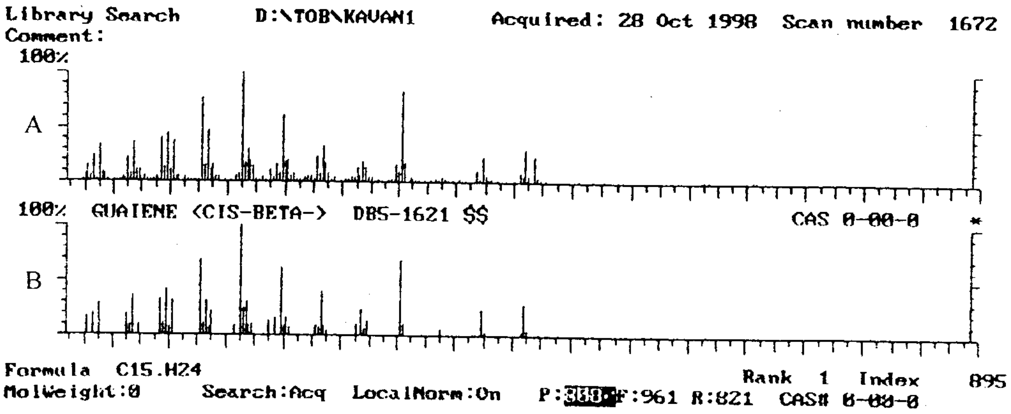


Figure 100 Mass spectra of guaiene < *cis*-β-> (A) and authentic guaiene < *cis*-β-> (B) by GC-MS

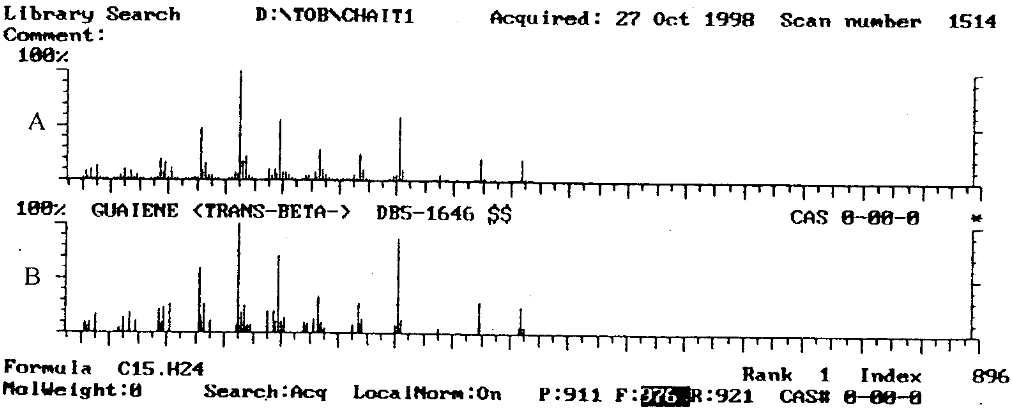


Figure 101 Mass spectra of guaiene < *trans*-β-> (A) and authentic guaiene < *trans*-β-> (B) by GC-MS

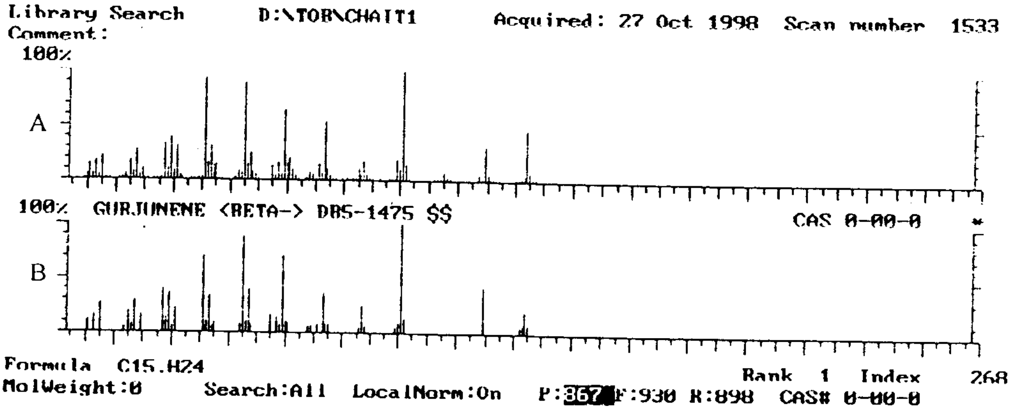
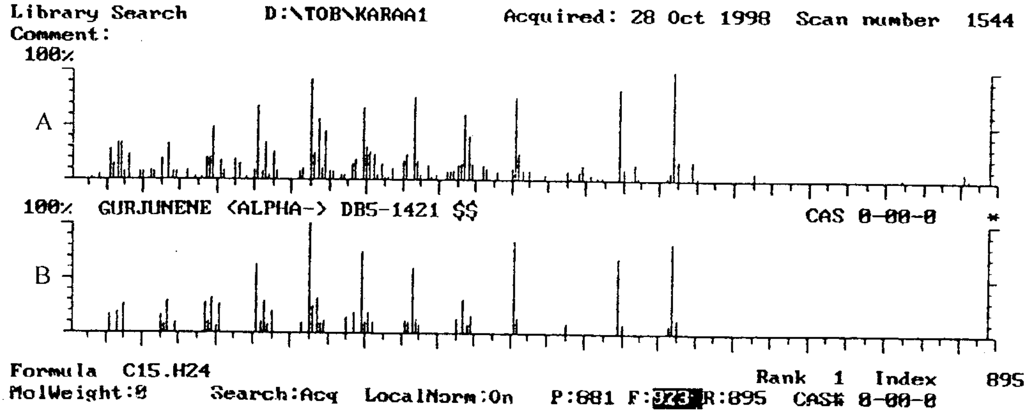


Figure 102 Mass spectra of gurjunene < β-> (A) and authentic gurjunene < β-> (B) by GC-MS



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Library Search        D:\TOB\KARAA1        Acquired: 28 Oct 1998   Scan number   1544
Comment:
100%
100%  GURJUNENE <ALPHA-> DBS-1421 $$                                   CAS 0-00-0     *
Formula  C15.H24                                              Rank   1   Index      895
MolWeight:0        Search:Acq   LocalNorm:On    P:881 F:973 R:895   CAS# 0-00-0
```
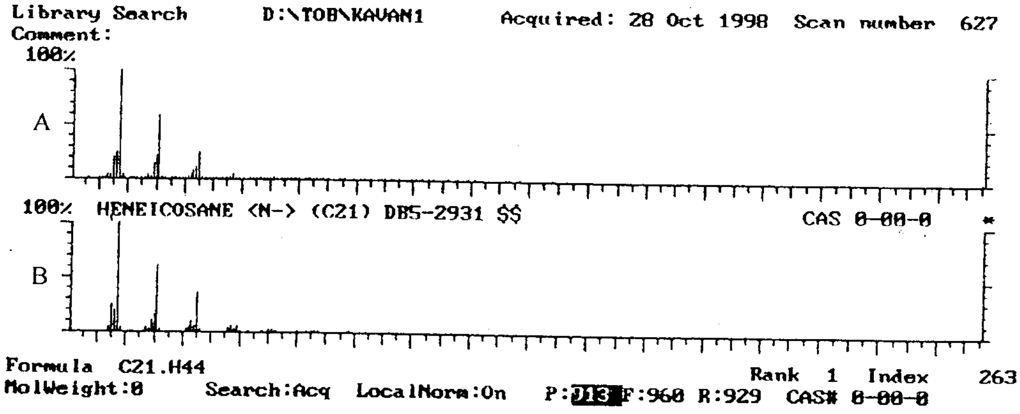

Figure 103 Mass spectra of gurjunene < α-> (A) and authentic gurjunene < α-> (B) by GC-MS



```
Library Search        D:\TOB\KAVAN1        Acquired: 28 Oct 1998   Scan number   627
Comment:
100%
100%  HENEICOSANE <N-> (C21) DBS-2931 $$                               CAS 0-00-0     *
Formula  C21.H44                                              Rank   1   Index      263
MolWeight:0        Search:Acq   LocalNorm:On    P:913 F:960 R:929   CAS# 0-00-0
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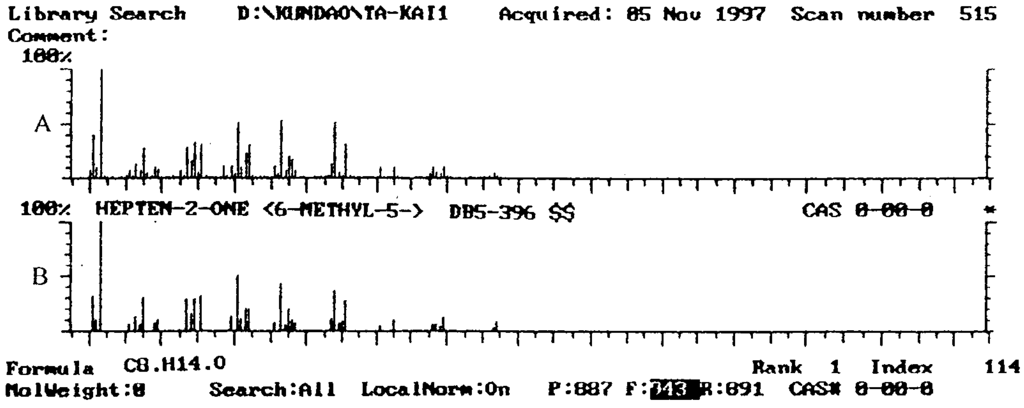
Figure 104 Mass spectra of heneicosane < *n*-> (A) and authentic heneicosane < *n*-> (B) by GC-MS



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Library Search     D:\KUNDAO\TA-KAI1     Acquired: 05 Nov 1997   Scan number   515
Comment:
100%
100%  HEPTEN-2-ONE <6-METHYL-5->  DBS-396 $$                           CAS 0-00-0     *
Formula   C8.H14.O                                            Rank   1   Index      114
MolWeight:0        Search:All   LocalNorm:On    P:887 F:743 R:891   CAS# 0-00-0
```

Figure 105 Mass spectra of hepten-*2-one* <*6*-methyl-*5*-> (A) and authentic hepten-*2-one* <*6*-methyl-*5*-> (B) by GC-MS

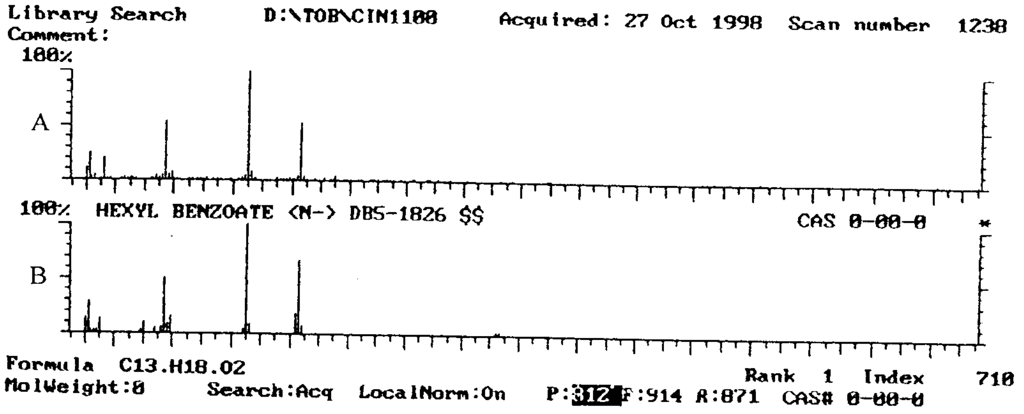


Figure 106 Mass spectra of hexyl benzoate < *n*-> (A) and authentic hexyl benzoate < *n*-> (B) by GC-MS

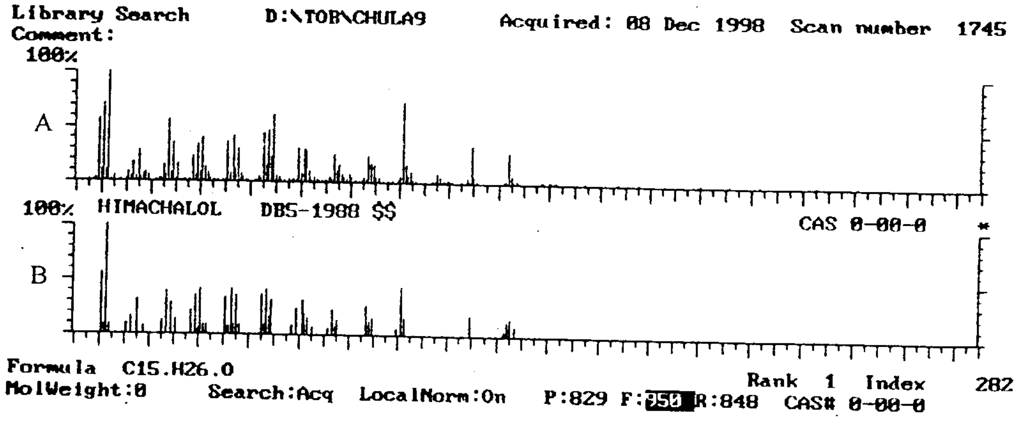


Figure 107 Mass spectra of himachalol (A) and authentic himachalol (B) by GC-MS

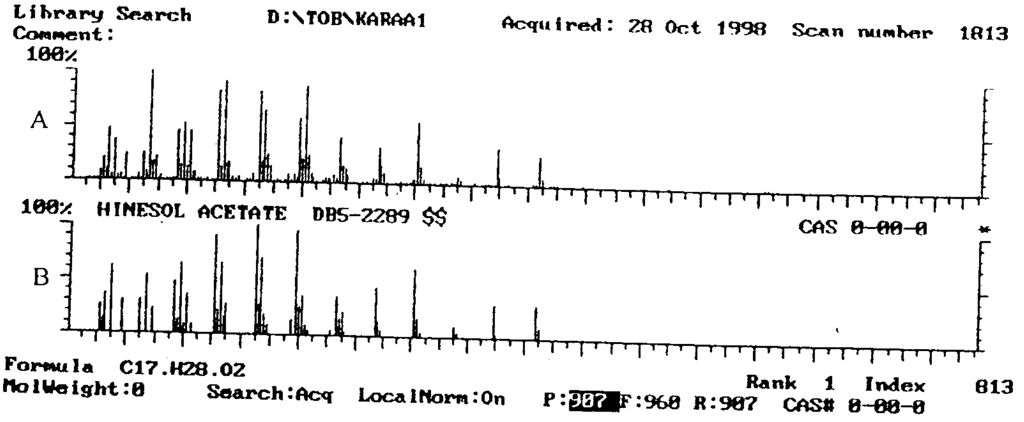
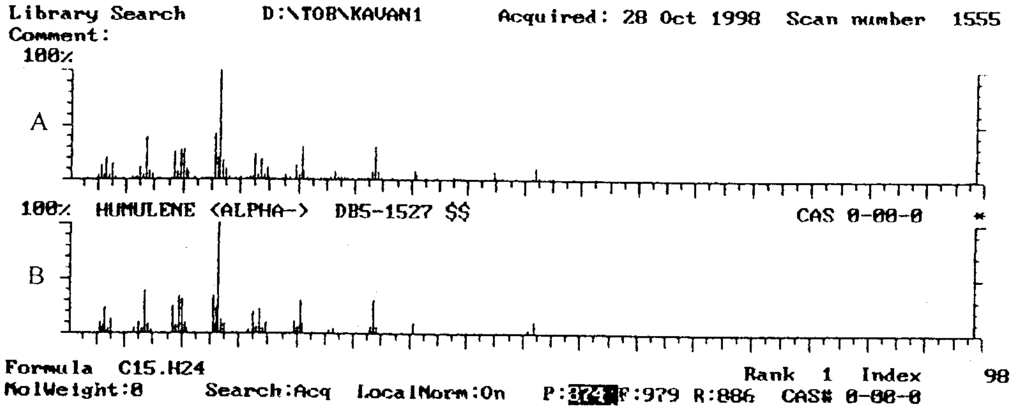
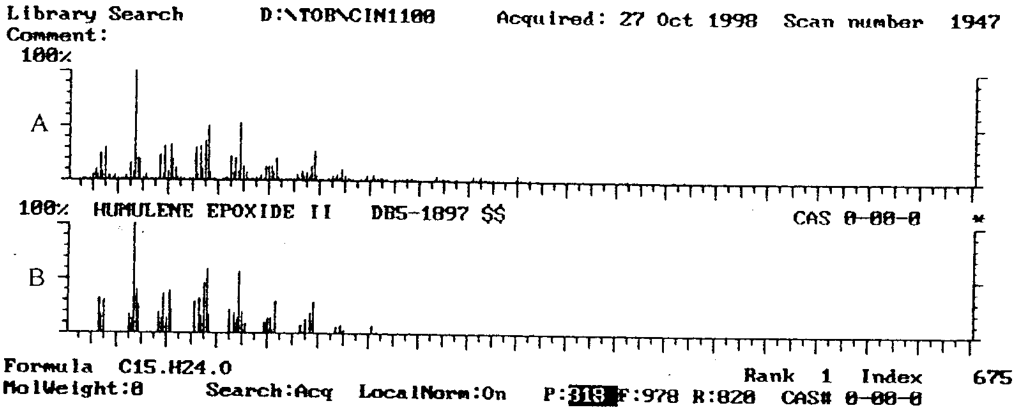


Figure 108 Mass spectra of hinesol acetate (A) and authentic hinesol acetate (B) by GC-MS



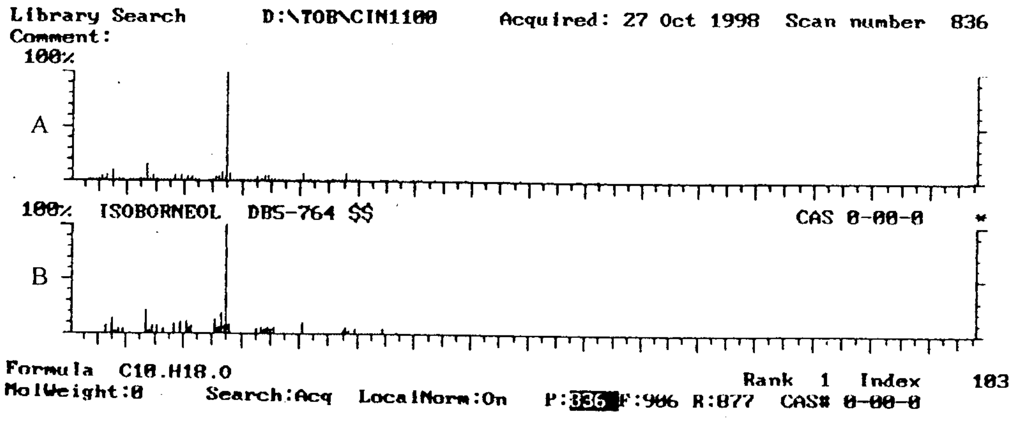
```
Library Search      D:\TOB\KAVAN1      Acquired: 28 Oct 1998   Scan number   1555
Comment:
100%
100%  HUMULENE <ALPHA->  DB5-1527 $$                            CAS 0-00-0      *
Formula   C15.H24                                             Rank   1   Index      98
MolWeight:0       Search:Acq    LocalNorm:On      P:374 F:979 R:886   CAS# 0-00-0
```

Figure 109 Mass spectra of humulene < α-> (A) and authentic humulene < α-> (B) by GC-MS



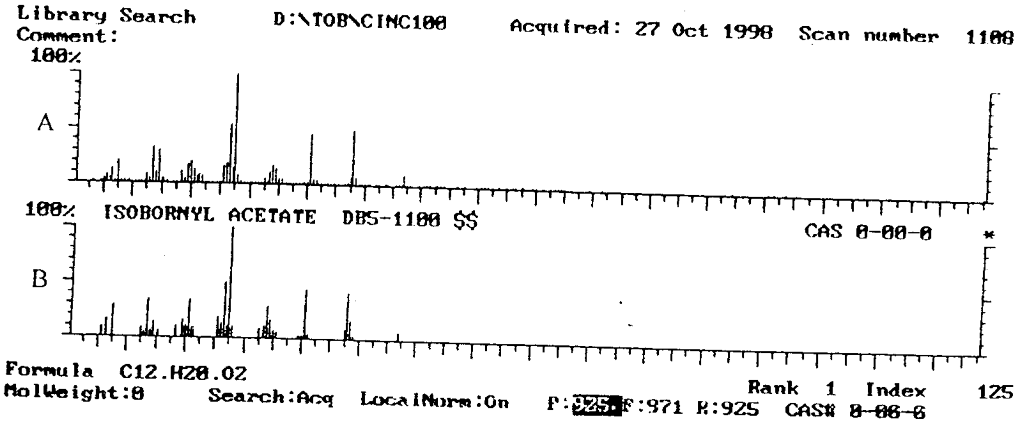
```
Library Search      D:\TOB\CIN1100      Acquired: 27 Oct 1998   Scan number   1947
Comment:
100%
100%  HUMULENE EPOXIDE II    DB5-1897 $$                          CAS 0-00-0      *
Formula   C15.H24.0                                           Rank   1   Index     675
MolWeight:0       Search:Acq    LocalNorm:On      P:318 F:978 R:820   CAS# 0-00-0
```

Figure 110 Mass spectra of humulene epoxide II (A) and authentic humulene epoxide II (B) by GC-MS



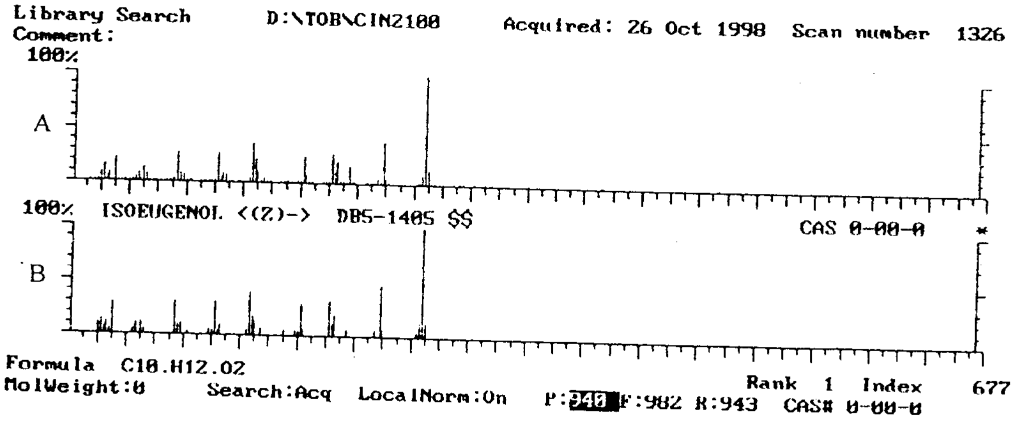
```
Library Search      D:\TOB\CIN1100      Acquired: 27 Oct 1998   Scan number   836
Comment:
100%
100%  ISOBORNEOL   DB5-764 $$                                   CAS 0-00-0      *
Formula   C10.H18.O                                           Rank   1   Index     103
MolWeight:0       Search:Acq    LocalNorm:On      P:336 F:966 R:877   CAS# 0-00-0
```

Figure 111 Mass spectra of isoborneol (A) and authentic isoborneol (B) by GC-MS



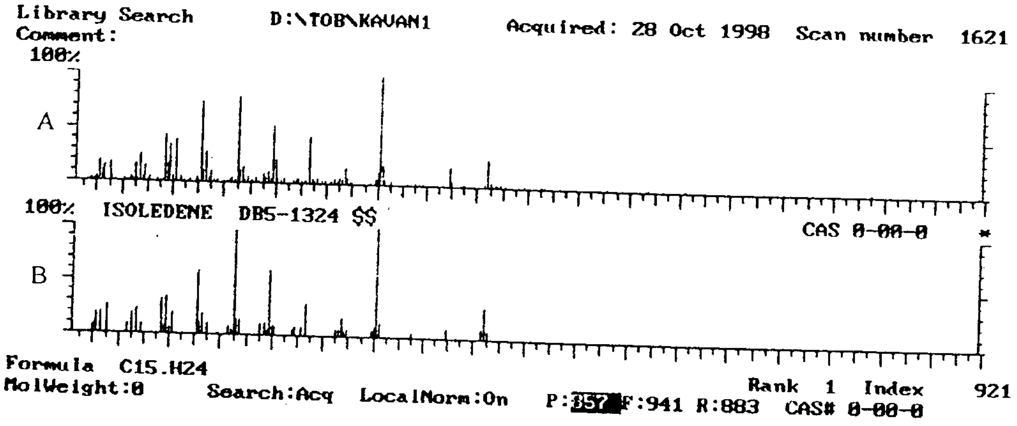
```
Library Search        D:\TOB\CINC100        Acquired: 27 Oct 1998   Scan number   1100
Comment:
100%
A
100%  ISOBORNYL ACETATE   DBS-1100 $$                                    CAS 0-00-0    *
B
Formula   C12.H20.O2
MolWeight:0        Search:Acq    LocalNorm:On      P:925 F:971 R:925    Rank  1  Index    125
                                                                        CAS# 0-00-0
```

Figure 112 Mass spectra of isobornyl acetate (A) and authentic isobornyl acetate (B) by GC-MS



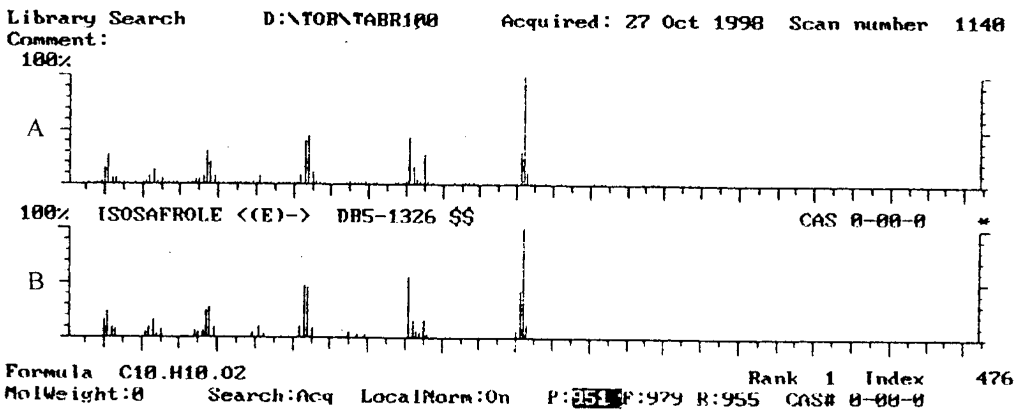
```
Library Search        D:\TOB\CIN2100        Acquired: 26 Oct 1998   Scan number   1326
Comment:
100%
A
100%  ISOEUGENOL <(Z)->   DBS-1405 $$                                    CAS 0-00-0    *
B
Formula   C10.H12.O2
MolWeight:0        Search:Acq    LocalNorm:On      P:940 F:982 R:943    Rank  1  Index    677
                                                                        CAS# 0-00-0
```

Figure 113 Mass spectra of isoeugenol *<(Z)->* (A) and authentic isoeugenol *<(Z)->* (B) by GC-MS



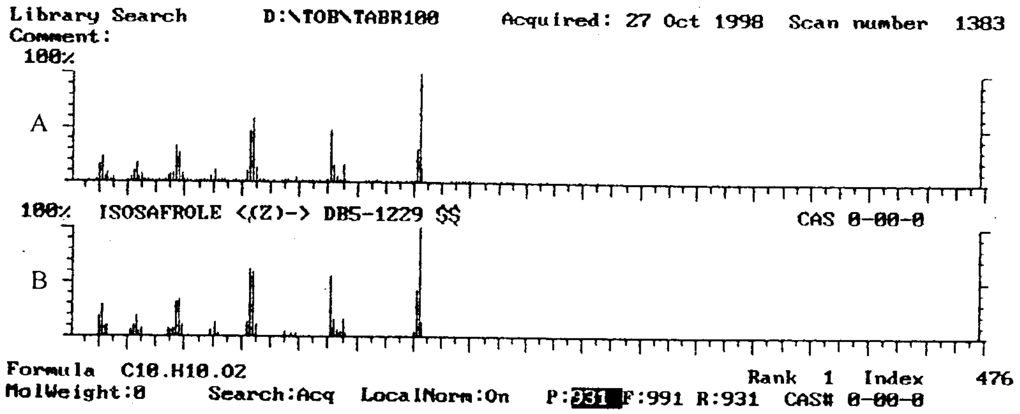
```
Library Search        D:\TOB\KAVAN1         Acquired: 28 Oct 1998   Scan number   1621
Comment:
100%
A
100%  ISOLEDENE   DBS-1324 $$                                            CAS 0-00-0    *
B
Formula   C15.H24
MolWeight:0        Search:Acq    LocalNorm:On      P:857 F:941 R:883    Rank  1  Index    921
                                                                        CAS# 0-00-0
```

Figure 114 Mass spectra of isoledene (A) and authentic isoledene (B) by GC-MS



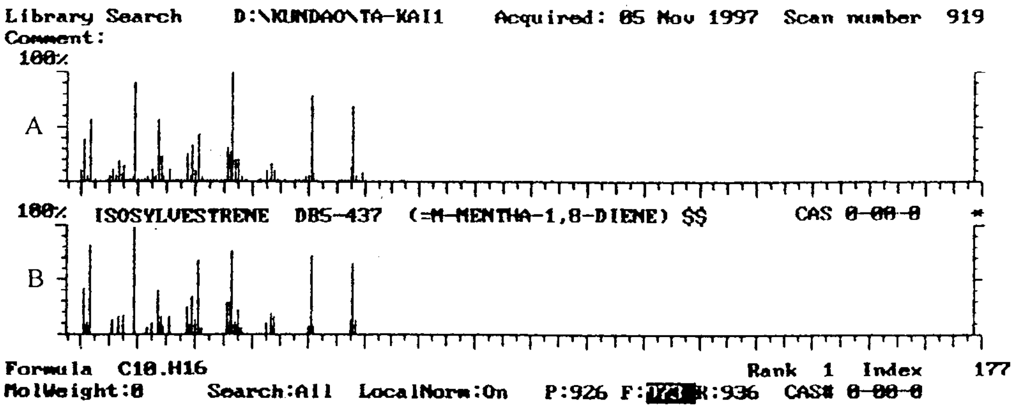
```
Library Search        D:\TOB\TABR100      Acquired: 27 Oct 1998   Scan number   1140
Comment:
100%
A
100%  ISOSAFROLE <(E)->  DB5-1326 $$                                  CAS 0-00-0      *
B
Formula   C10.H10.O2                                          Rank   1   Index      476
MolWeight:0        Search:Acq    LocalNorm:On     P:951 F:979 R:955   CAS# 0-00-0
```

Figure 115 Mass spectra of isosafrole *<(E)->* (A) and authentic isosafrole *<(E)->* (B) by GC-MS



```
Library Search        D:\TOB\TABR100      Acquired: 27 Oct 1998   Scan number   1383
Comment:
100%
A
100%  ISOSAFROLE <(Z)-> DB5-1229 $$                                   CAS 0-00-0
B
Formula   C10.H10.O2                                          Rank   1   Index      476
MolWeight:0        Search:Acq    LocalNorm:On     P:931 F:991 R:931   CAS# 0-00-0
```

Figure 116 Mass spectra of isosafrole *<(Z)->* (A) and authentic isosafrole *<(Z)->* (B) by GC-MS



```
Library Search     D:\KUNDAO\TA-KAI1     Acquired: 05 Nov 1997   Scan number   919
Comment:
100%
A
100%  ISOSYLVESTRENE   DB5-437   (=M-MENTHA-1,8-DIENE) $$          CAS 0-00-0      *
B
Formula   C10.H16                                              Rank   1   Index      177
MolWeight:0        Search:All    LocalNorm:On     P:926 F:973 R:936   CAS# 0-00-0
```

Figure 117 Mass spectra of isosylvestrene (A) and authentic isosylvestrene (B) by GC-MS

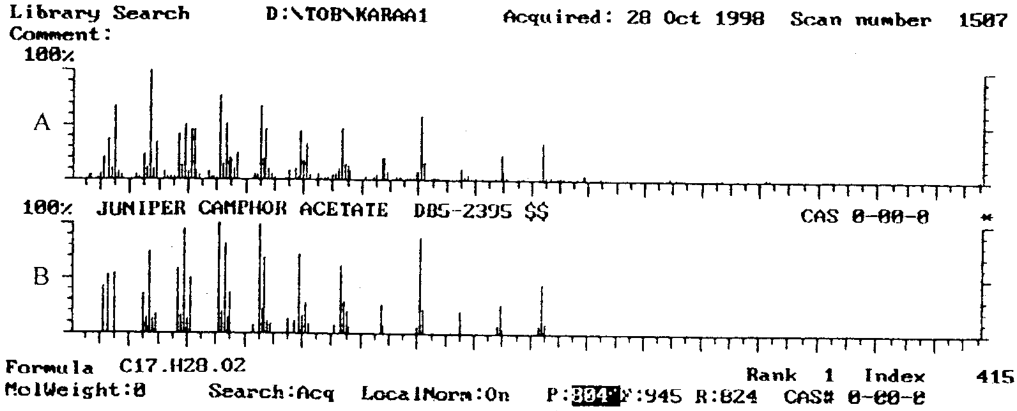


Figure 118 Mass spectra of juniper camphor acetate (A) and authentic juniper camphor acetate (B) by GC-MS

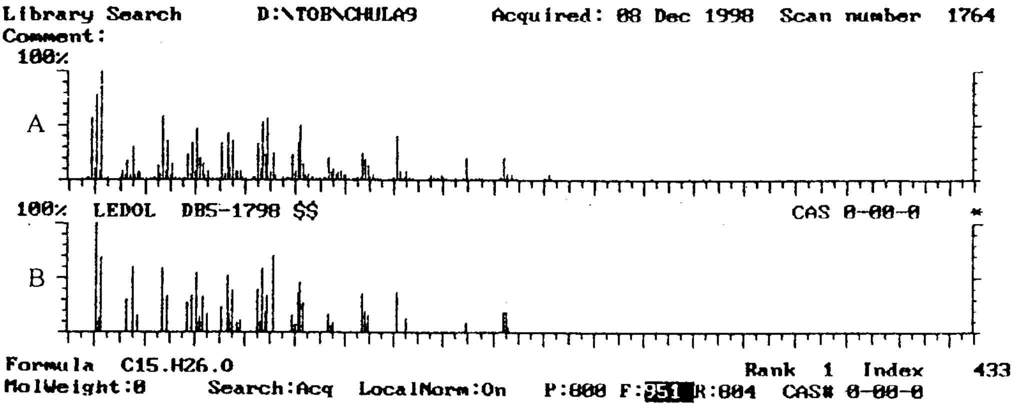


Figure 119 Mass spectra of ledol (A) and authentic ledol (B) by GC-MS

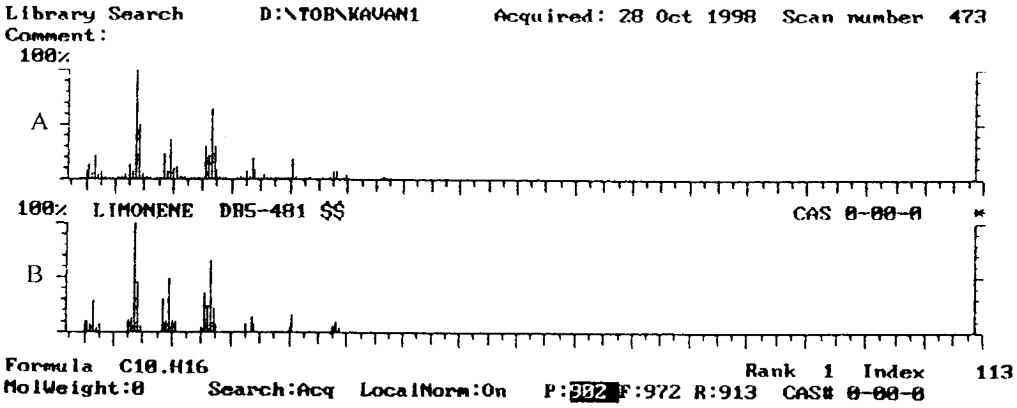
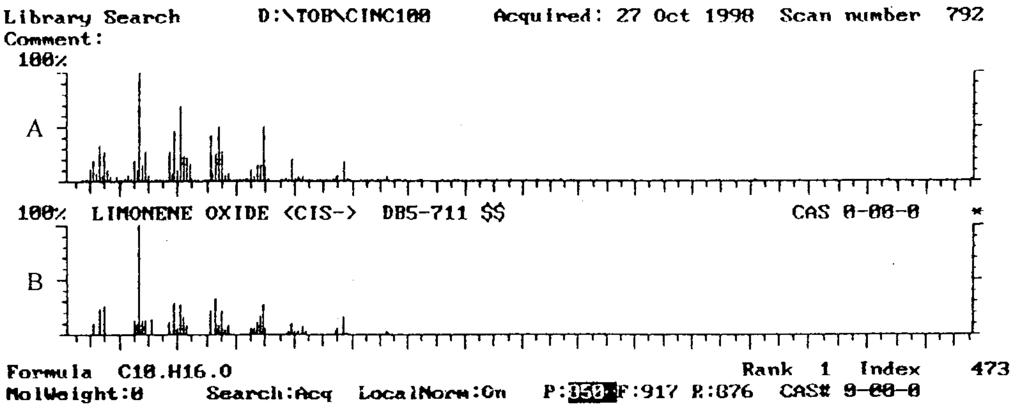
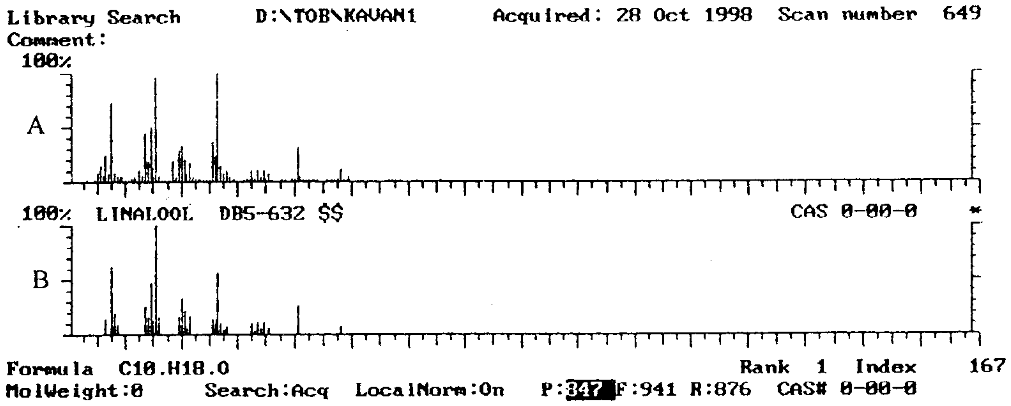


Figure 120 Mass spectra of limonene (A) and authentic limonene (B) by GC-MS



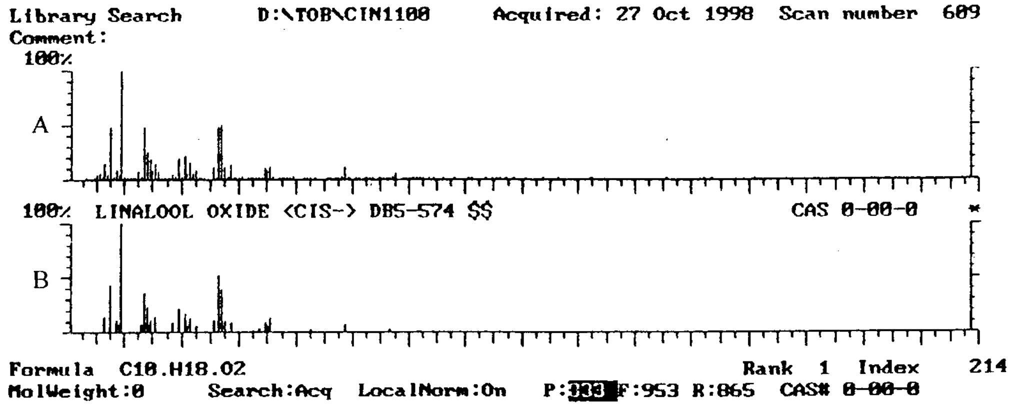
```
Library Search        D:\TOB\CINC100        Acquired: 27 Oct 1998   Scan number  792
Comment:
 100%
 A
100%  LIMONENE OXIDE <CIS->  DB5-711 $$                                CAS 0-00-0     *
 B
Formula   C10.H16.O                                              Rank   1   Index     473
MolWeight:0        Search:Acq    LocalNorm:On      P:350 F:917 R:876   CAS# 9-00-0
```

Figure 121 Mass spectra of limonene oxide < *cis*-> (A) and authentic limonene oxide < *cis*-> (B) by GC-MS



```
Library Search        D:\TOB\KAVAN1         Acquired: 28 Oct 1998   Scan number  649
Comment:
 100%
 A
100%  LINALOOL   DB5-632 $$                                           CAS 0-00-0     *
 B
Formula   C10.H18.O                                              Rank   1   Index     167
MolWeight:0        Search:Acq    LocalNorm:On      P:347 F:941 R:876   CAS# 0-00-0
```

Figure 122 Mass spectra of linalool (A) and authentic linalool (B) by GC-MS



```
Library Search        D:\TOB\CIN1100        Acquired: 27 Oct 1998   Scan number  609
Comment:
 100%
 A
100%  LINALOOL OXIDE <CIS-> DB5-574 $$                                CAS 0-00-0     *
 B
Formula   C10.H18.O2                                             Rank   1   Index     214
MolWeight:0        Search:Acq    LocalNorm:On      P:333 F:953 R:865   CAS# 0-00-0
```

Figure 123 Mass spectra of linalool oxide < *cis*-> (A) and authentic linalool oxide < *cis*-> (B) by GC-MS

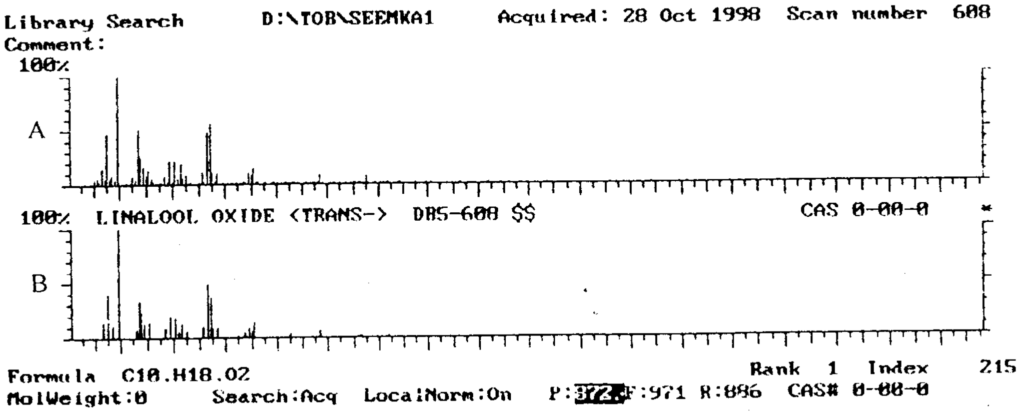


Figure 124 Mass spectra of linalool oxide < *trans*-> (A) and authentic linalool oxide < *trans*-> (B) by GC-MS

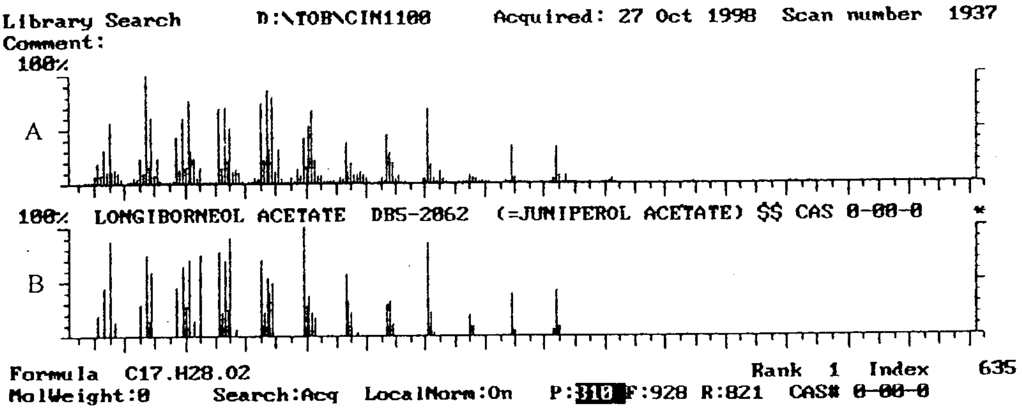


Figure 125 Mass spectra of longiborneol acetate (A) and authentic longiborneol acetate (B) by GC-MS

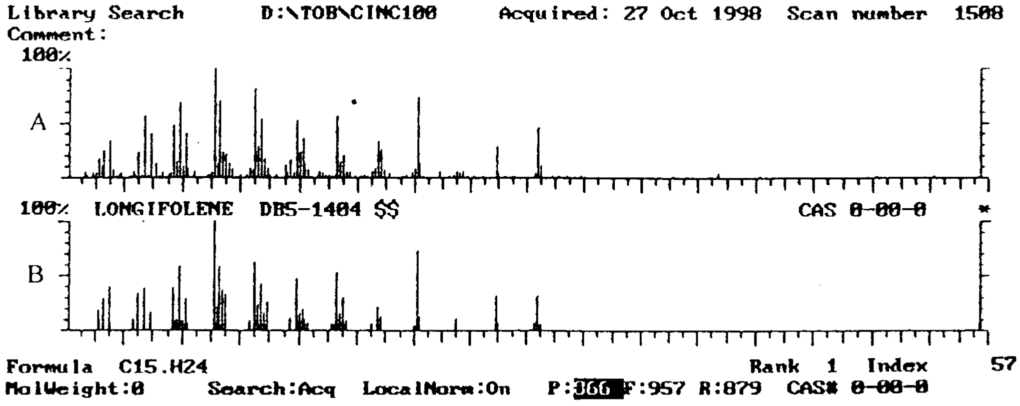
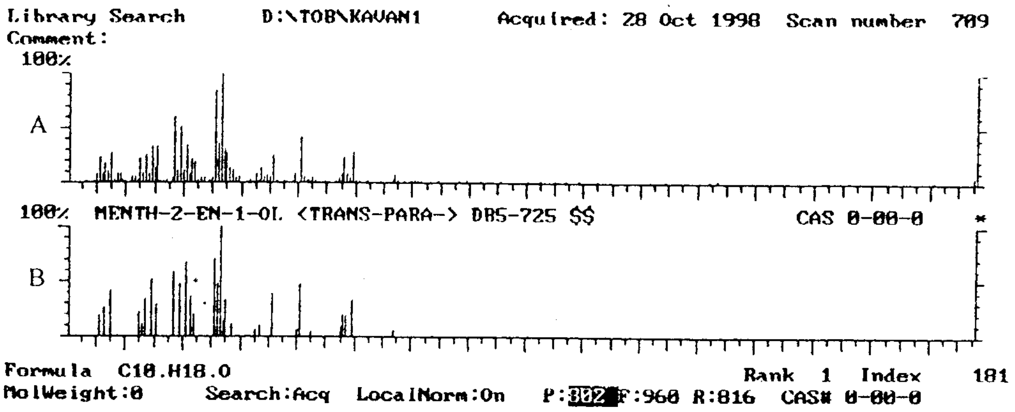
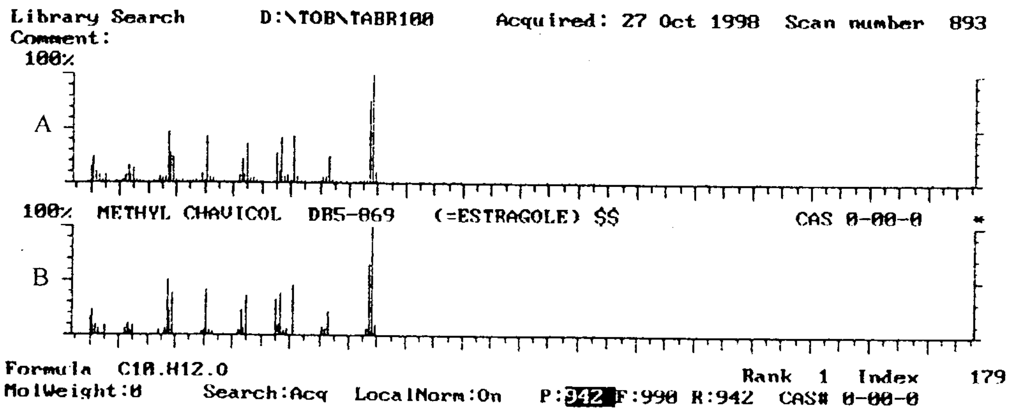


Figure 126 Mass spectra of longifolene (A) and authentic longifolene (B) by GC-MS



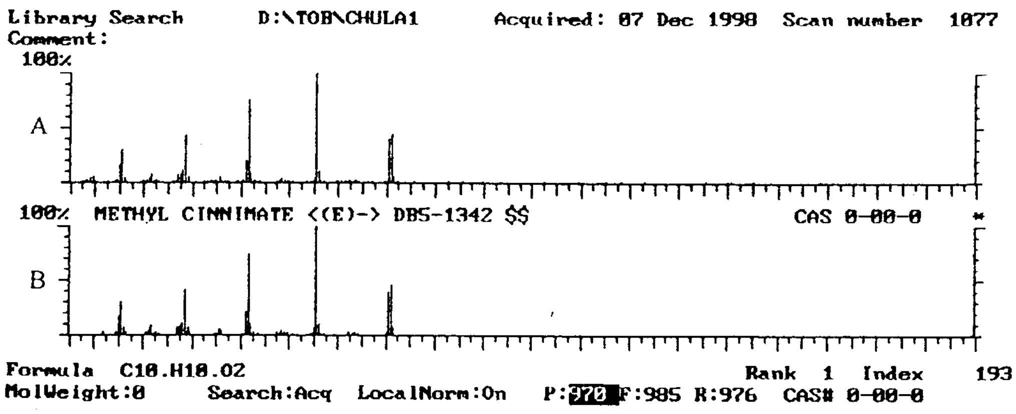
```
Library Search        D:\TOB\KAVAN1          Acquired: 28 Oct 1998   Scan number  709
Comment:
100%  MENTH-2-EN-1-OL <TRANS-PARA-> DB5-725 $$                       CAS 0-00-0     *
Formula   C10.H18.O                                                  Rank  1  Index    181
MolWeight:0        Search:Acq   LocalNorm:On      P:802 F:960 R:816  CAS# 0-00-0
```

Figure 127 Mass spectra of menth-*2*-en-*1-ol* < *trans-para->* (A) and authentic menth-*2*-en-*1-ol* < *trans-para->* (B) by GC-MS



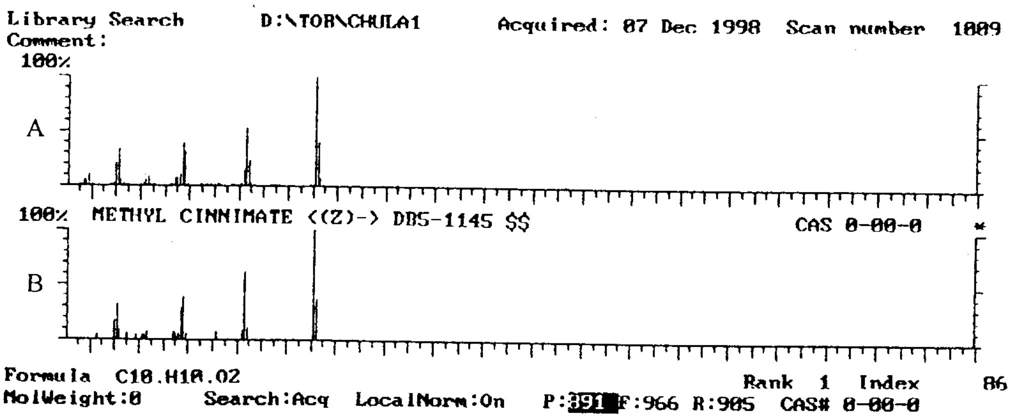
```
Library Search        D:\TOB\TABR100         Acquired: 27 Oct 1998   Scan number  893
Comment:
100%  METHYL CHAVICOL   DB5-869    (=ESTRAGOLE) $$                   CAS 0-00-0     *
Formula   C10.H12.O                                                  Rank  1  Index    179
MolWeight:0        Search:Acq   LocalNorm:On      P:942 F:990 R:942  CAS# 0-00-0
```

Figure 128 Mass spectra of methyl chavicol (A) and authentic methyl chavicol (B) by GC-MS



```
Library Search        D:\TOB\CHULA1          Acquired: 07 Dec 1998   Scan number  1077
Comment:
100%  METHYL CINNIMATE <(E)-> DB5-1342 $$                            CAS 0-00-0     *
Formula   C10.H10.O2                                                 Rank  1  Index    193
MolWeight:0        Search:Acq   LocalNorm:On      P:970 F:985 R:976  CAS# 0-00-0
```

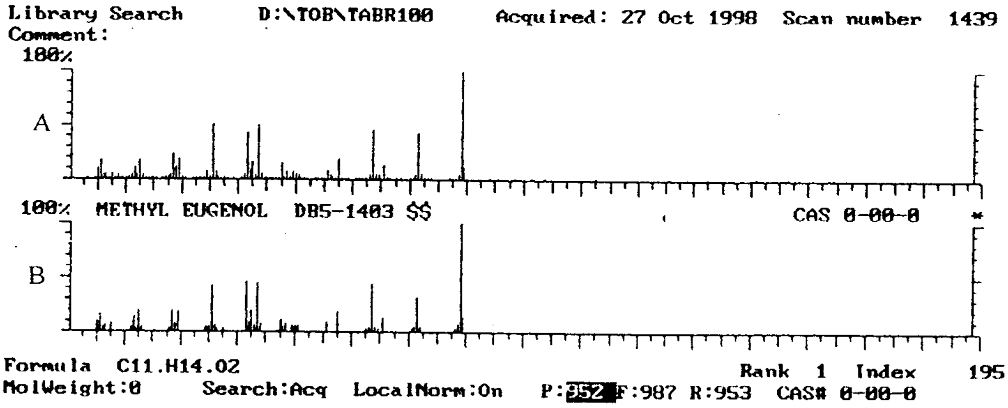
Figure 129 Mass spectra of methyl cinnamate < *(E)->* (A) and authentic methyl cinnamate < *(E)->* (B) by GC-MS


Library Search D:\TOB\CHULA1 Acquired: 07 Dec 1998 Scan number 1009
Comment:
100%

100% METHYL CINNIMATE <(Z)-> DBS-1145 $$ CAS 0-00-0 *

Formula C10.H10.O2 Rank 1 Index 86
MolWeight:0 Search:Acq LocalNorm:On P:891 F:966 R:905 CAS# 0-00-0

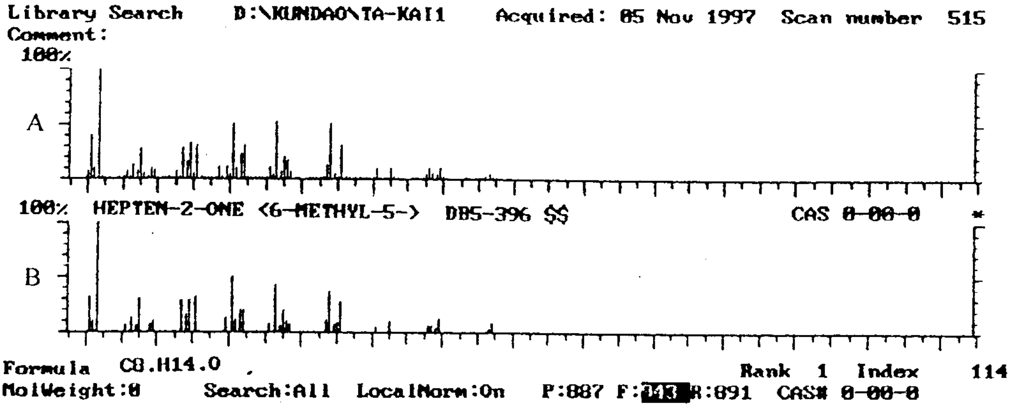
Figure 130 Mass spectra of methyl cinnamate < *(Z)*-> (A) and authentic methyl cinnamate < *(Z)*-> (B) by GC-MS


Library Search D:\TOB\TABR100 Acquired: 27 Oct 1998 Scan number 1439
Comment:
100%

100% METHYL EUGENOL DBS-1403 $$ CAS 0-00-0 *

Formula C11.H14.O2 Rank 1 Index 195
MolWeight:0 Search:Acq LocalNorm:On P:952 F:987 R:953 CAS# 0-00-0

Figure 131 Mass spectra of methyl eugenol (A) and authentic methyl eugenol (B) by GC-MS


Library Search D:\KUNDAO\TA-KAI1 Acquired: 05 Nov 1997 Scan number 515
Comment:
100%

100% HEPTEN-2-ONE <6-METHYL-5-> DBS-396 $$ CAS 0-00-0 *

Formula C8.H14.O Rank 1 Index 114
MolWeight:0 Search:All LocalNorm:On P:887 F:943 R:891 CAS# 0-00-0

Figure 132 Mass spectra of *6*-methyl-*5*-hepten-*2*-one (A) and authentic *6*-methyl-*5*-hepten-*2*-one (B) by GC-MS

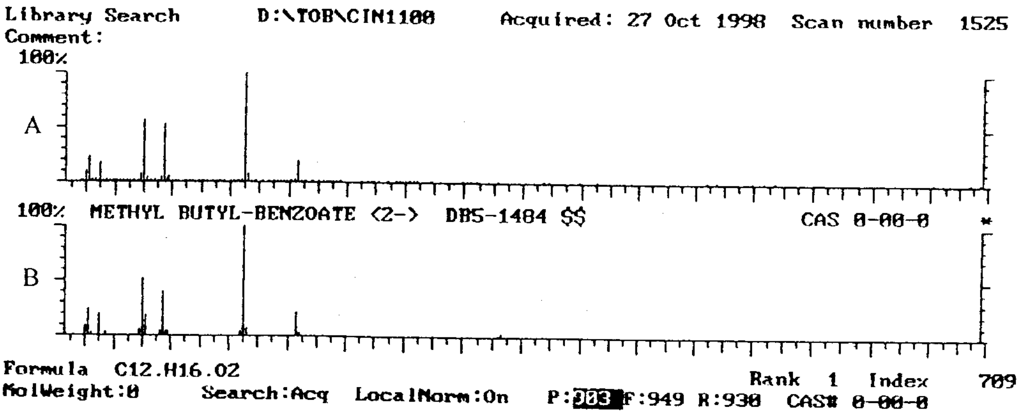


Figure 133 Mass spectra of methyl-butyl-benzoate < *2-*> (A) and authentic methyl-butyl-benzoate < *2-*> (B) by GC-MS

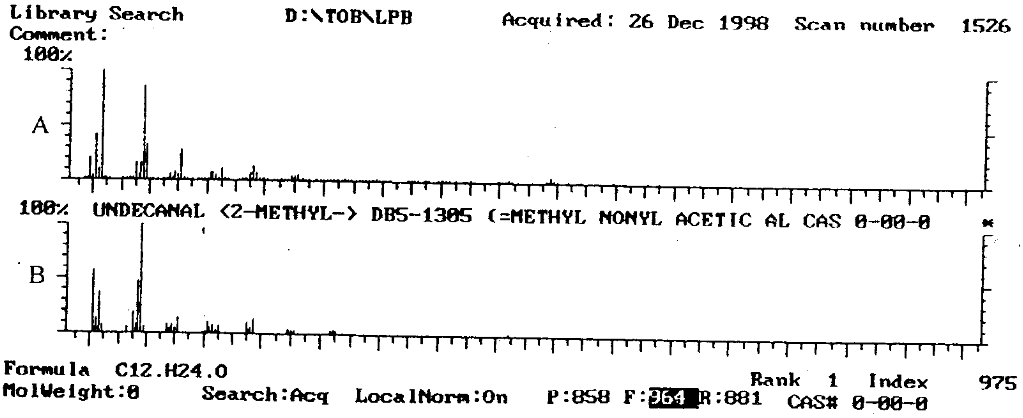


Figure 134 Mass spectra of methyl-undecanal < *2-*> (A) and authentic methyl-undecanal < *2-*> (B) by GC-MS

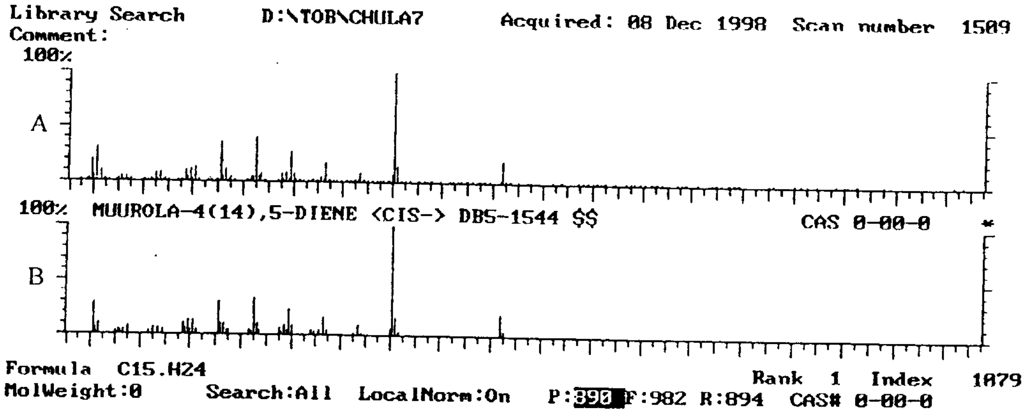
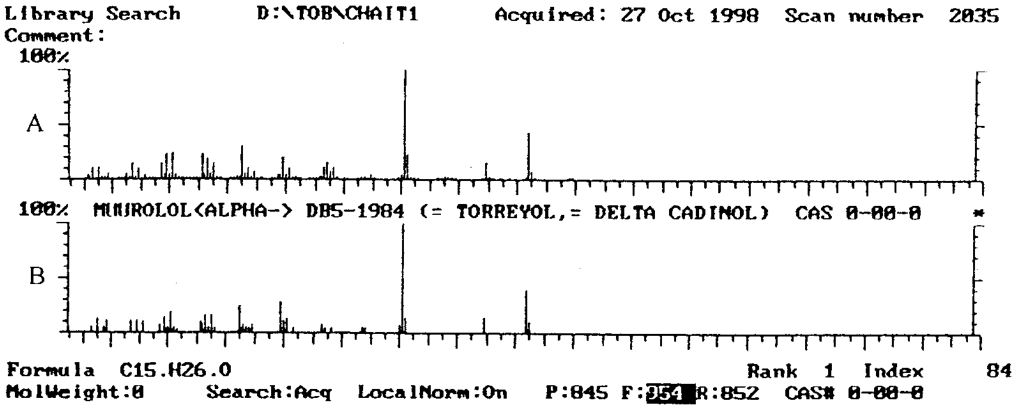
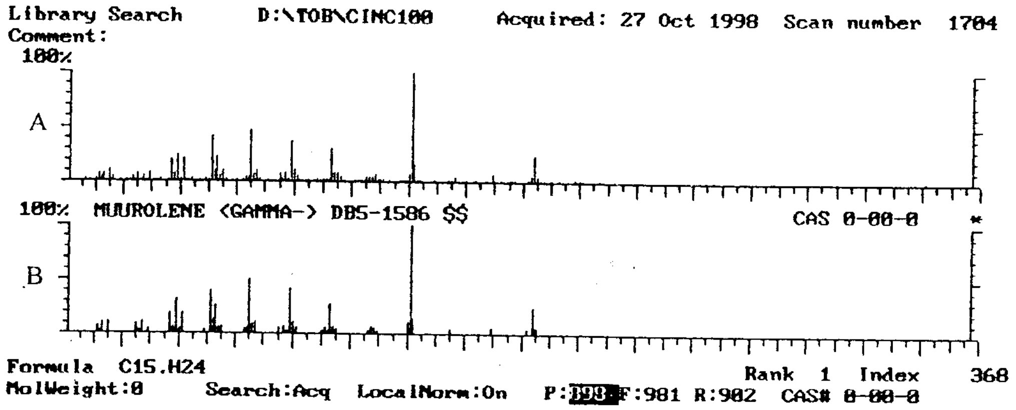


Figure 135 Mass spectra of muurola-*4(14),5-diene* < *cis-*> (A) and authentic muurola-*4(14),5-diene* < *cis-*> (B) by GC-MS



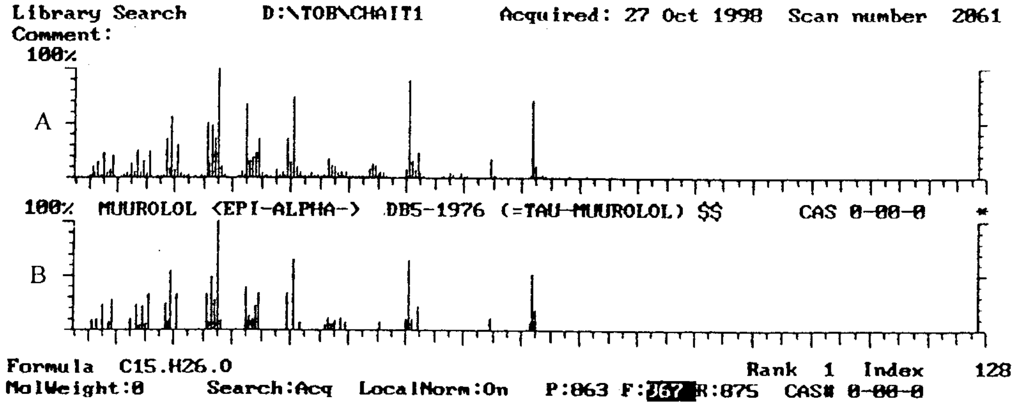
```
Library Search        D:\TOB\CHAIT1        Acquired: 27 Oct 1998  Scan number  2035
Comment:
100%
100%  MUUROLOL<ALPHA-> DB5-1984 (= TORREYOL,= DELTA CADINOL)  CAS 0-00-0     *
Formula  C15.H26.0                                      Rank  1  Index      84
MolWeight:0      Search:Acq   LocalNorm:On    P:845 F:854 R:852  CAS# 0-00-0
```

Figure 136 Mass spectra of muurolene < α-> (A) and authentic muurolene < α-> (B) by GC-MS



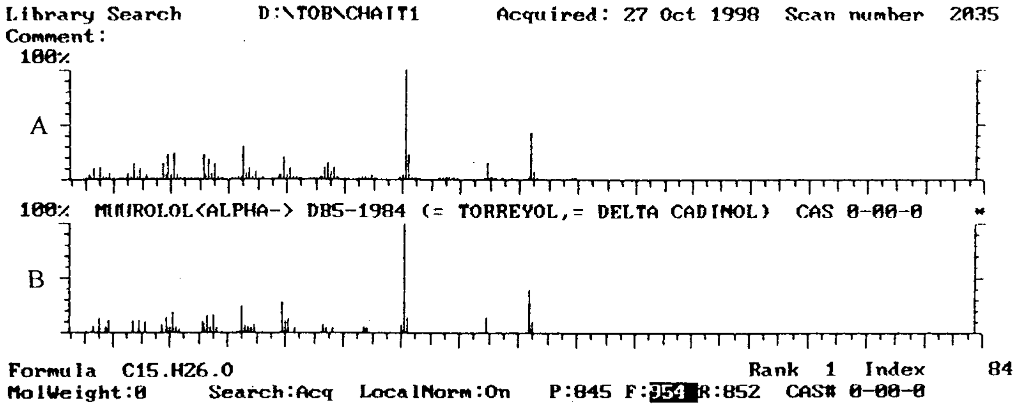
```
Library Search        D:\TOB\CINC100       Acquired: 27 Oct 1998  Scan number  1704
Comment:
100%
100%  MUUROLENE <GAMMA-> DB5-1586 $$                         CAS 0-00-0     *
Formula  C15.H24                                        Rank  1  Index     368
MolWeight:0      Search:Acq   LocalNorm:On    P:898 F:981 R:982  CAS# 0-00-0
```

Figure 137 Mass spectra of muurolene < γ-> (A) and authentic muurolene < γ-> (B) by GC-MS



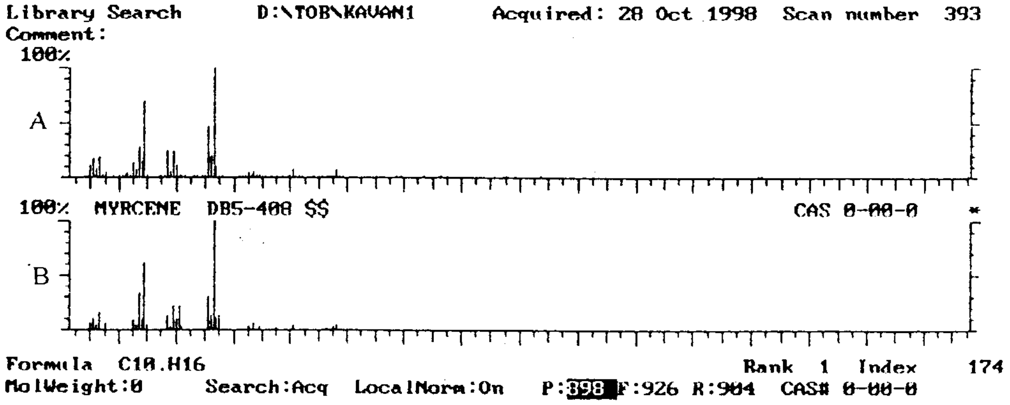
```
Library Search        D:\TOB\CHAIT1        Acquired: 27 Oct 1998  Scan number  2061
Comment:
100%
100%  MUUROLOL <EPI-ALPHA-> DB5-1976 (=TAU-MUUROLOL) $$      CAS 0-00-0     *
Formula  C15.H26.0                                      Rank  1  Index     128
MolWeight:0      Search:Acq   LocalNorm:On    P:863 F:867 R:875  CAS# 0-00-0
```

Figure 138 Mass spectra of muurolol <*epi*-α-> (A) and authentic muurolol <*epi*-α-> (B) by GC-MS



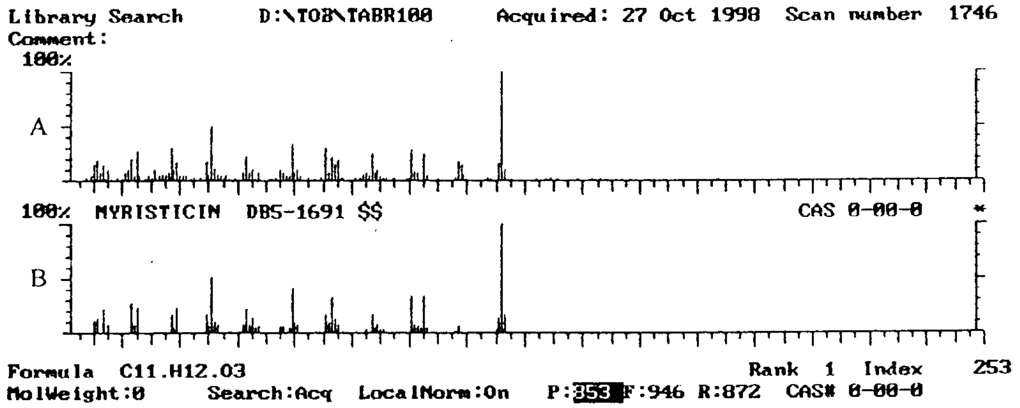
```
Library Search       D:\TOB\CHAIT1       Acquired: 27 Oct 1998  Scan number  2035
Comment:
100%  MUUROLOL<ALPHA-> DB5-1984 (= TORREYOL,= DELTA CADINOL)  CAS 0-00-0      *
Formula  C15.H26.O                                       Rank  1  Index      84
MolWeight:0      Search:Acq   LocalNorm:On    P:845 F:954 R:852  CAS# 0-00-0
```

Figure 139 Mass spectra of muurolol< α-> (A) and authentic muurolol< α-> (B) by GC-MS



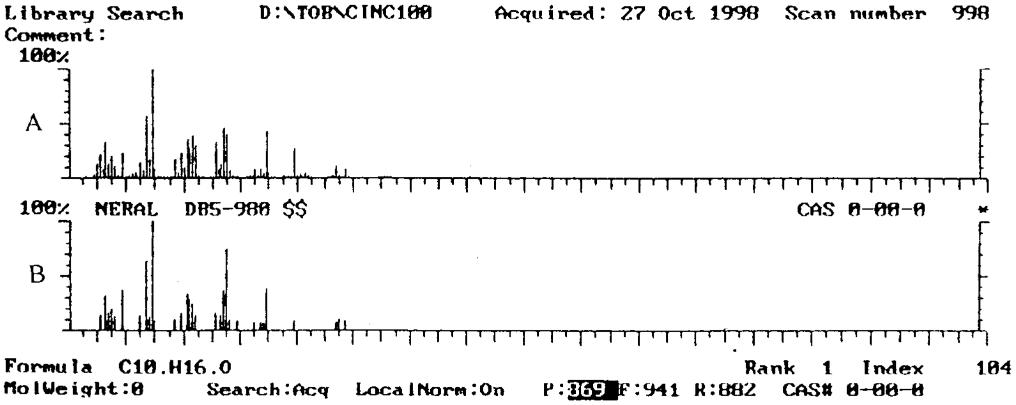
```
Library Search       D:\TOB\KAVAN1       Acquired: 28 Oct 1998  Scan number   393
Comment:
100%  MYRCENE  DB5-408 $$                                    CAS 0-00-0      *
Formula  C10.H16                                        Rank  1  Index      174
MolWeight:0      Search:Acq   LocalNorm:On   P:398 F:926 R:904  CAS# 0-00-0
```

Figure 140 Mass spectra of myrcene (A) and authentic myrcene (B) by GC-MS



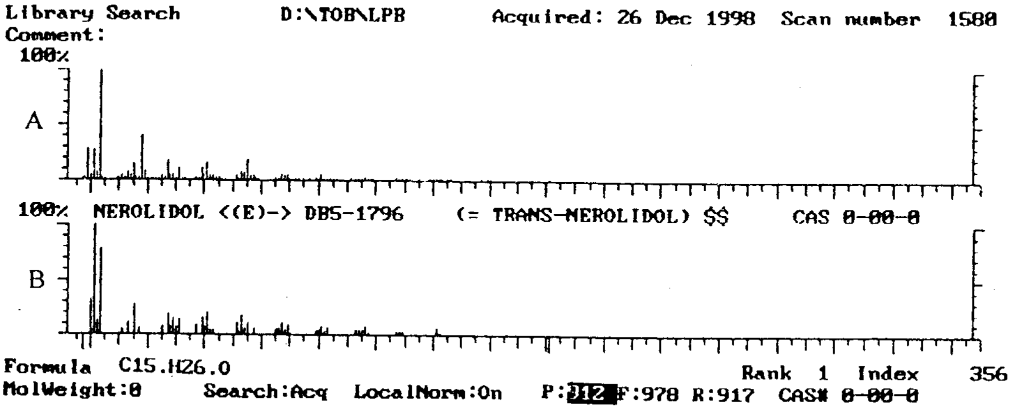
```
Library Search       D:\TOB\TABR100      Acquired: 27 Oct 1998  Scan number  1746
Comment:
100%  MYRISTICIN  DB5-1691 $$                                CAS 0-00-0      *
Formula  C11.H12.O3                                     Rank  1  Index      253
MolWeight:0      Search:Acq   LocalNorm:On   P:353 F:946 R:872  CAS# 0-00-0
```

Figure 141 Mass spectra of myristicin (A) and authentic myristicin (B) by GC-MS



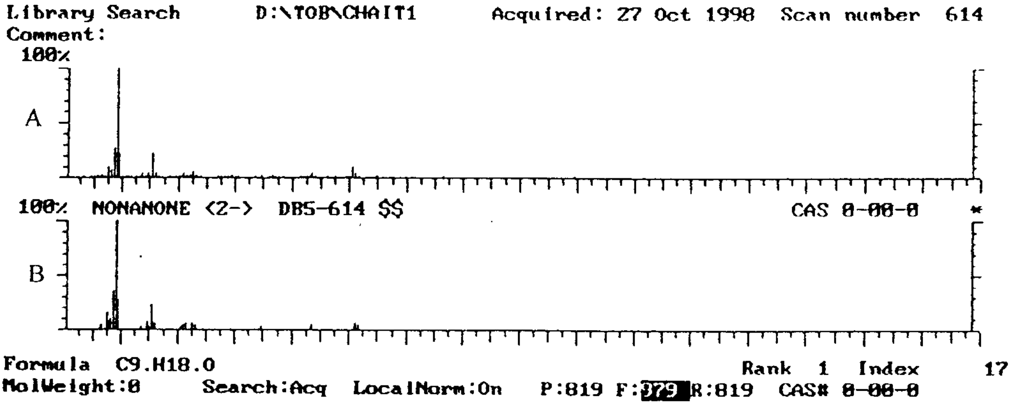
```
Library Search        D:\TOB\CINC100       Acquired: 27 Oct 1998  Scan number  998
Comment:
100%  NERAL   DB5-980 $$                                           CAS 0-00-0
Formula   C10.H16.0                                          Rank  1  Index     104
MolWeight:0      Search:Acq    LocalNorm:On     P:369 F:941 R:882  CAS# 0-00-0
```

Figure 142 Mass spectra of neral (A) and authentic neral (B) by GC-MS



```
Library Search        D:\TOB\LPB           Acquired: 26 Dec 1998  Scan number  1580
Comment:
100%  NEROLIDOL <(E)-> DB5-1796    (= TRANS-NEROLIDOL) $$       CAS 0-00-0
Formula   C15.H26.0                                          Rank  1  Index     356
MolWeight:0      Search:Acq    LocalNorm:On     P:912 F:978 R:917  CAS# 0-00-0
```

Figure 143 Mass spectra of nerolidol < *(E)*-> (A) and authentic nerolidol < *(E)*-> (B) by GC-MS



```
Library Search        D:\TOB\CHAIT1        Acquired: 27 Oct 1998  Scan number  614
Comment:
100%  NONANONE <2->  DB5-614 $$                                    CAS 0-00-0
Formula   C9.H18.0                                           Rank  1  Index      17
MolWeight:0      Search:Acq    LocalNorm:On     P:819 F:379 R:819  CAS# 0-00-0
```

Figure 144 Mass spectra of nonanone <2-> (A) and authentic nonanone <2-> (B) by GC-MS

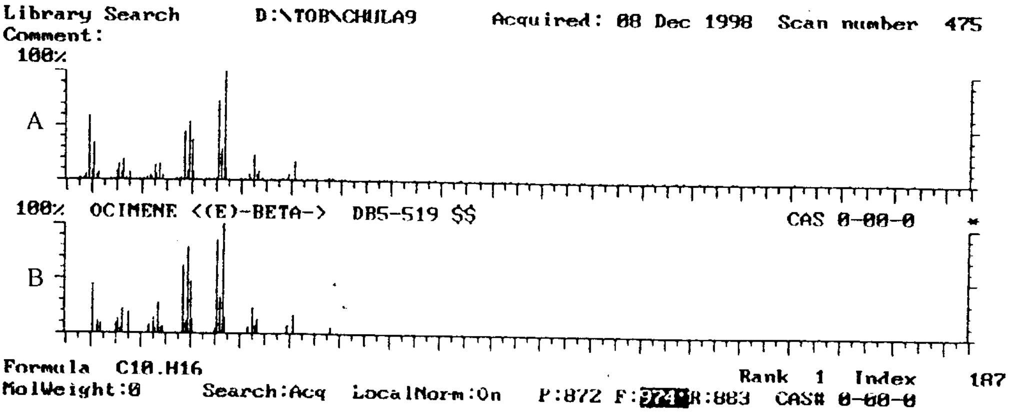


Figure 145 Mass spectra of ocimene < *(E)*-β-> (A) and authentic ocimene < *(E)*-β-> (B) by GC-MS

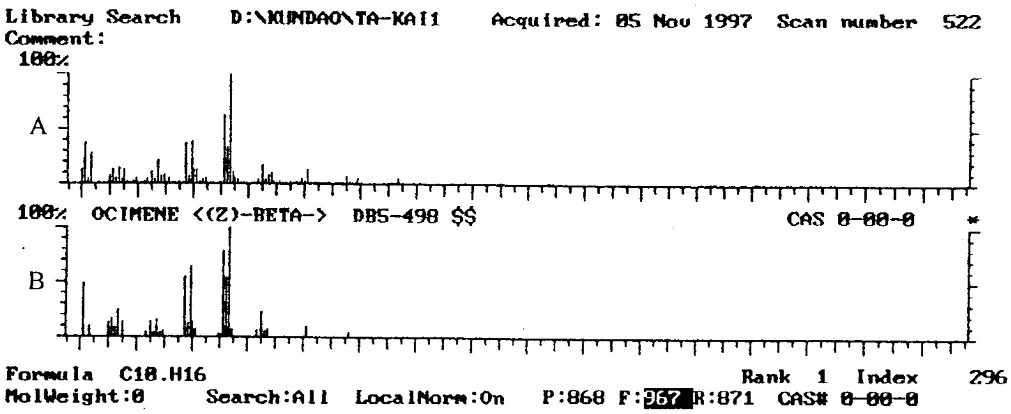


Figure 146 Mass spectra of ocimene < *(Z)*-β-> (A) and authentic ocimene < *(Z)*-β-> (B) by GC-MS

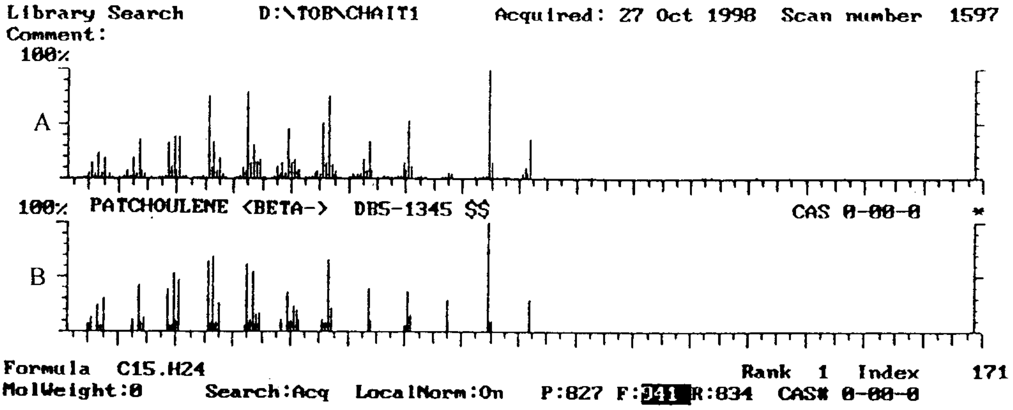
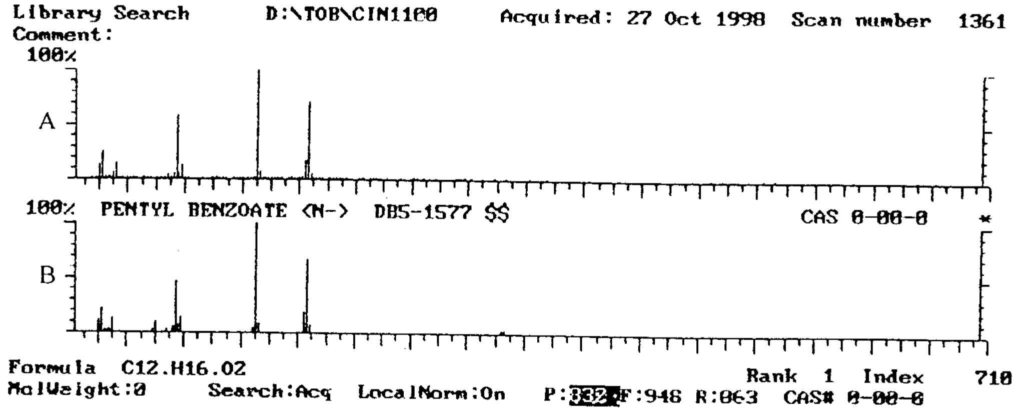
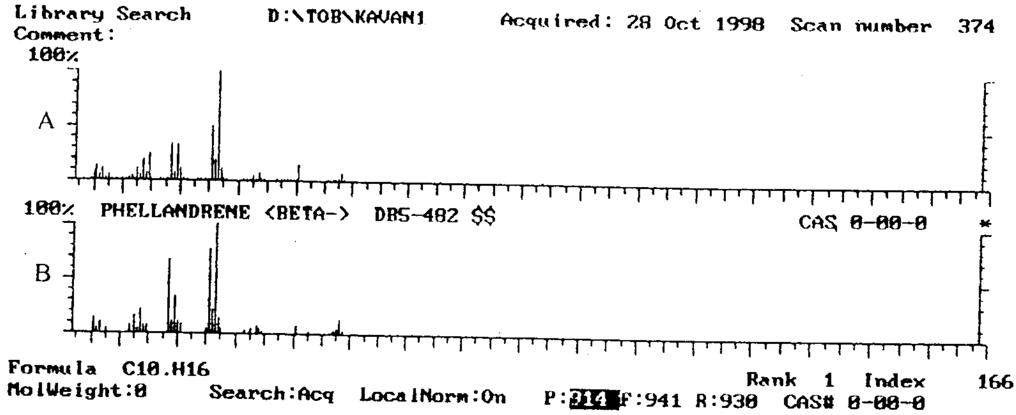


Figure 147 Mass spectra of patchoulene < β-> (A) and authentic patchoulene < β-> (B) by GC-MS



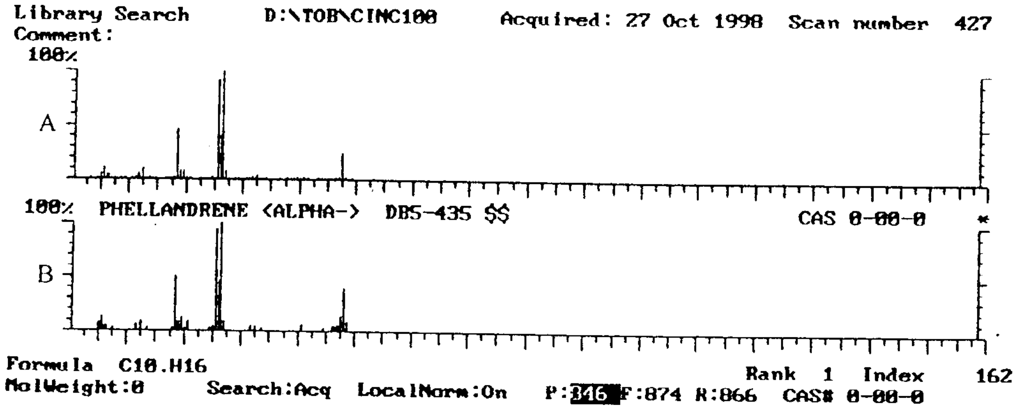
```
Library Search        D:\TOB\CIN1100        Acquired: 27 Oct 1998   Scan number   1361
Comment:
100%  PENTYL BENZOATE <N->  DBS-1577 $$                                 CAS 0-00-0     *
Formula   C12.H16.O2                                            Rank   1  Index      710
MolWeight:0        Search:Acq   LocalNorm:On     P:332 F:948 R:863   CAS# 0-00-0
```

Figure 148 Mass spectra of pentyl benzoate < *n*-> (A) and authentic pentyl benzoate < *n*-> (B) by GC-MS



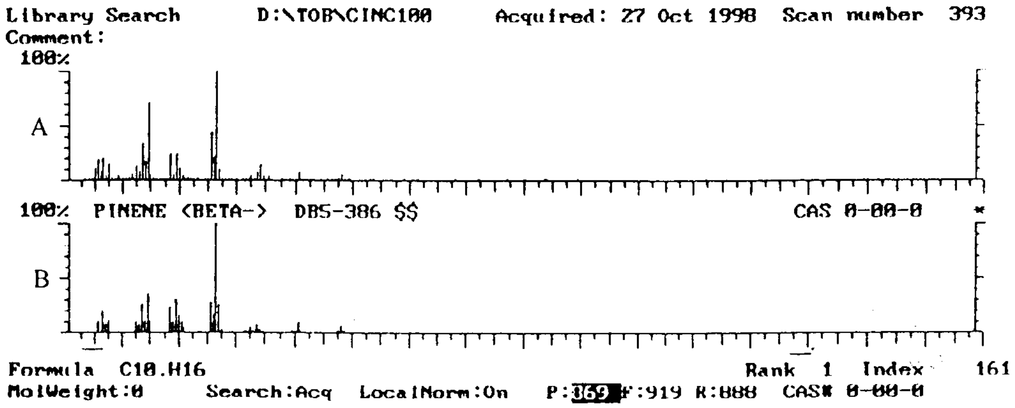
```
Library Search        D:\TOB\KAVAN1         Acquired: 28 Oct 1998   Scan number   374
Comment:
100%  PHELLANDRENE <BETA->  DBS-482 $$                                  CAS 0-00-0     *
Formula   C10.H16                                               Rank   1  Index      166
MolWeight:0        Search:Acq   LocalNorm:On     P:214 F:941 R:930   CAS# 0-00-0
```

Figure 149 Mass spectra of phellandrene < β-> (A) and authentic phellandrene < β-> (B) by GC-MS



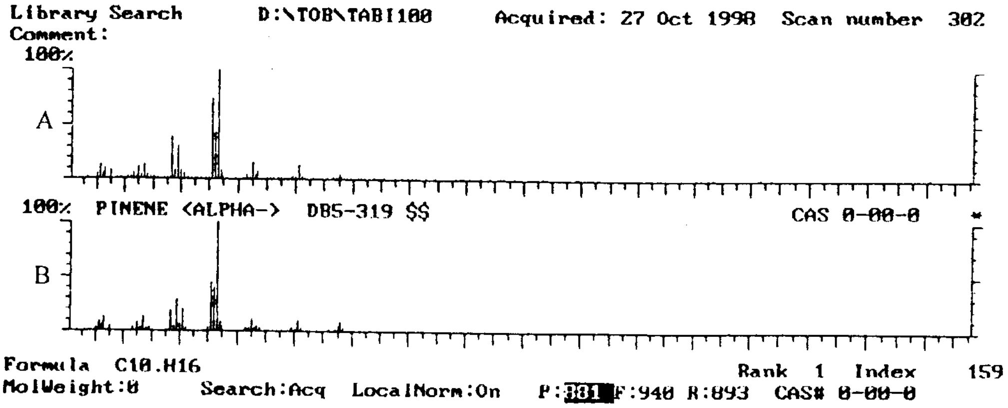
```
Library Search        D:\TOB\CINC100        Acquired: 27 Oct 1998   Scan number   427
Comment:
100%  PHELLANDRENE <ALPHA->  DBS-435 $$                                 CAS 0-00-0     *
Formula   C10.H16                                               Rank   1  Index      162
MolWeight:0        Search:Acq   LocalNorm:On     P:346 F:874 R:866   CAS# 0-00-0
```

Figure 150 Mass spectra of phellandrene <α-> (A) and authentic phellandrene <α-> (B) by GC-MS



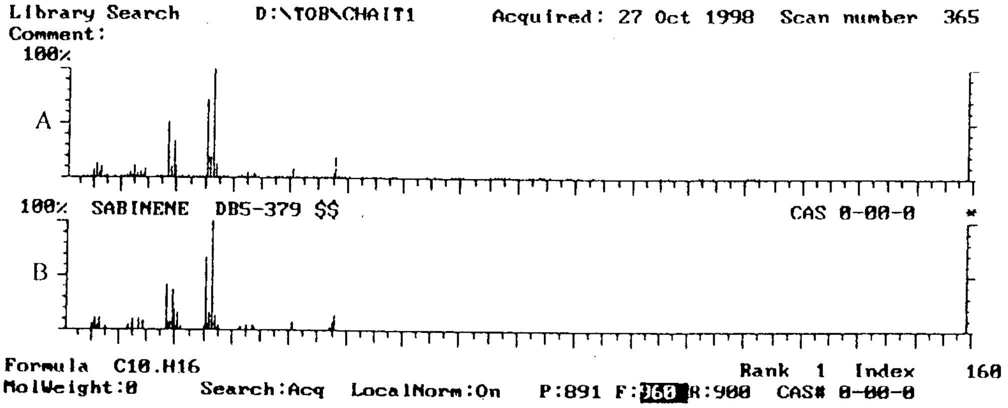
```
Library Search      D:\TOB\CINC100      Acquired: 27 Oct 1998   Scan number  393
Comment:
100%
100%  PINENE <BETA->  DBS-386 $$                             CAS 0-00-0      *
Formula   C10.H16                                      Rank  1  Index     161
MolWeight:0     Search:Acq   LocalNorm:On    P:869 F:919 R:888  CAS# 0-00-0
```

Figure 151   Mass spectra of pinene < β-> (A) and authentic pinene < β-> (B) by GC-MS



```
Library Search      D:\TOB\TABI100      Acquired: 27 Oct 1998   Scan number  302
Comment:
100%
100%  PINENE <ALPHA->  DBS-319 $$                            CAS 0-00-0      *
Formula   C10.H16                                      Rank  1  Index     159
MolWeight:0     Search:Acq   LocalNorm:On    P:881 F:940 R:893  CAS# 0-00-0
```

Figure 152   Mass spectra of pinene < α-> (A) and authentic pinene < α-> (B) by GC-MS



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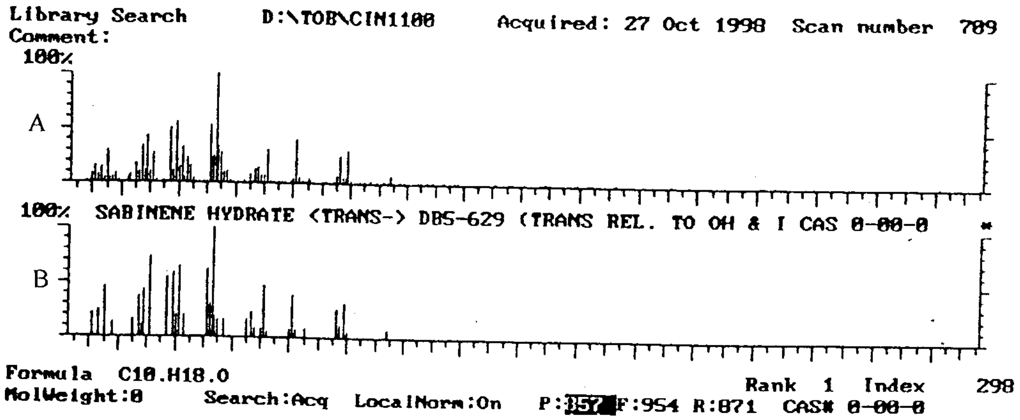
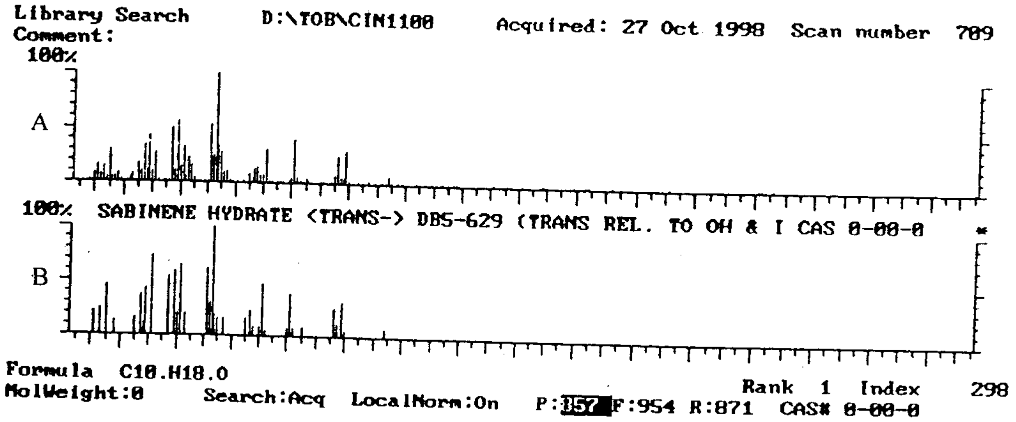
Library Search      D:\TOB\CHAIT1       Acquired: 27 Oct 1998   Scan number  365
Comment:
100%
100%  SABINENE  DBS-379 $$                                   CAS 0-00-0      *
Formula   C10.H16                                      Rank  1  Index     160
MolWeight:0     Search:Acq   LocalNorm:On    P:891 F:960 R:900  CAS# 0-00-0
```

Figure 153   Mass spectra of sabinene (A) and authentic sabinene (B) by GC-MS



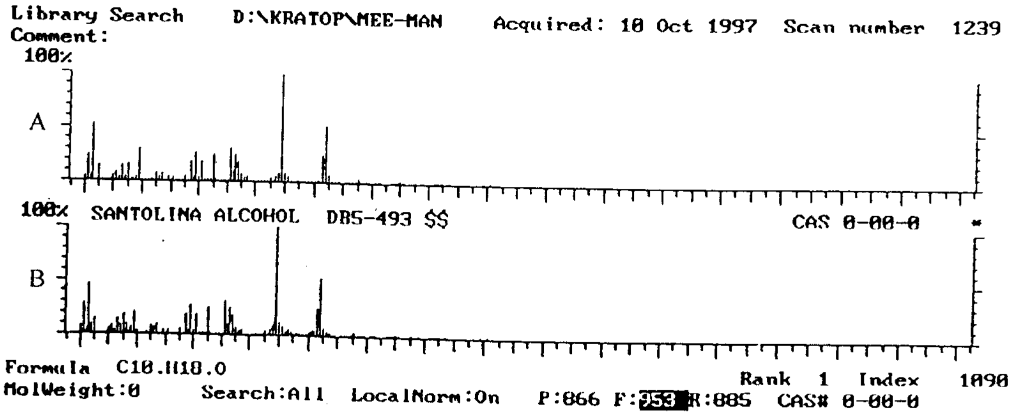
```
Library Search        D:\TOB\CIN1100        Acquired: 27 Oct 1998   Scan number   789
Comment:
100%
A
100%  SABINENE HYDRATE <TRANS-> DBS-629 (TRANS REL. TO OH & I CAS 0-00-0     *
B
Formula   C10.H18.O                                          Rank  1  Index     298
MolWeight:0       Search:Acq    LocalNorm:On      P:857 F:954 R:871   CAS# 0-00-0
```

Figure 154 Mass spectra of sabinene hydrate < *trans*-> (A) and authentic sabinene hydrate < *trans*-> (B) by GC-MS



```
Library Search        D:\TOB\CIN1100        Acquired: 27 Oct 1998   Scan number   789
Comment:
100%
A
100%  SABINENE HYDRATE <TRANS-> DBS-629 (TRANS REL. TO OH & I CAS 0-00-0     *
B
Formula   C10.H18.O                                          Rank  1  Index     298
MolWeight:0       Search:Acq    LocalNorm:On      P:857 F:954 R:871   CAS# 0-00-0
```

Figure 155 Mass spectra of sabinene hydrate acetate < *trans*-> (A) and authentic sabinene hydrate acetate < *trans*-> (B) by GC-MS



```
Library Search        D:\KRATOP\MEE-MAN     Acquired: 10 Oct 1997   Scan number   1239
Comment:
100%
A
100%  SANTOLINA ALCOHOL   DBS-493 $$                          CAS 0-00-0      *
B
Formula   C10.H18.O                                          Rank  1  Index     1090
MolWeight:0       Search:All    LocalNorm:On      P:866 F:953 R:885   CAS# 0-00-0
```

Figure 156 Mass spectra of santolina alcohol (A) and authentic santolina alcohol (B) by GC-MS

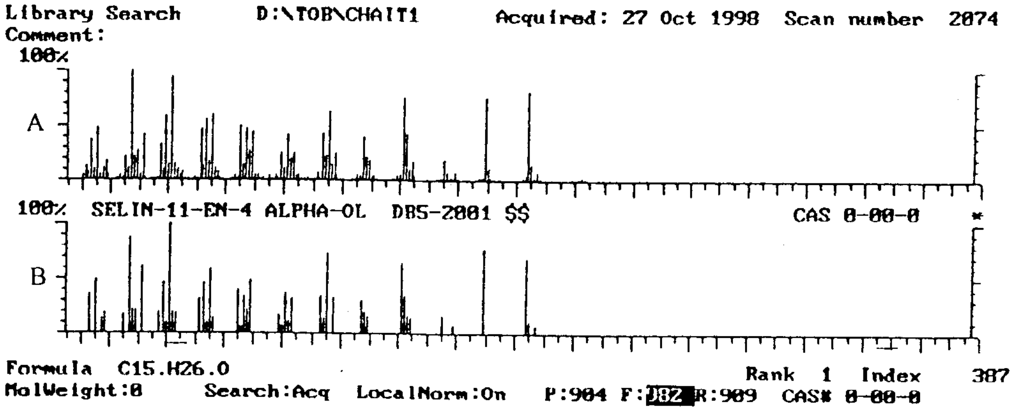


Figure 157 Mass spectra of selin-*11-en-4-alpha-ol* (A) and authentic selin-*11-en-4-alpha-ol* (B) by GC-MS

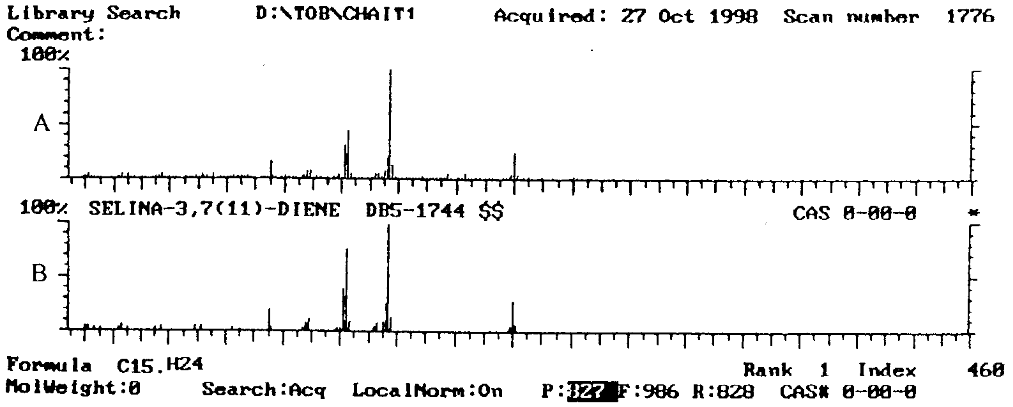


Figure 158 Mass spectra of selinadiene *<3,7(11)->* (A) and authentic selinadiene *<3,7(11)->* (B) by GC-MS

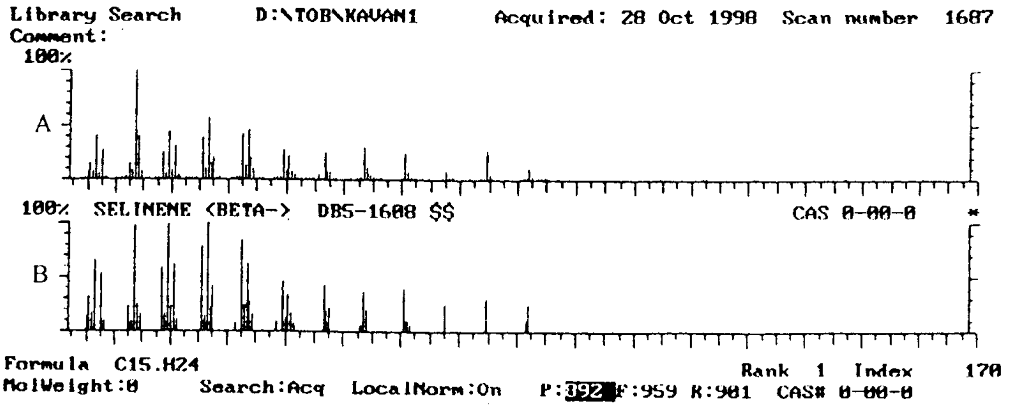


Figure 159 Mass spectra of selinene <β-> (A) and authentic selinene <β-> (B) by GC-MS

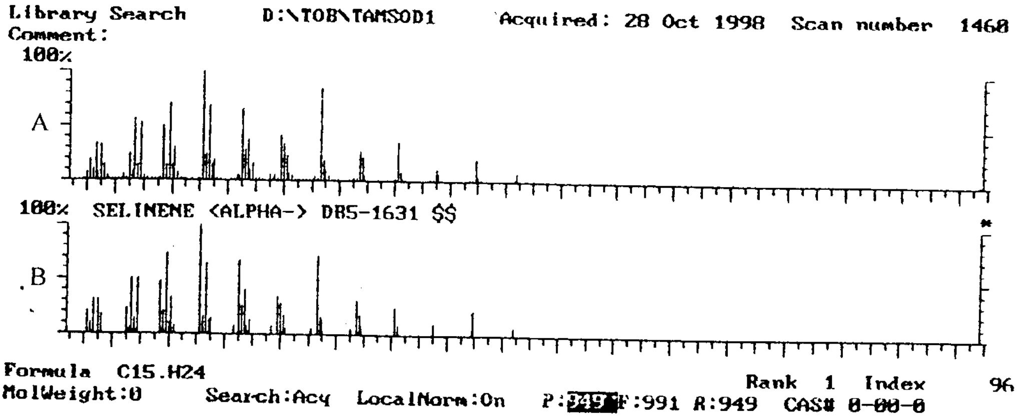


Figure 160 Mass spectra of selinene <α-> (A) and authentic selinene <α-> (B) by GC-MS

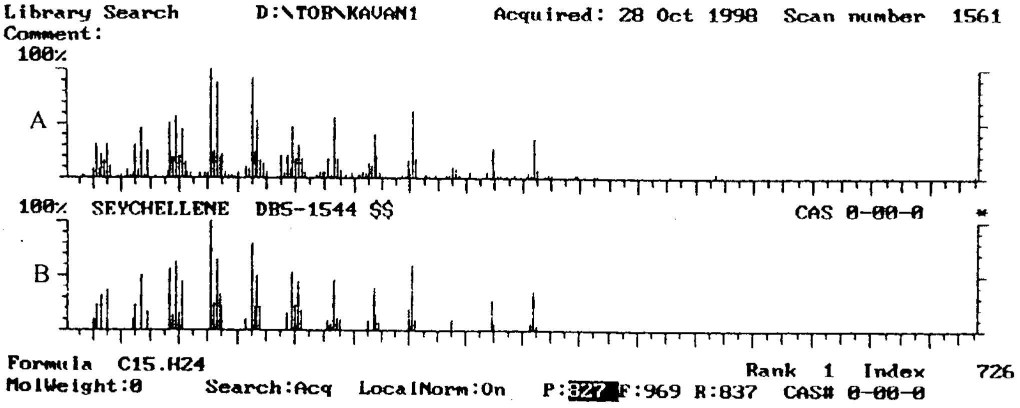


Figure 161 Mass spectra of seychellene (A) and authentic seychellene (B) by GC-MS

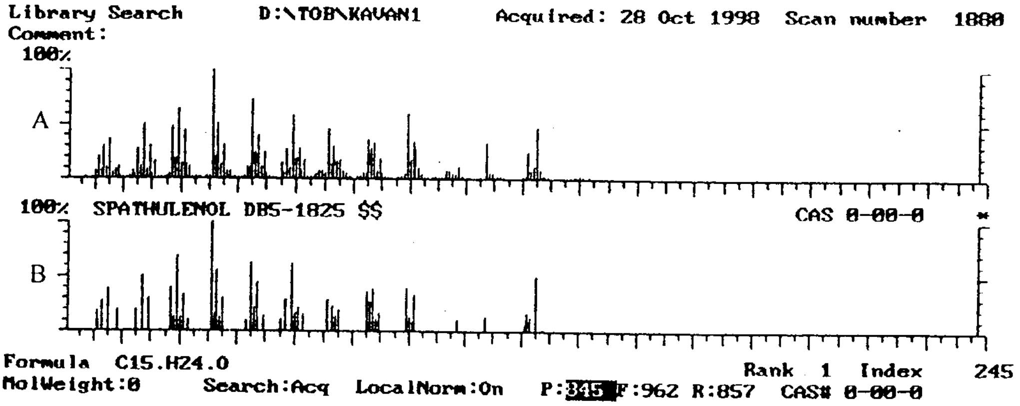


Figure 162 Mass spectra of spathulenol (A) and authentic spathulenol (B) by GC-MS

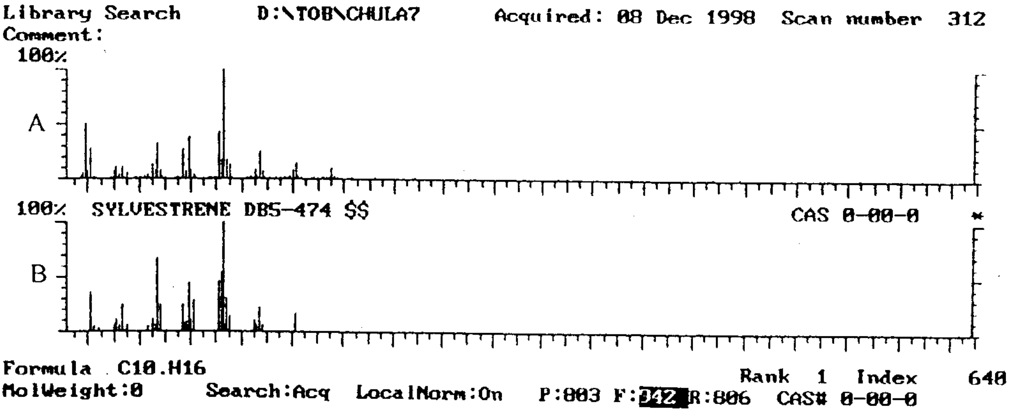


Figure 163 Mass spectra of sylvestrene (A) and authentic sylvestrene (B) by GC-MS

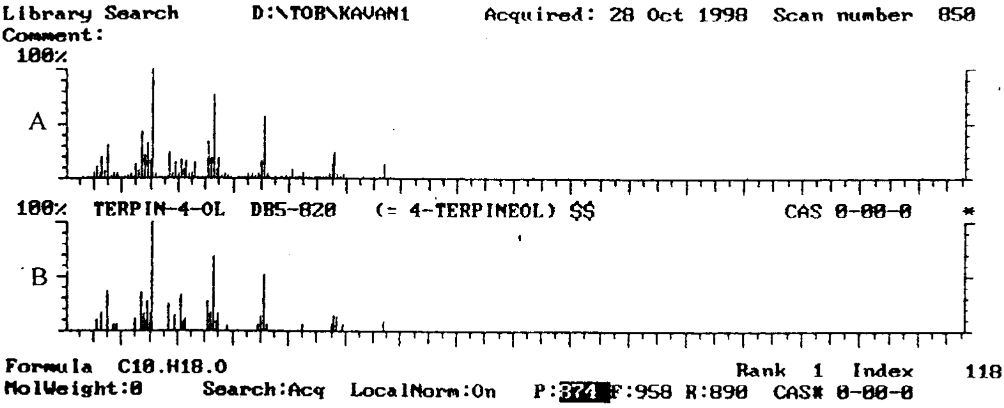


Figure 164 Mass spectra of terpin-*4-ol* (A) and authentic terpin-*4-ol* (B) by GC-MS

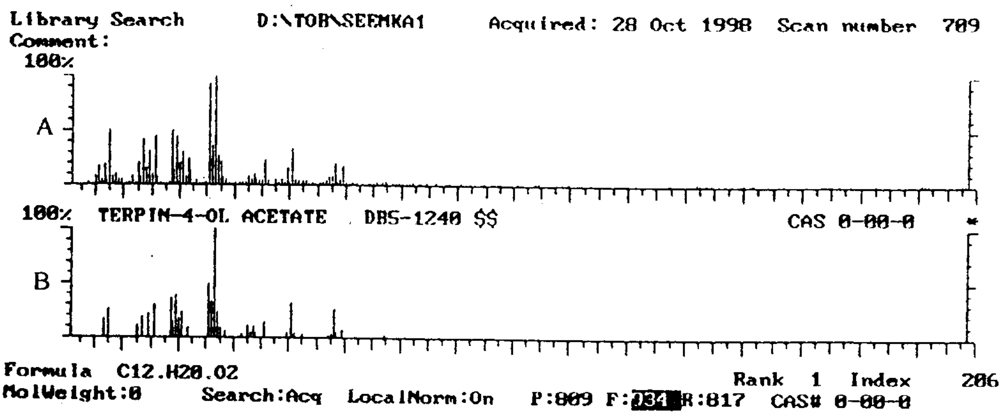
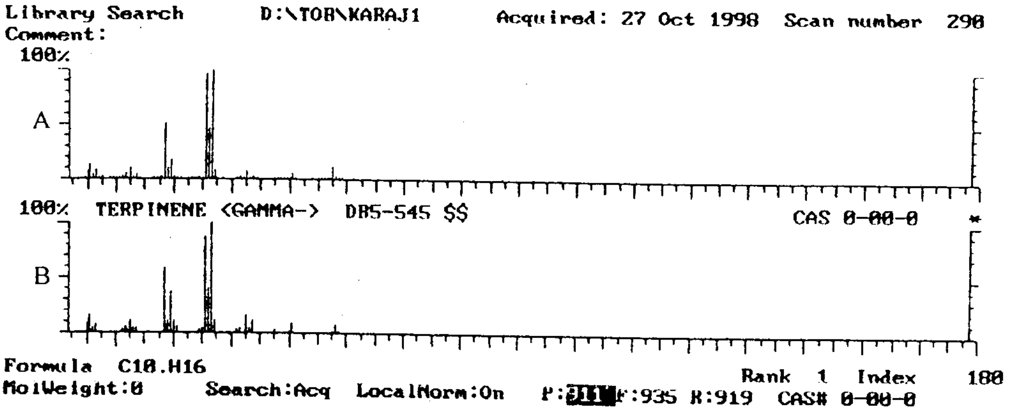
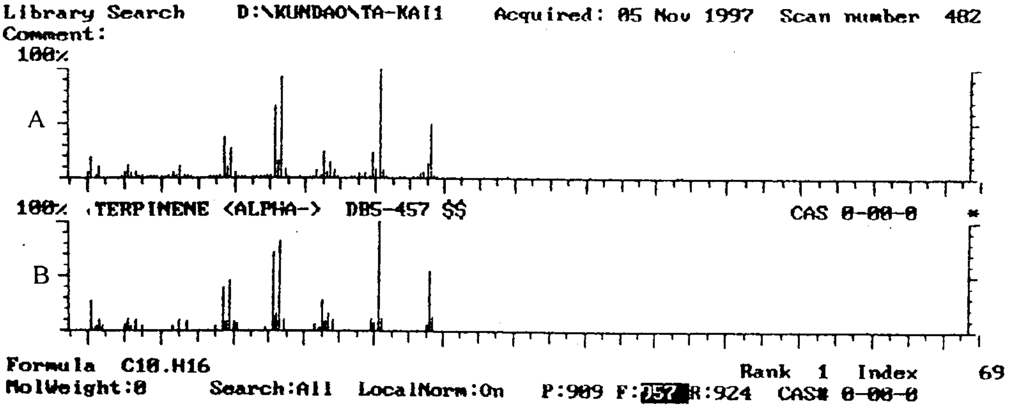


Figure 165 Mass spectra of terpin-*4-ol*-acetate (A) and authentic terpin-*4-ol*-acetate (B) by GC-MS



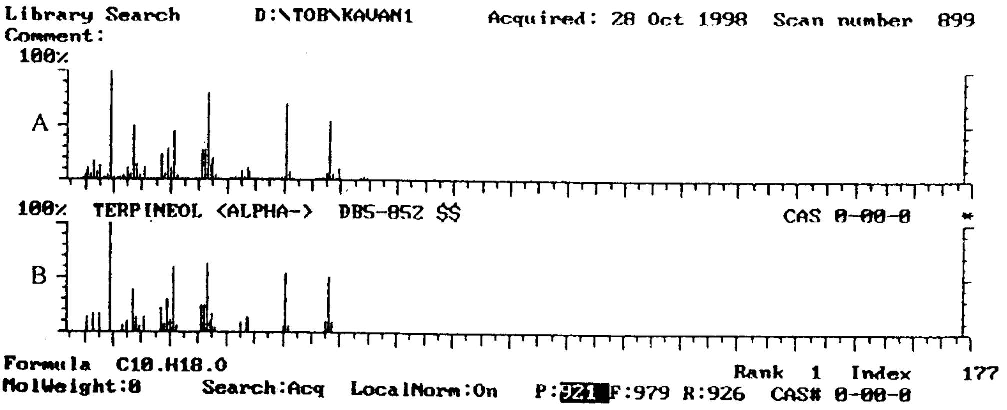
```
Library Search        D:\TOB\KARAJ1        Acquired: 27 Oct 1998   Scan number  290
Comment:
100%
100%  TERPINENE <GAMMA->  DBS-545 $$                                   CAS 0-00-0     *
Formula  C10.H16                                                  Rank   1   Index      100
MolWeight:0        Search:Acq   LocalNorm:On     P:911 F:935 R:919   CAS# 0-00-0
```

Figure 166 Mass spectra of terpinene < γ-> (A) and authentic terpinene < γ-> (B) by GC-MS



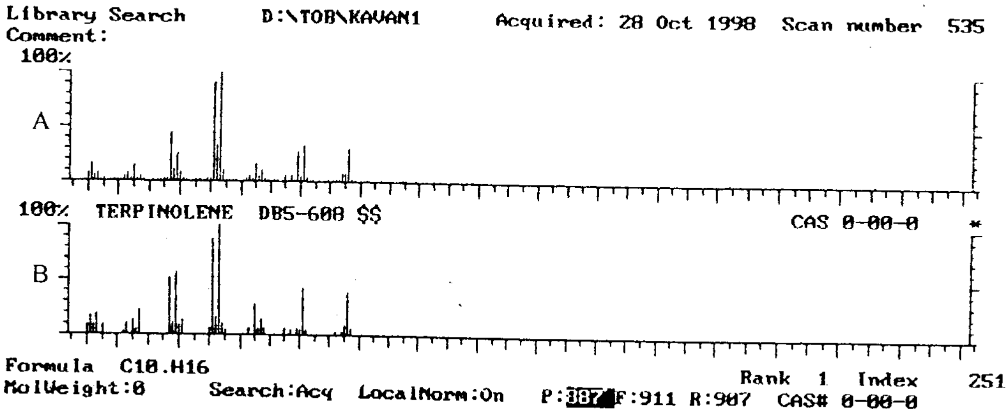
```
Library Search      D:\KUNDAO\TA-KAI1      Acquired: 05 Nov 1997   Scan number  482
Comment:
100%
100%  TERPINENE <ALPHA->  DBS-457 $$                                   CAS 0-00-0     *
Formula   C10.H16                                                 Rank   1   Index      69
MolWeight:0        Search:All   LocalNorm:On     P:909 F:957 R:924   CAS# 0-00-0
```

Figure 167 Mass spectra of terpinene < α-> (A) and authentic terpinene < α-> (B) by GC-MS



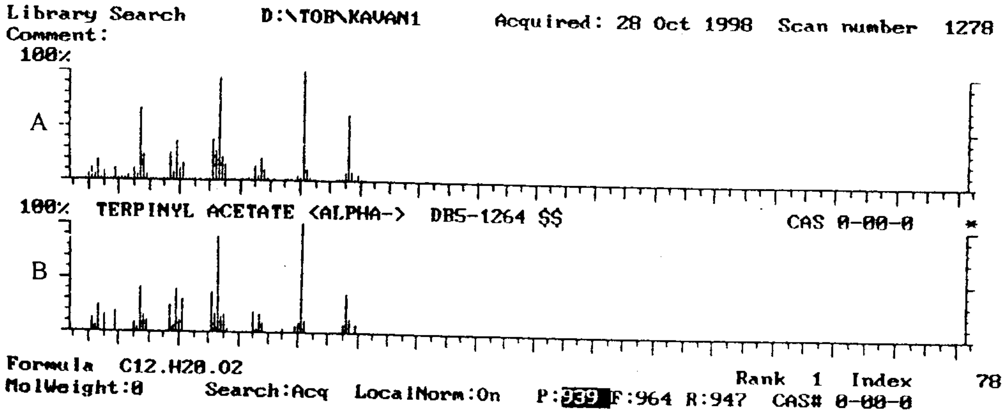
```
Library Search        D:\TOB\KAVAN1        Acquired: 28 Oct 1998   Scan number  899
Comment:
100%
100%  TERPINEOL <ALPHA->  DBS-852 $$                                   CAS 0-00-0     *
Formula  C10.H18.O                                                Rank   1   Index      177
MolWeight:0        Search:Acq   LocalNorm:On     P:921 F:979 R:926   CAS# 0-00-0
```

Figure 168 Mass spectra of terpineol < α-> (A) and authentic terpineol < α-> (B) by GC-MS



```
Library Search        D:\TOB\KAVAN1        Acquired: 28 Oct 1998   Scan number  535
Comment:
100%
A
100%  TERPINOLENE  DBS-608 $$                                      CAS 0-00-0     *
B
Formula   C10.H16                                               Rank   1   Index      251
MolWeight:0        Search:Acq    LocalNorm:On    P:387 F:911 R:907   CAS# 0-00-0
```

Figure 169 Mass spectra of terpinolene (A) and authentic terpinolene (B) by GC-MS



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Library Search        D:\TOB\KAVAN1        Acquired: 28 Oct 1998   Scan number  1278
Comment:
100%
A
100%  TERPINYL ACETATE <ALPHA->  DBS-1264 $$                      CAS 0-00-0     *
B
Formula   C12.H20.02                                            Rank   1   Index       78
MolWeight:0        Search:Acq    LocalNorm:On    P:939 F:964 R:947   CAS# 0-00-0
```
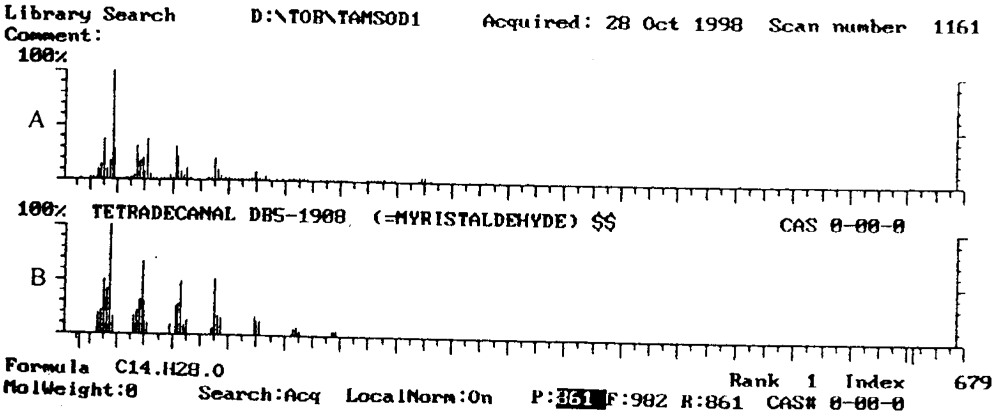
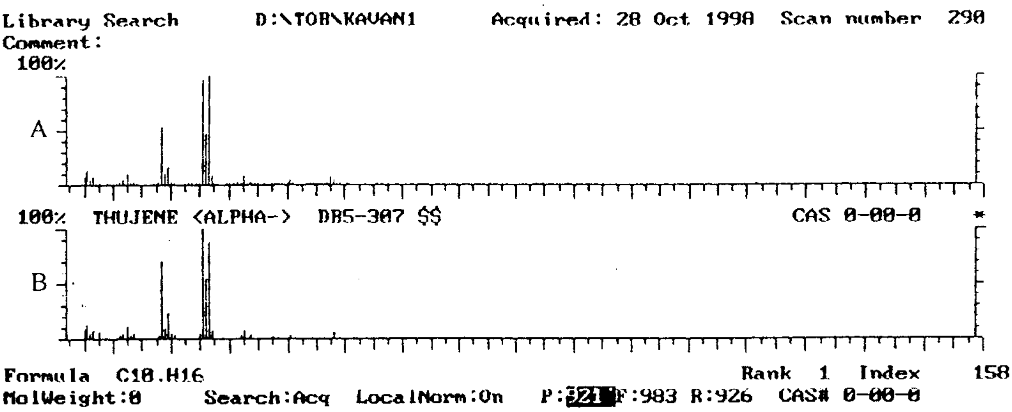

Figure 170 Mass spectra of terpinyl acetate < α-> (A) and authentic terpinyl acetate < α-> (B) by GC-MS



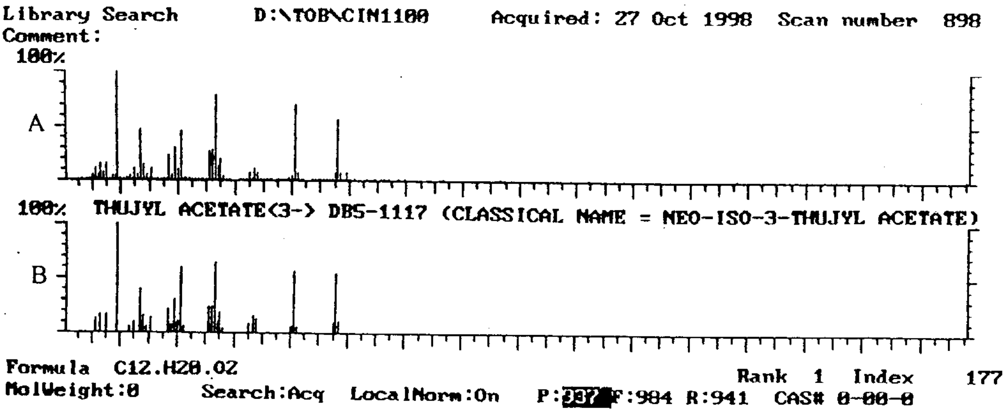
```
Library Search        D:\TOB\TAMSOD1       Acquired: 28 Oct 1998   Scan number  1161
Comment:
100%
A
100%  TETRADECANAL DBS-1908  (=MYRISTALDEHYDE) $$                  CAS 0-00-0
B
Formula   C14.H28.0                                             Rank   1   Index      679
MolWeight:0        Search:Acq    LocalNorm:On    P:861 F:982 R:861   CAS# 0-00-0
```

Figure 171 Mass spectra of tetradecanal (A) and authentic tetradecanal (B) by GC-MS



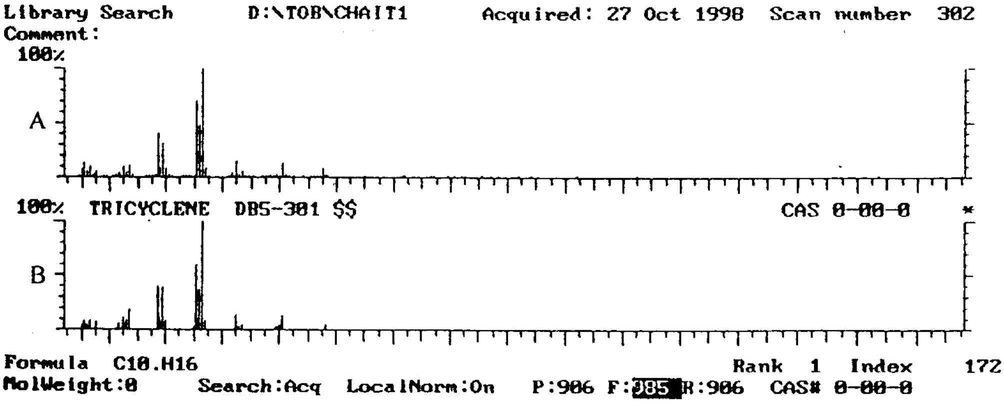
```
Library Search       D:\TOB\KAVAN1        Acquired: 28 Oct 1998   Scan number  290
Comment:
100%
100%  THUJENE <ALPHA->  DBS-307 $$                                CAS 0-00-0     *
Formula   C10.H16                                          Rank  1  Index      158
MolWeight:0       Search:Acq   LocalNorm:On     P:921 F:983 R:926   CAS# 0-00-0
```

Figure 172 Mass spectra of thujene < α-> (A) and authentic thujene < α-> (B) by GC-MS



```
Library Search       D:\TOB\CIN1100       Acquired: 27 Oct 1998   Scan number  898
Comment:
100%
100%  THUJYL ACETATE<3-> DBS-1117 (CLASSICAL NAME = NEO-ISO-3-THUJYL ACETATE)
Formula   C12.H20.O2                                       Rank  1  Index      177
MolWeight:0       Search:Acq   LocalNorm:On     P:937 F:984 R:941   CAS# 0-00-0
```

Figure 173 Mass spectra of thyjyl acetate <3-> (A) and authentic thyjyl acetate <3-> (B) by GC-MS



```
Library Search       D:\TOB\CHAIT1        Acquired: 27 Oct 1998   Scan number  302
Comment:
100%
100%  TRICYCLENE  DBS-301 $$                                      CAS 0-00-0     *
Formula   C10.H16                                          Rank  1  Index      172
MolWeight:0       Search:Acq   LocalNorm:On     P:906 F:985 R:906   CAS# 0-00-0
```

Figure 174 Mass spectra of tricyclene (A) and authentic tricyclene (B) by GC-MS

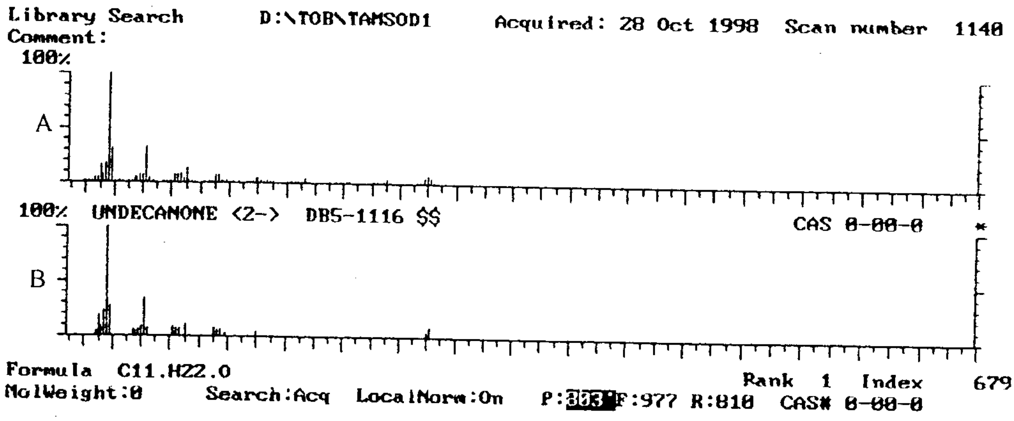


Figure 175 Mass spectra of undecanone < *2*-> (A) and authentic undecanone < *2*-> (B) by GC-MS

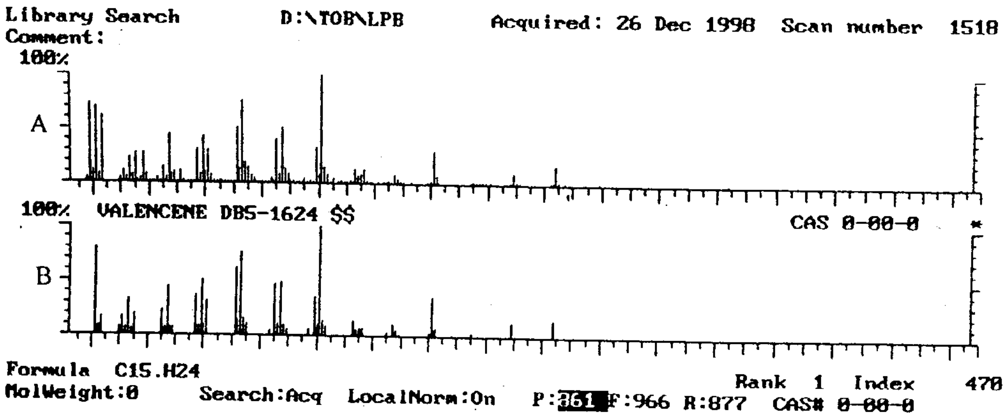


Figure 176 Mass spectra of valencene (A) and authentic valencene (B) by GC-MS

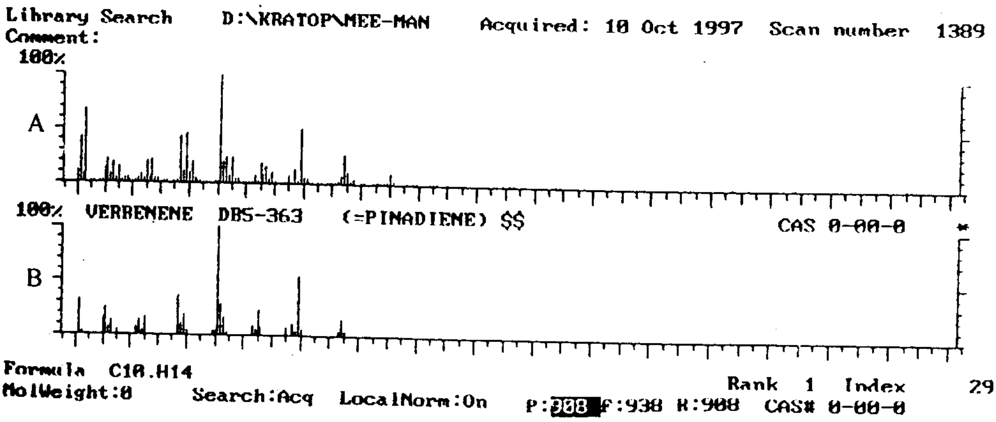
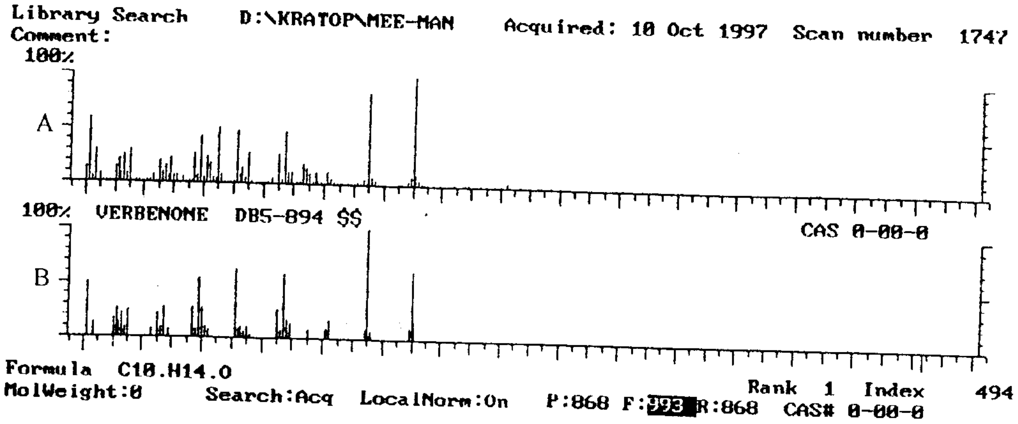
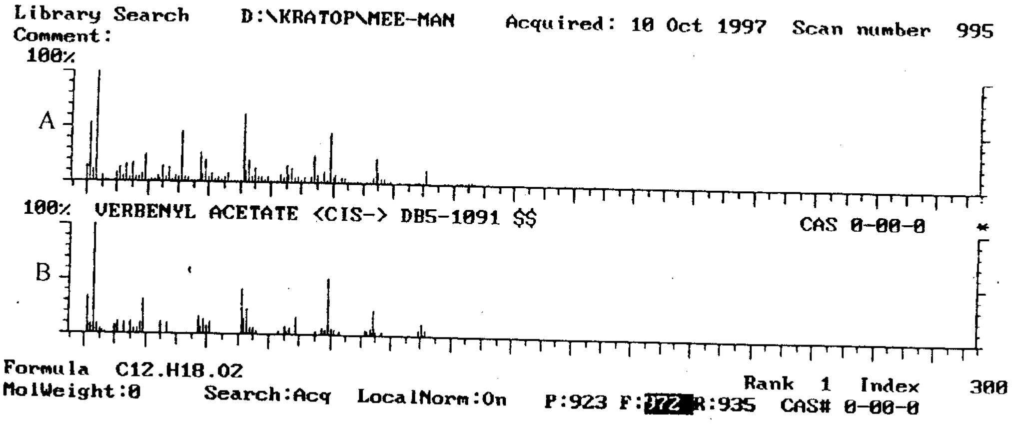


Figure 177 Mass spectra of verbenene (A) and authentic verbenene (B) by GC-MS



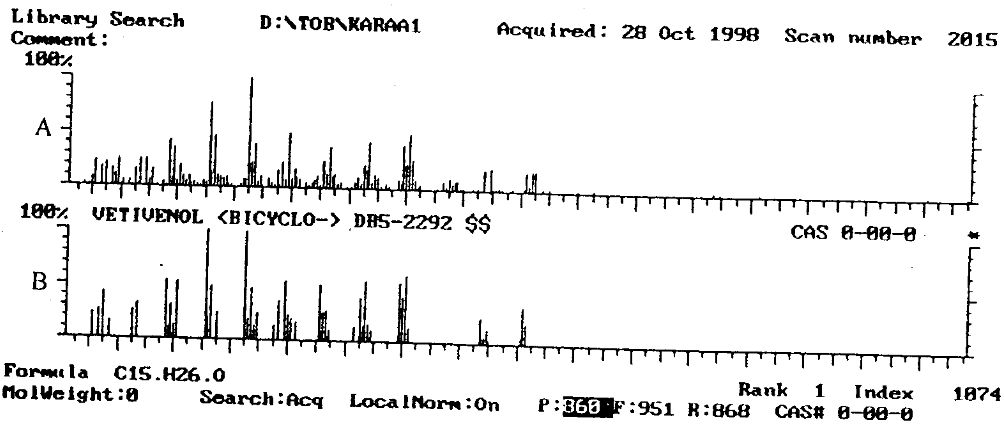
```
Library Search     D:\KRATOP\MEE-MAN     Acquired: 10 Oct 1997  Scan number  1747
Comment:
100%  VERBENONE  DB5-894 $$                                  CAS 0-00-0
Formula  C10.H14.O
MolWeight:0      Search:Acq   LocalNorm:On    P:868 F:993 R:868   Rank  1  Index    494
                                                                  CAS# 0-00-0
```

Figure 178 Mass spectra of verbenone (A) and authentic verbenone (B) by GC-MS



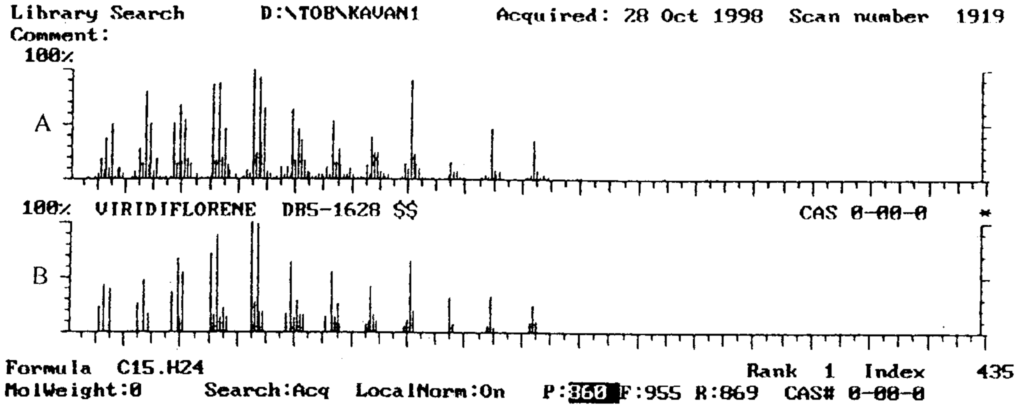
```
Library Search     D:\KRATOP\MEE-MAN     Acquired: 10 Oct 1997  Scan number  995
Comment:
100%  VERBENYL ACETATE <CIS-> DB5-1091 $$                    CAS 0-00-0   *
Formula  C12.H18.O2
MolWeight:0      Search:Acq   LocalNorm:On    P:923 F:972 R:935   Rank  1  Index    300
                                                                  CAS# 0-00-0
```

Figure 179 Mass spectra of verbenyl acetate < *cis*-> (A) and authentic verbenyl acetate < *cis*-> (B) by GC-MS



```
Library Search     D:\TOB\KARAA1         Acquired: 28 Oct 1998  Scan number  2015
Comment:
100%  VETIVENOL <BICYCLO-> DB5-2292 $$                       CAS 0-00-0   *
Formula  C15.H26.O
MolWeight:0      Search:Acq   LocalNorm:On    P:860 F:951 R:868   Rank  1  Index    1074
                                                                  CAS# 0-00-0
```

Figure 180 Mass spectra of vetivenol < *bicyclo*-> (A) and authentic vetivenol < *bicyclo*-> (B) by GC-MS



```
Library Search       D:\TOB\KAVAN1       Acquired: 28 Oct 1998  Scan number  1919
Comment:
100%  VIRIDIFLORENE  DBS-1628 $$                                 CAS 0-00-0      *
Formula  C15.H24                                           Rank  1  Index     435
MolWeight:0       Search:Acq  LocalNorm:On    P:360 F:955 R:869  CAS# 0-00-0
```

Figure 181 Mass spectra of viridiflorene (A) and authentic viridiflorene (B) by GC-MS

VITA

Miss Chomkamon Ubonnuch was born in April 23,1975 in Bangkok Thailand. She received her bechelor of Science in Pharmacy in 1997 from Rangsit University, Pathum Thani, Thailand. At present, she is a faculty member of the Department of Pharmacognosy, Faculty of Pharmacy, Rungsit University, Phathum Thani, Thailand.