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ปีการศึกษา 2551

CHEMICAL CONSTITUENTS OF *MILLETTIA LEUCANTHA* STEMWOOD

Miss Manussanunt Chatsumpun

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Pharmacy Program in Pharmacognosy
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Faculty of Pharmaceutical Sciences
Chulalongkorn University
Academic Year 2008

Thesis Title	CHEMICAL CONSTITUENTS OF *MILLETTIA LEUCANTHA* STEMWOOD
By	Miss Manussanunt Chatsumpun
Field of Study	Pharmacognosy
Thesis Principal Advisor	Associate Professor Kittisak Likhitwitayawuid, Ph.D.
Thesis Co-advisor	Assistant Professor Boonchoo Sritularak, Ph.D.

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มนัสนันท์ ชาติสัมปันน์ : องค์ประกอบทางเคมีของเนื้อไม้ต้นสาทร. (CHEMICAL CONSTITUENTS OF *MILLETTIA LEUCANTHA* STEMWOOD) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.ดร. กิตติศักดิ์ ลิขิตวิทยาวุฒิ, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม : ผศ.ดร. บุญชู ศรีตุลารักษ์, 152 หน้า.

การศึกษาทางพฤกษเคมีของเนื้อไม้สาทร สามารถแยกสารบริสุทธิ์ 6 ชนิด ได้แก่ cycloeucalenol, maackiain, 4-hydroxy-3-methoxybenzoic acid, syringic acid, balanocarpol และ diptoindonesin D นอกจากนี้ยังแยกได้สารผสมระหว่าง β-sitosterol กับ stigmasterol และสารผสมระหว่าง 7-oxositosterol กับ 7-oxostigmasterol การพิสูจน์โครงสร้างทางเคมีของสารที่แยกได้นี้อาศัยการวิเคราะห์สเปกตรัมของ UV, MS, NMR ร่วมกับการเปรียบเทียบข้อมูลของสารที่รายงานมาแล้ว และได้ทดสอบฤทธิ์ในการจับสารอนุมูลอิสระของสารที่แยกได้ พบว่า syringic acid มีฤทธิ์ปานกลางในการจับสารอนุมูลอิสระ

ภาควิชา.....เภสัชเวท..... ลายมือชื่อนิสิต.....

สาขาวิชา.....เภสัชเวท..... ลายมือชื่ออ.ที่ปรึกษาวิทยานิพนธ์หลัก.....

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Phytochemical study of the stemwood of *Millettia leucantha* Kurz led to the isolation of six pure compounds, including cycloeucalenol, maackiain, 4-hydroxy-3-methoxybenzoic acid, syringic acid, balanocarpol and diptoindonesin D. In addition, a mixture of β-sitosterol and stigmasterol and a mixture of 7-oxositosterol and 7-oxostigmasterol were identified. The identification and structure determination of the isolated compounds were achieved by analysis of their spectroscopic data (UV, MS, NMR) in comparison with previously reported data. Evaluation of the free radical scavenging activity of the isolated compounds showed moderate activity for syringic acid.

Department :.....Pharmacognosy..... Student's signature :.Manussanunt. Chatsumpun.....
Field of study :...Pharmacognosy..... Principal Advisor's signature :.....K. Likhit.....
Academic year :.... 2551..... Co-advisor's signature :.Boonchoo Sritularak.....

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ABBREVIATIONS

α	=	Alpha
Acetone-d_6	=	Deuterated acetone
β	=	Beta
br	=	Broad (for NMR spectra)
C	=	Concentration
ºC	=	Degree Celsius
$CDCl_3$	=	Deuterated chloroform
CH_2Cl_2	=	Dichloromethane
^{13}C NMR	=	Carbon-13 Nuclear Magnetic Resonance
cm	=	Centimeter
1-D	=	One dimensional (for NMR spectra)
2-D	=	Two dimensional (for NMR spectra)
d	=	Doublet (for NMR spectra)
dd	=	Doublet of doublets (for NMR spectra)
DEPT	=	Distortionless Enhancement by Polarization Transfer
δ	=	Chemical shift
EIMS	=	Electron Impact Mass Spectrometry
ESIMS	=	Electrospray Ionization Mass Spectrrmetry
EtOAc	=	Ethyl acetate
FCC	=	Flash Column Chromatography
g	=	Gram
GF	=	Gel Filtration Chromatography
^1H-NMR	=	Proton Nuclear Magnetic Resonance
HMBC	=	^1H-detected Heteronuclear Multiple Bond Correlation
HMQC	=	^1H-detected Heteronuclear Multiple Quantum Coherence
HPLC	=	High Pressure Liquid Chromatography
Hz	=	Hertz
IR	=	Infrared
IC_{50}	=	Concentration showing 50% inhibition
J	=	Coupling constant
Kg	=	Kilogram

L	=	Liter
μl	=	microliter
λ_{max}	=	Wavelength at maximal absorption
ε	=	Molar absorptivity
M^+	=	Molecular ion
m	=	Multiplet (for NMR spectra)
MeOH	=	Methanol
mg	=	Milligram
μg	=	Microgram
MHz	=	Mega Hertz
ml	=	Milliliter
mm	=	Millimeter
MLPC	=	Medium Pressure Liquid Chromatography
m/z	=	Mass to charge ratio
MS	=	Mass spectrum
MW	=	Molecular weight
nm	=	Nanometer
NMR	=	Nuclear Magnetic Resonance
ppm	=	Part per million
s	=	Singlet (for NMR spectra)
spp.	=	Species
t	=	Triplet (for NMR spectra)
TLC	=	Thin Layer Chromatography
UV-VIS	=	Ultraviolet and Visible spectrophotometry
VLC	=	Vacuum Liquid Column Chromatography
υ_{max}	=	Wave number at maximal absorption
$[\alpha]^{20}_{D}$	=	Specific rotation at 20ºC and Sodium D line (589 nm)

CHAPTER I

INTRODUCTION

Plants of the genus *Millettia* are trees, shrubs, and climbers. They are members of Leguminosae family. Leaves are odd-pinnate with 3-10 pairs of opposite leaflets, often with tiny points (stipels) at base of leaflet stalks. Flowers are white or pink, in branched clusters (cymes) at leaf axils, with top petal curved sharply backwards. Calyx is wider than long with 5 short teeth, the 2 upper ones often united. Ten stamens are fused into a single sheath, sometimes with 1 stamen free from others, ovary without stalk. Pods are flattened, not veined or swollen over seeds, eventually splitting into 2 sections, but often not until after falling from the tree (Gardner *et al*., 2000).

The species of *Millettia* in Thailand according to Smitinand (2001) are as follows.

Millettia atropurpurea Wall.	= *Collerya atropurpurea* (Wall.) Schott
M. brandisiana Kurz	กระพี้จั่น Kra phi chan, จั่น Phi chan, (General); ปี๊จั่น Pi chan (Northern).
M. caerulea Baker	ปัวเปาะเด๊าะ Pua-po-do (Karen-Mae Hong Son); ผักเยี่ยววัว Phak yiao wua (Nakhon Sawan, Northern); หางไหลแดง Hang lai daeng (Kanchanaburi).
M. decipiens Prain	ปารี Pari (Malay-Narathiwat).
M. extensa Benth. (*M. auriculata* Bak. var. *extensa* Benth)	ก๋าวเครือ Kao khruea, กวาวเครือ Kwao khruea (Chiang Mai); ตานครบ Tan krop (Lampang).
M. glaucescens Kurz	ยาดา Yada (Malay-Narathiwat); หยีน้ำ Yi nam (Peninsular).

M. kangensis Craib	กระเจาะ Kra cho, ขะเจาะ Kha cho, ขะเจาะน้ำ Kha chon am (Chiang Mai).
M. kityana Craib	เครือข้าวเย็น Khruea khao yen, ลางเย็น Lang yen, ฮางจืด Hang chute, ฮางเย็น Hang yen (Northern).
M. latifolia Dunn	ขะเจาะ Kha cho (General).
M. leucantha Kurz var. *leucantha*	กะเซาะ Kaso (Central); กระเจาะ Kra cho, ขะเจาะ Khra cho (Northern); กระพี้เขาควาย Kra phi khao khwai (Prachuap Kgiri khan); ขะแมบ Kha maep, คำแมบ Kham maep (Chiang Mai).
M. leucantha Kurz var. *buteoides* (Gagnep.) P.K.Loc (*M. buteoides* Gagnep.var. *siamensis* Craib, *M. pendula* Benth)	กระเจ๊าะ Kra cho, ขะเจ๊าะ Kha cho (Lampang); กระท้อน Kra thon (Phetchabun, Phisanulok); ไม้กระทงน้ำผัก Mai kra thong nam phak (Loei); สะท้อน Sa sathon (Saraburi); สาธร Sa thon (Ubon Ratchathani).
M. macrostachya Collett & Hemsl. var. *macrostachya*	ขะเจาะน้ำ Kha cho nam (Chiang Mai)
M. macrostachya Collett & Hemsl. var. *tecta*	ขะเจาะหลวง Kha cho luang, ขะเจาะใหญ่ Kha cho yai (Narathiwat).
M. pachycarpa Beth. Kurz	เกถะ Ke-tha (Karen-Chiang Mai); เครือไหล Kruea lai (Chiang Mai)
M. peguensis Ali (*M. ovalifolia* Kurz)	ตอหิ To-hi (Karen-Kanchanaburi).
M. pulchra Benth. Kurz	จันพอ Chan pho (Northern).

M. racemosa (Roxb.) Benth.	= *Endosamara racemosa* (Roxb.) R.Geesink
M. sericea (Vent.) Benth.	จะไนโค๊ะ Cha-nai-kho, ปาตู Pa-tu (Malay-Narathiwat); นอเราะ No-ro (Malay-Yala, Pattani); ยิมแมเก๊าะ Yim-mae-ko (Malay-Yala); อ้อยสามสวน Oi sam suan (Nong Khai).
M. thorelii Gagnep.	= *Derris thorelii* Craib
M. utilis Dunn	สะท้อนน้ำผัก Sathon nam phak (Loei).
M. xylocarpa Miq. var. *tecta* (*M. hemsleyana* Prain, *M. pubinervis* Kurz)	กะเจ้ะ Ka che, ขะเจาะ Kho cho (General); คะแมด Kha maet (Chiang Mai); จักจั่น Chakkachan (Loei); พี้พง Phi phong (Phrae); ยะดา Ya-da (Malay-Yal); ไย่ยี Yai-yi (Karen-Mae Hong son); สาธร Sa thon, หยีน้ำ yin am (Pattai, Yala).

Millettia leucantha Kurz has a local name as ka so, kra cho, sa thon. It is a deciduous tree to 20 m, with 3 pairs of leaflets, 5-12 cm, abruptly tepped, completely smooth, stalks ± 4 mm with persistent narrow stipels. Flowers are ± 1.2 cm, white, smooth petals. Pods are 4-10 x 2 cm, woody, widest near top, rough with many lenticles, rounded edges (Gardner *et al*., 2000).

A previous study on the ethanol extract of the stem bark of *M. leucantha* revealed the presence of flavones and chalcones. Some of these compounds possessed moderate cytotoxic activity, moderate anti-herpes simplex virus activity and significant anti-inflammatory effect inhibiting both cyclooxygenases-1 and -2 (Phrutivorapongkul *et al*., 2003). This chemical investigation is focused on the constituents of the stemwood of *M. leucantha*.

The main objectives in this study are as follows.

1. Isolation and purification of compounds from *M. leucantha* stemwood.
2. Determination of the chemical structure of each isolated compound.

3. Evaluation of each isolated compound for its free radical scavenging activity.

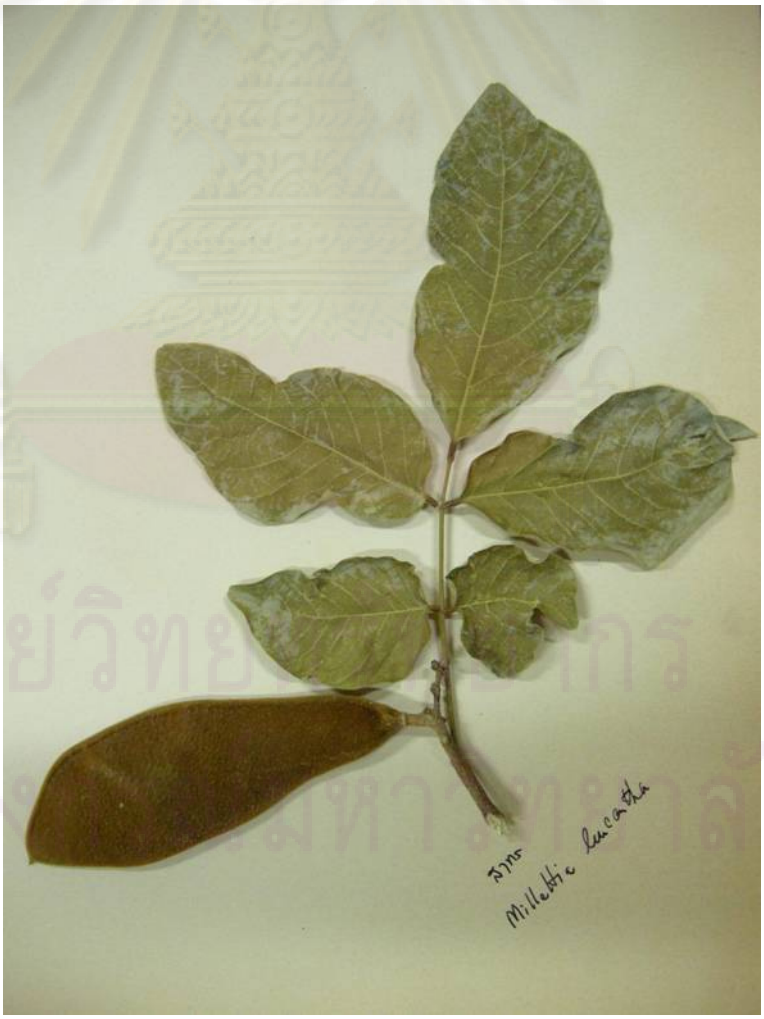


Figure 1 *Millettia leucantha* Kurz

CHAPTER II

HISTORICAL

1. Chemical constituents of *Millettia* spp.

A number of chemical constituents isolated from the genus *Millettia* can be classified as flavonoids of various types. In addition, other classes of natural compounds such as terpenoids, coumarins and miscellaneous substances have been found (Table 1).

Table 1 Distribution of chemical constituents in the genus *Millettia.*

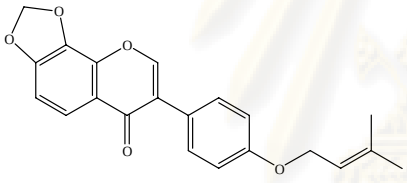
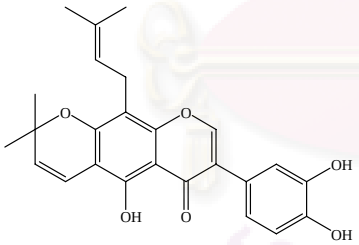
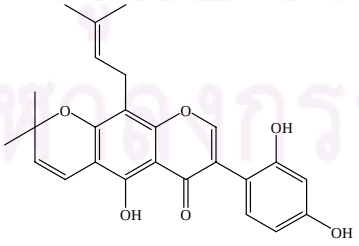
Plant and compound	Category	Plant part	Reference
Millettia auriculata			
Auricularin [**1**] 	Isoflavone	Root	Rao, Prasad and Ganapaty, 1992
Auriculasin [**2**] 	Isoflavone	Leaf	Minhaj *et al*., 1976
Auriculatin [**3**] 	Isoflavone	Root	Shabbir *et al*., 1968

Table 1 (continued)

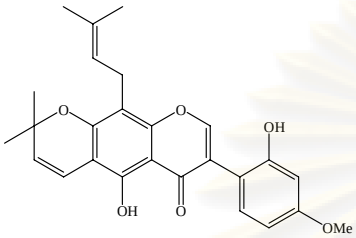
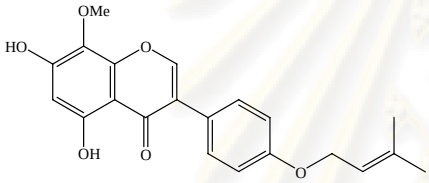
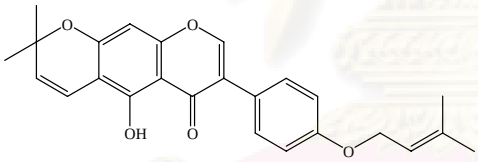
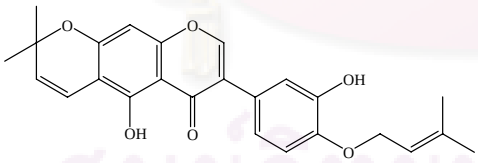
Plant and compound	Category	Plant part	Reference
Millettia auriculata			
Auriculin [**4**] 	Isoflavone	Root	Shabbir and Zaman, 1970
Aurmillone [**5**] 	Isoflavone	Seed	Raju and Srimannarayana, 1978
2′-Deoxyisoauriculatin [**6**] 	Isoflavone	Root	Rao, Prasad and Ganapaty, 1992
Isoauriculasin [**7**] 	Isoflavone	Leaf	Minhaj *et al*., 1976
Isoauriculatin [**8**] 	Isoflavone	Root	Shabbir and Zaman, 1970

Table 1 (continued)

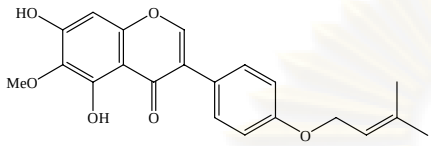
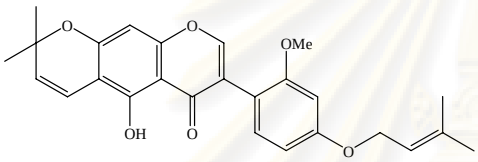
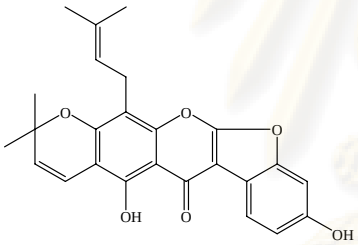
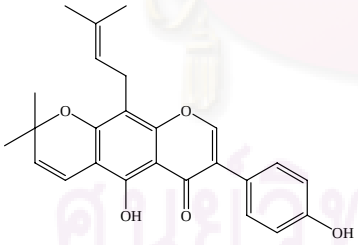
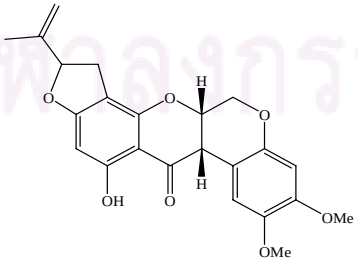
Plant and compound	Category	Plant part	Reference
Millettia auriculata			
Isoaurmillone [**9**] 	Isoflavone	Pod	Gupta *et al*., 1983
2′-*O*-Methyisoauriculatin [**10**] 	Isoflavone	Root	Rao, Prasad and Ganapaty, 1992
Millettin [**11**] 	Isoflavone	Root	Rao, Prasad and Ganapaty, 1992
Scandenone [**12**] 	Isoflavone	Root	Rao, Prasad and Ganapaty, 1992
Sumatrol [**13**] 	Rotenoid	Root, Seed	Rao, Prasad and Ganapaty, 1992

Table 1 (continued)

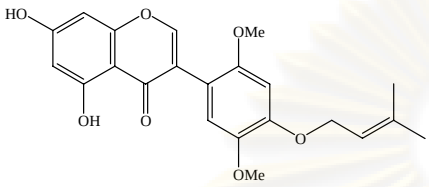
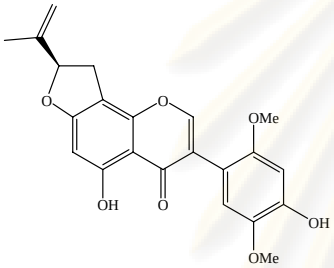
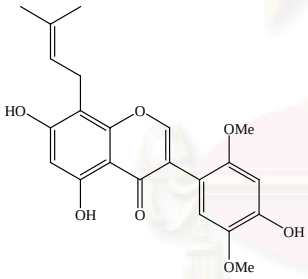
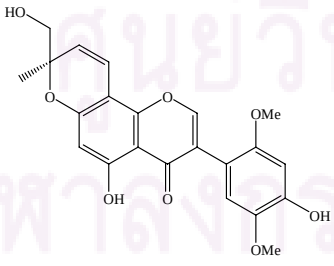
Plant and compound	Category	Plant part	Reference
Millettia brandisiana			
Brandisianin A [**14**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007
Brandisianin B [**15**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007
Brandisianin C [**16**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007
Brandisianin D [**17**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007

Table 1 (continued)

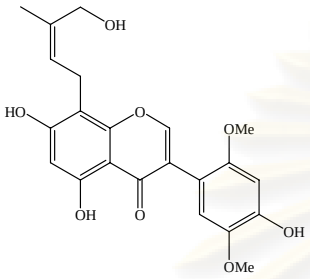
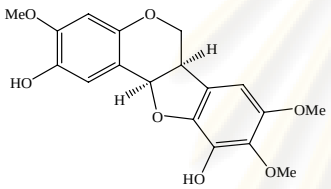
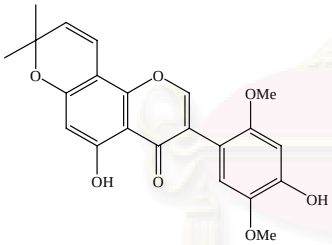
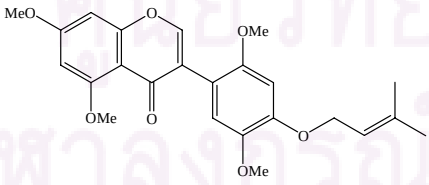
Plant and compound	Category	Plant part	Reference
Millettia brandisiana			
Brandisianin E [**18**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007
Brandisianin F [**19**] 	Pterocarpan	Leaf	Kikuchi *et al*., 2007
4′-Demethyltoxicarol isoflavone [**20**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007
4′-γ,γ-Dimethylallyloxy-5,7,2′,5′-tetramethoxyisoflavone [**21**] 	Isoflavone	Leaf	Pancharoen *et al*., 2008

Table 1 (continued)

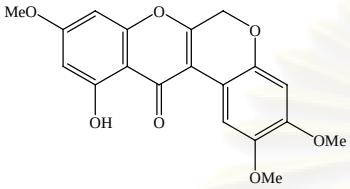
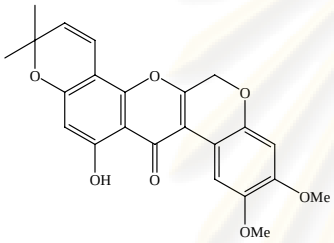
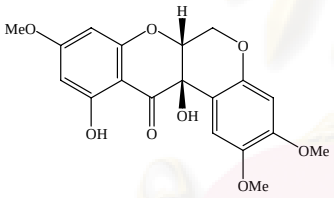
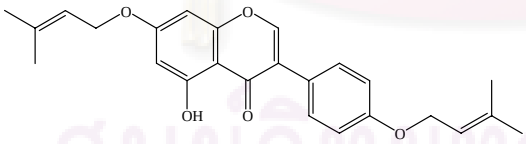
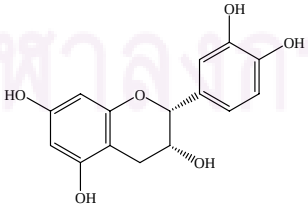
Plant and compound	Category	Plant part	Reference
Millettia brandisiana			
6a,12a-Dehydrosermundone [**22**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
6a,12a-Dehydro-α–toxicarol [**23**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
6-Deoxyclitoriacetal [**24**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
7,4′-Di-*O*-prenylgenistein [**25**] 	Isoflavone	Leaf	Pancharoen *et al*., 2008
(-)-Epicatechin [**26**] 	Flavan	Leaf	Kikuchi *et al*., 2007

Table 1 (continued)

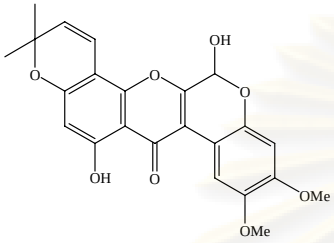
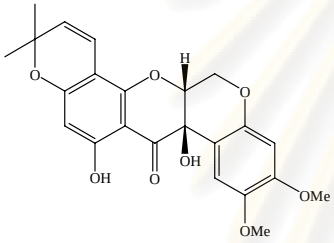
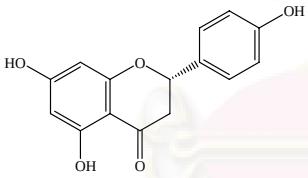
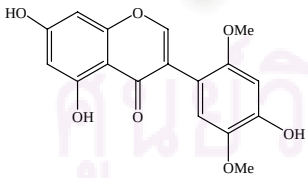
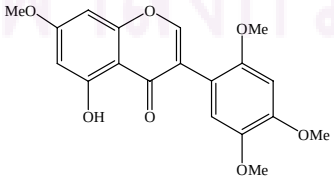
Plant and compound	Category	Plant part	Reference
Millettia brandisiana			
6-Hydroxy-6a,12a-dehydro-α-toxicarol [**27**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
12a-Hydroxy-α-toxicarol [**28**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
Naringenin [**29**] 	Flavanone	Leaf	Kikuchi *et al*., 2007
Olibergin A [**30]** 	Isoflavone	Leaf	Kikuchi *et al*., 2007
Robustigenin [**31**] 	Isoflavone	Leaf	Pancharoen *et al*., 2008

Table 1 (continued)

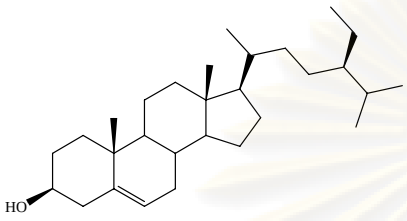
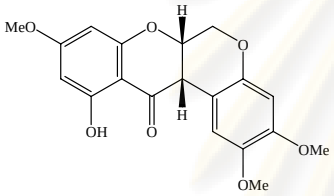
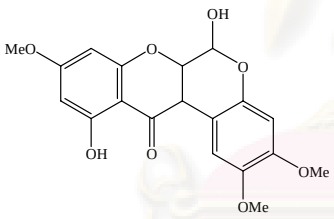
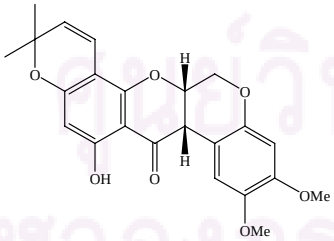
Plant and compound	Category	Plant part	Reference
Millettia brandisiana			
β-Sitosterol [**32**] 	Steroid	Leaf	Pancharoen *et al*., 2008
Sermundone [**33**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
Stemonal [**34**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008
α –Toxicarol [**35**] 	Rotenoid	Leaf	Pancharoen *et al*., 2008

Table 1 (continued)

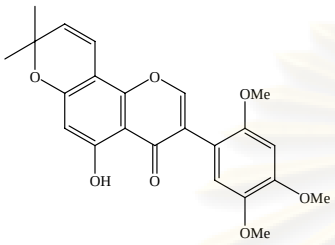
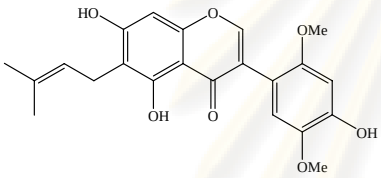
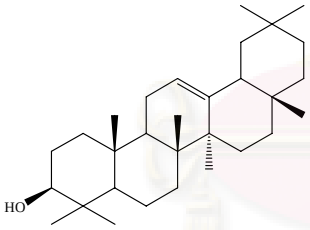
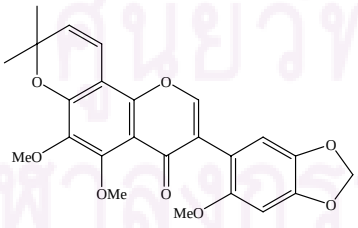
Plant and compound	Category	Plant part	Reference
Millettia brandisiana			
Toxicarol isoflavone [**36**] 	Isoflavone	Leaf	Pancharoen *et al*., 2008
Viridiflorin [**37**] 	Isoflavone	Leaf	Kikuchi *et al*., 2007, Pancharoen *et al*., 2008
Millettia conraui			
β-amyrin [**38**] 	Triterpenoid	Stem bark	Tchinda *et al*., 2007
Conrauinone A [**39**] 	Isoflavone	Stem bark	Fuendjiep *et al*., 1998a

Table 1 (continued)

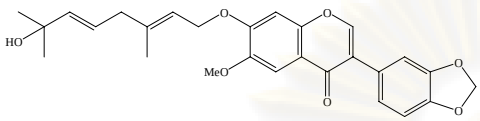
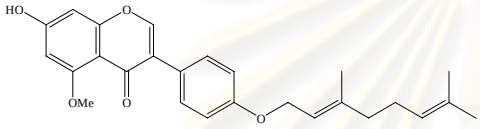
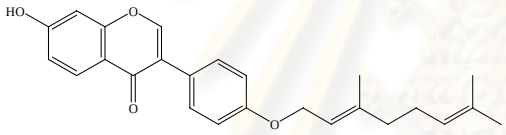
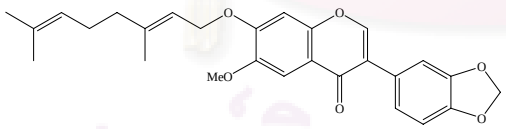
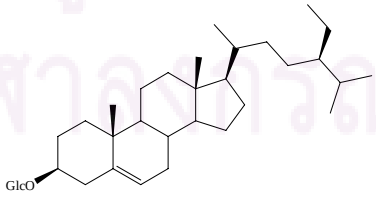
Plant and compound	Category	Plant part	Reference
Millettia conraui			
Conrauinone B [**40**] 	Isoflavone	Stem bark	Fuendjiep *et al*., 1998a
Conrauinone C [**41**] 	Isoflavone	Stem bark	Fuendjiep *et al*., 1998b
Conrauinone D [**42**] 	Isoflavone	Stem bark	Fuendjiep *et al*., 1998b
n-Docosanol [**43**]	Alcohol	Stem bark	Tchinda *et al*., 2007
7-*O*-Geranyl-6-methoxypseudo-baptigenin [**44**] 	Isoflavone	Stem bark	Tchinda *et al*., 2007
3-*O*-β-D-Glucopyranosyl sitosterol [**45**] 	Steroid	Stem bark	Tchinda *et al*., 2007

Table 1 (continued)

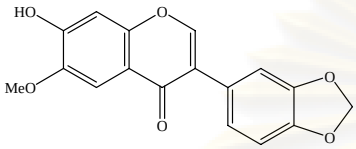
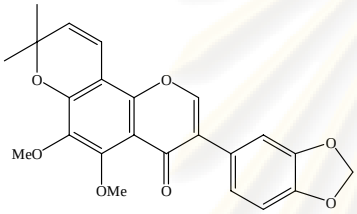
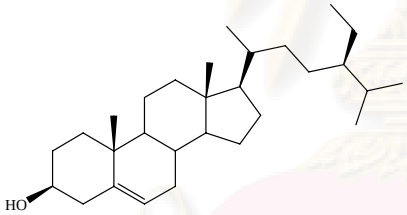
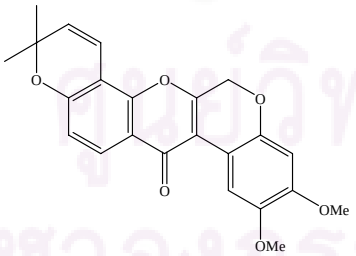
Plant and compound	Category	Plant part	Reference
Millettia conraui			
7-Hydroxy-6-methoxy-3′,4′-methylenedioxyisoflavone [**46**] 	Isoflavone	Stem bark	Fuendjiep *et al.*, 1998b
5-Methoxydurmillone [**47**] 	Isoflavone	Stem bark	Fuendjiep *et al.*, 1998a
Sitosterol [**32**] 	Steroid	Stem bark	Tchinda *et al.*, 2007
Millettia duchesnei			
6a,12a-Dehydrodeguelin [**48**] 	Rotenoid	Twig	Ngandeu *et al.*, 2008

Table 1 (continued)

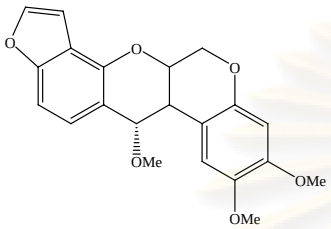
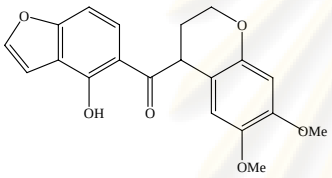
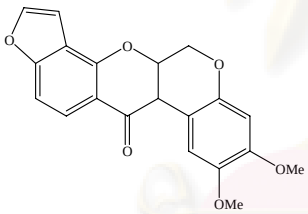
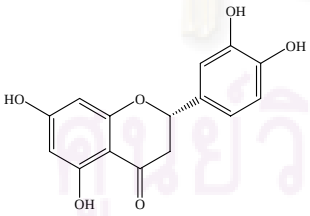
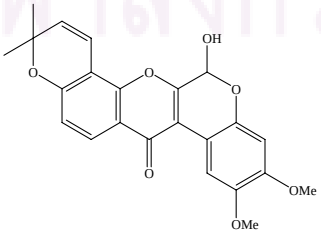
Plant and compound	Category	Plant part	Reference
Millettia duchesnei			
12-Deoxo-12α-methoxyelliptone [**49**] 	Rotenoid	Twig	Ngandeu *et al*., 2008
Elliptol [**50**] 	Rotenoid	Twig	Ngandeu *et al*., 2008
Elliptone [**51**] 	Rotenoid	Twig	Ngandeu *et al*., 2008
Eriodictyol [**52**] 	Flavanone	Twig	Ngandeu *et al*., 2008
6-Hydroxy-6a,12a-dehydrodeguelin [**53**] 	Rotenoid	Twig	Ngandeu *et al*., 2008

Table 1 (continued)

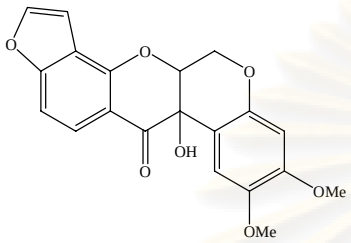
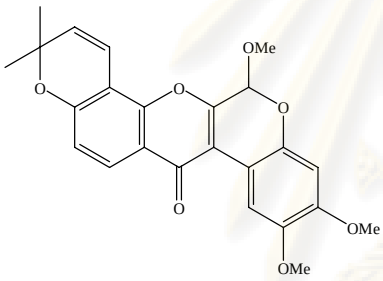
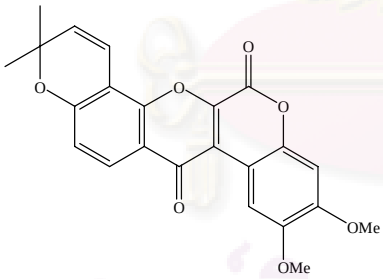
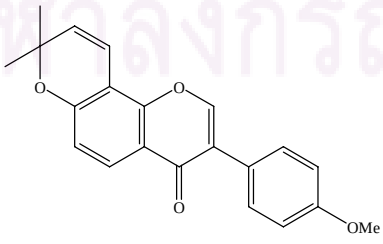
Plant and compound	Category	Plant part	Reference
Millettia duchesnei			
12a-Hydroxyelliptone [**54**] 	Rotenoid	Twig	Ngandeu *et al.*, 2008
6-Methoxy-6a,12a-dehydrodeguelin [**55**] 	Rotenoid	Twig	Ngandeu *et al.*, 2008
6-Oxo-6a,12a-dehydrodeguelin [**56**] 	Rotenoid	Twig	Ngandeu *et al.*, 2008
Millettia dura			
Calopogonium isoflavone A [**57**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1996

Table 1 (continued)

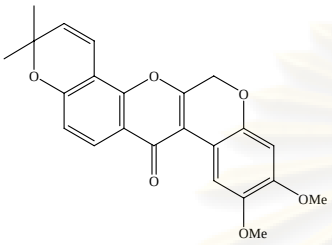
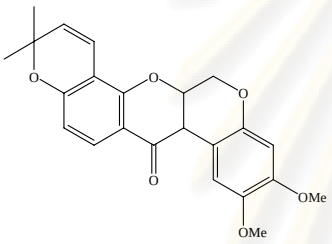
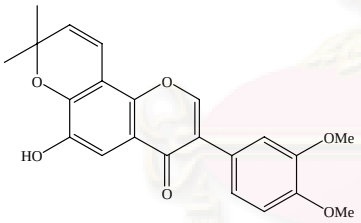
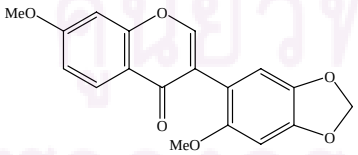
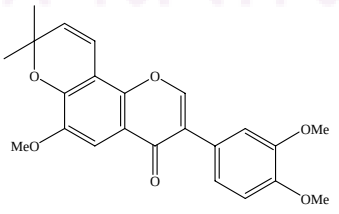
Plant and compound	Category	Plant part	Reference
Millettia dura			
6a,12a-Dehydrodeguelin [**48**] 	Rotenoid	Seed	Ollis, Rhodes and Sutherland, 1967
Deguelin [**58**] 	Rotenoid	Seed	Dagne, Mammo and Bekele, 1991
6-Demethyldurallone [**59**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1996
7,2′-Dimethoxy-4′,5′-methylene-dioxyisoflavone [**60**] 	Isoflavone	Stem bark, Root bark	Dagne, Mammo and Bekele, 1991
Durallone [**61**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1996

Table 1 (continued)

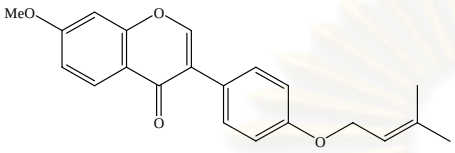
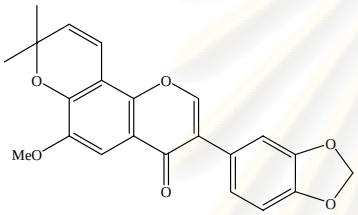
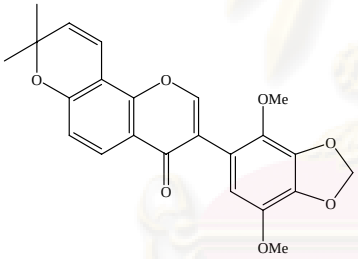
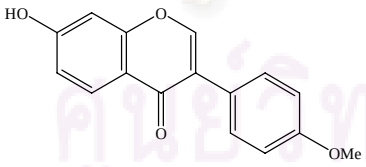
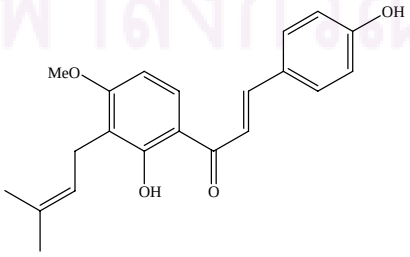
Plant and compound	Category	Plant part	Reference
Millettia dura			
Durlettone [**62**] 	Isoflavone	Seed	Ollis, Rhodes and Sutherland, 1967
Durmillone [**63**] 	Isoflavone	Seed, Stem bark	Ollis, Rhodes and Sutherland, 1967 Yenesew, Midiwo and Waterman, 1996
Ferrugone [**64**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1997
Formononetin [**65**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1997
4-Hydroxyderricin [**66**] 	Chalcone	Stem bark, Root bark	Dagne, Mammo and Bekele, 1991

Table 1 (continued)

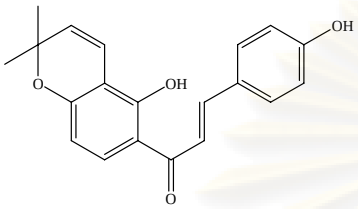
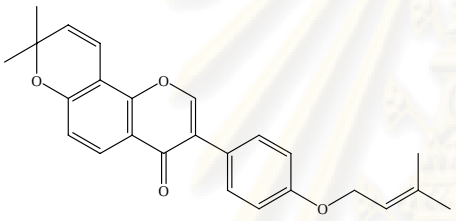
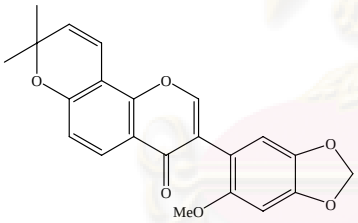
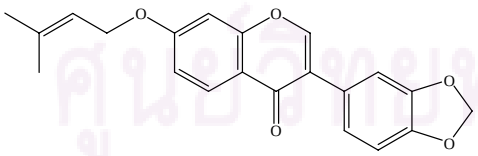
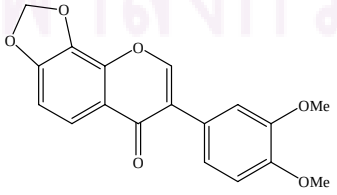
Plant and compound	Category	Plant part	Reference
Millettia dura			
4-Hydroxylonchocarpin [**67**] 	Chalcone	Stem bark, Root bark	Dagne, Mammo and Bekele, 1991
Isoerythrin-A-4′-(3-methylbut-2-enyl) ether [**68**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1996
Jamaicin [**69**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1997
Maximaisoflavone B [**70**] 	Isoflavone	Stem bark	Dagne, Mammo and Bekele, 1991
Maximaisoflavone D [**71**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1996

Table 1 (continued)

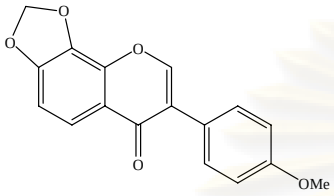
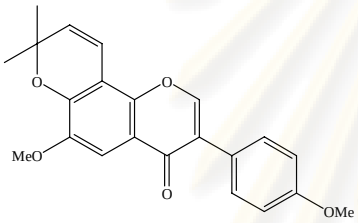
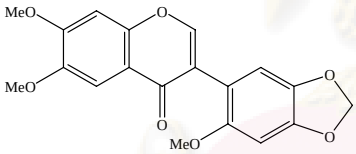
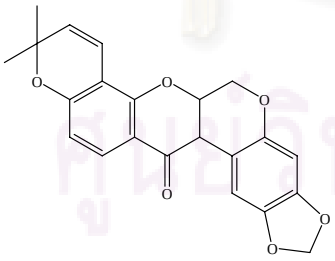
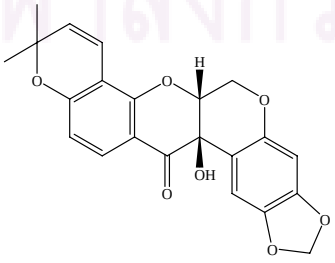
Plant and compound	Category	Plant part	Reference
Millettia dura			
Maximaisoflavone H [**72**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1996
6-Methoxycalopogonium isoflavone A [**73**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1997
Milldurone [**74**] 	Isoflavone	Seed	Ollis, Rhodes and Sutherland, 1967
Millettone [**75**] 	Rotenoid	Seed	Ollis, Rhodes and Sutherland, 1967
Millettosin [**76**] 	Rotenoid	Seed	Ollis, Rhodes and Sutherland, 1967

Table 1 (continued)

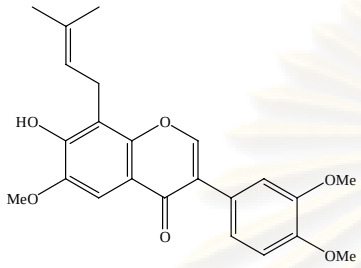
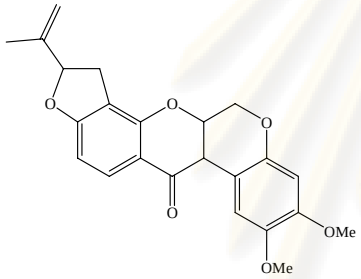
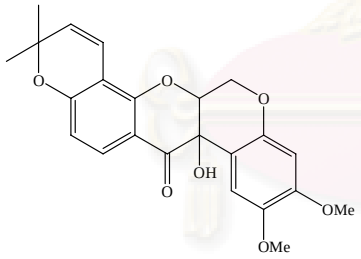
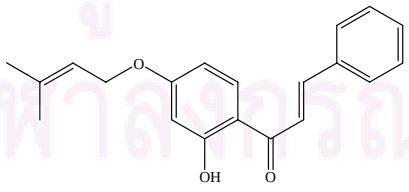
Plant and compound	Category	Plant part	Reference
Millettia dura			
Predurrallone [**77**] 	Isoflavone	Seed pod	Yenesew, Midiwo and Waterman, 1996
Rotenone [**78**] 	Rotenoid	Seed	Ollis, Rhodes and Sutherland, 1967
Tephrosin [**79**] 	Rotenoid	Seed, Seed pod	Ollis, Rhodes and Sutherland, 1967 Yenesew, Midiwo and Waterman, 1997
Millettia erythrocalyx			
Derricidin [**80**] 	Chalcone	Stem bark, Root	Sritularak *et al*., 2002a Sritularak *et al*., 2002b

Table 1 (continued)

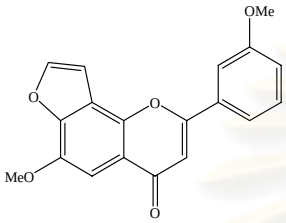
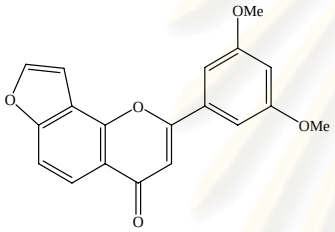
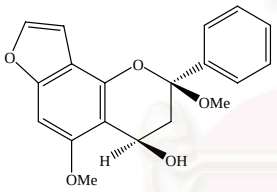
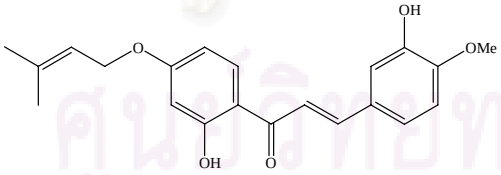
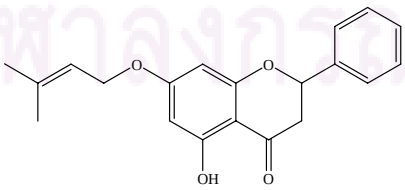
Plant and compound	Category	Plant part	Reference
Millettia erythrocalyx			
6,3′-Dimethoxy-[2′′,3′′:7,8]-furanoflavone [**81**] 	Flavone	Pod	Sritularak and Likhitwitayawuid, 2006
3′,5′-Dimethoxy-[2′′,3′′ : 7,8]-furanoflavone [**82**] 	Flavone	Leaf	Likhitwitayawuid *et al*., 2005
2,5-Dimethoxy-4-hydroxy-[2′′,3′′:7,8]-furanoflavan [**83**] 	Flavan	Root	Sritularak *et al*., 2002b
2′,3-Dihydroxy-4-methoxy-4′-γ,γ-dimethylallyloxychalcone [**84**] 	Chalcone	Pod	Sritularak and Likhitwitayawuid, 2006
7- γ, γ -Dimethylallyloxyflavanone [**85**] 	Flavanone	Stem bark	Sritularak *et al*., 2002a

Table 1 (continued)

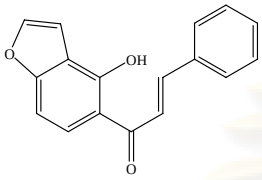
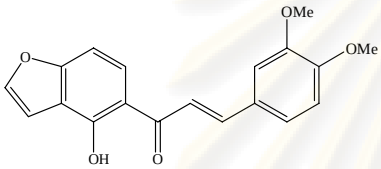
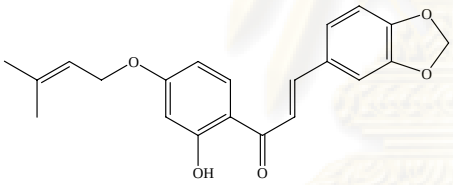
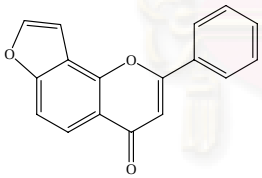
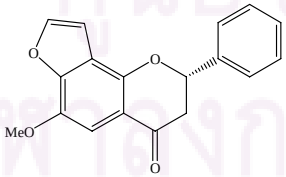
Plant and compound	Category	Plant part	Reference
Millettia erythrocalyx			
1-(4-Hydroxy-5-benzofuranyl)-3-phenyl-2-propen-1-one [**86**] 	Chalcone	Root	Sritularak *et al*., 2002b
2′-Hydroxy-3,4-dimethoxy-[2″,3″:4′,3′]-furanochalcone [**87**] 	Chalcone	Pod	Sritularak and Likhitwitayawuid, 2006
2′-Hydroxy-3,4-methylenedioxy-4′-γ, γ -dimethylallyloxychalcone [**88**] 	Chalcone	Stem bark, Pod	Sritularak *et al*., 2002a Sritularak and Likhitwitayawuid, 2006
Lanceolatin B [**89**] 	Flavone	Root	Sritularak *et al*., 2002b
6-Methoxy-[2″,3″:7,8]-furano-flavanone [**90**] 	Flavanone	Root	Sritularak *et al*., 2002b

Table 1 (continued)

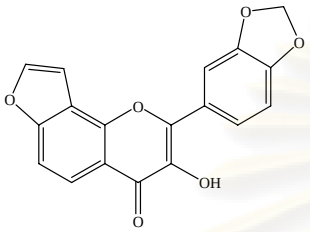
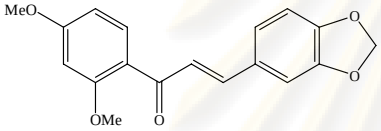
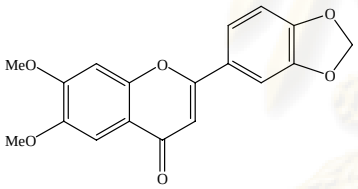
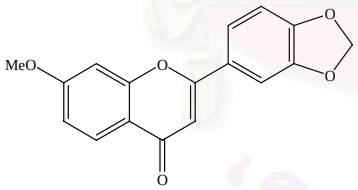
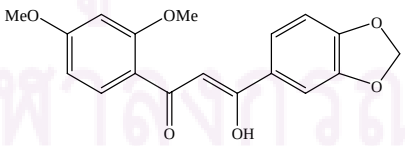
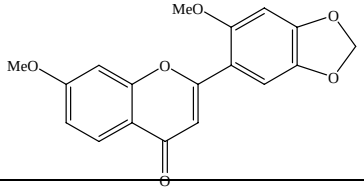
Plant and compound	Category	Plant part	Reference
Millettia erythrocalyx			
3′,4′-Methylenedioxy-[2′′,3′′:7,8]-furanoflavonol [**91**] 	Flavonol	Pod	Sritularak and Likhitwitayawuid, 2006
3,4-Methylenedioxy-2′,4′-dimethoxy-chalcone [**92**] 	Chalcone	Root	Sritularak *et al*., 2002b
3′,4′-Methylenedioxy-6,7-dimethoxyflavone or milletenin C [**93**] 	Flavone	Stem bark, Leaf	Sritularak *et al*., 2002a Likhitwitayawuid *et al*., 2005
3′,4′-Methylenedioxy-7-methoxy-flavone [**94**] 	Flavone	Stem bark, Leaf	Sritularak *et al*., 2002a Likhitwitayawuid *et al*., 2005
Milletenone [**95**] 	Chalcone	Stem bark, Root	Sritularak *et al*., 2002a Sritularak *et al*., 2002b
Millettocalyxin A [**96**] 	Flavone	Stem bark	Sritularak *et al*., 2002a

Table 1 (continued)

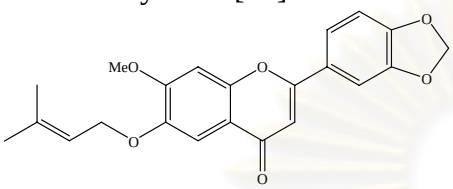
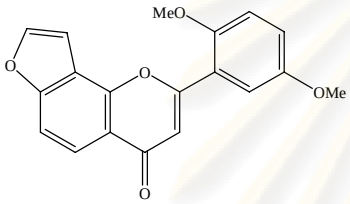
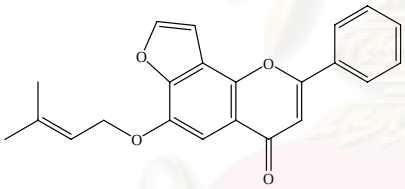
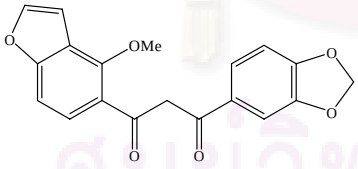
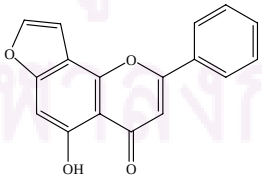
Plant and compound	Category	Plant part	Reference
Millettia erythrocalyx			
Millettocalyxin B [**97**] 	Flavone	Stem bark	Sritularak *et al*., 2002a
Millettocalyxin C [**98**] 	Flavone	Stem bark, Pod	Sritularak *et al*., 2002a Sritularak and Likhitwitayawuid, 2006
Ovalifolin [**99**] 	Flavone	Stem bark, Pod	Sritularak *et al*., 2002a Sritularak and Likhitwitayawuid, 2006
Ovalitenone [**100**] 	Chalcone	Root	Sritularak *et al*., 2002b
Pongaglabol [**101**] 	Flavone	Root	Sritularak *et al*., 2002b

Table 1 (continued)

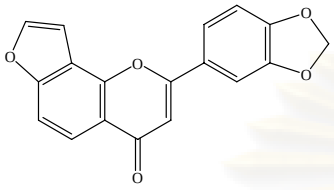
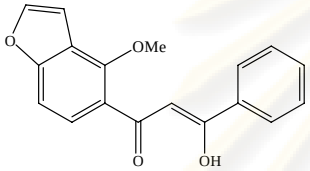
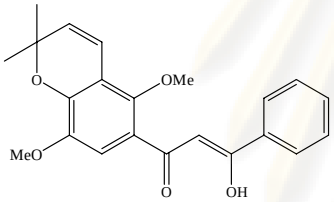
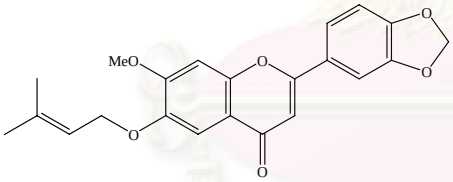
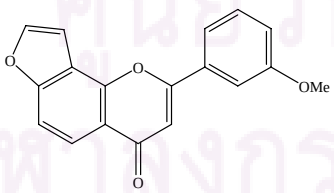
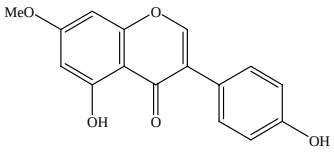
Plant and compound	Category	Plant part	Reference
Millettia erythrocalyx			
Pongaglabrone [**102**] 	Flavone	Stem bark, Leaf	Sritularak *et al*., 2002a Likhitwitayawuid *et al*., 2005
Pongamol [**103**] 	Chalcone	Root	Sritularak *et al*., 2002b
Ponganone I [**104**] 	Chalcone	Stem bark, Root	Sritularak *et al*., 2002a Sritularak *et al*., 2002b
Ponganone V [**105**] 	Flavanone	Root	Sritularak *et al*., 2002b
Pongol methyl ether [**106**] 	Flavone	Stem bark, Pod	Sritularak *et al*., 2002a Sritularak and Likhitwitayawuid, 2006
Prunetin [**107**] 	Isoflavone	Stem bark	Sritularak *et al*., 2002a

Table 1 (continued)

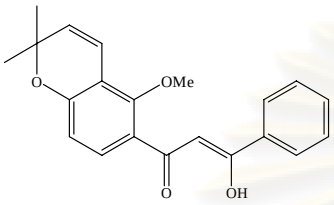
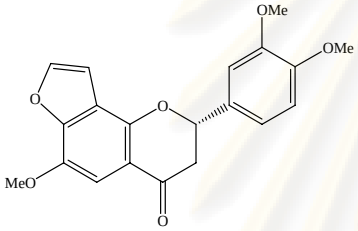
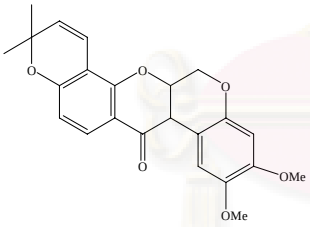
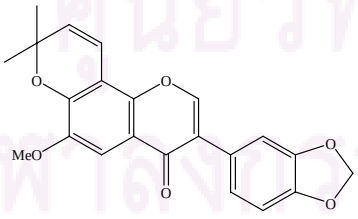
Plant and compound	Category	Plant part	Reference
Millettia erythrocalyx			
Purpurenone [**108**] 	Chalcone	Root	Sritularak *et al*., 2002b
(-)-(2*S*)-6,3′,4′-Trimethoxy-[2″,3″:7,8]-furanoflavanone [**109**] 	Flavanone	Pod	Sritularak and Likhitwitayawuid, 2006
Millettia ferruginea			
Deguelin [**58**] 	Rotenoid	Seed	Highet and Highet, 1967
Durmillone [**63**] 	Isoflavone	Seed	Highet and Highet, 1967

Table 1 (continued)

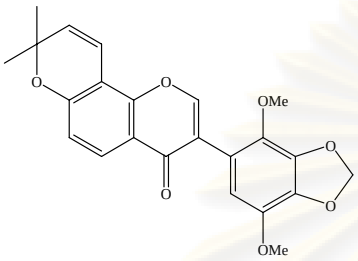
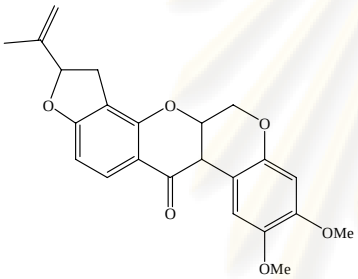
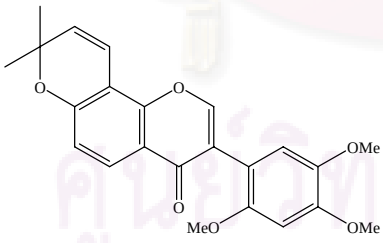
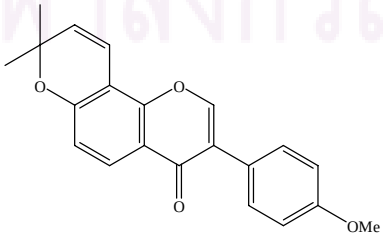
Plant and compound	Category	Plant part	Reference
Millettia ferruginea			
Ferrugone [**64**] 	Isoflavone	Seed	Highet and Highet, 1967
Rotenone [**78**] 	Rotenoid	Seed	Highet and Highet, 1967
Millettia ferruginea* subsp. *darassana			
Barbigerone [**110**] 	Isoflavone	Seed	Dagne and Bekele, 1990
Calopogonium isoflavone A [**57**] 	Isoflavone	Seed	Dagne and Bekele, 1990

Table 1 (continued)

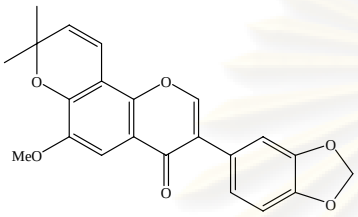
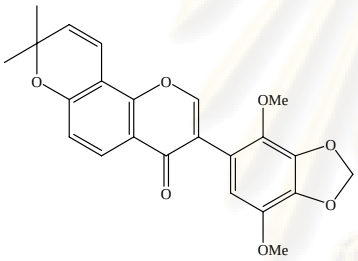
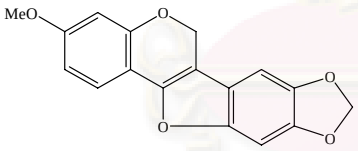
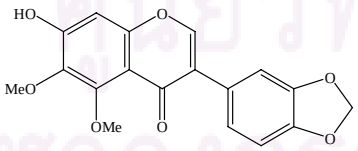
Plant and compound	Category	Plant part	Reference
Millettia ferruginea* subsp. *darassana			
Durmillone [**63**] 	Isoflavone	Seed pod,	Dagne, Bekele and Waterman, 1989
		Seed	Dagne and Bekele, 1990
Ferrugone [**64**] 	Isoflavone	Stem bark,	Dagne, Bekele and Waterman, 1989
		Seed	Dagne and Bekele, 1990
Flemichapparin B [**111**] 	Pterocarpene	Stem bark	Dagne, Bekele and Waterman, 1989
7-Hydroxy-5,6-dimethoxy-3′,4′-methylenedioxyisoflavone [**112**] 	Isoflavone	Stem bark	Dagne, Bekele and Waterman, 1989

Table 1 (continued)

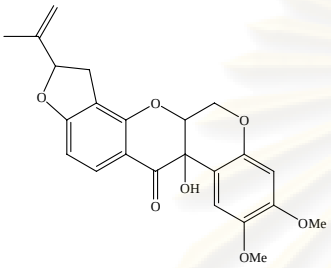
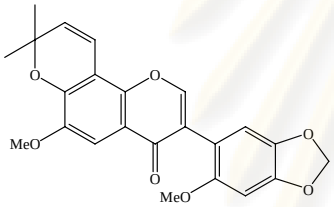
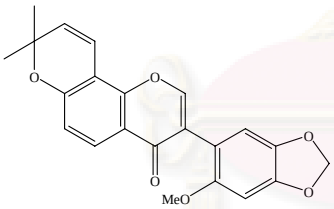
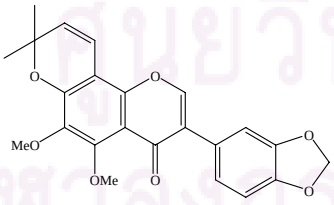
Plant and compound	Category	Plant part	Reference
Millettia ferruginea* subsp. *darassana			
12a-Hydroxyrotenone [**113**] 	Rotenoid	Seed	Dagne and Bekele, 1990
Ichthynone [**114**] 	Isoflavone	Stem bark	Dagne, Bekele and Waterman, 1989
Jamaicin [**69**] 	Isoflavone	Stem bark	Dagne, Bekele and Waterman, 1989
5-Methoxydurmillone [**47**] 	Isoflavone	Stem bark	Dagne, Bekele and Waterman, 1989 Dagne and Bekele, 1990

Table 1 (continued)

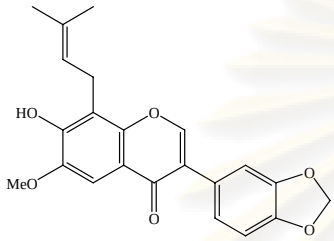
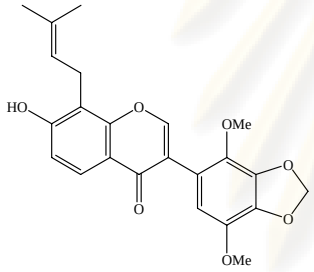
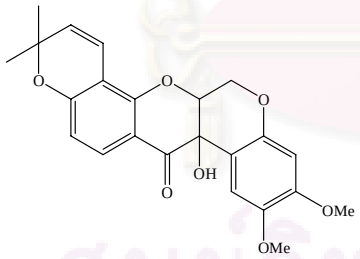
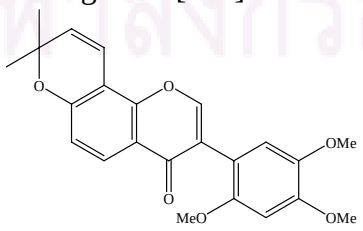
Plant and compound	Category	Plant part	Reference
Millettia ferruginea* subsp. *darassana			
Predurmillone [**115]** 	Isoflavone	Seed	Dagne and Bekele, 1990
Prefurrugone [**116]** 	Isoflavone	Seed	Dagne and Bekele, 1990
Tephrosin [**79**] 	Rotenoid	Seed	Dagne and Bekele, 1990
Millettia ferruginea* subsp. *ferruginea			
Barbigerone [**110**] 	Isoflavone	Seed	Dagne and Bekele, 1990

Table 1 (continued)

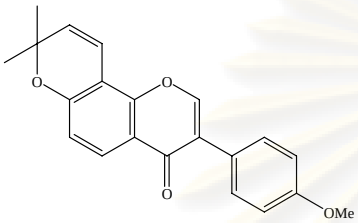
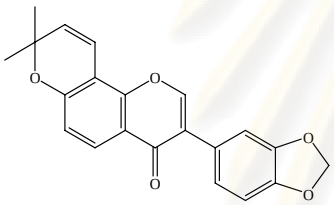
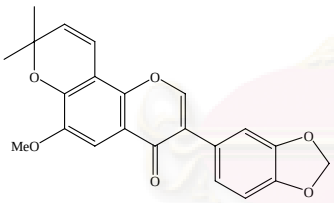
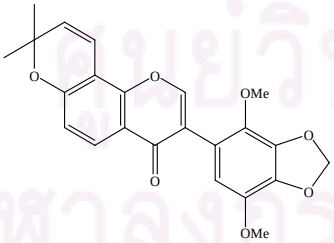
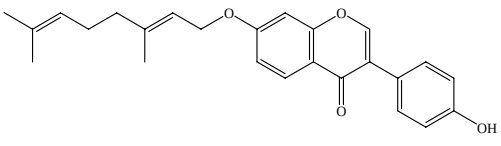
Plant and compound	Category	Plant part	Reference
Millettia ferruginea* subsp. *ferruginea			
Calopogonium isoflavone A [**57**] 	Isoflavone	Seed	Dagne and Bekele, 1990
Calopogonium isoflavone B [**117**] 	Isoflavone	Stem bark	Dagne and Bekele, 1990
Durmillone [**63**] 	Isoflavone	Seed	Dagne and Bekele, 1990
Ferrugone [**64**] 	Isoflavone	Seed, Root bark	Dagne and Bekele, 1990 Dagne *et al*,.1990
7-*O*-Geranylformononetin [**118**] 	Isoflavone	Root bark	Dagne *et al*,.1990

Table 1 (continued)

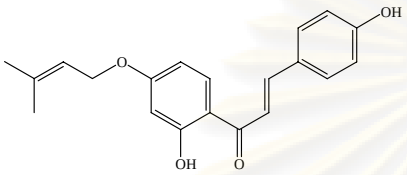
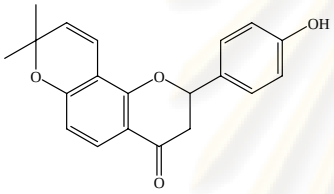
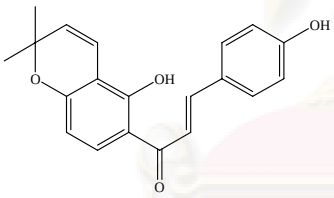
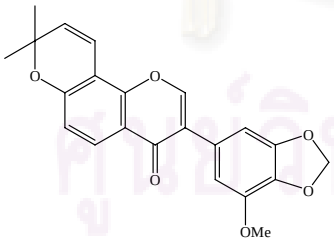
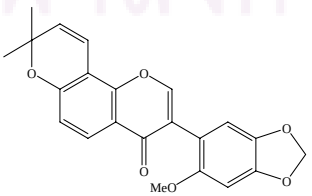
Plant and compound	Category	Plant part	Reference
Millettia ferruginea* subsp. *ferruginea			
4′-*O*-Geranylisoliquiritigenin [**119**] 	Chalcone	Root bark	Dagne *et al*,.1990
4′-Hydroxyisolonchocarpin [**120**] 	Flavanone	Stem bark	Dagne, Bekele and Waterman, 1989
4-Hydroxylonchocarpin [**67**] 	Chalcone	Stem bark	Dagne, Bekele and Waterman, 1989
Isojamaicin [**121**] 	Isoflavone	Stem bark	Dagne, Bekele and Waterman, 1989
Jamaicin [**69**] 	Isoflavone	Stem bark	Dagne, Bekele and Waterman, 1989

Table 1 (continued)

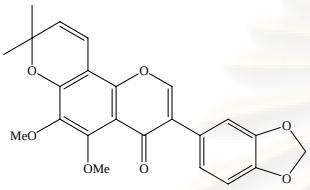
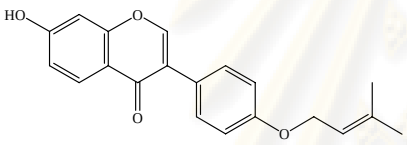
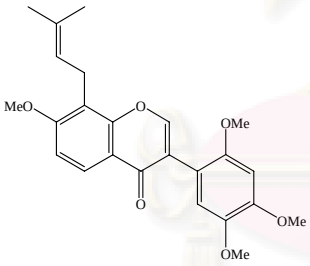
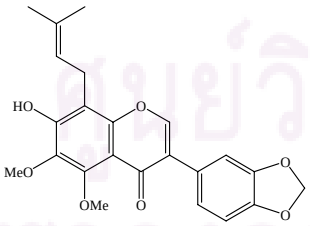
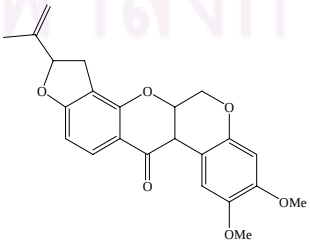
Plant and compound	Category	Plant part	Reference
Millettia ferruginea* subsp. *ferruginea			
5-Methoxydurmillone [**47**] 	Isoflavone	Stem bark, Root bark	Dagne, Bekele and Waterman, 1989 Dagne *et al*,.1990
Nordurlettone [**122**] 	Isoflavone	Seed	Dagne *et al*,.1990
Prebarbigerone [**123**] 	Isoflavone	Seed	Dagne and Bekele, 1990
Pre-5-methoxydurmillone [**124**] 	Isoflavone	Root bark	Dagne and Bekele, 1990
Rotenone [**78**] 	Rotenoid	Seed	Dagne and Bekele, 1990

Table 1 (continued)

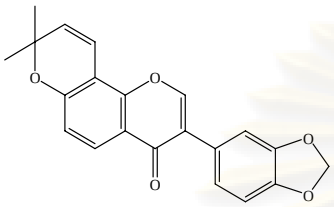
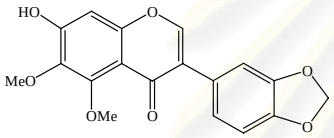
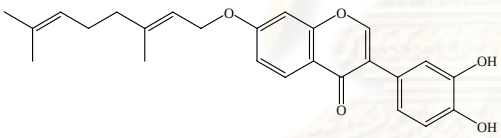
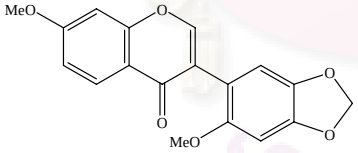
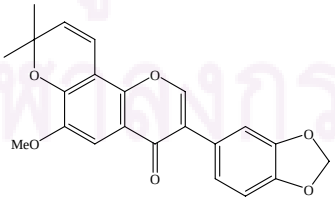
Plant and compound	Category	Plant part	Reference
Millettia griffoniana			
Calopogonium isoflavone B [**117**] 	Isoflavone	Root bark, Seed	Yankep, Fomum and Dagne, 1997 Ngamga *et al*., 2005a
Dipterixine [**125**] 	Isoflavone	Seed	Ngamga *et al*., 2005b
3′,4′-Dihydroxy-7-*O*-[(*E*)-3,7-dimethyl-2,6-octadienyl]-isoflavone [**126**] 	Isoflavone	Root bark	Yankep *et al*., 1998
7,2′-Dimethoxy-4′,5′-methylene-dioxyflavone [**60**] 	Isoflavone	Root bark, Seed	Yankep, Fomum and Dagne, 1997 Ngamga *et al*., 2005a
Durmillone [**63**] 	Isoflavone	Root bark	Yankep, Fomum and Dagne, 1997

Table 1 (continued)

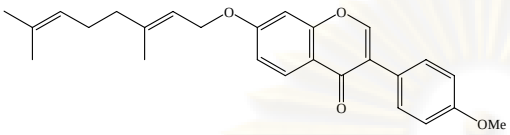
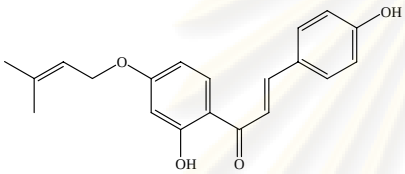
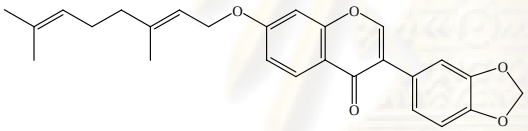
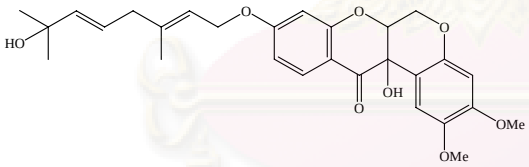
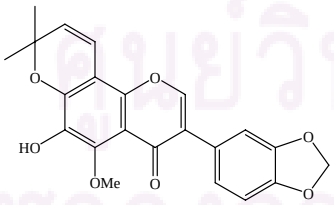
Plant and compound	Category	Plant part	Reference
Millettia griffoniana			
7-*O*-Geranylformononetin [**118**] 	Isoflavone	Root bark	Yankep, Fomum and Dagne, 1997
4′-*O*-Geranylisoliquiritigenin [**119**] 	Chalcone	Root bark	Yankep, Fomum and Dagne, 1997
7-*O*-Geranylpseudobaptigenin [**127**] 	Isoflavone	Root bark	Yankep, Fomum and Dagne, 1997
Griffonianone A [**128**] 	Rotenoid	Root bark	Yankep *et al*., 2001
Griffonianone B [**129**] 	Isoflavone	Root bark	Yankep *et al*., 2001

Table 1 (continued)

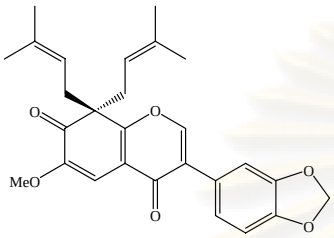
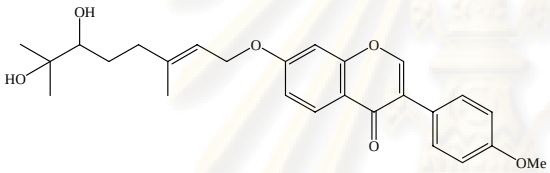
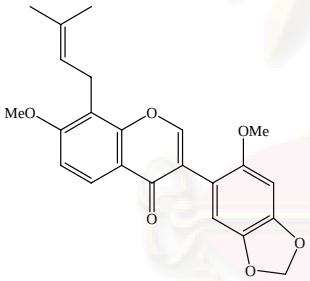
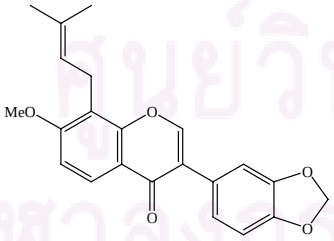
Plant and compound	Category	Plant part	Reference
Millettia griffoniana			
Griffonianone C [**130**] 	Isoflavone	Root bark	Yankep *et al*., 2001
Griffonianone D [**131**] 	Isoflavone	Root bark	Yankep *et al*., 2003
Griffonianone E [**132**] 	Isoflavone	Seed	Ngamga *et al*., 2005a
Griffonianone F [**133**] 	Isoflavone	Seed	Ngamga *et al*., 2005b

Table 1 (continued)

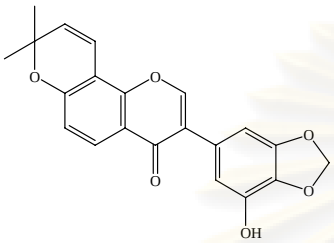
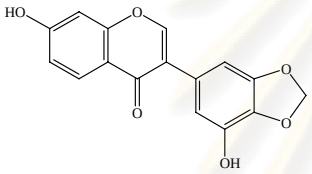
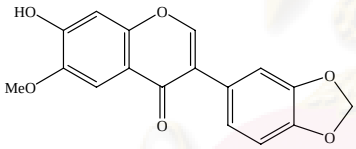
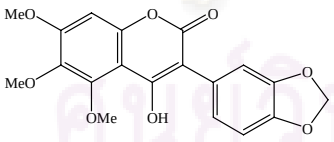
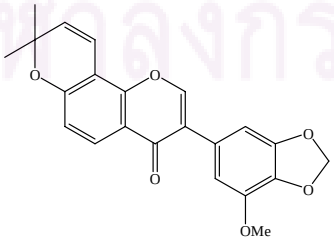
Plant and compound	Category	Plant part	Reference
Millettia griffoniana			
Griffonianone G [**134**] 	Isoflavone	Seed	Ngamga *et al*., 2005b
Griffonianone H [**135**] 	Isoflavone	Seed	Ngamga *et al*., 2005b
7-Hydroxy-6-methoxy-3′,4′-methylenedioxyisoflavone [**46**] 	Isoflavone	Root bark	Yankep *et al*., 2001
4-Hydroxy-5,6,7-trimethoxy-3-(3,4-methlenedioxy) phenylcoumarin [**136**] 	Coumarin	Root bark	Yankep *et al*., 1998
Isojamaicin [**121**] 	Isoflavone	Seed	Ngamga *et al*., 2005b

Table 1 (continued)

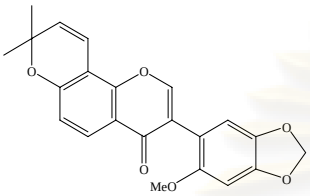
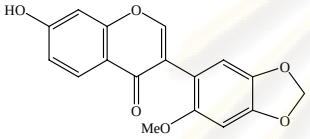
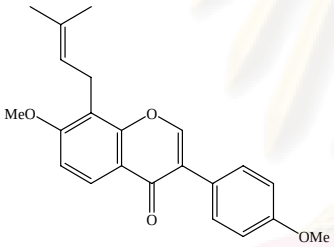
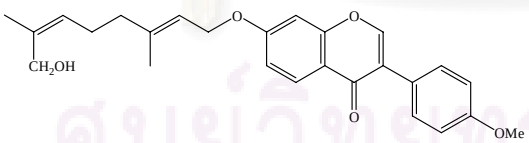
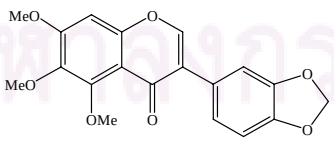
Plant and compound	Category	Plant part	Reference
Millettia griffoniana			
Jamaicin [**69**] 	Isoflavone	Root bark	Yankep, Fomum and Dagne, 1997
Maximaisoflavne G [**137**] 	Isoflavone	Root bark	Yankep *et al*., 2001
7-Methoxyebenosin [**138**] 	Isoflavone	Seed	Ngamga *et al*., 2005a
4′-Methoxy-7-*O*-[(*E*)-3-methyl-7-hydroxymethyl-2,6-octadienyl] isoflavone [**139**] 	Isoflavone	Root bark	Yankep *et al*., 2001
Odorantin [**140**] 	Isoflavone	Root bark	Yankep, Fomum and Dagne, 1997

Table 1 (continued)

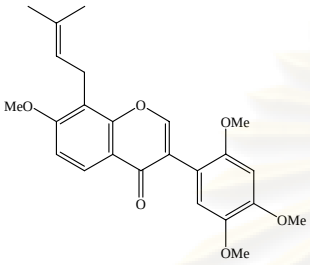
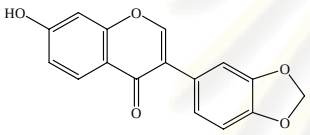
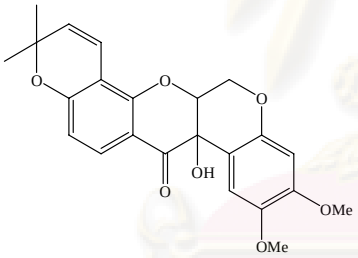
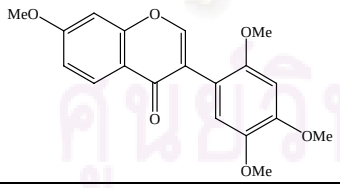
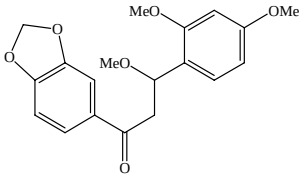
Plant and compound	Category	Plant part	Reference
Millettia griffoniana			
Prebarbigerone [**123**] 	Isoflavone	Seed	Ngamga *et al*., 2005b
Pseudobaptigenin [**141**] 	Isoflavone	Seed	Ngamga *et al*., 2005b
Tephrosin [**79**] 	Rotenoid	Seed	Ngamga *et al*., 2005b
7,2′,4′,5′-Tetramethoxyisoflavone [**142**] 	Isoflavone	Seed	Ngamga *et al*., 2005b
Millettia hemsleyana			
Dihydroisomilletenone methyl ether [**143**] 	Chalcone	Stem bark	Mahmoud and Waterman, 1985

Table 1 (continued)

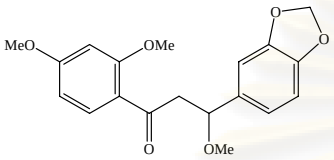
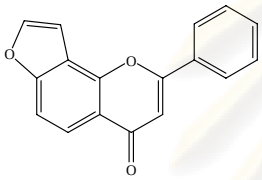
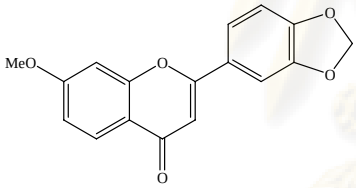
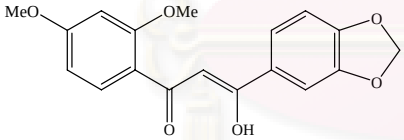
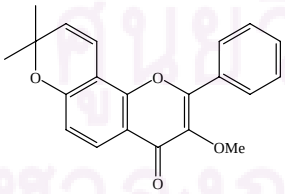
Plant and compound	Category	Plant part	Reference
Millettia hemsleyana			
Dihydromilletenone methyl ether [**144**] 	Chalcone	Stem bark	Mahmoud and Waterman, 1985
Lanceolatin B [**89**] 	Flavone	Stem bark	Mahmoud and Waterman, 1985
3′,4′-Methylenedioxy-7-methoxy-flavone [**94**] 	Flavone	Stem bark	Mahmoud and Waterman, 1985
Milletenone [**95**] 	Chalcone	Stem bark	Mahmoud and Waterman, 1985
Pongaflavone [**145**] 	Flavone	Stem bark	Mahmoud and Waterman, 1985

Table 1 (continued)

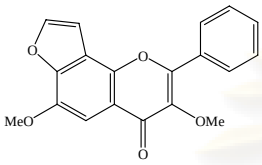
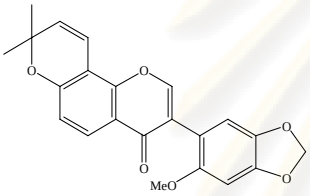
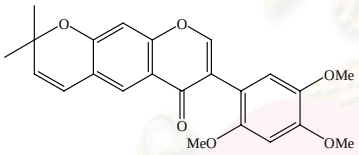
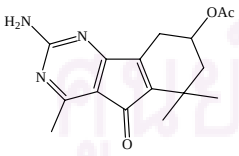
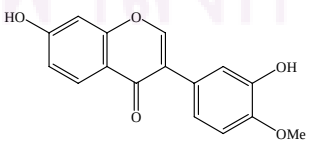
Plant and compound	Category	Plant part	Reference
Millettia ichthyochtona			
3,6-Dimethoxyfurano[4′′,5′′:8,7] flavone [**146**] 	Flavone	Leaf	Kamperdick *et al.*, 1998
Jamaicin [**69**] 	Isoflavone	Leaf	Kamperdick *et al.*, 1998
2′,4′,5′-Trimethoxy-2′′,2′′-dimethyl-pyrano[5′′,6′′:6,7] isoflavone [**147**] 	Isoflavone	Leaf	Kamperdick *et al.*, 1998
Millettia laurentii			
O-Acetylmillaurine [**148**] 	Alkaloid	Seed	Ngamga *et al.*, 1993
Calycosin [**149**] 	Isoflavone	Wood	Kamnaing *et al.*, 1999

Table 1 (continued)

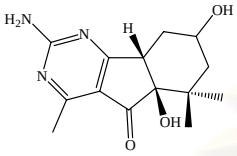
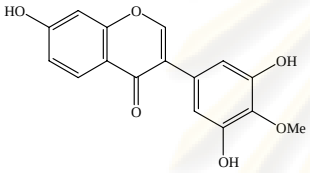
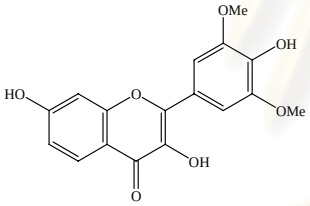
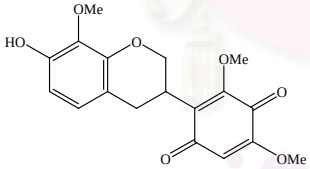
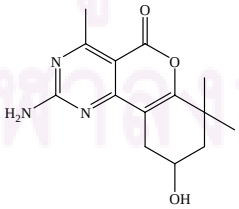
Plant and compound	Category	Plant part	Reference
Millettia laurentii			
5a,9a-dihydro-5a-hydroxyrnillaurine [**150**] 	Alkaloid	Seed	Ngamga *et al.*, 1994
Glyricidin [**151**] 	Isoflavone	Wood	Kamnaing *et al.*, 1999
Laurentinol [**152**] 	Flavonol	Wood	Kamnaing *et al.*, 1999
Laurentiquinone [**153**] 	Isoflavan	Wood	Kamnaing *et al.*, 1999
Millettonine [**154**] 	Alkaloid	Stem bark	Kamnaing *et al.*, 1994

Table 1 (continued)

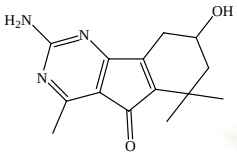
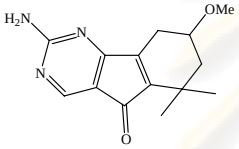
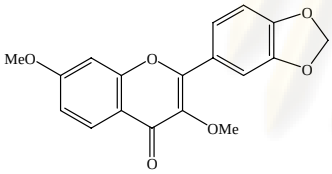
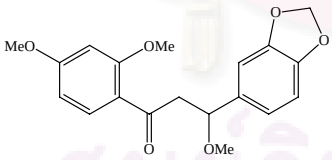
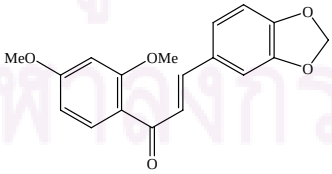
Plant and compound	Category	Plant part	Reference
Millettia laurentii			
Millaurine [**155**] 	Alkaloid	Seed	Ngamga *et al.*, 1993
Millaurine A [**156**] 	Alkaloid	Seed	Ngamga *et al.*, 2007
Millettia leucantha			
Desmethoxykanugin [**157**] 	Flavone	Stem bark	Phrutivorapongkul *et al.*, 2003
Dihydromilletenone methyl ether [**144**] 	Chalcone	Stem bark	Phrutivorapongkul *et al.*, 2003
2′,4′-Dimethoxy-3,4-methylene-dioxychalcone [**158**] 	Chalcone	Stem bark	Phrutivorapongkul *et al.*, 2003

Table 1 (continued)

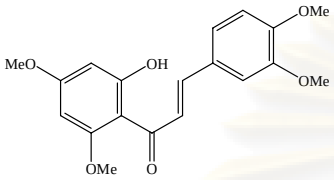
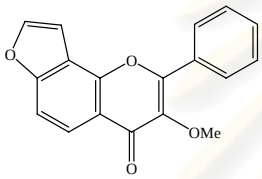
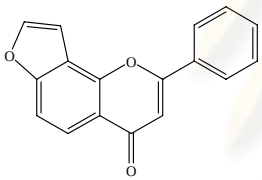
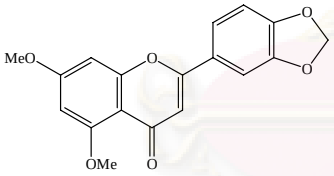
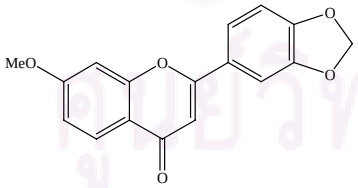
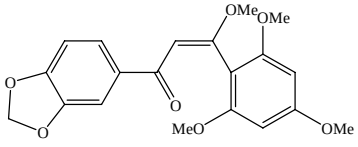
Plant and compound	Category	Plant part	Reference
Millettia leucantha			
2′-Hydroxy-3,4,4′,6′-tetramethoxy-chalcone [**159**] 	Chalcone	Stem bark	Phrutivorapongkul *et al.*, 2003
Karanjin [**160**] 	Flavone	Stem bark	Phrutivorapongkul *et al.*, 2003
Lanceolatin B [**89**] 	Flavone	Stem bark	Phrutivorapongkul *et al.*, 2003
3′,4′-methylenedioxy-5,7-dimethoxyflavone [**161**] 	Flavone	Stem bark	Phrutivorapongkul *et al.*, 2003
3′,4′-Methylenedioxy-7-methoxy-flavone [**94**] 	Flavone	Stem bark	Phrutivorapongkul *et al.*, 2003
2,4,6,β -tetramethoxy-3′,4′-methylenedioxychalcone [**162**] 	Chalcone	Stem bark	Phrutivorapongkul *et al.*, 2003

Table 1 (continued)

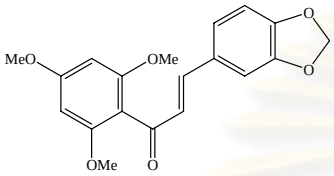
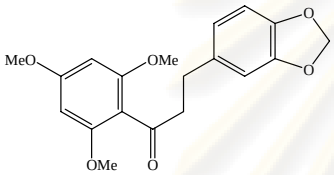
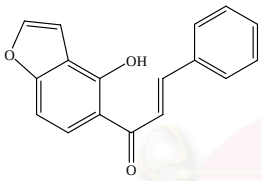
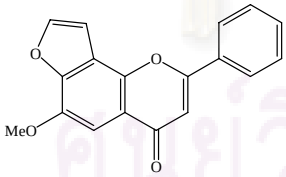
Plant and compound	Category	Plant part	Reference
Millettia leucantha			
2′,4′,6′-Trimethoxy-3,4-methylene-dioxychalcone [**163**] 	Chalcone	Stem bark	Phrutivorapongkul *et al.*, 2003
2′,4′,6′-Trimethoxy-3,4-methylene-dioxydihydrochalcone [**164**] 	Chalcone	Stem bark	Phrutivorapongkul *et al.*, 2003
Millettia ovalifolia			
1-(4-Hydroxy-5-benzofuranyl)-3-phenyl-2-propen-1-one [**86**] 	Chalcone	Root	Saxena *et al.*, 1987
Kanjone [**165**] 	Flavone	Seed	Gupta and Krishnamurti, 1976a
Karanjin [**160**] 	Flavone	Seed	Gupta and Krishnamurti, 1976a

Table 1 (continued)

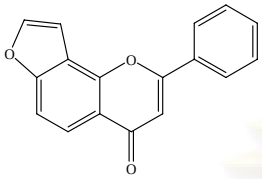
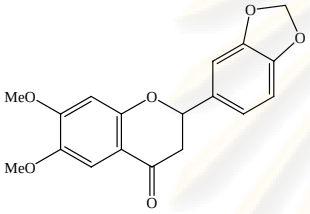
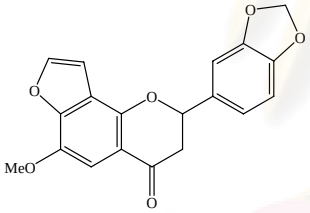
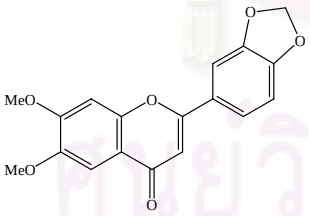
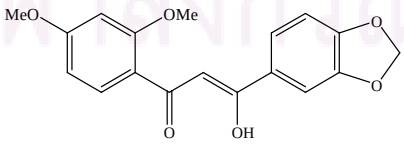
Plant and compound	Category	Plant part	Reference
Millettia ovalifolia			
Lanceolatin B [**89**] 	Flavone	Seed	Gupta and Krishnamurti, 1976a
Milletenin A [**166**] 	Flavanone	Leaf	Khan and Zaman, 1974
Milletenin B [**167**] 	Flavanone	Leaf	Khan and Zaman, 1974
Milletenin C [**93**] 	Flavone	Leaf	Khan and Zaman, 1974
Milletenone [**95**] 	Chalcone	Leaf	Khan and Zaman, 1974

Table 1 (continued)

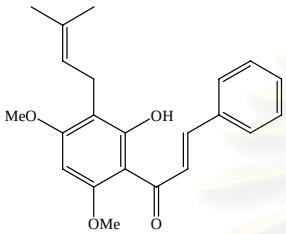
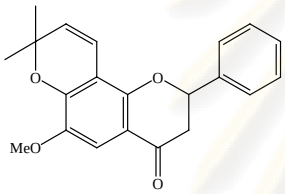
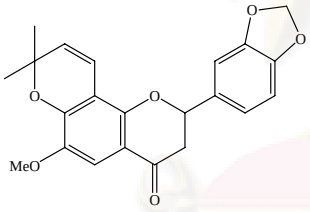
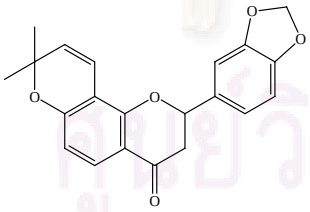
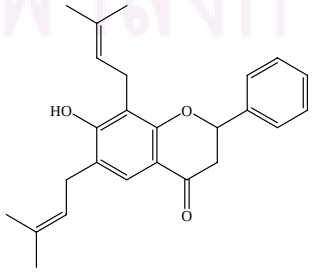
Plant and compound	Category	Plant part	Reference
Millettia ovalifolia			
Ovalichalkone [**168**] 	Chalcone	Seed	Gupta and Krishnamurti, 1977a
Ovalichromene [**169**] 	Flavanone	Seed	Gupta and Krishnamurti, 1976b
Ovalichromene A [**170**] 	Flavanone	Seed	Gupta and Krishnamurti, 1976c
Ovalichromene B [**171**] 	Flavanone	Seed	Gupta and Krishnamurti, 1976c
Ovaliflavanone A [**172**] 	Flavanone	Seed	Gupta and Krishnamurti, 1976a

Table 1 (continued)

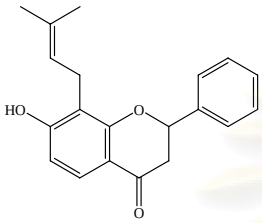
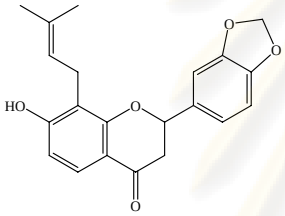
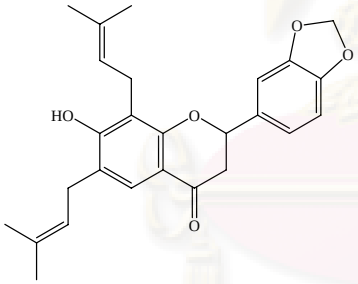
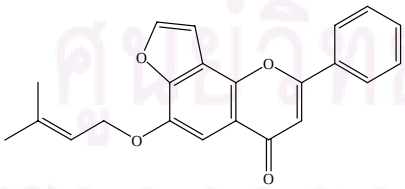
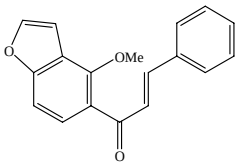
Plant and compound	Category	Plant part	Reference
Millettia ovalifolia			
Ovaliflavanone B [**173**] 	Flavanone	Seed	Gupta and Krishnamurti, 1976a
Ovaliflavanone C [**174**] 	Flavanone	Seed	Islam, Gupta and Krishnamurti, 1980
Ovaliflavanone D [**175**] 	Flavanone	Seed	Islam, Gupta and Krishnamurti, 1980
Ovalifolin [**99**] 	Flavone	Leaf	Khan and Zaman, 1974
Ovalitenin A [**176**] 	Chalcone	Seed	Gupta and Krishnamurti, 1977

Table 1 (continued)

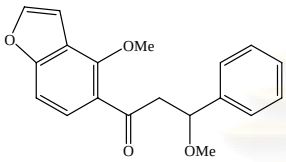
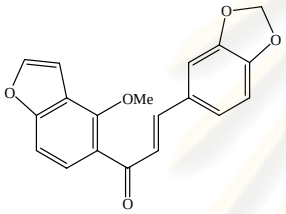
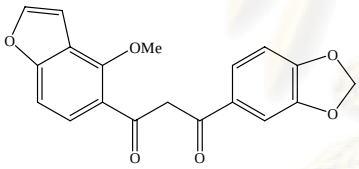
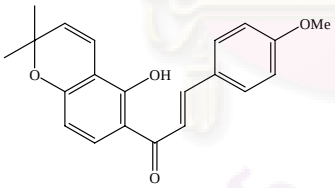
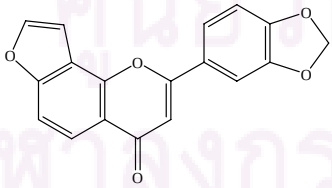
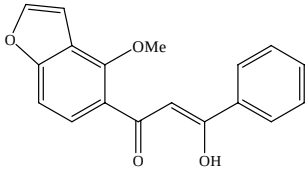
Plant and compound	Category	Plant part	Reference
Millettia ovalifolia			
Ovalitenin B [**177**] 	Chalcone	Seed	Gupta and Krishnamurti, 1977
Ovalitenin C [**178**] 	Chalcone	Seed	Islam, Gupta and Krishnamurti, 1980
Ovalitenone [**100**] 	Chalcone	Seed	Gupta and Krishnamurti, 1977
Pongachalcone I [**179**] 	Chalcone	Seed	Gupta and Krishnamurti, 1976c
Pongaglabrone [**102**] 	Flavone	Seed	Gupta and Krishnamurti, 1976a
Pongamol [**103**] 	Chalcone	Seed	Gupta and Krishnamurti, 1976b

Table 1 (continued)

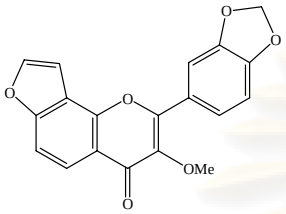
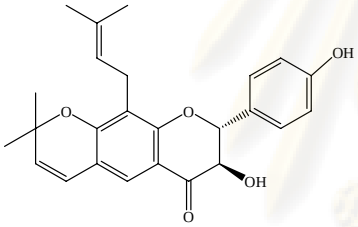
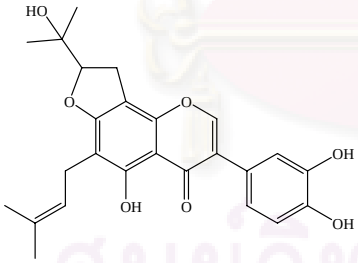
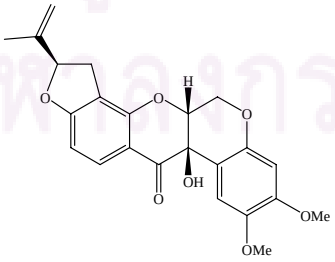
Plant and compound	Category	Plant part	Reference
Millettia ovalifolia			
Pongapin [**180**] 	Flavone	Seed	Gupta and Krishnamurti, 1976b
Millettia pachycarpa			
(2*R*,3*R*)-5,4′-Dihydroxy-8-Prenyl-6″,6″-dimethylpyranol[2″,3″:7,6]-dihydroflavonol [**181**] 	Flavonol	Aerial part	Singhal *et al*., 1980
Furowanin [**182**] 	Flavone	Leaf	Ito *et al*., 2006
cis-12a-Hydroxyrotenone [**183**] 	Rotenoid	Root	Singhal *et al*., 1980

Table 1 (continued)

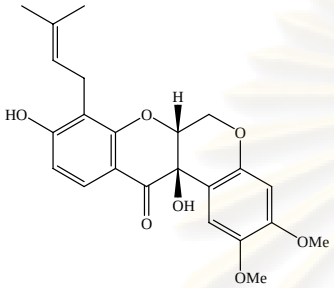
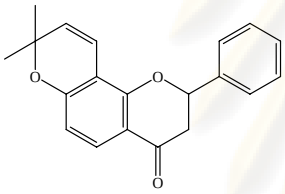
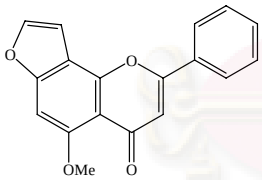
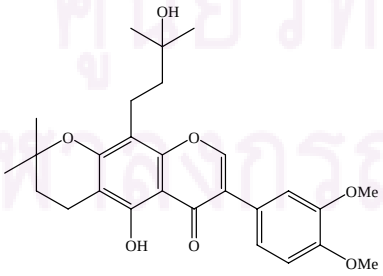
Plant and compound	Category	Plant part	Reference
Millettia pachycarpa			
cis-12a-Hydroxyrot-2′-enoic acid [**184**] 	Rotenoid	Root	Singhal *et al*., 1980
Isolonchocarpin [**185**] 	Flavanone	Root	Shao *et al*., 2001a
5-Methoxy furo[8,7:4′′,5′′]flavone [**186**] 	Flavone	Root	Lu *et al*., 1999
Millettia isoflavone 7A [**187**] 	Isoflavone	Leaf	Singhal *et al*., 1981

Table 1 (continued)

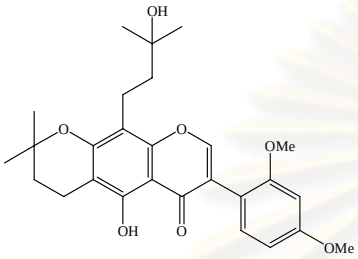
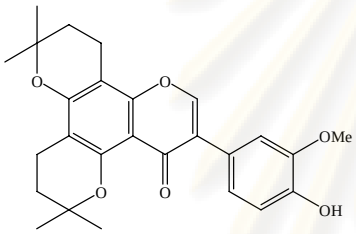
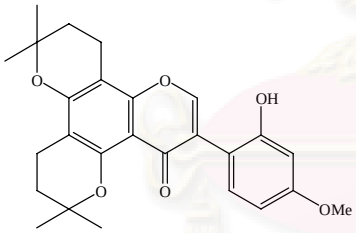
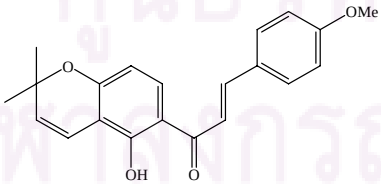
Plant and compound	Category	Plant part	Reference
Millettia pachycarpa			
Millettia isoflavone 7B [**188**] 	Isoflavone	Leaf	Singhal *et al*., 1981
Millettia isoflavone 10B [**189**] 	Isoflavone	Leaf	Singhal *et al*., 1981
Millettia isoflavone 11A [**190**] 	Isoflavone	Leaf	Singhal *et al*., 1981
Millettia pachycarpa pyranochalcone [**191**] 	Chalcone	Seed	Singhal *et al*., 1983

Table 1 (continued)

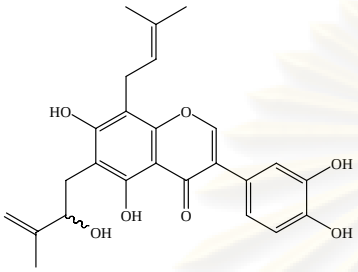
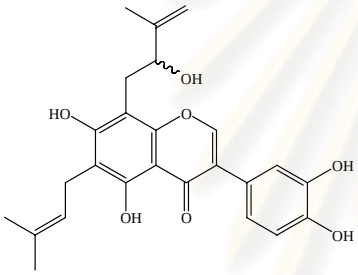
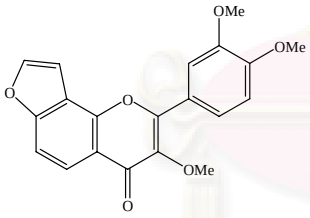
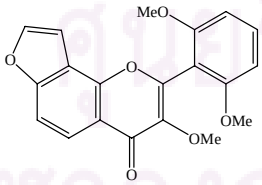
Plant and compound	Category	Plant part	Reference
Millettia pachycarpa			
Millewanin G [**192**] 	Flavone	Leaf	Ito *et al*., 2006
Millewanin H [**193**] 	Flavone	Leaf	Ito *et al*., 2006
Pachycarin A [**194**] 	Flavone	Root	Chen *et al.*, 1999
Pachycarin B [**195**] 	Flavone	Root	Chen *et al.*, 1999

Table 1 (continued)

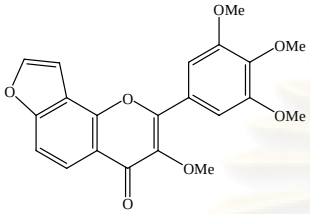
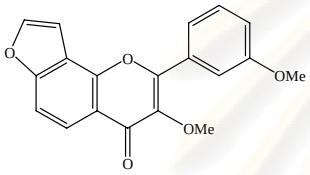
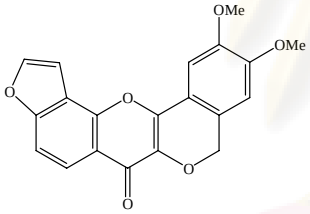
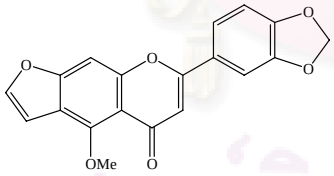
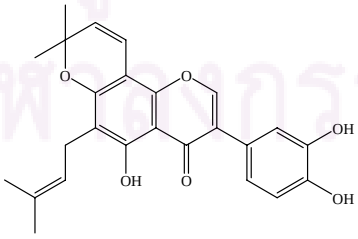
Plant and compound	Category	Plant part	Reference
Millettia pachycarpa			
Pachycarin C [**196**] 	Flavone	Root	Shao *et al.*, 2001b
Pachycarin D [**197**] 	Flavone	Root	Shao *et al.*, 2001b
Pachycarin E [**198**] 	Flavone	Root	Shao *et al.*, 2001b
Pinnatin [**199**] 	Flavone	Root	Shao *et al.*, 2001b
Pomiferin [**200**] 	Isoflavone	Seed	Singhal *et al.*, 1983

Table 1 (continued)

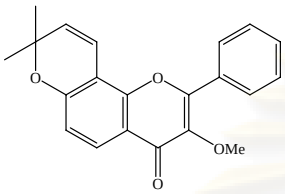
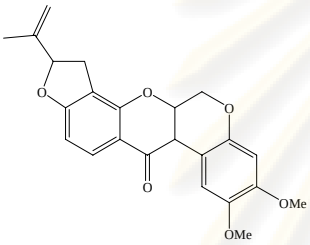
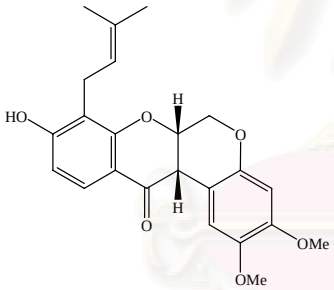
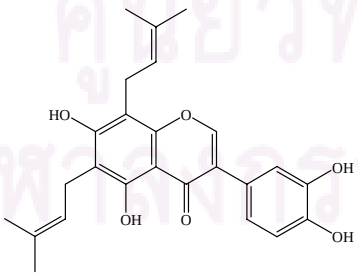
Plant and compound	Category	Plant part	Reference
Millettia pachycarpa			
Pongaflavone [**145**] 	Flavone	Root	Shao *et al.*, 2001a
Rotenone [**78**] 	Rotenoid	Root	Singhal *et al.*, 1982
Rot-2′-enonic acid [**201**] 	Rotenoid	Root	Singhal *et al.*, 1982
5,7,3′,4′-Tetrahydroxy-6,8-diprenyl-isoflavone [**202**] 	Isoflavone	Aerial part	Singhal *et al.*, 1980

Table 1 (continued)

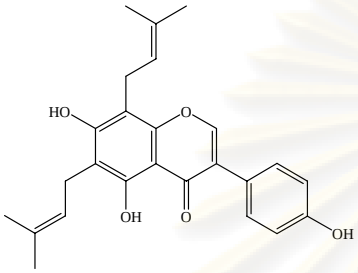
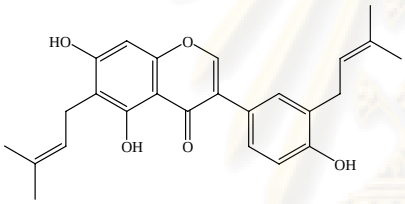
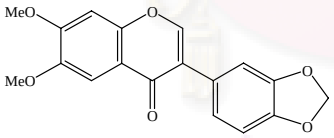
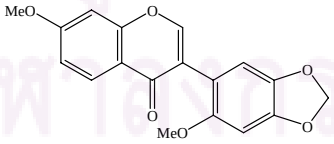
Plant and compound	Category	Plant part	Reference
Millettia pachycarpa			
5,7,4′-Trihydroxy-6,8-diprenyl-isoflavone [**203**] 	Isoflavone	Aerial part	Singhal *et al.*, 1980
5,7,4′-Trihydroxy-6, 3′-diprenyl-isoflavone [**204**] 	Isoflavone	Aerial part	Singhal *et al.*, 1980
Millettia peguensis			
6,7-Dimethoxy-3′,4′-methylene-dioxyisoflavone [**205**] 	Isoflavone	Root	Kapingu, *et al.*, 2006
7,2′-Dimethoxy-4′,5′-methylene-dioxyisoflavone [**206**] 	Isoflavone	Root	Kapingu, *et al.*, 2006

Table 1 (continued)

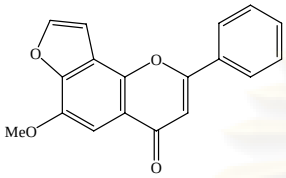
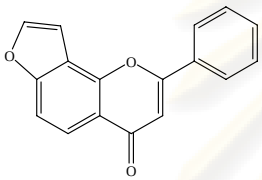
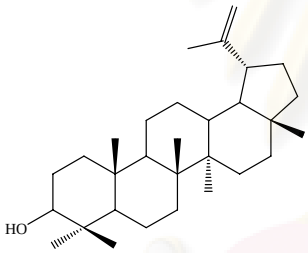
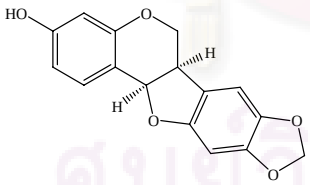
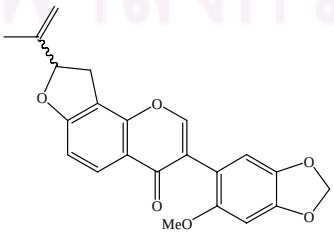
Plant and compound	Category	Plant part	Reference
Millettia peguensis			
Kanjone [**165**] 	Flavone	Stem bark	Ganapaty *et al.*, 1998
Lanceolatin B [**89**] 	Flavone	Stem bark	Ganapaty *et al.*, 1998
Lupeol [**207**] 	Triterpenoid	Root	Kapingu, *et al.*, 2006
Maackiain [**208**] 	Pterocarpan	Root	Kapingu, *et al.*, 2006
2′-Methoxy-4′,5′-methylenedioxy-7,8-[2-(1-methylethnyl)furo] isoflavone [**209**] 	Isoflavone	Root	Kapingu, *et al.*, 2006

Table 1 (continued)

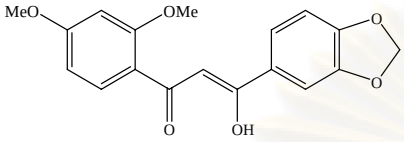
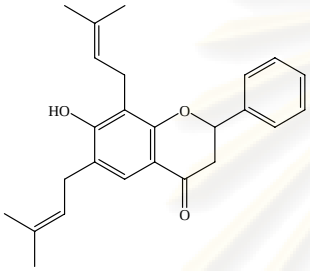
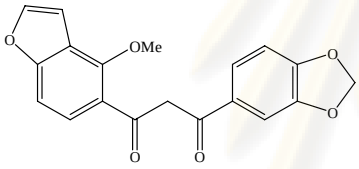
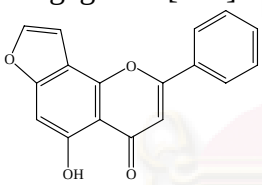
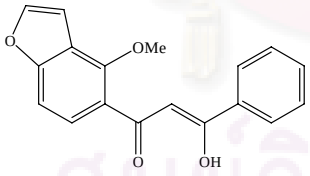
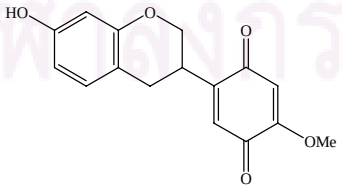
Plant and compound	Category	Plant part	Reference
Millettia peguensis			
Milletenone [**95**] 	Chalcone	Stem bark	Ganapaty *et al.*, 1998
Ovaliflavanone A [**172**] 	Flavanone	Stem bark	Ganapaty *et al.*, 1998
Ovalitenone [**100**] 	Chalcone	Stem Bark	Ganapaty *et al.*, 1998
Pongaglabol [**101**] 	Flavone	Leaf	Ganapaty *et al.*, 1998
Pongamol [**103**] 	Chalcone	Leaf	Ganapaty *et al.*, 1998
Millettia pendura			
Claussequinine [**210**] 	Isoflavan	Heart-wood	Hayashi *et al.*, 1978

Table 1 (continued)

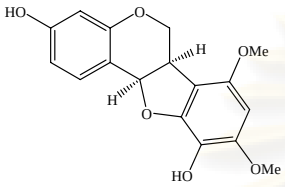
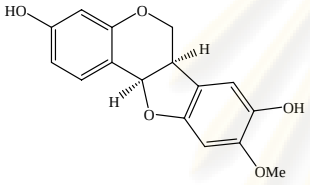
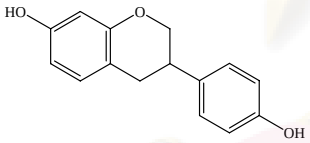
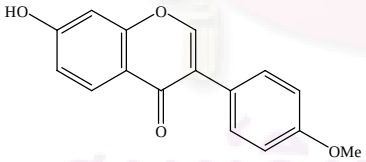
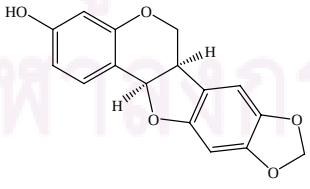
Plant and compound	Category	Plant part	Reference
Millettia pendura			
3,10-Dihydroxy-7,9-dimethoxy-pterocarpan [**211**] 	Pterocapan	Timber	Takahashi *et al.*, 2006
3,8- Dihydroxy-9-methoxy-pterocarpan [**212**] 	Pterocapan	Timber	Takahashi *et al.*, 2006
Equol [**213**] 	Isoflavan	Heart-wood	Hayashi *et al.*, 1978
Formononetin [**65**] 	Isoflavone	Timber	Takahashi *et al.*, 2006
Maackiain [**208**] 	Pterocarpan	Heart-wood	Hayashi *et al.*, 1978

Table 1 (continued)

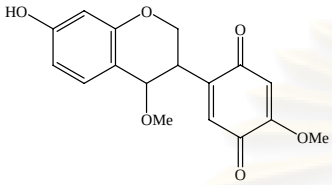
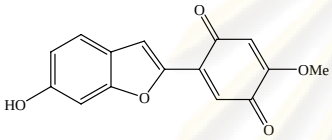
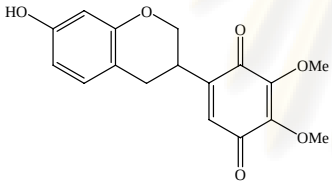
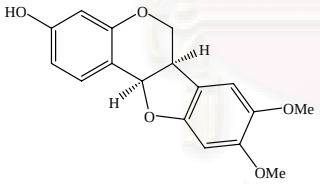
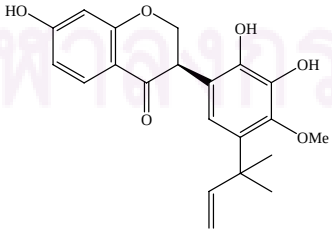
Plant and compound	Category	Plant part	Reference
Millettia pendura			
Millettilone A [**214**] 	Isoflavan	Timber	Takahashi *et al.*, 2006
Millettilone B [**215**] 	Arylbenzo-furan	Timber	Takahashi *et al.*, 2006
Pendulone [**216**] 	Isoflavan	Heart-wood	Hayashi *et al.*, 1978
Secundiflorol I [**217**] 	Pterocarpan	Timber	Takahashi *et al.*, 2006
Millettia pervilleana			
3′-Demethylpervilleanone [**218**] 	Isoflavanone	Root bark	Galeffi *et al.*, 1997

Table 1 (continued)

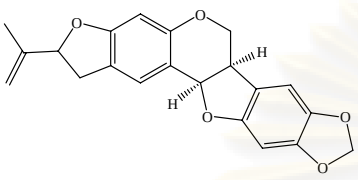
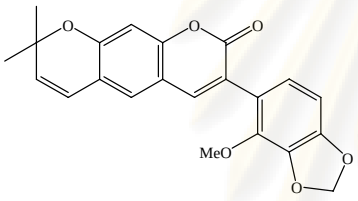
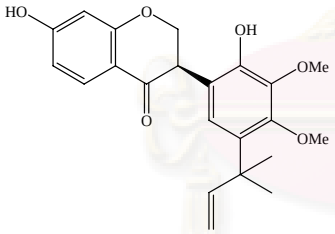
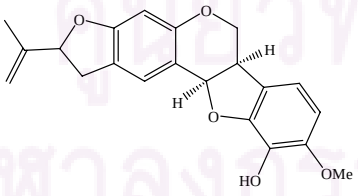
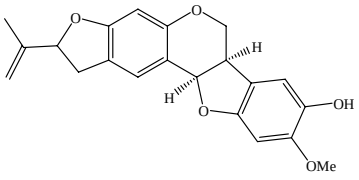
Plant and compound	Category	Plant part	Reference
Millettia pervilleana			
Emoroidocarpan [**219**] 	Pterocarpan	Root bark	Palazzino *et al.*, 2003
3α-Hydroxyrotenone [**220**]	Rotenoid	Root bark	Palazzino *et al.*, 2003
Pervilleanine [**221**] 	Coumarin	Root bark	Palazzino *et al.*, 2003
Pervilleanone [**222**] 	Isoflavanone	Root bark	Galeffi *et al.*, 1997
Pervilline [**223**] 	Pterocarpan	Root bark	Palazzino *et al*., 2003
Pervillinine [**224**] 	Pterocarpan	Root bark	Palazzino *et al.*, 2003

Table 1 (continued)

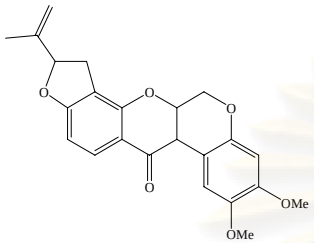
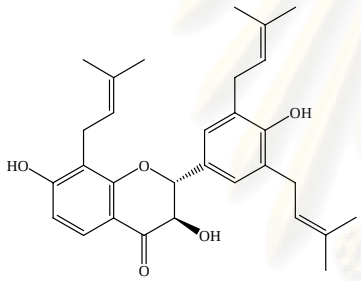
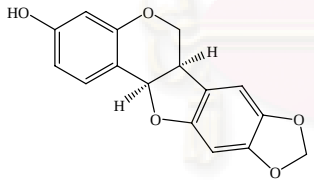
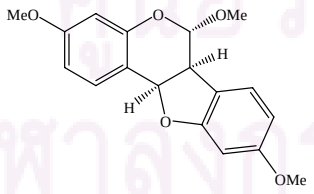
Plant and compound	Category	Plant part	Reference
Millettia pervilleana			
Rotenone [**78**] 	Rotenoid	Root bark	Palazzino *et al.*, 2003
Millettia pulchra			
7,4′-Dihydroxy-8,3′,5′-triprenyl-dihydroflavanol [**225**] 	Flavanonol	Aerial part	Baruah *et al.*, 1984
Maackiain [**208**] 	Pterocarpan	Aerial part	Baruah *et al.*, 1984
6α-Methoxyhomopterocarpin [**226**] 	Pterocarpan	Aerial part	Baruah *et al.*, 1984

Table 1 (continued)

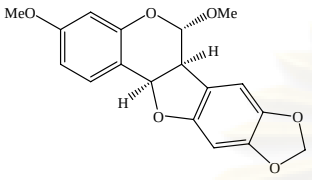
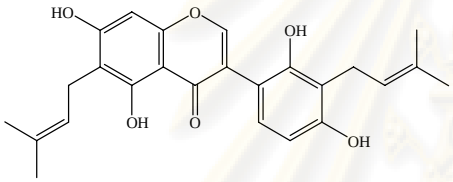
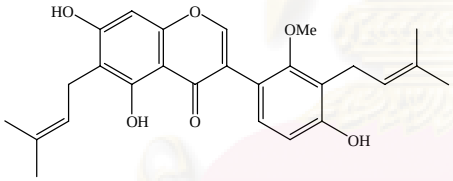
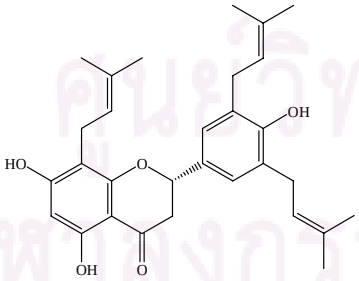
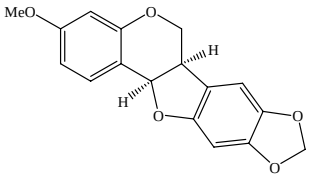
Plant and compound	Category	Plant part	Reference
Millettia pulchra			
6α-Methoxypterocarpin [**227**] 	Pterocarpan	Aerial part	Baruah *et al.*, 1984
5,7,2′,4′-Tetrahydroxy-6,3′-diprenyl-isoflavone [**228**] 	Isoflavone	Aerial part	Baruah *et al.*, 1984
5,7,4′-Trihydroxy-2′-methoxy-6,3′-diprenylisoflavone [**229**] 	Isoflavone	Aerial part	Baruah *et al.*, 1984
5,7,4′-Trihydroxy-8,3′,5′-triprenyl-flavanone [**230**] 	Flavanone	Aerial part	Baruah *et al.*, 1984
Pterocarpin [**231**] 	Pterocarpan	Aerial part	Baruah *et al.*, 1984

Table 1 (continued)

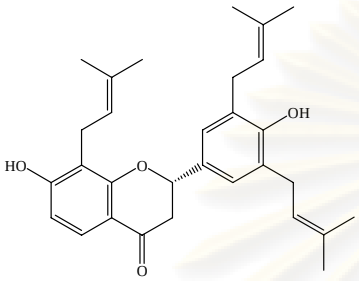
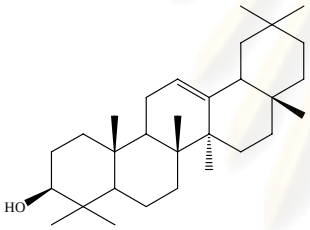
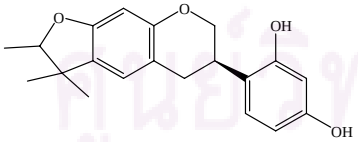
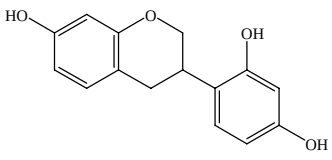
Plant and compound	Category	Plant part	Reference
Millettia pulchra			
Sophoranone [**232**] 	Flavanone	Aerial part	Baruah *et al.*, 1984
Millettia racemosa			
β-amyrin [**38**] 	Triterpenoid	Stem	Rao and Krupadanam, 1994
Behenic acid [**233**] $H_3C(CH_2)_{20}COOH$	Fatty acid	Stem	Rao and Krupadanam, 1994
(+)-Cyclomillinol [**234**] 	Isoflavan	Stem	Kumar, Krupadanam and Srimannarayana, 1989
Demethylvestitol [**235**] 	Isoflavan	Stem	Rao and Krupadanam, 1996

Table 1 (continued)

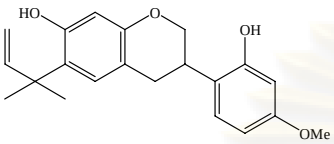
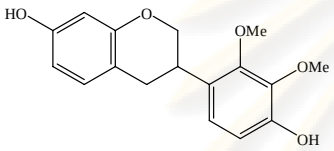
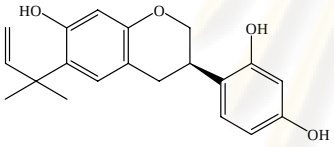
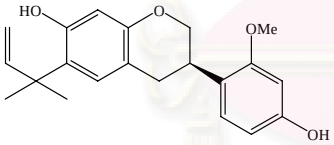
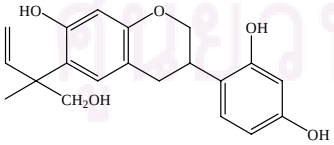
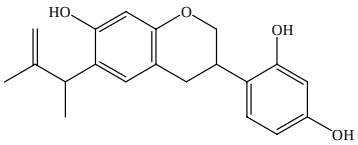
Plant and compound	Category	Plant part	Reference
Millettia racemosa			
(-)-Isomillinol B [**236**] 	Isoflavan	Stem	Rao and Krupadanam, 1994
Laxifloran [**237**] 	Isoflavan	Stem	Rao and Krupadanam, 1994
(+)-Millinol [**238**] 	Isoflavan	Stem	Kumar, Krupadanam and Srimannarayana, 1989
(+)-Millinol B [**239**] 	Isoflavan	Stem	Kumar, Krupadanam and Srimannarayana, 1989
Millinolol [**240**] 	Isoflavan	Stem	Rao and Krupadanam, 1996
Neomillinolol [**241**] 	Isoflavan	Stem	Rao and Krupadanam, 1996

Table 1 (continued)

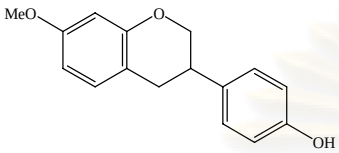
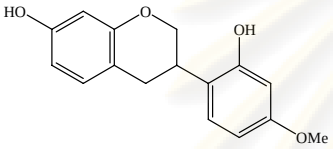
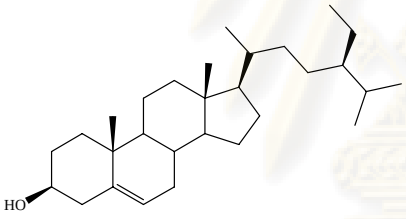
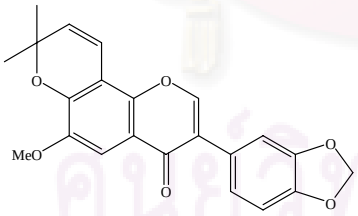
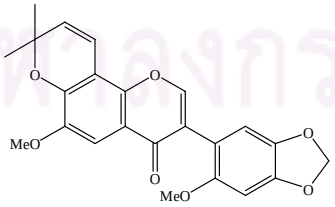
Plant and compound	Category	Plant part	Reference
Millettia racemosa			
Neovestitol [**242**] 	Isoflavan	Stem	Rao and Krupadanam, 1996
Vestitol [**243**] 	Isoflavan	Stem	Rao and Krupadanam, 1994
Sitosterol [**32**] 	Triterpenoid	Stem	Rao and Krupadanam, 1994
Millettia rubiginosa			
Durmillone [**63**] 	Isoflavone	Root	Desai *et al*., 1977
Ichthynone [**114**] 	Isoflavone	Root	Desai *et al*., 1977

Table 1 (continued)

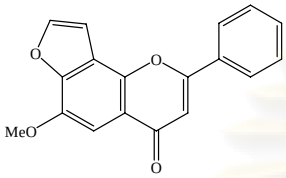
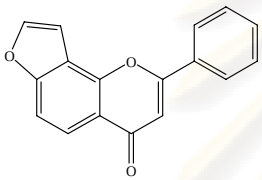
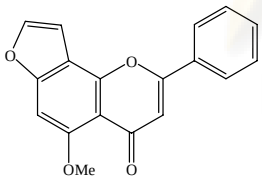
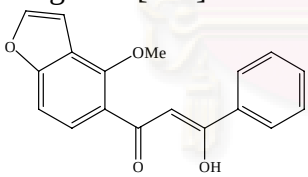
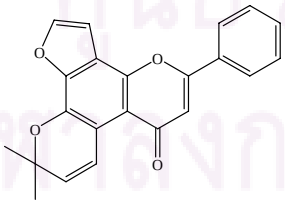
Plant and compound	Category	Plant part	Reference
Millettia sanagana			
Kanjone [**165**] 	Flavone	Root bark	Mbafor *et al.*, 1995
Lanceolatin B [**89**] 	Flavone	Root bark	Mbafor *et al.*, 1995
5-Methoxyfurano[7,8:4″,5″]flavone [**244**] 	Flavone	Root bark	Mbafor *et al.*, 1995
Pongamol [**103**] 	Chalcone	Root bark	Mbafor *et al.*, 1995
Sanaganone [**245**] 	Flavone	Root bark	Mbafor *et al.*, 1995

Table 1 (continued)

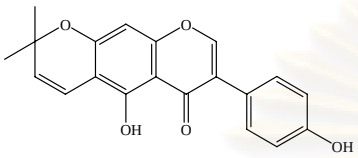
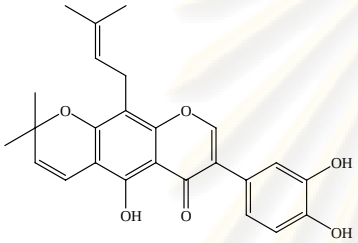
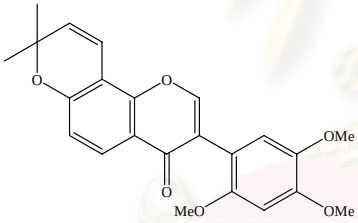
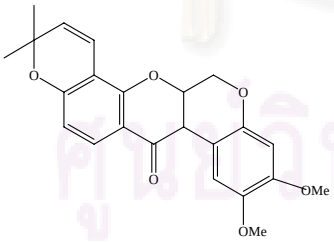
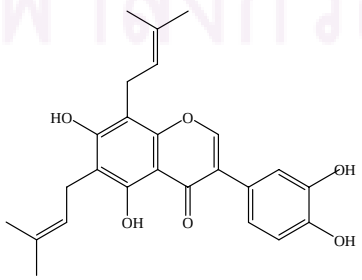
Plant and compound	Category	Plant part	Reference
Millettia taiwaniana			
Alpinumisoflavone [**246**] 	Isoflavone	Stem	Ito *et al*., 2004
Auriculasin [**2**] 	Isoflavone	Stem	Ito *et al*., 2004
Barbigerone [**110**] 	Isoflavone	Stem	Ito *et al*., 2004
Deguelin [**58**] 	Rotenoid	Stem	Ito *et al*., 2004
6,8-Di-γ,γ-dimethylallylorobol [**247**] 	Isoflavone	Leaf	Ito *et al*., 2006

Table 1 (continued)

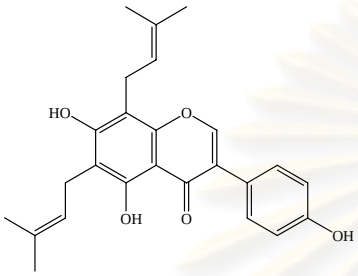
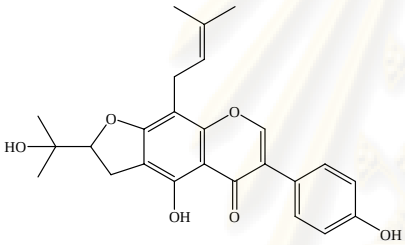
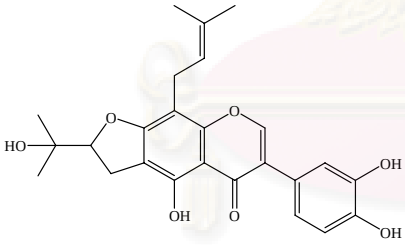
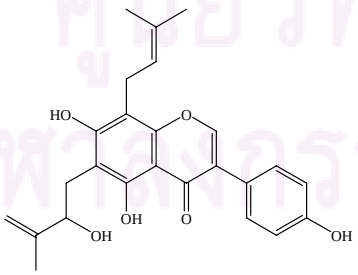
Plant and compound	Category	Plant part	Reference
Millettia taiwaniana			
8-γ,γ-Dimethylallylwightenone [**248**] 	Isoflavone	Stem, Leaf	Ito *et al*., 2004 Ito *et al*., 2006
Euchrenone b_{10} [**249**] 	Isoflavone	Leaf	Ito *et al*., 2006
Furowanin A [**250**] 	Isoflavone	Leaf	Ito *et al*., 2006
Isoerysenegalensein-E [**251**] 	Isoflavone	Leaf	Ito *et al*., 2006

Table 1 (continued)

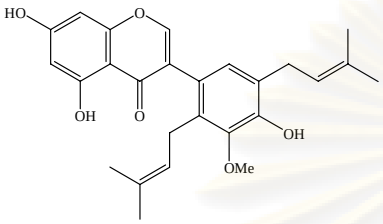
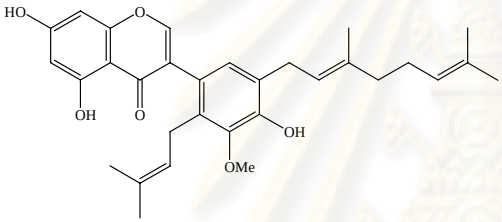
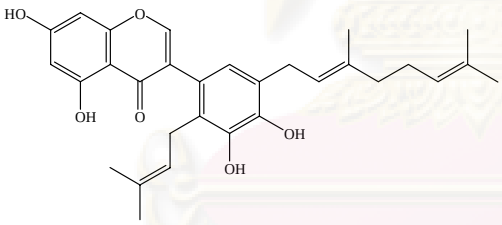
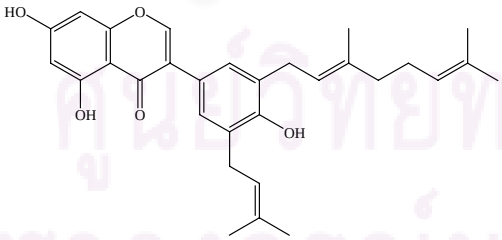
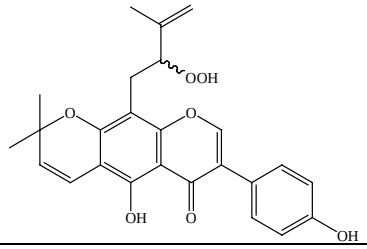
Plant and compound	Category	Plant part	Reference
Millettia taiwaniana			
Millewanin A [**252**] 	Isoflavone	Stem	Ito *et al*., 2004
Millewanin B [**253**] 	Isoflavone	Stem	Ito *et al*., 2004
Millewanin C [**254**] 	Isoflavone	Stem	Ito *et al*., 2004
Millewanin D [**255**] 	Isoflavone	Stem	Ito *et al*., 2004
Millewanin E [**256**] 	Isoflavone	Stem	Ito *et al*., 2004

Table 1 (continued)

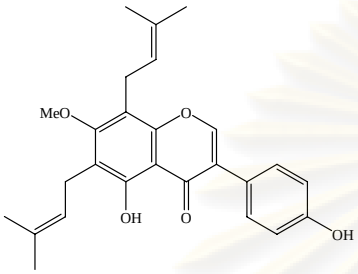
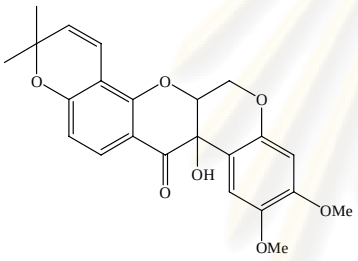
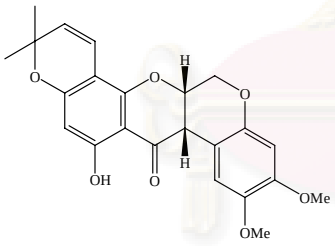
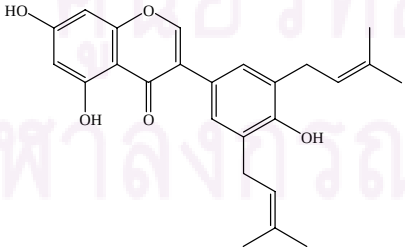
Plant and compound	Category	Plant part	Reference
Millettia taiwaniana			
Millewanin F [**257**] 	Isoflavone	Leaf	Ito *et al*., 2006
Tephrosin [**79**] 	Rotenoid	Stem	Ito *et al*., 2004
α –Toxicarol [**35**] 	Rotenoid	Stem	Ito *et al*., 2004
5,7,4′-Trihydroxy-3′,5′-di-γ,γ-dimethylallylisoflavone [**258**] 	Isoflavone	Stem	Ito *et al*., 2004

Table 1 (continued)

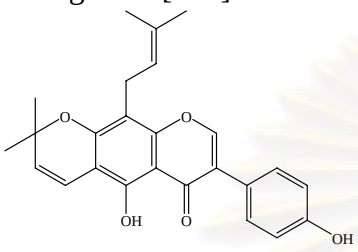
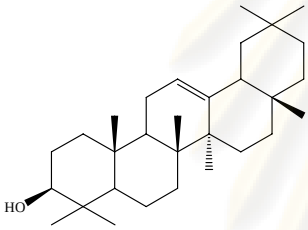
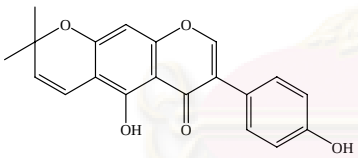
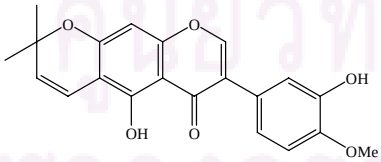
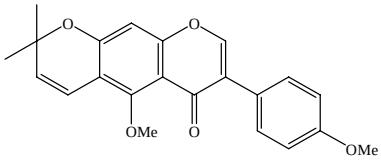
Plant and compound	Category	Plant part	Reference
Millettia taiwaniana			
Waragalone [**259**] 	Isoflavone	Stem, Leaf	Ito *et al*., 2004 Ito *et al*., 2006
Millettia thonningii			
β-amyrin [**38**] 	Triterpenoid	Root bark	Asomaning *et al*., 1995
Alpinumisoflavone [**246**] 	Isoflavone	Seed	Olivares *et al.*, 1982
3′,5-Dihydroxy-4′-methoxy-2′′,2′′-dimethylpyrano-(5′′,6′′: 6,7) isoflavone [**260**] 	Isoflavone	Seed	Olivares *et al.*, 1982
Dimethylalpinumisoflavone [**261**] 	Isoflavone	Seed	Olivares *et al.*, 1982

Table 1 (continued)

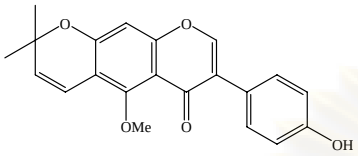
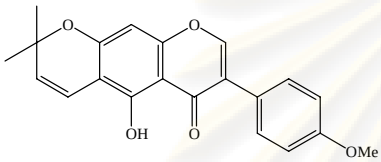
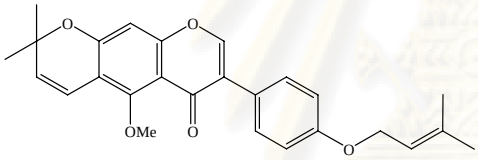
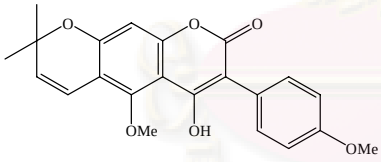
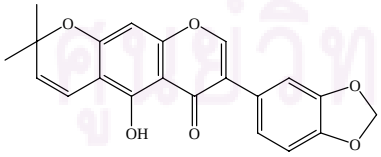
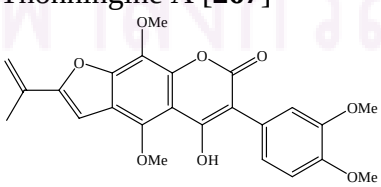
Plant and compound	Category	Plant part	Reference
Millettia thonningii			
5-*O*-Methylalpinumisoflavone [**262**] 	Isoflavone	Root	Asomaning *et al*., 1999
4′-Methylalpinumisoflavone [**263**] 	Isoflavone	Seed	Olivares *et al.*, 1982
5-*O*-Methyl-4′-*O*-(3-methyl-2-butenyl)alpinumisoflavone [**264**] 	Isoflavone	Root bark	Asomaning *et al*., 1995
Robustic acid [**265**] 	Coumarin	Seed	Olivares *et al.*, 1982
Robustone [**266**] 	Isoflavone	Seed	Khalid and Waterman, 1983
Thonningine A [**267**] 	Coumarin	Seed	Khalid and Waterman, 1983

Table 1 (continued)

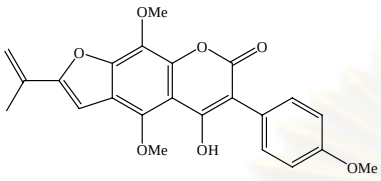
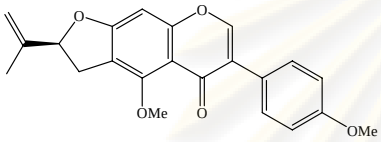
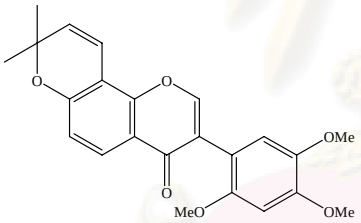
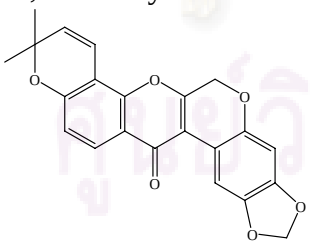
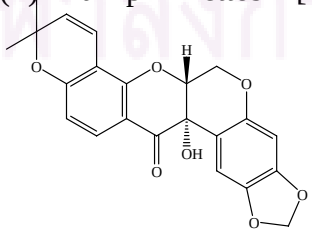
Plant and compound	Category	Plant part	Reference
Millettia thonningii			
Thonningine B [**268**] 	Coumarin	Seed	Khalid and Waterman, 1983
Thonninginisoflavone [**269**] 	Isoflavone	Root bark	Asomaning *et al*., 1995
Millettia usaramensis* subsp. *usaramensis			
Barbigerone [**110**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1998 Yenesew *et al*., 2003
6a,12a-Dehydromillettone [**270**] 	Rotenoid	Stem bark	Yenesew *et al*., 2003
(+)-12a-Epimillettosin [**271**] 	Rotenoid	Stem bark	Yenesew, Midiwo and Waterman, 1998

Table 1 (continued)

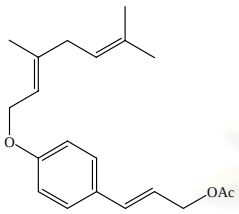
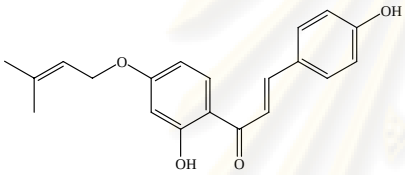
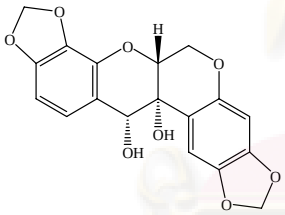
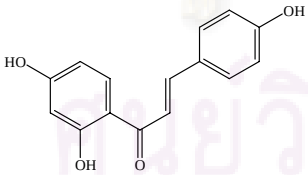
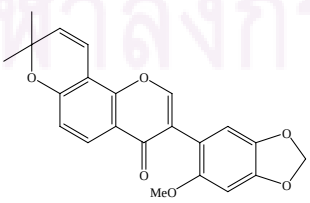
Plant and compound	Category	Plant part	Reference
Millettia usaramensis* subsp. *usaramensis			
4′-*O*-Geranylcinnamylacetate [**272**] 	Phenyl propanoid	Stem bark	Yenesew, Midiwo and Waterman, 1998
4′-*O*-Geranylisoliquiritigenin [**119**] 	Chalcone	Stem bark	Yenesew, Midiwo and Waterman, 1998
(+)-12α-Hydroxy-12-dihydro-usararotenoid A [**273**] 	Rotenoid	Stem bark	Yenesew, Midiwo and Waterman, 1998
Isoliquiritigenin [**274**] 	Chalcone	Stem bark	Yenesew, Midiwo and Waterman, 1998
Jamaicin [**69**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1998

Table 1 (continued)

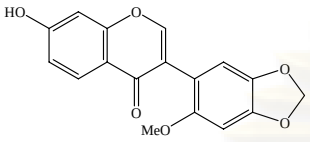
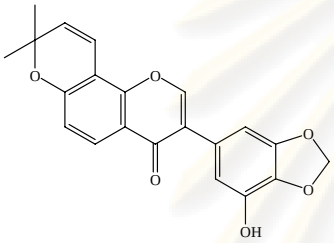
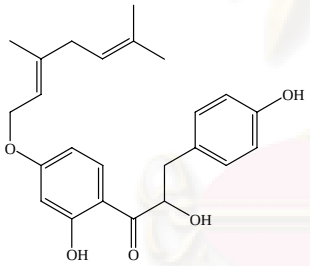
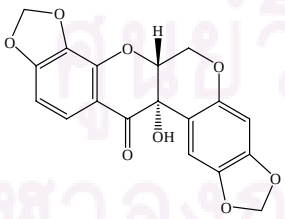
Plant and compound	Category	Plant part	Reference
Millettia usaramensis* subsp. *usaramensis			
Maximaisoflavone G [**137**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1998
Norisojamaicin [**275**] 	Isoflavone	Stem bark	Yenesew, Midiwo and Waterman, 1998
α,4,2′-Trihydroxy-4′-*O*-geranyl-dihydrochalcone [**276**] 	Chalcone	Stem bark	Yenesew, Midiwo and Waterman, 1998
(+)-Usararotenoid A [**277**] 	Rotenoid	Stem bark	Yenesew, Midiwo and Waterman, 1998 Yenesew *et al*., 2003

Table 1 (continued)

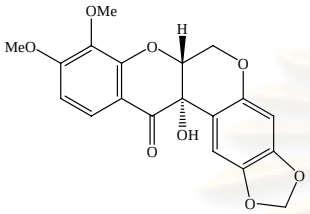
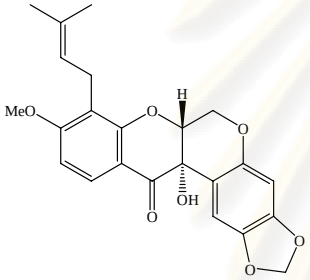
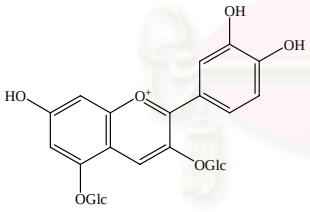
Plant and compound	Category	Plant part	Reference
Millettia usaramensis* subsp. *usaramensis			
(+)-Usararotenoid B [**278**] 	Rotenoid	Stem bark	Yenesew, Midiwo and Waterman, 1998
Usararotenoid C [**279**] 	Rotenoid	Stem bark	Yenesew *et al*., 2003
Millettia zechiana			
Cyanidin-3,5-diglucoside [**280**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990
3-Hydroxy-4′-methoxyflavone [**281**] 	Flvonol	Flower	Parvez and Ogbeide, 1990

Table 1 (continued)

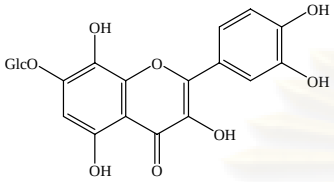
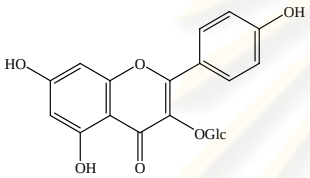
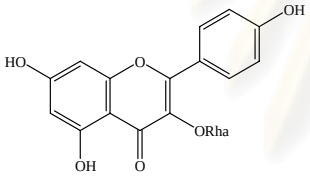
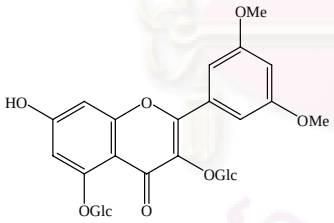
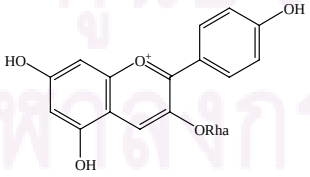
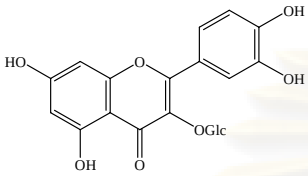
Plant and compound	Category	Plant part	Reference
Millettia zechiana			
8-Hydroxyquercetin-7-glucoside [**282**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990
Kaempferol-3-glucoside [**283**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990
Kaempferol-3-rhamnoside [**284**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990
Malvidin-3,5-diglucoside [**285**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990
Pelargonidin-3-rhamnoside [**286**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990

Table 1 (continued)

Table 1 (continued)

Plant and compound	Category	Plant part	Reference
Millettia zechiana Quercetin-3-glucoside [**287**] 	Flavonoid glycoside	Flower	Parvez and Ogbeide, 1990

2. Traditional uses and biological activities of *Millettia* constituents

Plants of the genus *Millettia* were used in traditional medicine in many countries. In Cameroon, *M. sanagana* and *M. conraui* were used in the treatment of intestinal parasites and cholic in children (Mbafor *et al*., 1995, Tchinda *et al.*, 2007). Potions made from the root bark of *M. griffoniana* were employed by some village communities of Cameroon as an oral treatment for boils (Yankep *et al.*, 2003). The bark of *M. erythrocalyx* was used for treating stomach pain (Sritularak *et al*., 2002). Root of *M. puguensis,* together with those of *Suregada zanzivariensis* (Euphorbiaceae), was boiled, and the decoction was used for stomach problems for adults of both sexes in Tanzania (Kapingu *et al*., 2006). The bark pulp of *M. zechiana*, with sea water and Guinea grains diluted with warm water, was used as a gargle for rhinopharyngal and bronchial troubles, and the purple leaves were rubbed on painful parts (Parvez and Ogbeide 1990). *M. thonningii* was used throughout the sub-region of west and central Africa in traditional medicine as a laxative, a blood purifier, a dewormer, an analgesic and for the treatment of diarrhea (Asomaning *et al.,* 1995).

Other uses of plants in this genus were insecticidal, piscicidal and molluscicidal activities. In Madagascar, *M. pervilleana* was used as a fish poison (Galeffi *et al*., 1997). The seed of *M. ichthyochtona* was served as a fishpoison and an insecticide (Kamperdick *et al*., 1998). Extract and aqueous suspension of finely ground seed of *M. pachycarpa* were reported to possess insecticidal activity when used in sprays against a variety of insects, e.g. houseflies, bean aphids, pentatomids, leaf beetles and cabbage worms (Singhal *et al*., 1983). The juice from the leaves of M. *thonningii* was reported to be lethal to the *Bulinus* snail, the vector for schistosomiasis (Asomaning *et al*., 1995).

In view of biological activities of compounds from *Millettia* plants, β-amyrin and 7-*O*-geranyl-6-methoxypseudobaptigenin had significant α-glucosidase inhibitory activity (Tchinda *et al*., 2007). From *M. puguensis*, moderate antileishmanial activity was observed for 6,7-dimethoxy-3′,4′-methylenedioxy-isoflavone (IC_{50} = 32 μM against *Leishmania infantum*) and moderate cytotoxicity for maackiain (IC_{50} = 43 μM on MRC-5 cells) (Kapingu *et al*., 2006). Ovalifolin, pongol methyl ether and millettocalyxin A possessed moderate activity against both types of herpes simplex visus (Likhitwitayawuid *et al*., 2005). Isomillinol-B and vesitol were found to be highly toxic even at 0.1 μg/ml to *S. aureus* and *E.coli*. (Rao and Krupadanam, 1994).

CHAPTER III

EXPERIMENTAL

1. Source of plant materials

The stemwood of *Millettia leucantha* Kurz was collected from Tungkru district, Bangkok, Thailand in August 2006. Authentication was performed by comparison with herbarium specimen (BKF No. 18009) at National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment. A voucher specimen (KL 052547) has been deposited at Department of Pharmacognosy, Faculty of Pharmaceutical Sciences, Chulalongkorn University, Bangkok, Thailand.

2. General techniques

2.1 Analytical thin-layer chromatography (TLC)

Technique	:	One dimension, ascending
Absorbent	:	Silica gel 60 F_{254} (E. Merck) precoated plate
Layer thickness	:	0.2 mm
Distance	:	6 cm
Temperature	:	Laboratory temperature (30-35ºC)
Detection	:	1. Ultraviolet light at wavelengths of 254 and 365 nm. 2. Anisaldehyde and heating at 105°C for 10 min.

2.2 Column chromatography

2.2.1 Vacuum liquid column chromatography

Adsorbent	:	Silica gel 60 (No.7734) particle size 0.063-0.200 nm (70-230 mesh ASTM) (E. Merck)
Packing method	:	Dry packing
Sample loading	:	The sample was dissolved in a small amount of organic solvent, mixed with a small quantity of adsorbent, triturated, dried and then placed gently on top of the column.
Detection	:	Fractions were examined by TLC under UV light at the wavelengths of 254 and 365 nm.

2.2.2 Flash column chromatography

Adsorbent	:	Silica gel 60 (No.9385) particle size 0.040-0.063 nm (70-230 mesh ASTM) (E. Merck)
Packing method	:	Wet packing
Sample loading	:	The sample was dissolved in a small amount eluent and then applied gently on top of the column.
Detection	:	Fractions were examined in the same way as described in section 2.2.1

2.2.3 Medium pressure liquid chromatography

Adsorbent	:	Silica gel 60 (No.9385) particle size 0.040-0.063 nm (70-230 mesh ASTM) (E. Merck)
Packing method	:	Dry packing
Sample loading	:	The sample was dissolved in a small amount of organic solvent, mixed with a small quantity of adsorbent, triturated, dried and then placed gently on top of the column.
Detection	:	Fractions were examined in the same way as described in section 2.2.1

2.2.4 Gel filtration chromatography

Adsorbent	:	Sephadex LH 20 (Pharmacia)
Packing method	:	Gel filter was suspended in the eluent and left standing to swell for 24 hours prior to use. It was then poured into the column and allowed to set tightly.
Sample loading	:	The sample was dissolved in a small amount eluent and then applied gently on top of the column.

2.2.5 High pressure liquid chromatography

Column	:	Shim-pack Prep-ODS No. 2025820
Flow rate	:	2 ml/min
Mobile phase	:	Isocratic 50% methanol in water

Sample preparation	:	The sample was dissolved in small of eluent and filtered through Millipore filter paper before injection.
Injection volume	:	1 ml
Pump	:	LC-8A (Shimadzu)
Detector	:	SPD-10A UV Detector (Shimadzu)
Recorder	:	C-R6A Chromatopac (Shimadzu)
Temperature	:	Room temperature

2.3 Spectroscopy

2.3.1 Ultraviolet (UV) absorption spectra

UV (in methanol) spectra were obtained on a Shimadzu UV-160A UV/vis spectrophotometer (Pharmaceutical Research Instrument Center, Faculty of Pharmaceutical Sciences, Chulalongkorn University).

2.3.2 Mass spectra

Mass spectra were recorded on a Micromass LCT spectrtometer or a Thermo-Finnigan Polaris Q mass spectrometer (Department of Chemistry, Faculty of Science, Mahidol University) or a Bruker microTOF mass spectrometer (National Center for Genetic Engineering and Biotechnology).

2.3.3 Proton and carbon-13 nuclear magnetic resonance (^{1}H and ^{13}C-NMR) spectra

^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectra were obtained with a Bruker Avance DPX-300 FT-NMR spectrometer (Faculty of Pharmaceutical Sciences, Chulalongkorn University).

^{1}H NMR (500 MHz) and ^{13}C NMR (125 MHz) spectra were obtained with a JEOL JMN-A 500 NMR spectrometer (Scientific and Technological Research Equipment Center, Chulalongkorn University).

Solvents for NMR spectra were deuterated chloroform (chloroform-*d*) and deuterated acetone (acetone-d_6). Chemical shifts were reported in ppm scale using the chemical shift of the solvent as the reference signal.

2.4 Physical property

2.4.1 Optical rotation

Optical rotations were measured on a Perkin Elmer Polarimeter 341 (Pharmaceutical Research Instrument Center, Faculty of Pharmaceutical Sciences, Chulalongkorn University).

2.5 Solvents

All organic solvents employed throughout this work were of commercial grade and were redistilled prior to use.

3. Extraction and isolation

3.1 Extraction

The dried stemwood (6.9 kg) was chopped, ground and then macerated with methanol (3x10 L) to give, after removal of the solvent, a methanol extract (142 g). The methanol extract was triturated with dichloromethane (CH_2Cl_2) and ethyl acetate (EtOAc), respectively, to give CH_2Cl_2 extract (20 g) and EtOAc extract (11 g).

3.2 Separation of CH_2Cl_2 extract

The CH_2Cl_2 extract (10 g) was separated by vacuum liquid column chromatography using a sintered glass filter column of silica gel (No.7734, 250 g). The CH_2Cl_2 extract was dissolved in a small amount of CH_2Cl_2, triturated with silica gel (No.7734) and dried under vacuum. Elution was performed in a polarity gradient manner with mixtures of hexane and EtOAc (10:0 to 0:10). The eluates were collected 200 ml per fraction and examined by TLC (silica gel, EtOAc-hexane 6:4) to yield 77 fractions. Another portion of CH_2Cl_2 extract (10 g) was separated in the same manner to give 72 fractions. Fractions (149 fractions) with similar chromatographic manner were combined to yield 17 fractions: A (148.9 mg), B (2.34 g), C (2.20 g), D (709.4 mg), E (346.9 mg), F (256.8 mg), G (399.6 mg), H (218.2 mg), I (1.01 g), J (1.17 g), K (1.61 g), L (1.16 g), M (1.23 g), N (1.27 g), O (1.24 g), P (97.4 mg), Q (1.61 g).

3.2.1 Isolation of compound ML1 (cycloeucalenol)

Fraction G (399.6 mg) was fractionated on a silica gel (No. 9385) column. Elution was performed in a polarity gradient manner with mixtures of hexane and EtOAc (10:0 to 0:10). Fractions (62 fractions) showing similar chromatographic

pattern were combined (TLC, silica gel, EtOAc-hexane 4:6) to yield 14 fractions: G1 (6.4 mg), G2 (1.4 mg), G3 (10.4 mg), G4 (33.4 mg), G5 (21.1 mg), G6 (202.8 mg), G7 (7.6 mg), G8 (23.4 mg), G9 (3.5 mg), G10 (5.4 mg), G11 (2.8 mg), G12 (0.5 mg), G13 (5.5 mg), G14 (30 mg).

Fraction G5 (21.1 mg) was purified on a Sephadex LH20 column (acetone) to give compound ML1 as white needles (12 mg, R_f 0.34, silica gel, EtOAc-hexane 2:8). It was identified as cycloeucalenol.

3.2.2 Isolation of mixture ML2 (mixture of β-sitosterol and stigmasterol)

Repeated column chromatography was performed on fraction G6 (202.8 mg) (silica gel No.9385, gradient elution, hexane-EtOAc 10:0 to 0:10). The eluates (51 fractions) were combined based on their TLC behavior (silica gel, EtOAc-hexane 4:6) to afford 20 fractions: G6A (0.7 mg), G6B (3.2 mg), G6C (6.1 mg), G6D (1.2 mg), G6E (1.3 mg), G6F (1.7 mg), G6G (0.8 mg), G6H (56.2 mg), G6I (69.9 mg), G6J (14.4 mg), G6K (2.1 mg), G6L (2.6 mg), G6M (4.4 g), G6N (14.9 mg), G6O (7 mg), G6P (3 mg), G6Q (5 mg), G6R (0.9 mg), G6S (1.1 mg), G6T (19.2 mg).

Fraction G6H (56.2 mg) was further separated on a Sephadex LH20 column (acetone). Twenty fractions were combined according to their TLC pattern (silica gel, EtOAc-hexane 4:6) to yield 3 fractions: G6H1 (3 mg), G6H2 (18.7 mg), G6H3 (30.9 mg).

Fraction G6H3 (30.9 mg) was repeatedly fractionated on a Sephadex LH20 column (acetone). Thirty four fractions with similar chromatographic pattern were combined (TLC, silica gel, EtOAc-hexane 4:6) to give 6 fractions: G6H3A (0.6 mg.), G6H3B (2.8 mg), G6H3C (14.2 mg), G6H3D (6.4 mg), G6H3E (3.5 mg), G6H3F (0.3 mg).

Fraction G6H3C (14.2 mg) was washed three times with methanol to yield mixture ML2 as a white powder (7.6 mg, R_f 0.43, silica gel, EtOAc-hexane 4:6). It was identified as a mixture of β-sitosterol and stigmasterol.

3.2.3 Isolation of mixture ML3 (mixture of 7-oxositosterol and 7-oxostigmasterol)

Fraction J (1.17 g) was further subjected under column chromatography (silica gel, gradient mixtures of hexane-EtOAc 10:0 to 0:10) to yield 49 fractions. Fraction K

(1.61 g) was further separated under the same condition to give 56 fractions. Fractions (105 fractions) with similar TLC patterns (silica gel, EtOAc-hexane 4:6) were combined to afford 26 fractions: JK1 (19.6 mg), JK2 (52.5 mg), JK3 (33.9 mg), JK4 (64 mg), JK5 (17.7 mg), JK6 (174.3 mg), JK7 (80.5 mg), JK8 (127 mg), JK9 (104.7 mg), JK10 (65.2 mg), JK11 (82.3 mg), JK12 (14.9 mg), JK13 (166.7 mg), JK 14 (193.6 mg), JK15 (387 mg), JK16 (73.4 mg), JK17 (190.9 mg), JK18 (32.1 mg), JK19 (95.1 mg), JK20 (291.7 mg), JK21 (23.7 mg), JK22 (77.1 mg), JK23 (48.4 mg), JK24 (23.5 mg), JK25 (50.4 mg), JK 26 (164 mg).

Fraction JK14 (193.6 mg) was fractionated by repeated column chromatography (silica gel, gradient mixture of CH_2Cl_2-EtOAc 10:0 to 0:10) to afford compound ML3 as a white powder (19.6 mg, R_f 0.39, silica gel, EtOAc-CH_2Cl_2 2:3). It was identified as a mixture of 7-oxositosterol and 7-oxostigmasterol.

3.3 Separation of EtOAc extract

The EtOAc (11 g) was separated into 3 portions. The first portion (3 g) was subjected to medium pressure liquid chromatography (MPLC) (silica gel, gradient mixture of CH_2Cl_2-acetone 10:0 to 0:10). The eluates were collected 200 ml per fraction to yield 42 fractions. The second portion (4 g) was separated under the same condition to give 62 fractions. The third portion (4 g) was fractionated under the same condition to afford 68 fractions. Fractions (172 fractions) with similar chromatographic pattern were combined (TLC, silica gel, acetone- CH_2Cl_2 1:9) to give 17 fractions: 1 (97.8 mg), 2 (186.2 mg), 3 (80 mg), 4 (167 mg), 5 (47.1 mg), 6 (63.8 mg), 7 (139 mg), 8 (137.6 mg), 9 (251.8 mg), 10 (296.7 mg), 11 (401.6 mg), 12 (17.7 mg), 13 (355.8 mg), 14 (1.14 g), 15 (1.23 g), 16 (1.24 g), 17 (2.54 g).

3.3.1 Isolation of compound ML4 (maackiain)

Fraction 6 (63.8 mg) was purified on a Sephadex LH20 column (acetone) to give 7 mg of compound ML4 as a brown powder (R_f 0.42, silica gel, acetone- CH_2Cl_2 0.6:9.4). It was identified as maackiain.

3.3.2 Isolation of compound ML5 (4-hydroxy-3-methoxybenzoic acid) and ML6 (syringic acid)

Fraction 10 (296.7 mg) was fractionated on a Sephadex LH20 column (acetone) to yield 9 fractions: 10A (111.5 mg), 10B (78.2 mg), 10C (79 mg), 10D (7.6 mg), 10E (2.4 mg), 10F (2 mg), 10G (1.2 mg), 10H (1.2 mg), 10I (2.6 mg).

Fraction 10C (79 mg) was separated by flash column chromatography (silica gel, gradient mixture of hexane-EtOAc 10:0 to 0:10) to give compound ML5 as a brown powder (9.7 mg, R_f 0.51, silica gel, EtOAc-CH_2Cl_2 7:3) and compound ML6 as a brown powder (12.3 mg, R_f 0.41, silica gel, EtOAc-CH_2Cl_2 7:3). ML5 and ML6 were identified as 4-hydroxy-3-methoxybenzoic acid and syringic acid, respectively.

3.3.3 Isolation of compound ML7 (balanocarpol)

Fraction 14 (1.14 g) was separated on a flash column (silica gel, gradient mixtures of hexane-EtOAc 10:0 to 0:10). Sixty eight fractions were combined on the basis of their TLC composition (silica gel, EtOAc-hexane 2:8) to yield 15 fractions: 14A (16.7 mg), 14B (14.8 mg), 14C (73.1 mg), 14D (53.1 mg), 14E (78.4 mg), 14F (48.1 mg), 14G (161.3 mg), 14H (75.6 mg), 14I (112.9 mg), 14J (99 mg), 14K (78.2 mg), 14L (23.5 mg), 14M (40 mg), 14N (30.7 mg), 14O (88.3 mg).

Fraction 14G (161.3 mg) was repeatedly fractionated on a flash column (silica gel, gradient mixtures of CH_2Cl_2-acetone 10:0 to 0:10). Fifty seven fractions with similar chromatographic pattern (TLC, silica gel, acetone- CH_2Cl_2 1:1) were combined to yield 9 fractions: 14G1 (3.9 mg), 14G2 (2 mg), 14G3 (9.2 mg), 14G4 (64.6 mg), 14G5 (3 mg), 14G6 (2.1 mg), 14G7 (10 mg), 14G8 (26.3 mg), 14G9 (18.5 mg).

Fraction 14G4 (64.6 mg) was separated on a Sephadex LH20 column (acetone). Fractions (64 fractions) were combined according to their TLC pattern (silica gel, acetone- CH_2Cl_2 1:1) to give 8 fractions: 14G4A (0.1 mg), 14G4B (0.7 mg), 14G4C (0.2 mg), 14G4D (0.9 mg), 14G4E (3.5 mg), 14G4F (40.9 mg), 14G4G (5.6 mg), 14G4H (2.5 mg).

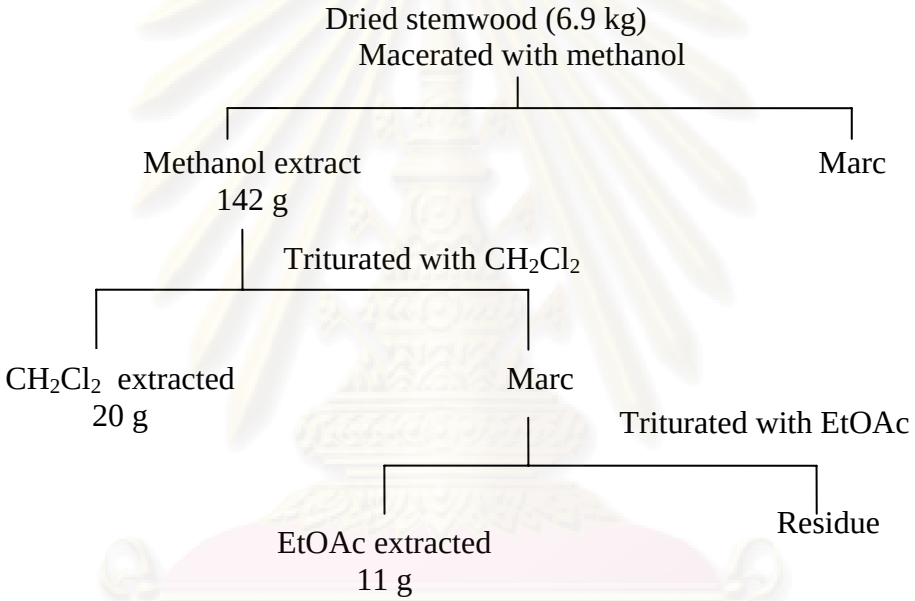
Fraction 14G4F (40.9 mg) was further separated by repeated Sephadex LH20 (MeOH) column chromatography. Forty three fractions were combined based on their TLC behavior (silica gel, acetone- CH_2Cl_2 1:1) to afford 12 fractions: I (0.5 mg), II (0.3 mg), III (0.2 mg), IV (0.7 mg), V (0.3 mg), VI (2 mg), VII (25.8 mg), VIII (5.1 mg), IX (4 mg), X (0.9 mg), XI (1.8 mg), XII (16.5 mg).

Purification of fraction VII (25.8 mg) by RP18 HPLC (Shim-pack Prep-ODS) with 50% methanol in water as eluent and UV-VIS detection (λ 254 nm.) gave compound ML7 as a brown powder (4.6 mg, R_f 0.34, silica gel, acetone- CH_2Cl_2 1:1). It was identified as balanocarpol.

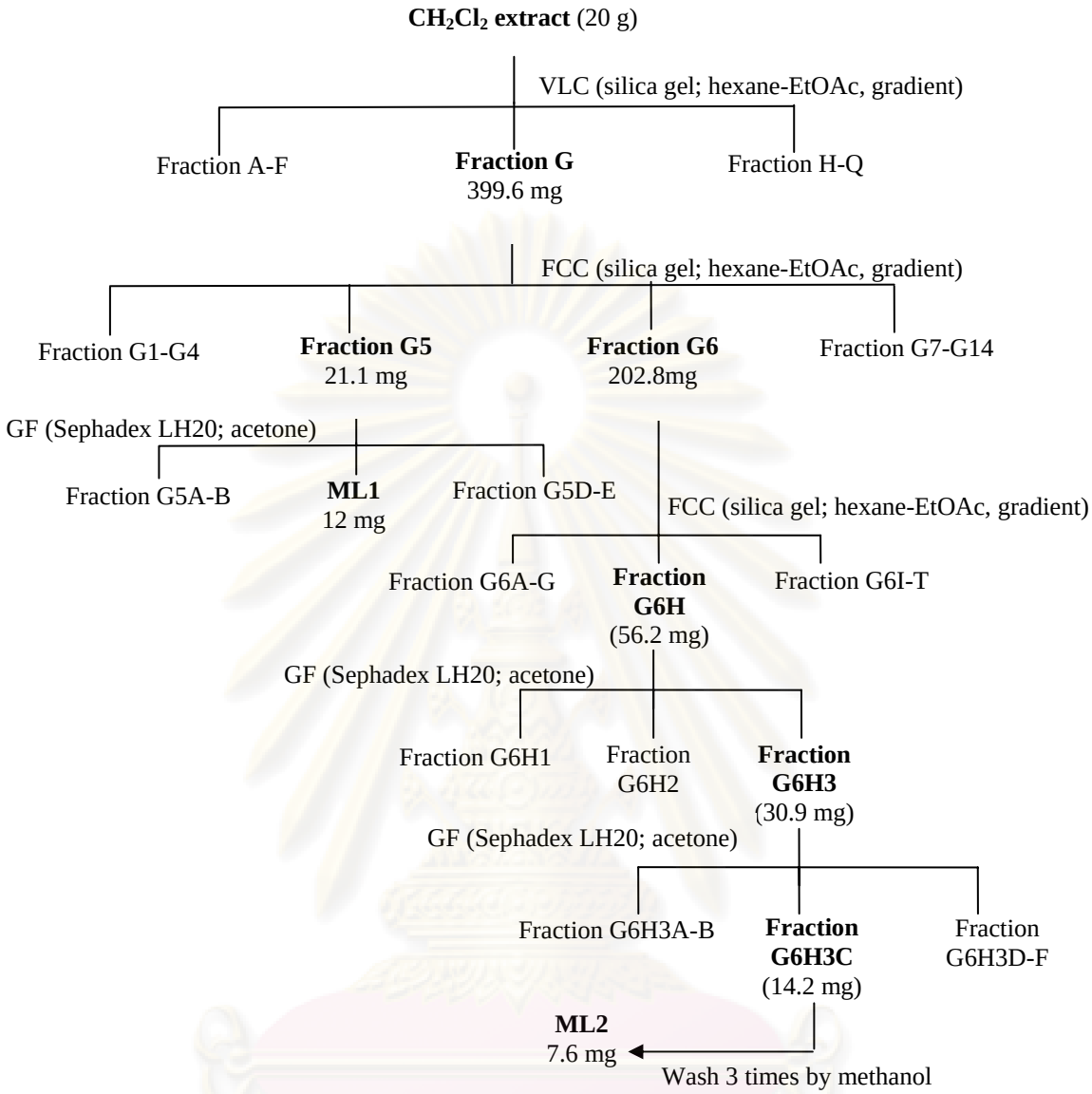
3.3.4 Isolation of compound ML8 (diptoindonesin D)

Fraction 15 (1.23 g) was subjected to flash column chromatography (silica gel). The elution was performed in a polarity manner with mixtures of CH_2Cl_2-methanol (10:0 to 0:10). Fractions (55 fractions) with similar TLC pattern (silica gel, methanol-CH_2Cl_2 1:9) were combined to give 13 fractions: 15A (27.7 mg), 15B (12.9 mg), 15C (54.7 mg), 15D (49.2 mg), 15E (76.7 mg), 15F (63.8 mg), 15G (170.6 mg), 15H (237.4 mg), 15I (111.7 mg), 15J (104.8 mg), 15K (47.8 mg), 15L (85.3 mg), 15M (55.1 mg).

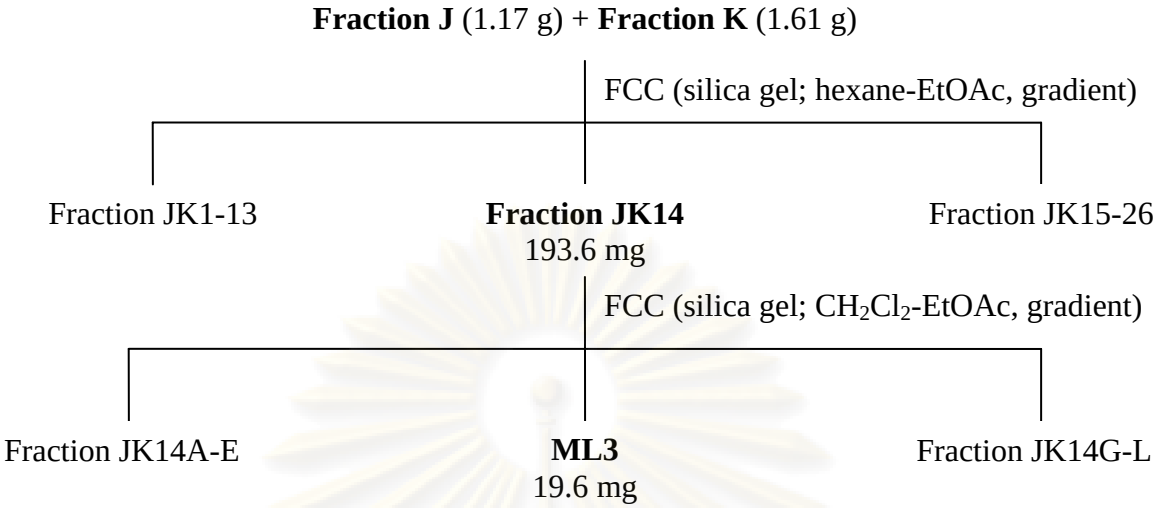
Fraction 15H (237.4 mg) was purified on a Sephadex LH20 (MeOH) column to yield compound ML8 as a brown powder (4 mg, R_f 0.17, silica gel, methanol-CH_2Cl_2 1:9). It was identified as diptoindonesin D.



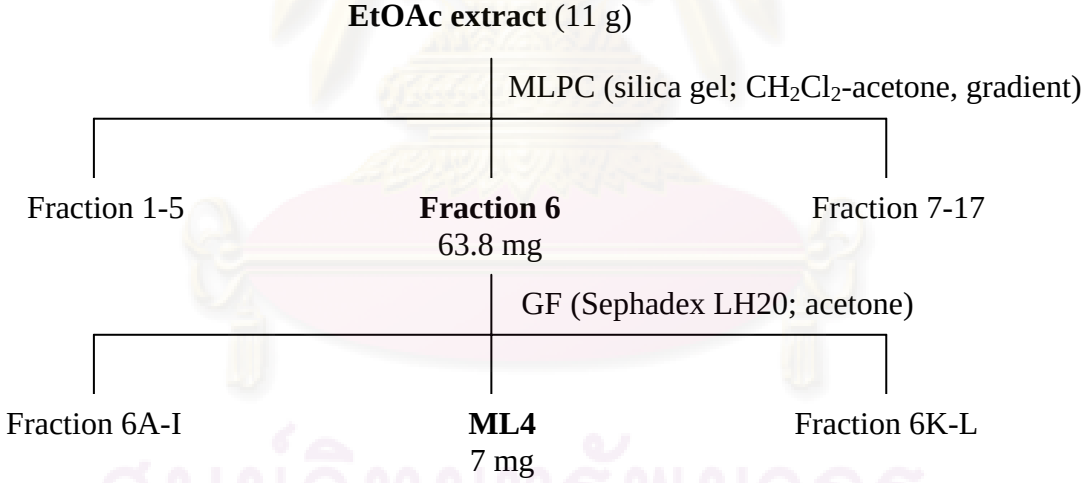
Scheme 1 Extraction of *Millettia leucantha* stemwood



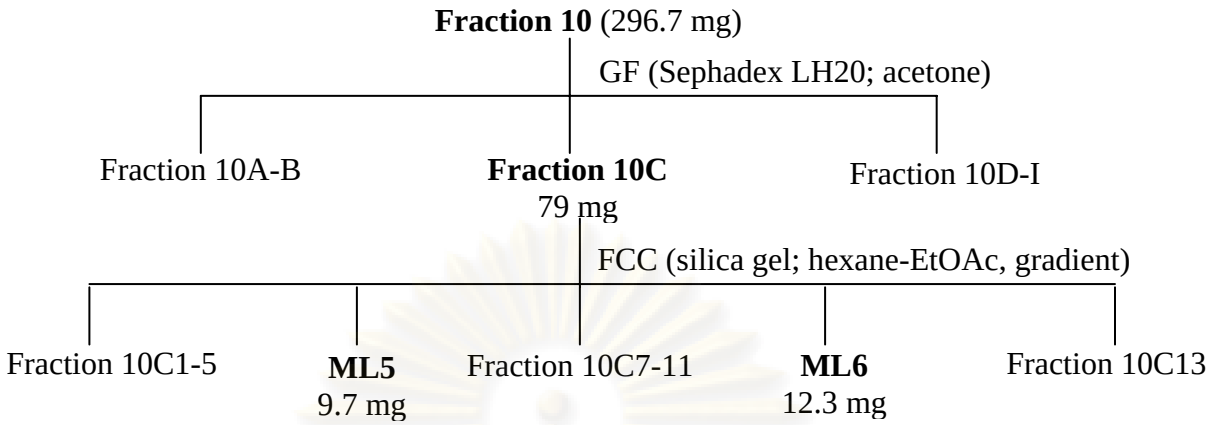
Scheme 2 Separation of the CH_2Cl_2 extract of *Millettia leucantha*



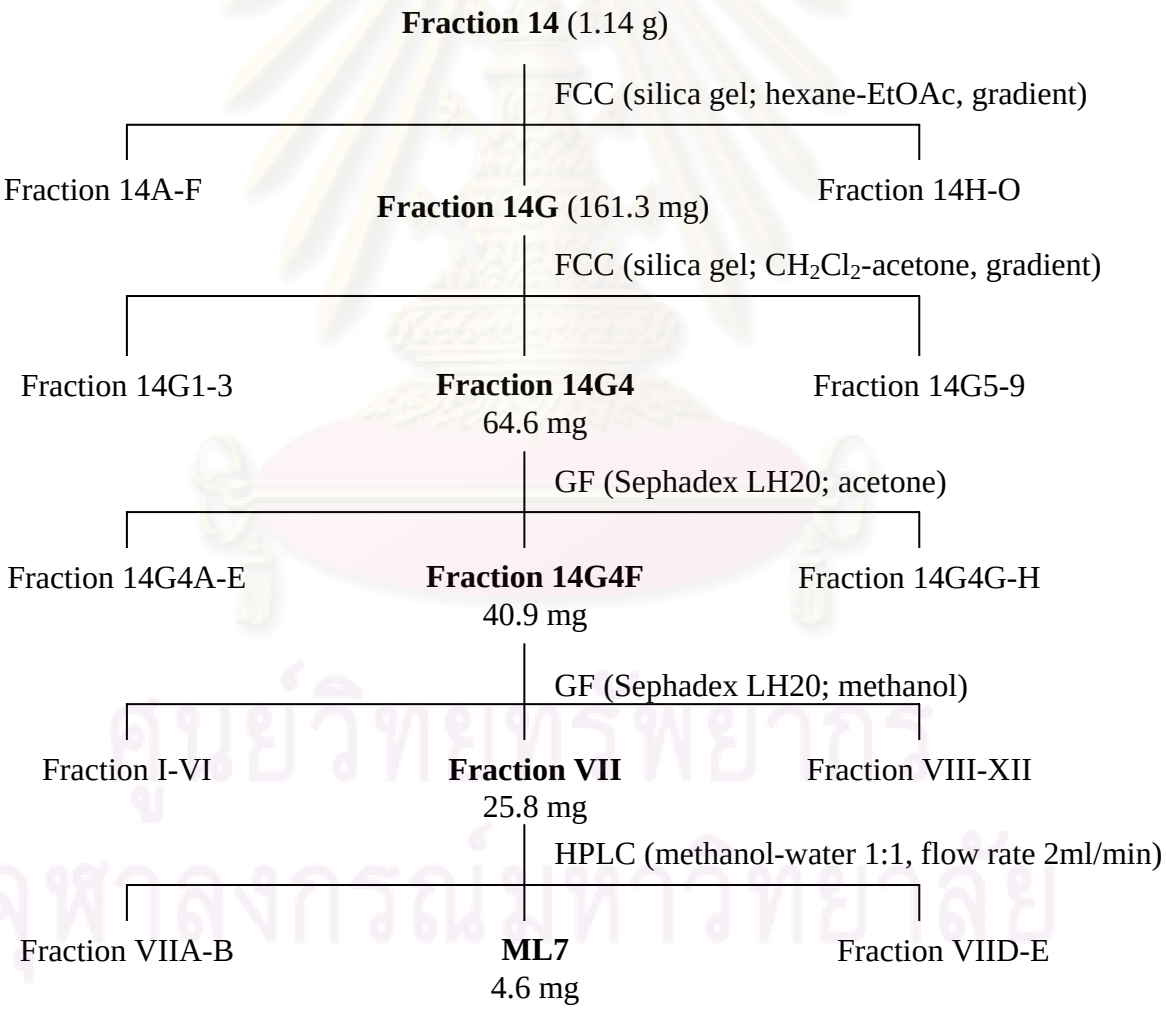
Scheme 3 Separation of fraction J and K of the CH_2Cl_2 extract



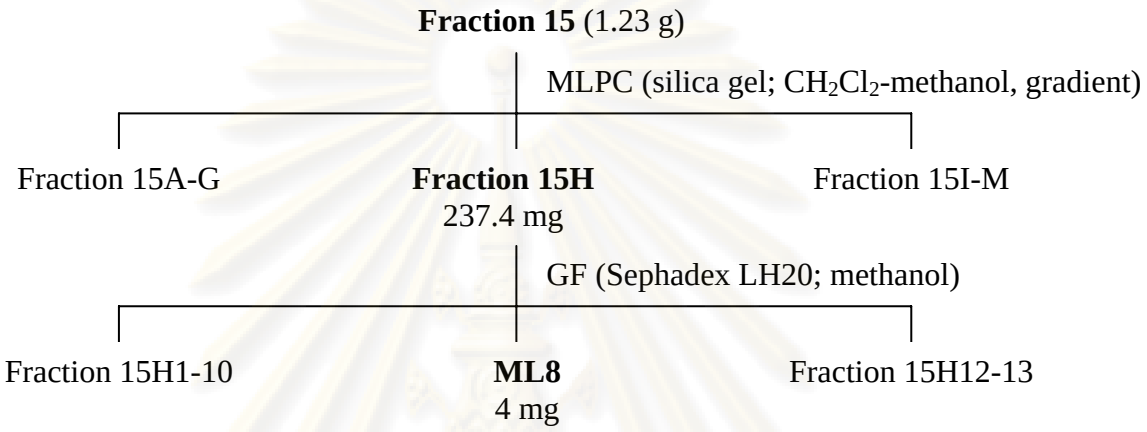
Scheme 4 Separation of the EtOAc extract of *Millettia leucantha*



Scheme 5 Separation of fraction 10 of EtOAc extract



Scheme 6 Separation of fraction 14 of EtOAc extract



Scheme 7 Separation of fraction 15 of EtOAc extract

4. Physical and spectral data of isolated compounds

4.1 Compound ML1 (cycloeucalenol)

Compound ML1 was obtained as white needles, soluble in CH_2Cl_2 (21.1 mg, 3.06 x 10^{-4} % based on dried weight of stemwood).

EIMS : *m/z* (% relative intensity); **Figure 2**

426 (10), 408 (24), 393 (45), 189 (20), 163 (24), 161 (42), 147 (53), 145 (48), 135 (30), 133 (53), 123 (23), 121 (44), 119 (58), 109 (41), 107 (45), 105 (79), 95 (44), 81 (52)

^{1}H NMR : δ ppm, 300 MHz, in $CDCl_3$; see **Figure 3**

^{13}C NMR : δ ppm, 75 MHz, in $CDCl_3$; see **Table 2, Figure 4**

4.2 Mixture ML2 (mixture of β-sitosterol and stigmasterol)

Mixture ML2 was obtained as a white powder, soluble in CH_2Cl_2 (7.6 mg, 2.06 x 10^{-4} % based on dried weight of stemwood).

^{1}H NMR : δ ppm, 300 MHz, in $CDCl_3$; see **Figure 6**

^{13}C NMR : δ ppm, 75 MHz, in $CDCl_3$; see **Table 3, Figure 7**

4.3 Mixture ML3 (mixture of 7-oxositosterol and 7-oxostigmasterol)

Mixture ML3 was obtained as a white powder, soluble in CH_2Cl_2 (19.6 mg, 1.10 x 10^{-4} % based on dried weight of stemwood).

^{1}H NMR : δ ppm, 300 MHz, in $CDCl_3$; see **Figure 8**

^{13}C NMR : δ ppm, 75 MHz, in $CDCl_3$; see **Table 4, Figure 9**

4.4 Compound ML4 (maackiain)

Compound ML4 was obtained as a brown powder, soluble in CH_2Cl_2 (7 mg, 1.01 x 10^{-4} % based on dried weight of stemwood).

EIMS : *m/z* (% relative intensity); **Figure 12**

284 (42), 267 (17), 175 (12), 162 (16)

$[\alpha]^{20}_D$: -255 ° (*c* 0.02; MeOH)

UV : λ_{max} nm (log ε), in methanol; **Figure 11**

227.5 (5.06), 286.5 (4.77), 311 (4.88)

^{1}H NMR : δ ppm, 300 MHz, in $CDCl_3$; see **Table 5, Figure 13**

^{13}C NMR : δ ppm, 75 MHz, in $CDCl_3$; see **Table 5, Figure 14**

4.5 Compound ML5 (4-hydroxy-3-methoxybenzoic acid)

Compound ML5 was obtained as a brown powder, soluble in acetone (9.7 mg, 1.41 x 10^{-4}% based on dried weight of stemwood).

EIMS **:** *m/z* (% relative intensity); **Figure 16**
168 (100), 153 (68), 151 (13), 125 (27), 97 (43)

UV **:** λ_{max} nm (log ε), in methanol; **Figure 15**
258 (3.95), 290 (3.72)

^{1}H NMR **:** δ ppm, 300 MHz, in Acetone-d_6; see **Table 6, Figure 17**

^{13}C NMR **:** δ ppm, 75 MHz, in Acetone-d_6; see **Table 6, Figure 18**

4.6 Compound ML6 (syringic acid)

Compound ML6 was obtained as a brown powder, soluble in acetone (12.3 mg, 1.78 x 10^{-4} % based on dried weight of stemwood).

EIMS **:** *m/z* (% relative intensity); **Figure 20**
198 (100), 183 (36), 149 (12), 127 (18), 109 (23), 81 (10), 65 (12)

UV **:** λ_{max} nm (log ε), in methanol; **Figure 19**
273 (3.97)

^{1}H NMR **:** δ ppm, 300 MHz, in Acetone-d_6; see **Table 7, Figure 21**

^{13}C NMR **:** δ ppm, 75 MHz, in Acetone-d_6; see **Table 7, Figure 22**

4.7 Compound ML7 (balanocarpol)

Compound ML7 was obtained as a brown powder, soluble in acetone (4.6 mg, 6.67 x 10^{-5} % based on dried weight of stemwood).

EIMS **:** *m/z* (% relative intensity); **Figure 23**
470 (2), 452 (25), 376 (3), 348 (8), 107 (9), 94 (19)

$[\alpha]^{20}_{D}$ **:** -15 ° (*c* 0.033; MeOH)

UV **:** λ_{max} nm (log ε), in methanol; **Figure 24**
226.6 (4.33), 284 (3.78)

^{1}H NMR **:** δ ppm, 300 MHz, in Acetone-d_6; see **Table 8, Figure 25**

^{13}C NMR **:** δ ppm, 75 MHz, in Acetone-d_6; see **Table 8, Figure 26**

4.8 Compound ML8 (diptoindonesin D)

Compound ML8 was obtained as a brown powder, soluble in acetone (4 mg, 5.80 x 10^{-5} % based on dried weight of stemwood).

ESIMS : $[M+H]^+$ *m/z* 379.37; **Figure 29**

$[\alpha]^{20}_D$: +100 ° (*c* 0.035; MeOH)

UV : λ_{max} nm (log ε), in methanol; **Figure 28**
226 (4.07), 372 (3.60)

^{1}H NMR : δ ppm, 500 MHz, in Acetone-d_6; see **Table 9, Figure 30**

^{13}C NMR : δ ppm, 125 MHz, in Acetone-d_6; see **Table 9, Figure 31**

5. Determination of free radical scavenging activity

5.1 TLC screening assay (Takao *et al*., 1994**)**

The samples were spotted and developed on TLC plate with suitable developing solvent. After drying, the TLC plate was sprayed with 0.2% solution of 1,1-diphenyl-2-picrylhydrazyl (DPPH) in methanol. After 30 min, active compounds appeared as yellow spots on the purple background.

5.2 Free radical scavenging activity assay (Braca *et al*., 2002)

5.2.1 Preparation of test sample

The test compound (0.5 mg) was dissolved in 1 ml methanol (or suitable solvent) and diluted with methanol until a suitable range of concentration (mg/ml) was obtained. The concentration was expressed as μM in final concentration. For example, ML1 (MW 426) at 0.5 mg/1ml was equal to 1173 μM (0.5 mg/1ml x 426). For each well, 20 μl of test solution was added to the reaction mixture to furnish the total volume of 200 μl. The final concentration was calculated by the formula below.

$$N_1V_1 = N_2V_2$$

N_1 = Beginning concentration (μM)

V_1 = Beginning volume (μl)

N_2 = Final concentration (μM)

V_2 = Final volume (μl)

Thus, the final concentration of ML1 solution = 1173 μM x 20 μl / 200 μl
= 117.3 μM

5.2.2 Preparation of DPPH solution (100 μM)

DPPH (2 mg) was dissolved in 100 ml of methanol, and the solution was stirred for 30 min.

5.2.3 Measurement of activity

The test sample (20 μl) was added to 180 μl DPPH solution (100 μM) in 96-well plate. The solution mixture was incubated at 37ºC for 30 min and then the absorbance of each well was measured at 510 nm. The DPPH solution (180 μl) mixed with methanol (20 μl) was used as negative control and quercetin as a reference compound.

5.2.4 Calculation of percent inhibition of DPPH free radical scavenging activity

The percentage of DPPH reduction was calculated as follows.

$$\% \text{ DPPH reduction} = (A-B) \times 100 / A$$

A = The absorbance of DPPH solution after incubation at 510 nm

B = The absorbance of the reaction mixture after incubation at 510 nm

For IC_{50} evaluation of pure compounds, a graph showing concentration versus % DPPH reduction was plotted. The IC_{50} was calculated from the graph.

CHAPTER IV

RESULTS AND DISCUSSION

The dried powdered of *Millettia leucantha* stemwood (6.9 kg) was macerated with methanol. The methanol extract (142 g) was triturated with CH_2Cl_2 and EtOAc, respectively. The CH_2Cl_2 extract (20 g) was separated using several chromatographic techniques to afford a pure compound (ML1) and two mixtures (ML2 and ML3). The EtOAc extract (11 g) was separated using several chromatographic techniques to yield six pure compounds (ML4-ML8). The structure determinations of all isolates were carried out by interpretation of their UV, MS and NMR data, and further comfirmed by comparison with literature values.

1. Structure determination of isolated compounds

1.1 Structure determination of compound ML1

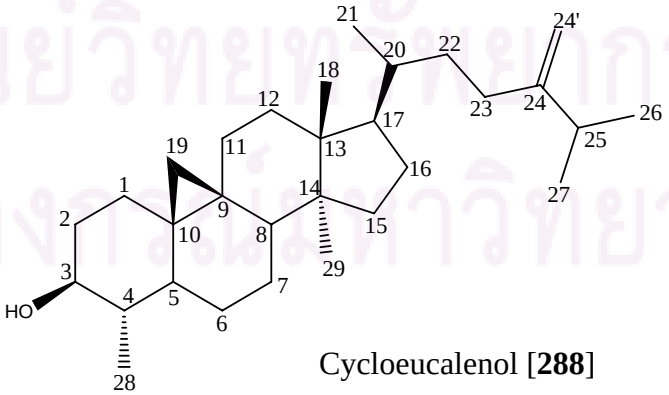
Compound ML1 was obtained as white needles. The EI mass spectrum (Figure 2) showed a molecular ion [M^+] at *m/z* 426, corresponding to $C_{30}H_{50}O$.

The ^{1}H NMR spectrum (Figure 3) of compound ML1 showed signals at δ 4.69 (1H, br s) and 4.64 (1H, br s) assignable to H-24′, 3.19 (1H, m) due to H-3, and 0.37 (1H, d, *J*=3.6) and 0.12 (1H, d, *J*=3.9) assignable to H-19.

The ^{13}C NMR, DEPT 90 and DEPT 135 spectra (Figures 4-5 and Table 2) exhibited 30 carbon signals, corresponding to 6 methyls, 12 methylenes, 7 methines and 5 quarternary carbons. Through comparison of its ^{1}H and ^{13}C NMR data, and MS data with reported values (Kikuchi *et al*., 1986), it was identified as cycloeucalenol [**288**].

Table 2 NMR Spectral data of compound ML1 and cycloeucalenol

Carbon position	Chemical shift (ppm)	
	ML1	Cycloeucalenol
1	30.8	30.88
2	34.8	34.90
3	76.6	76.64
4	44.6	44.69
5	43.3	43.43
6	24.7	24.73
7	25.1	25.22
8	46.8	46.90
9	23.5	23.64
10	29.5	29.65
11	27.2	27.08
12	32.9	32.99
13	45.3	45.45
14	48.9	49.00
15	35.3	35.42
16	28.1	28.18
17	52.2	52.31
18	17.8	17.84
19	27.0	27.28
20	36.1	36.21
21	18.3	18.42
22	35.0	35.13
23	31.3	31.41
24	156.9	156.89
25	33.8	33.90
26	22.0	22.06
27	21.9	21.94
28	14.4	14.46
29	19.1	19.21
24'	105.9	106.05



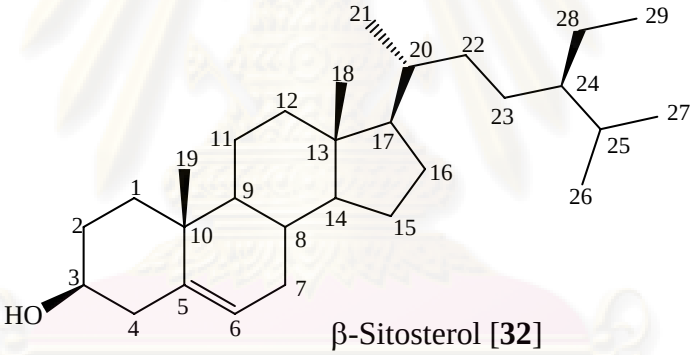
Cycloeucalenol [**288**]

1.2 Structure determination of mixture ML2

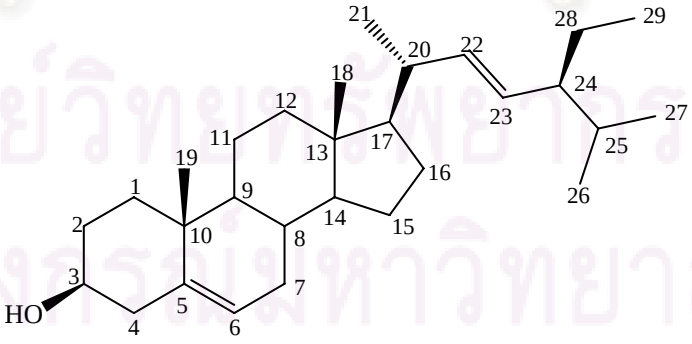
Mixture ML2 was isolated as a white powder. Anisaldehyde TS test gave a purple color, indicative of steroidal or triterpenoid skeleton. It was identified as a mixture of β-sitosterol [**32**] and stigmasterol [**289**] through comparison of its ^{1}H and ^{13}C NMR data with previous reported values (Wright *et al*., 1978).

The ^{1}H NMR spectrum (Figure 6) of ML2 showed signals at δ 5.33 (0.7H, d, *J* = 4.8Hz) due to H-6 of β-sitosterol and stigmasterol and 5.14 (0.26H, dd, *J* = 15, 8.4Hz) and 5.02 (0.26H, dd, *J* = 15, 8.4Hz) due to H-22 and H-23 of stigmasterol. The integration of H-6, H-22 and H-23 were approximate in the ratio of 0.7:0.26:0.26. Therefore, it could be calculated that ML2 was a mixture of β-sitosterol and stigmasterol in the ratio of 2:1.

The ^{13}C NMR spectrum (Figure 7 and Table 3) exhibited 42 signals. Comparison of these data with ^{13}C NMR data of β-sitosterol and stigmasterol (Wright *et al*., 1978) is shown in Table 3



β-Sitosterol [**32**]



Stigmasterol [**289**]

Table 3 NMR Spectral data of mixture ML2, β-sitosterol and stigmasterol ($CDCl_3$)

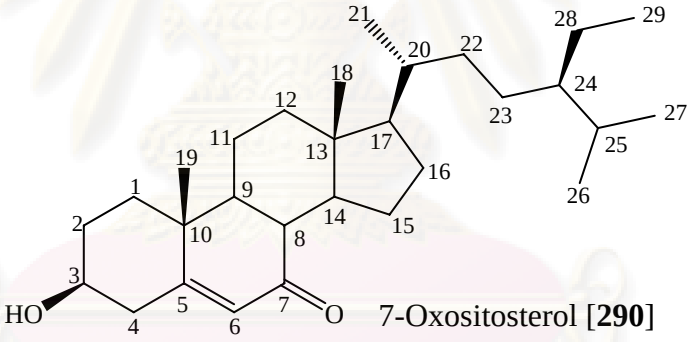
Carbon position	Chemical shift (ppm)		
	β-sitosterol	**stigmasterol**	**ML2**
1	37.31	37.31	37.3
2	31.57	31.69	31.7
3	71.69	71.81	71.8
4	42.25	42.35	42.3
5	140.76	140.80	140.8
6	121.59	121.69	121.7
7	31.92	31.94	31.9
8	31.92	31.94	31.9
9	50.17	50.20	50.2
10	36.51	36.56	36.5
11	21.11	21.11	21.1
12	39.81	39.74	39.8, 39.7
13	42.33	42.35	42.3
14	56.79	56.91	56.8, 56.9
15	24.32	24.39	24.3, 24.4
16	28.26	28.96	28.2, 28.9
17	56.11	56.06	56.1, 56.0
18	11.87	12.07	11.9, 12.1
19	19.40	19.42	19.4
20	36.17	40.54	36.2
21	18.82	21.11	19.0, 21.1
22	33.95	138.37	34.0, 138.3
23	26.13	129.32	26.1, 129.3
24	45.85	51.29	45.9, 51.2
25	29.18	31.94	29.2, 31.9
26	19.84	21.26	19.8, 21.2
27	19.07	19.02	19.0
28	23.09	25.44	23.1, 25.4
29	12.32	12.27	12.2

1.3 Structure determination of mixture ML3

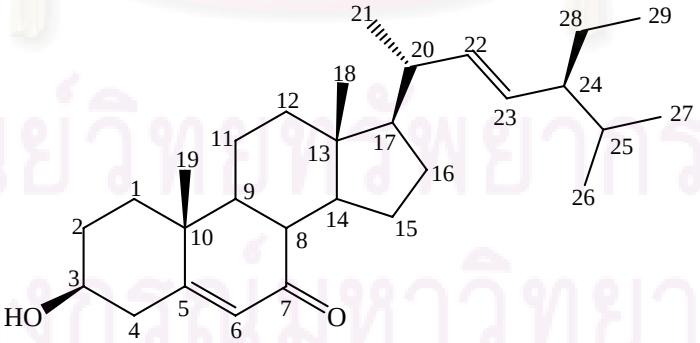
Mixture ML3 was isolated as a white powder. Anisaldehyde TS test gave a purple color, indicative of steroidal or triterpenoid skeleton. It was identified as a mixture of 7-oxositosterol [**290**] and 7-oxostigmasterol [**291**] through comparison of its ^{1}H and ^{13}C NMR data with previous reported values (Greca *et al*., 1990, Aliotta *et al*., 1991).

The ^{1}H NMR spectrum (Figure 8) of compound ML3 showed signals at δ 5.67 (0.9H, s) due to H-6 of 7-oxositosterol and 7-oxostigmasterol, 5.15 (0.22H, dd, *J* = 15, 8.4Hz) and 5.00 (0.22H, dd, *J* = 15, 8.4Hz) due to H-22 and H-23 of 7-oxostigmasterol and 3.65 (1H, m) due to H-3. The integration of H-6, H-22 and H-23 were approximate in the ratio of 0.9:0.2:0.2. Therefore, it could be calculated that ML3 was a mixture of 7-oxositosterol and 7-oxostigmasterol in the ratio 4:1.

The ^{13}C NMR spectrum (Figure 9 and Table 4) exhibited 33 signals. Comparison of these data with ^{13}C NMR data of 7-oxositosterol and 7-oxostigmasterol (Greca *et al*., 1990, Aliotta *et al*., 1991) is shown in Table 4



7-Oxositosterol [**290**]



7-Oxostigmasterol [**291**]

Table 4 NMR Spectral data of mixture ML3, 7-oxositosterol and 7-oxo-stigmasterol ($CDCl_3$)

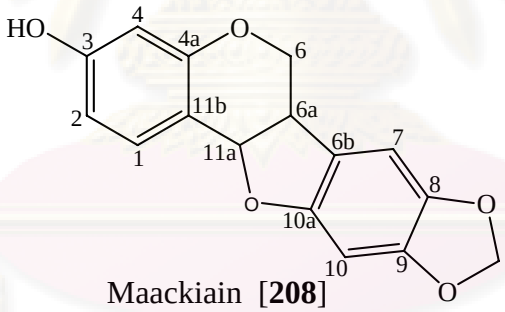
Carbon position	Chemical shift (ppm)		
	7-oxositosterol	**7-oxostigmasterol**	**ML3**
1	36.62	36.58	36.5
2	31.18	31.24	31.2
3	70.52	70.45	70.5
4	41.79	41.70	41.8
5	169.35	169.22	165.1
6	126.13	126.04	126.1
7	204.21	204.15	202.3
8	45.39	45.22	45.4
9	50.02	50.18	50.0
10	38.24	38.12	38.3
11	21.20	21.28	21.2
12	39.68	39.74	38.7
13	41.79	41.84	41.8
14	49.93	49.87	50.0
15	26.30	26.38	26.3
16	28.53	28.46	28.5
17	54.69	54.55	54.7
18	11.87	11.96	12.0
19	17.28	17.28	17.3
20	36.06	40.33	36.1, 40.2
21	18.90	21.29	18.9, 21.4
22	33.93	138.26	33.9, 138.1
23	26.07	129.30	26.1, 129.1
24	45.80	51.21	45.8, 51.2
25	29.11	31.80	29.1, 31.9
26	19.77	21.16	19.8, 21.0
27	19.01	19.20	19.0
28	23.04	25.58	23.0, 25.6
29	11.95	12.36	12.0

1.4 Structure determination of Compound ML4

Compound ML4 was obtained as a brown powder. The UV spectrum (Figure 11) showed absorption at 227.5, 286.5 and 311 nm. The EI mass spectrum (Figure 12) displayed a molecular ion peak at *m/z* 284, consistent with the formula $C_{16}H_{12}O_5$.

The ^{1}H NMR spectrum (Figure 13 and Table 5) showed aromatic protons at δ 7.34 (1H, d, *J* = 8.4 Hz) for H-1, 6.70 (1H, s) for H-7, 6.52 (1H, dd, *J* = 8.4, 2.1 Hz) for H-2, 6.41 (1H, s) for H-10 and 6.39 (1H, d, *J* = 2.1 Hz) for H-4. The signal at 5.88 (2H, d, *J* = 8.1 Hz) represented methylene protons of O-CH_2-O. Other proton signals appeared at δ 5.45 (1H, d, *J* = 6.9 Hz) for H-11a, 4.20 (1H, dd, *J* = 11.1, 5.1 Hz) for H-6α, 3.62 (1H, t, *J* = 11.1 Hz) for H-6β and 3.46 (1H, m) for H-6a.

The ^{13}C NMR and DEPT spectra (Figure 14 and Table 5) exhibited 16 signals that were 2 methylenes, 7 methines and 7 quarternary carbons. Through comparison of these data with previously published data, compound ML4 was identified as maackiain [**208**] (Chaudhuri *et al.*, 1995).



Maackiain [**208**]

Table 5 NMR Spectral data of compound ML4 ($CDCl_3$) and maackiain ($CDCl_3$)

Position	ML4		Maackiain	
	δH (mult., *J* in Hz)	**δC**	**δH (mult., *J* in Hz)**	**δC**
1	7.34 (d, 8.4)	132.1	7.35 (d,8.5)	132.1
2	6.52 (dd, 8.4, 2.1)	109.8	6.54 (dd, 8.5, 2.5)	109.8
3	-	157.1	-	157.1
4	6.39 d (2.1)	103.7	6.40 (d, 2.5)	103.6
4a	-	156.6	-	156.6
6	6α 4.20 (dd, 11.1, 5.1)	66.5	6α 4.21 (dd, 11, 5)	66.4
	6β 3.62 (t, 11.1)		6β 3.64 (t, 11.0)	
6a	3.46 (m)	40.2	3.45 (ddd, 11, 7, 5)	40.1
6b	-	117.9	-	117.9
7	6.70 (s)	104.7	6.72 (s)	104.7
8	-	141.7	-	141.7
9	-	148.2	-	148.1
10	6.41 (s)	93.8	6.43 (s)	93.8
10a	-	154.2	-	154.2
11a	5.45 (d, 6.9)	78.5	5.47 (d,7)	78.5
11b	-	112.6	-	112.5
OCH_2O	5.88 (d, 8.1)	101.3	5.91 (d, 14)	101.3

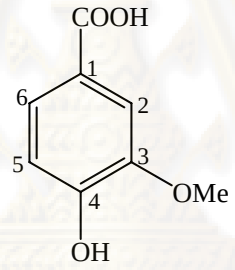
1.5 Structure determination of compound ML5

Compound ML5 was obtained as a brown powder. The UV spectrum (Figure 15) showed absorption at 258 and 290 nm. It showed a molecular ion peak at *m/z* 168 in the EIMS (Figure 16), corresponding to the molecular formula $C_8H_8O_4$.

The ^{1}H NMR spectrum (Figure 17 and Table 6) showed aromatic protons at δ 7.58 (1H, dd, *J* = 8.4, 1.5 Hz) for H-6, 7.55 (1H, s) for H-2 and 6.89 (1H, d, *J* = 8.1 Hz) for H-5. A methoxy signal showed at δ 3.89 (3H, s).

The ^{13}C NMR spectrum (Figure 18 and Table 6) displayed 8 signals. A ketone carbon was found at δ 167.5, aromatic carbons were at δ 152.0, 148.1, 124.8, 122.9, 115.5 and 113.5 and a methoxy peak was at δ 56.3.

This compound was identified as 4-hydroxy-3-methoxybenzoic acid **[292]** by comparison of the above data with earlier reported values (Pouchert and Behnke, 1993)



4-Hydroxy-3-methoxybenzoic acid **[292]**

Table 6 NMR Spectral data of compound ML5 (acetone-d_6) and 4-hydroxy-3-methoxybenzoic acid ($CDCl_3$+DMSO-d_6)

Position	**Compound ML5**		**4-hydroxy-3-methoxybenzoic acid**
	δH (mult., *J* in Hz)	**δC**	**δC**
1	-	122.9	121.74
2	7.55 (s)	113.5	112.62
3	-	152.0	150.95
4	-	148.1	147.02
5	6.89 (d, 8.1)	115.5	114.84
6	7.58 (dd, 8.1, 1.5)	124.8	123.56
COOH	-	167.5	167.46
OMe	3.89 (s)	56.3	55.55

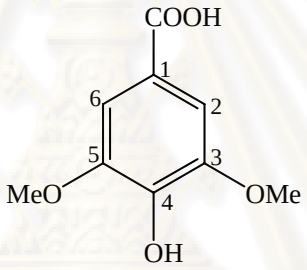
1.6 Structure determination of compound ML6

Compound ML6 was obtained as a brown powder. The UV spectrum (Figure 19) showed absorption at 273 nm. The molecular weight should be 198 ($C_9H_{10}O_5$) as shown by the molecular ion peak at *m/z* 198 in the EIMS (Figure 20).

The ^{1}H NMR spectrum (Figure 21 and Table 7) exhibited aromatic protons at δ 7.32 (2 x 1H, s) representing H-2 and 6. A methoxy signal showed at δ 3.87 (2 x 3H, s).

The ^{13}C NMR spectrum (Figure 22 and Table 7) showed 7 signals. A ketone carbon appeared at δ 167.52, aromatic carbons were at δ 148.3, 141.6, 121.5 and 108.1 and a methoxy peak was at δ 56.6.

Through comparison of these data with reported values, compound ML6 was identified as syringic acid [**293**] (Abbas *et al*., 2007).



Syringic acid [**293**]

Table 7 NMR Spectral data of compound ML6 (acetone-d_6) and syringic acid (CD_3OD)

Position	ML6		Syringic acid	
	δH (mult., *J* in Hz)	**δC**	**δH (mult., *J* in Hz)**	**δC**
1	-	121.5	-	121.9
2	7.32 (s)	108.1	7.35 (s)	108.4
3	-	148.3	-	148.9
4	-	141.6	-	141.8
5	-	148.3	-	148.9
6	7.32 (s)	108.1	7.35 (s)	108.4
COOH	-	167.5	-	170.0
OMe x 2	3.87 (s)	56.6	3.90 (s)	56.8

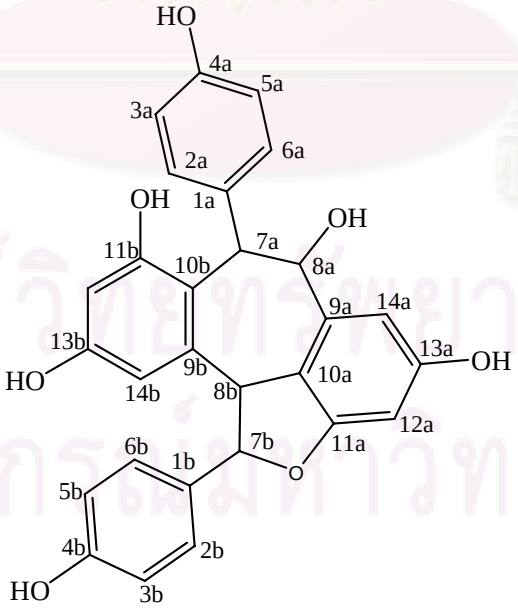
1.7 Structure determination of Compound ML7

Compound ML7, a brown powder, was analyzed for $C_{28}H_{22}O_7$ from its molecular ion peak at *m/z* 470 in the EIMS (Figure 23). The UV spectrum (Figure 24) showed absorption at 226.6 and 284 nm.

The ^{1}H NMR spectrum (Figure 25 and Table 8) showed aromatic protons at δ 7.48 (2H, d, *J* = 8.4 Hz) for H-2b and 6b, 6.94 (2H, d, *J* = 8.4Hz) for H-3b and 5b, 6.74 (2H, d, *J* = 8.4 Hz) for H-2a and 6a, 6.42 (2H, d, *J* = 8.4 Hz) for H-3a and 5a, 6.25 (1H, br s) for H-12b, 6.20 (1H, br s) for H-14b, 6.08 (1H, br s) for H-14a and 5.95 (1H, br s) for H-12a. The signal appearing at δ 5.69 (1H, d, 9.6), 5.39 (1H, br s), 5.15 (1H, d, 9.3) and 4.89 were due to H-7b, 8a, 8b and 7a, respectively.

The ^{13}C NMR and DEPT spectra (Figure 26 and Table 8) displayed 28 carbons indicating 16 methines and 12 quarternary carbons. The compound was identified as balanocarpol [**294**] by analysis of the above data in comparison with earlier reported data (Tanaka *et al*., 2000).

From HMQC spectrum (Figure 27), the proton at δ 5.95 correlated with the carbon at δ 95.1 of position 12a. The proton at δ 6.90 correlated with the carbon at δ 104.4 of position 14a. The proton at δ 6.25 correlated with the carbon at δ 102.0 of position 12b. The proton at δ 6.20 correlated with the carbon at δ 106.8 of position 14b. These findings are different from those earlier reported (Tanaka *et al*., 2000).



Balanocarpol [**294**]

Table 8 NMR Spectral data of compound ML7 (acetone-d_6) and balanocarpol (acetone-d_6)

position	ML7		Balanocarpol	
	δH (mult., *J* in Hz)	**δC**	**δH (mult., *J* in Hz)**	**δC**
1a	-	133.5	-	133.5
2a, 6a	6.74 (d, 8.4)	131.5	6.75 (d, 8.3)	131.5
3a, 5a	6.42 (d, 8.4)	114.2	6.42 (d, 8.3)	114.2
4a	-	155.8	-	155.8
7a	4.89 (br s)	50.3	4.90 (br s)	50.3
8a	5.39 (br s)	73.2	5.40 (br s)	73.2
9a	-	140.8	-	140.8
10a	-	113.8	-	113.8
11a	-	159.7	-	159.7
12a	5.95 (br s)	95.1	6.20 (br s)	95.1
13a	-	159.2	-	159.2
14a	6.09 (br s)	104.4	6.26 (br s)	104.4
1b	-	133.7	-	133.7
2b, 6b	7.49 (d, 8.4)	130.5	7.50 (d, 8.3)	130.5
3b, 5b	6.94 (d, 8.4)	116.5	6.95 (d, 8.3)	116.4
4b	-	158.6	-	158.6
7b	5.69 (d, 9.3)	93.5	5.69 (d, 9.3)	93.5
8b	5.15 (d, 9.3)	52.3	5.16 (d, 9.3)	52.3
9b	-	142.9	-	142.8
10b	-	120.5	-	120.4
11b	-	157.4	-	157.4
12b	6.25 (br s)	102.0	6.09 (br s)	102.0
13b	-	156.9	-	156.9
14b	6.20 (br s)	106.8	5.96 (br s)	106.8

1.8 Structure determination of Compound ML8

Compound ML8 was obtained as a brown powder. The UV spectrum (Figure 28) showed absorption at 226 and 372 nm. It showed a $[M+H]^+$ peak at *m/z* 379 in the TOF MS (Figure 29), corresponding to the molecular formula $C_{21}H_{14}O_7$.

The ^1H NMR spectrum (Figure 30 and Table 9) exhibited aromatic protons at δ 6.92 (1H, d, *J* = 2.5 Hz) for H-14b, 6.90 (1H, d, *J* = 2.5 Hz) for H-14a, 6.79 (1H, d, *J* = 2.5 Hz) for H-12a, 6.68 (1H, d, *J* = 8 Hz) for H-2b and 6b, 6.63 (1H, d, *J* = 9 Hz) for H-3b and 5b and 6.38 (1H, d, *J* = 2.5 Hz) for H-12b. The signals at δ 5.88 (1H, s) was assigned to H-7b. The sharp singlet at δ 13.69 indicated a chelated OH group of C-11b.

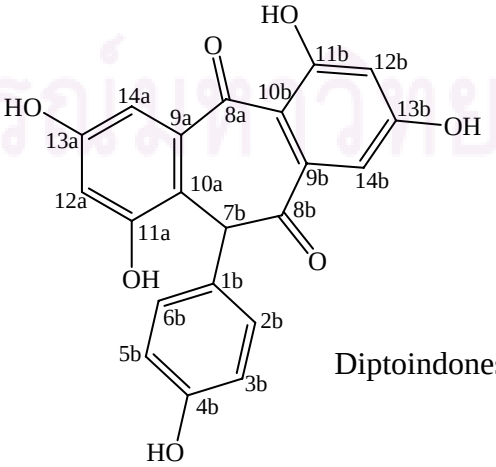
The ^{13}C NMR and DEPT data (Figures 31-32 and Table 9) presented 21 carbons, consisting of 9 methines and 12 quarternary carbons. The HMBC spectrum (Figures 34-43) showed correlation of the long-range coupled ^1H and ^{13}C nuclei. The proton at position 12a showed long range correlations with C-11a, C-13a and C-14a. The methine proton at position 14a showed long range correlations with C-8a, C-10a, C-12a and C-13a. The protons at positions 2b and 6b displayed long range correlations with C-4b, C-2b, C-6b and C-7b. The protons at positions 3b and 5b presented long range correlations with C-1b, C-3b and C-5b. The methine proton at position 7b showed long range correlations with C-9a, C-10a, C-11a, C-1b, C-2b, C-3b, C-5b, C-6b, C-8b and C-9b. The proton at position 12b showed long range correlations with C-10b, C-11b, C-13b and C-14b. The methine proton at position 14b showed long range correlations with C-8b, C-10b, C-12b and C-13b. The H-bonded hydroxyl proton at position 11b showed long range correlations with C-10b, C-11b and C-12b.

Through comparison of these data with reported values, compound ML9 was identified as diptoindonesin D [**295**] (Sahidin *et al.*, 2005).

The data in Table 9 suggest that revisions for ^1H and ^{13}C assignments for positions 2b, 6b, 3b and 5b are needed, based on the HMQC data (Figure 33), and HMBC correlation (Figure 34) from H-2b and H-6b to C-7.

Table 9 NMR Spectral data of compound ML8 (acetone-d_6) and diptoindonesin D (acetone-d_6)

position	ML8		Diptoindonesin D	
	δH (mult., *J* in Hz)	**δC**	**δH (mult., *J* in Hz)**	**δC**
8a	-	197.4	-	197.1
9a	-	142.8	-	142.3
10a	-	111.2	-	110.7
11a	-	156.8	-	156.6
12a	6.79 (d, 2.5)	107.5	6.8 (d, 2.6)	107
13a	-	158.8	-	158.4
14a	6.90 (d, 2.5)	110.2	6.9 (d, 2.6)	109.8
1b	-	130.5	-	130.0
2b, 6b	6.68 (d, 9)	128.9	6.63 (d, 8.8)	128.5
3b, 5b	6.63 (d, 9)	116.2	6.68 (d, 8.8)	115.8
4b	-	157.0	-	156.4
7b	5.88 (s)	55.2	5.89 (br s)	54.8
8b	-	196.7	-	196.3
9b	-	139.6	-	139.2
10b	-	111.7	-	111.3
11b	-	167.3	-	166.8
12b	6.38 (d, 2.5)	107.0	6.39 (d, 2.6)	106.6
13b	-	165.2	-	164.5
14b	6.92 (d, 2.5)	113.1	6.92 (d, 2.6)	112.5
11b-OH	13.69 (s)		13.68 (s)	



Diptoindonesin D [**295**]

2. Free radical scavenging activity

Free radicals can be defined as molecules or molecular fragments containing one or more unpaired electrons in atomic or molecular orbitals. Radicals derived from oxygen represent the most important class of radical species generated in living systems, including superoxide ($O_2^{\bullet -}$), peroxyl ($ROO^{\bullet}$), alkoxyl ($RO^{\bullet}$), hydroxyl ($HO^{\bullet}$), nitric oxide ($NO^{\bullet}$) and hydrogen peroxide (H_2O_2). Oxygen free radicals or reactive oxygen species (ROS), as well as reactive nitrogen species (RNS), are products of normal cellular metabolism. ROS and RNS are well recognized for playing a dual role as both deleterious and beneficial species, since they can be either harmful or beneficial to living systems. Beneficial effects of ROS occur at low/moderate concentrations and involve physiological roles in cellular responses to noxia, as for example in defense against infectious agents. The harmful effect of free radicals causing potential biological damage is termed oxidative stress and nitrosative stress. This occurs in biological systems when there is an overproduction of ROS/RNS on one side and a deficiency of enzymatic and non-enzymatic antioxidants. The excess ROS can damage cellular lipids, proteins, or DNA inhibiting their normal function (Valko *et al*., 2007, Pietta 2000).

Defense mechanisms against free radical-induced oxidative stress involve: (i) preventative mechanisms, (ii) repair mechanisms, (iii) physical defences, and (iv) antioxidant defences. The mechanisms of antioxidant action can include (1) suppressing ROS formation by inhibition of enzymes or chelating trace elements involved in free radical production; (2) scavenging ROS; and (3) upregulating or protecting antioxidant defenses (Valko *et al*., 2007, Pietta 2000).

By TLC screening assay, the MeOH extract of *M. leucantha* presented free radical scavenging activity. Isolated compounds were first test at 50 μg/ml. Compounds exhibiting more than 50% inhibition were further evaluated for IC_{50} values. Quercetin was employed as positive control. The results are summarized in Table 10.

Table 10 Percentage of DPPH reduction by isolated compounds from *M. leucantha*

Compounds	**% DPPH reduction at 50 μg/ml**	**IC_{50} (μM)**
ML1	1.66	-
ML2	2.07	-
ML3	2.50	-
ML4	11.56	-
ML5	33.08	-
ML6 [**293**]	93.79	16.94
ML7	40.28	-
ML8	16.52	-
Quercetin	93.94	6.07

From Table 10, six pure compounds and two mixtures were tested for free radical scavenging activity. It was found that syringic acid [**293**] showed moderate activity against DPPH free radical as compared with quercetin.

CHAPTER V

CONCLUSION

In this study, six known compounds were isolated from stemwood of *Millettia leucantha* Kurz (Leguminosae). These compounds were identified as cycloeucalenol [**288**], maackiain [**208**], 4-hydroxy-3-methoxybenzoic acid [**292**], syringic acid [**293**], balanocarpol [**294**] and diptoindonesin D [**295**]. In addition, a mixture of β-sitosterol [**32**] and stigmasterol [**289**], and a mixture of 7-oxositosterol [**290**] and 7-oxostigmasterol [**291**] were identified. The isolated compounds were tested for free radical scavenging activity. Syringic acid [**293**] showed moderate activity, and the other compounds showed no activity.

References

Abbas, F. A., Al-Massarany, S. M., Khan, S., Al-Howiriny, T. A., Mossa, J. S., and Abourashed, E. A. 2007. Phytochemical and biological studies on Saudi *Commiphora opobalsamum* L. Nat. Prod. Res. 21: 383-389.

Aliotta, G., Monaco, P., Pinto, G., Pollio, A., and Previtera, L. 1991. Potential allelochemicals from *Pistia stratiotes* L. J. Chem. Ecol. 17: 2223-2234.

Asomaning, W. A., Amoako, C., Oppong, I. V., Phillips, W. R., Addae-Mensah, I., Osei-Twum, E, Y., Waibel, R., and Achenbach, H. 1995. Pyrono- and dihydrofurano-isoflavones from *Millettia thonningii*. Phytochemistry 39: 1215-1218.

Asomaning, W. A., Otoo, E., Akoto, O., Oppong, I. V., Addae-Mensah, I., Waibel, R., and Achenbach, H. 1999. Isoflavones and coumarins from *Millettia thonningii*. Phytochemistry 51: 937-941.

Baruah, P., Barua, N. C., Sharma, R. P., Baruah, J. N., Kulanthaivel, P., and Herz, W. 1984. Flavonoids from *Millettia pulchra*. Phytochemistry 23: 443-447.

Braca, A., Sortino, C., Politi, M., Morelli, I., and Mendez, J. 2002. Antioxidant activity of flavonoids from *Licania licaniaeflora*. J. Ethnopharmacology 79: 379-381.

Chaudhuri, S. K., Huang, L., Fullas, F., Brown, D. M., Wani, M. C., and Wall, M. E. 1995. Isolation and structure identification of an active DNA strand-scission agent, (+)-3,4-dihydroxy-8,9-methylenedixoyptercarpan. J. Nat. Prod. 58: 1966-1969.

Chen, F. T., Zhong, S. Z., Lu, J. H., Chen, G., Guo, J. G., Yan, X. Z., and Zhu, Y. F. 1999. Chemical constituents of thickfruit *Millettia* root (*Millettia pachycarpa*) I. Chung IT' AO Yao 30: 3-5. (CA. 131: 2779h)

Dagne, E., and Bekele, A. 1990. *C*-Prenylated isoflavones from *Millettia ferruginea*. Phytochemistry 29: 2679-2682.

Dagne, E., Bekele, A., and Waterman, P. G. 1989. The flavonoids of *Millettia ferruginea* subsp. *ferruginea* and subsp. *darassana* in Ethiopia. Phytochemistry 28: 189-1900.

Dagne, E., Bekele, A., Noguchi, H., Shibuya, M., and Sankawa, U. 1990. *O*-Geranylated and *O*-prenylated flavonoids from *Millettia ferruginea*. Phytochemistry 29: 2671-2673.

Dagne, E., Mammo, W., and Bekele, A. 1991. Flavonoids of *Millettia dura*. Bull. Chem. Soc. Ethiop. 5: 81-86.

Desai, H. K., Gawad, D. H., Joshi, B. S., Parthasarathy, P. C., Ravindranath, K. R., Saindane, M. T., Sidhaye, A. R., and Viswanathan, N. 1977. Chemical investigatin of indian plants: part X. Indian J. Chem. 15B: 291-293.

Fuendjiep, V., Nkengfack, A. E., Fomum, Z. T., Sondengam, B. L., and Bodom, B. 1998a. Conrauinones A and B, two isoflavones from stem bark of *Millettia conraui*. J. Nat. Prod. 61: 380-383.

Fuendjiep, V., Nkengfack, A. E., Fomum, Z. T., Sondengam, B. L., and Bodom, B. 1998b. Conrauinones C and D, two isoflavones from stem bark of *Millettia conraui*. Phytochemistry 47: 113-115.

Galeffi, C., Rasoanaivo, P., Federici, E., Palazzino, G., Nicoletti, M., and Rasolondratovo, B. 1997. Two prenylated isoflavanones from *Millettia pervilleana*. Phytochemistry 45:189-192.

Ganapaty, S., Pushpalatha, V., Babu, G. J., Naidu, K. C., and Waterman, P. G. 1998. Flavonoids from *Millettia peguensis* Ali (Fabaceae). Biochem. Sys. Ecol. 26: 125-126.

Gardner, S., Sidsunthorn, P., and Anusarnsunthorn, V. 2000. A field guide to forest trees of northern Thailand. Bangkok: Kobfai Publishing Project.

Greca, M. D., Monaco, P., and Previtera, L. 1990. Stigmasterols from *Typha latifolia*. J. Nat. Prod. 53: 1430-1435.

Gupta, B. B., Bhattacharryya, A., Mitra, S. R., and Adityachaudhury, N. 1983. Isoaurmillone, an isoflavone from the pods of *Millettia auriculata*. Phytochemistry 22: 1306-1307.

Gupta, R. K., and Krishnamurti, M. 1976a. Prenylated flavanones from *Millettia ovalifolia* seeds. Phytochemistry 15: 832-833.

Gupta, R. K., and Krishnamurti, M. 1976b. Pyranoflavanone from *Millettia ovalifolia* seeds. Phytochemistry 15: 1795.

Gupta, R. K., and Krishnamurti, M. 1976c. Chromenoflavanones from *Millettia ovalifolia*. Phytochemistry 15: 2011.

Gupta, R. K., and Krishnamurti, M. 1977. New dibenzoylmethane and chalcone derivatives from *Millettia ovalifolia* seeds. Phytochemistry 16: 1104-1105.

Hayashi, Y., Shirato, T., Sakurai, K., and Takahashi, T., 1978. Isoflavonoids from the heartwood from *Milletia pendura*. MokuzakiGakkaishi 24: 898. (CA. 90: 100111p)

Highet, R. J., and Highet, P. F. 1967. The structure of two isoflavones from the Abyssinian Berebera tree. J. Org. Chem. 32: 1055-1058.

Islam, A., Gupta, R. K., and Krishnamurti, M. 1980. Furano chalcone and prenylated flavanones from *Millettia ovalifolia* seeds. Phytochemistry 19: 1558-1559.

Ito, C., Itoigawa, M., Kojima, N., Tokuda, H., Hirata, T., Nishino, H., and Furukawa, H. 2004. Chemical constituents of *Millettia taiwaniana*: structure elucidation of five new isoflavonoids and their cancer chemopreventive activity. J. Nat. Prod. 67: 1125-1130.

Ito, C., Itoigawa, M., Kumagaya, M., Okamoto, Y., Ueda, K., Nishihara, T., Kojima, N., and Furukawa, H. 2006. Isoflavonoids with antiestrogenic activity from *Millettia pachycarpa*. J. Nat. Prod. 69: 138-141.

Ito, C., Murata, T., Itoigawa, M., Nakao, K., Kumagai, M., Kaneda, N., and Furukawa, H. 2006. Induction of apoptosis by isoflavonoids from the leaves

of *Millettia taiwaniana* in human leukemia HL-60 cells. Planta Med. 72: 424-429.

Kamnaing, P., Fanso Free, S. N. Y., Fomum, Z. T., Martin, M. T., and Bodo, B. 1994. Millettonine, a guanidine from *Millettia laurentii*. Phytochemistry 36: 1561-1562.

Kamnaing, P., Fanso Free, S. N. Y., Nkengfack, A. E., Folefoc, G., and Fomum, Z. T. 1999. An isoflavan quinine and a flavonol from *Millettia laurentii*. Phytochemistry 51: 829-832.

Kamperdick, C., Phoung, N. M., Sung, T. V., and Adam, G. 1998. Flavones and isoflavones from *Millettia ichthyochtona*. Phytochemistry 48: 577-379.

Kapingu, M. C., Mbwambo, Z. H., Moshi, M. J., Magadula, J. J., Cos, P., Berghe, D. V., Maes, L., Theunis, M., Apers, S., Pieters, L., and Vlietinck, A. 2006. A novel isoflavonoid from *Millettia puguensis*. Planta Med. 72: 1341-1343.

Khalid, S. A., and Waterman, P. G. 1983. Thonnongine-A and thonningine-B: two 3-phenylcoumarins form the seeds of *Millettia thonningii*. Phytochemistry 22: 1001-1003.

Khan, H., and Zaman, A. 1974. Extractives of *Millettia ovalifolia*. Tetrahedron 30: 2811-2815.

Kikuchi, T., Kadota, S., and Tsubono, K. 1986. Studies on the constituents of Orchidaceous Plant. IV. Proton and carbon-13 signal assignments of cycloeucalenol-type triterpenes from *Nervilia purpurea* Schlechter by two-dimensional nuclear magnetic resonance spectroscopy. Chem. Pharm. Bull. 34: 2479-2486.

Kikuchi, H., Ohtsuki, T., Koyano, T., Kowithayakorn, T., Sakai, T., and Ishibashi, M. 2007. Brandisianins A-F, Isoflavonoids isolated from *Millettia brandisiana* in a screening program for death-receptor expression enhancement activity. J. Nat. Prod. 70:1910-1914.

Kumar, R. J., Krupadanam, G. L. D., and Srimannarayana, G. 1989. Isoflavans from *Millettia racemosa*. Phytochemistry 28: 913-916.

Likhitwitayawuid, K., Sritularak, B., Benchanak, K., Lipipun, V., Mathew, J., and Schinazi, R. F. 2005. Phenolics with antiviral activity from *Millettia erythrocalyx* and *Artocarpus lakoocha*. Nat. Prod. Res. 19: 177-182.

Lu, J. H., Zeng, J. X., Kuang, Z. T., and Chen, F. T. 1999. Chemical constituents of thickfruit *Millettia* roots (*Millettia pachycarpa*) II. Chung TS' Ao Yao 30: 721-723. (Napralert: H26738)

Mahmoud, E. N., and Waterman, P. G. 1985. Flavonoids from the stem bark of *Millettia hemsleyana*. Phytochemistry. 24: 369-371.

Mbafor, J. T., Atchade, A. T., Nkengfack, A. E., Fomum, Z. T., and Sterner, O. 1995. Furanoflavones from root bark of *Millettia sanagana*. Phytochemistry 40: 949-952.

Minhaj, N., Khan, H., Kapoor, S. K., and Zaman, A. 1976. Extractives of *Millettia auriculata*-III. Tetrahedron 32: 749-751.

Ngamga, D., Fanso Free, S. N. Y., and Fomum, Z. T. 1993. Millaurine and acetlmillaurine: alkaloids from *Millettia laurentii*. J. Nat. Prod. 56 : 2126-2132.

Ngamga, D., Fanso Free, S. N. Y., and Fomum, Z. T. 1994. A new guanidine alkaloid from *Millettia laurentii*. J. Nat. Prod. 57: 1022-1024.

Ngamga, D., Fanso Free, S. N. Y., Tane, P., and Fomum, Z. T. 2007. Millaurine A, a new guanidine alkaloid from seeds of *Millettia laurentii*. Fitoterapia 78: 276-277.

Ngamga, D., Yankep, E., Tane, P., Bezabih, M., Ngadjui, B. T., Fomum, Z. T., and Abegaz, B. M. 2005a. Antiparasitic prenylated isoflavonoids from seeds of *Millettia griffoniana*. Bull. Chem. Soc. Ethiop. 19: 75-80.

Ngamga, D., Yankep, E., Tane, P., Bezabih, M., Ngadjui, B. T., Fomum, Z. T., and Abegaz, B. M. 2005b. Isoflavonoids from seeds of *Millettia griffoniana* (Bail). Z. Naturforsch B. 60: 973-977.

Ngandeu, F., Bezabih, M., Ngamga, D., Tchinda, A. T., Ngadjui, B. T., Abegaz, B. M., Dufat, H., and Tillequin, F. 2008. Rotenoid derivatives and other constituents of the twigs of *Millettia duchesnei*. Phytochemistry 69: 258-263.

Olivares, E. M., Lwande, W., Monache, F. D., and Bettolo, G. B. M. 1982. A pyrano-isoflavone from seeds of *Millettia thonningii*. Phytochemistry 21: 1763-1765.

Ollis, W. D., Rhodes, C. A. and Suntherland, I. O. 1967. The extractives of *Millettia dura*. The constitions of durlettone, durmillone, milldurone, millettone and millettosin. Tetrahedron 23: 4741.

Palazzino, G., Rasoanaivo, P., Federici, E., Nicoletti, M., and Galeffi, C. 2003. Prenylated isoflavonoids form *Millettia pervilleana*. Phytochemistry 63: 471-474.

Pancharoen, O., Athipornchai, A., Panthong, A., and Taylor, W. C. 2008. Isoflavones and rotenoids from the leaves of *Millettia brandisiana*. Chem. Pharm. Bull. 56 : 835-838.

Parvez, M., and Ogbeide, O. N. 1990. 3-Hydroxy-4′-methoxyflavone from *Millettia zechiana*. Phytochemistry 29: 2043-2044.

Pietta, P. G. 2000. Flavonoids as antioxidant. J. Nat. Prod. 63: 1035-1042.

Phrutivorapongkul, A., Lipipun, V., Ruangrungsi, N., Kirtikara, K., Nishikawa, K., Maruyama, S., Watanabe, T., and Ishikawa, T. 2003. Studies on the chemical constituents of stem bark of *Millettia leucantha*: isolation of new chalcones with cytotoxic, anti-herpes simplex virus and anti-inflammatory activities. Chem. Pharm. Bull. 51: 187-190.

Pouchert, C. J., and Behnke, J. 1993. The Aldrich library of ^{13}C and ^{1}H FT NMR spectra. 1st edition. U. S. A.: Aldrich Chemical Company, Inc.

Raju, K. V. S., and Srimannarayana, G. 1978. Aurmillone, a new isoflvone from the seeds of *Millettia auriculata*. Phytochemistry 17: 1065-1066.

Rao, C. P., and Krupadanam, G. L. D. 1994. An isoflavan from *Millettia racemosa*. Phytochemistry 35: 1597-1599.

Rao, E. V., Prasad, Y. R., and Ganapaty, S. 1992. Three prenylated isoflavones from *Millettia auriculata*. Phytochemistry 31:1015-1017.

Rao, C. P., Prashant, A., and Krupadanam, G. L. D. 1996. Two prenylated isoflavans from *Millettia racemosa*. Phytochemistry 41: 1223-1224.

Sahidin, Hakim, E. H., Juliawaty, L. D., Syah, Y. M., Din, L. B., Ghisalberti, E. L., Latip, J., Said, I. M., and Achmad, S. A. 2005. Cytotoxic properties of oligostilbenoids from the tree barks of *Hopea dryobalanoides*. Z. Naturforsch C. 60: 723-727.

Saxena, D. B., Tomar, S. S., Singh, R. P., and Mukerjee, S. K. 1987. A new chalcone from *Millettia ovalifolia*. Indian J. Chem. 26B: 704.

Shabbir, M., and Zaman, A. 1970. Structure of isoauriculatin and auricurin, extractives of *Millettia auriculata*-II. Tetrahedron 26: 5041-5044.

Shabbir, M., Zaman, A., Crombie, L., Tuck, B., and Whitig, D. A. 1968. Structure of auriculatin, extractive of *Millettia auriculata*. J. Chem. Soc. (C): 1899-1901.

Shao, W. Y., Huang, X. F., Zhu, Y. F., Guan, S. Y., Chen, F. T., and Zhang, S. Z. 2001b. NMR study on three new furanoflavones. Fenxi Ceshi Xuebao 20: 8-11. (Napralert: H28309)

Shao, W. Y., Zhu, Y. F., Guan, S. Y., Zhang, S. Z., and Chen, F. T. 2001a. Study on chemical constituents of thickfruit root aoo. Tianran Chanwu Yanjiu Yu Kaifa 13: 1-4. (Napralert: H28568)

Singhal, A. K., Barua, N. C., Sharma, R. P., and Baruah, J. N. 1983. A chalcone and an isoflavone from *Millettia pachycarpa* seeds. Phytochemistry 22: 1005-1006.

Singhal, A. K., Sharma, R. P., Baruah, J. N., Govindan, S. W., and Herz, W. 1982. Rotenoids form roots of *Millettia pachycarpa*. Phytochemistry 21: 949-951.

Singhal, A. K., Sharma, R. P., Madhusudanan, K. P., Thyagarajan, G., Herz, W., and Govindan, S. W. 1981. New prenylated isoflavones from *Millettia pachycarpa*. Phytochemistry 20: 803-806.

Singhal, A. K., Sharma, R. P., Thyagarajan, G., Herz, W., and Govindan, S. W. 1980. New prenylated isoflavones and prenylated dihydroflavonol from *Millettia pachycarpa*. Phytochemistry 19: 929-934.

Smitinand, T. 2001. Thai plant names (botanical names-vernacular names) revised edition. pp. 359-360. Bangkok:The Forest Herbarium, Royal Forest Department.

Sritularak, B., and Likhitwitayawuid, K. 2006. Flavonoids from the pods of *Millettia erythrocalyx*. Phytochemistry 67: 812-817.

Sritularak, B., Likhitwitayawuid, K., Conrad, J., Vogler, B., Reef, S., Klaiber, I., and Kraus, W. 2002a. New flavones from *Millettia erythrocalyx*. J. Nat. Prod. 65: 589-591.

Sritularak, B., Likhitwitayawuid, K., Conrad, J., and Kraus, W. 2002b. Flavonoids from the roots of *Millettia erythrocalyx*. Phytochemistry 61: 943-947.

Takao, T., Kitatani, F., Watanabe, N., Yaki, A., and Sakata, K. 1994. A simple screening method for antioxidants and isolation of several antioxidants produced by marine bacteria from fish and shellfish. Biosci. Biotech. Biochem. 58: 1780-1783.

Takahashi, M., Fuchino, H., Sekita, S., Satake, M., and Kiuchi, F. 2006. *In vitro* leishmanicidal constituents of *Millettia pendula*. Chem. Pharm. Bull. 54: 915-917.

Tanaka, T., Ito, T., Ido, Y., Son, T.-K., Nakaya, K., Iinuma, M., Ohyama, M., and Chelladurai, V. 2000. Stilbenoids in the stem bark of *Hopea parviflora*. Phytochemistry 53: 1015-1019.

Tchinda, A. T., Khan, S. N., Fuendjiep, V., Ngandeu, F., Ngane, A. N., and Choudhary, M. I. 2007. α-Glucosidase inhibitors from *Millettia conraui*. Chem. Pharm. Bull. 55: 1402-0403.

Valko, M., Leibfritz, D., Moncol, J., Cronin, M. T. D., Mazur, M., and Telser. 2007. Free radicals and antioxidants in normal physiological functions and human disease. J. Biochem. Cell. Biol. 36: 44-84.

Wright, J. L. C., Mcinnes, A. G., Shimizu, S., Smith, D. G., and Walter, J. A. 1978. Identification of C-24 alkyl epimers of marine sterols by ^{13}C nuclear magnetic resonance spectroscopy. Can. J. Chem. 56: 1898-1903.

Yankep, E., Fomum, Z. T., and Dagne, E. 1997. An *O*-Geranylated isoflavone from *Millettia griffoniana*. Phytochemistry 46: 591-593.

Yankep, E., Fomum, Z. T., Bisrat, D., Dagne, E., Hellwig, V., and Steglich, W. 1998. *O*-Geranylated isoflavones and a 3-phenylcoumarin from *Milletiia griffoniana*. Phytochemistry 49: 2521-2523.

Yankep, E., Mbafor, J. T., Fomum, Z. T., Steinbeck, C., Messanga, B. B., Nyasse, B., Budzikiewicz, H., Lenz, C., and Schmickler, H. 2001. Further isoflavonoid metabolites from *Millettia griffoniana* (Bail). Phytochemistry 56: 363-368.

Yankep, E., Njamen, D., Fotsing, M. T., Fomum, Z. T., Mbanya, J. C., Giner, R. M., Recio, M. C., Manez, S., and Rios, J. L. 2003. Griffonianone D, an isoflavone with anti-inflammatory activity from root bark of *Millettia griffoniana*. J. Nat. Prod. 66: 1288-1290.

Yenesew, A., Derese, S., Midiwo, J. O., Oketch-Rabah, H. A., Lisgarten, J., Palmer, R., Heydenreich, M., Peter, M. G., Akala, H., Wangui, J., Liyala, P., and Waters, N. C. 2003. Anti-plasmodial activities and X-ray crystal structures of rotenoids from *Millettia usaramensis* subspecies *usaramensis*. Phytochemistry 64: 773-779.

Yenesew, A., Midiwo, J. O., and Waterman, P. G. 1996. Four isoflavones from seed pods of *Millettia dura*. Phytochemistry 41: 951-955.

Yenesew, A., Midiwo, J. O., and Waterman, P. G. 1997. 6-Methoxy-calopogonium isoflvone A: a new isoflavone from the seed pods of *Milletia dura*. J. Nat. Prod. 60: 806-807.

Yenesew, A., Midiwo, J. O., and Waterman, P. G. 1998. Rotenoids, isoflavones and chalcones from the stem bark of *Millettia usaramensis* subspecies *usaramensis*. Phytochemistry 47: 295-300.

APPENDIX

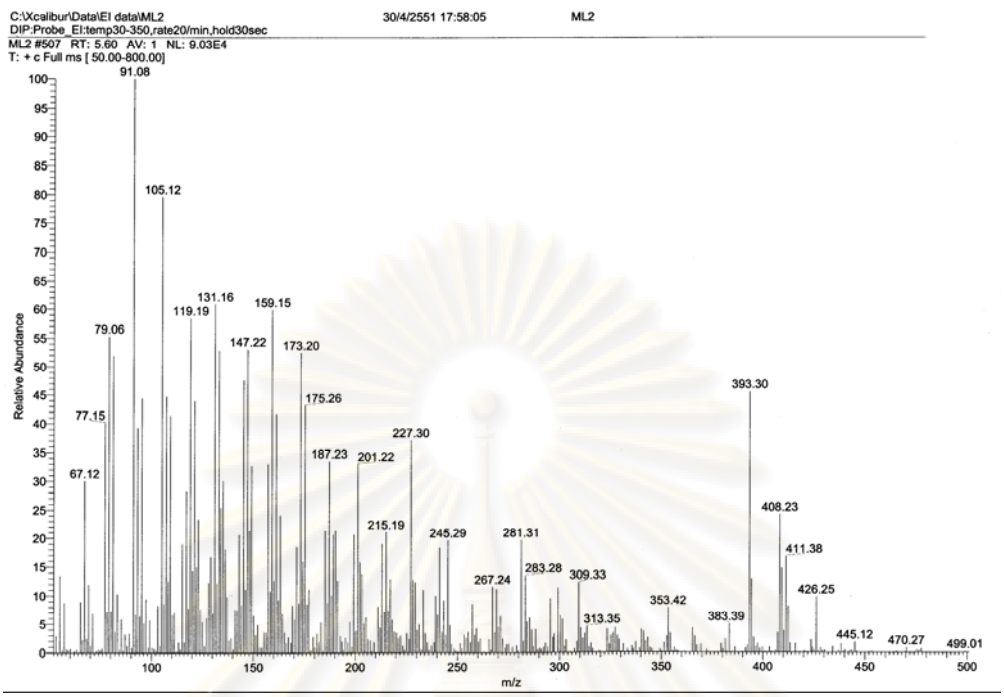


Figure 2 Mass spectrum of compound ML1

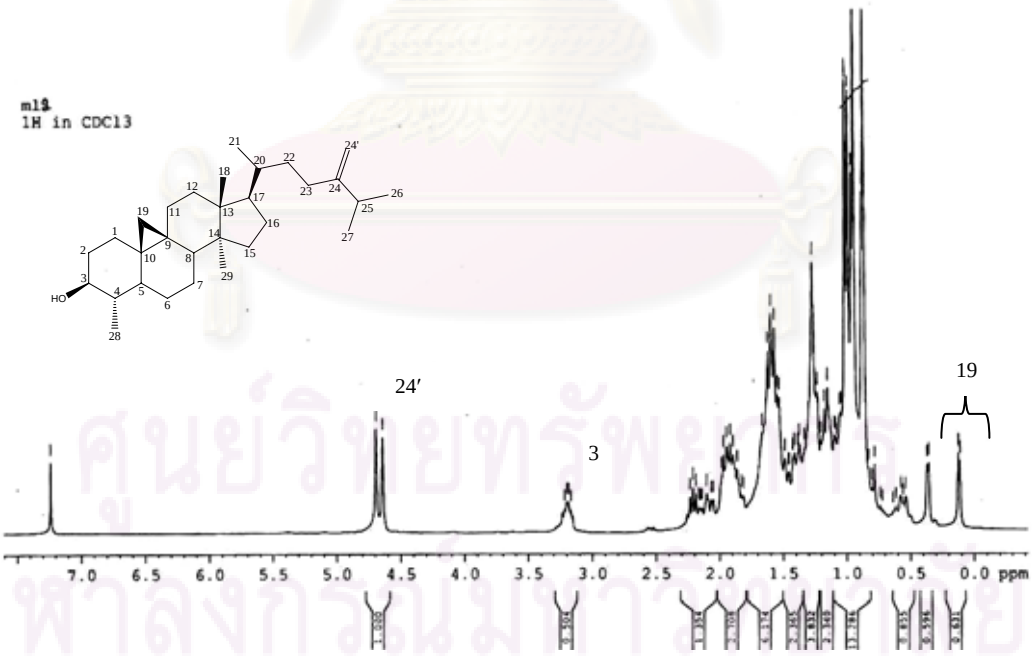


Figure 3 ^{1}H-NMR (300 MHz) Spectrum of compound ML1 ($CDCl_3$)

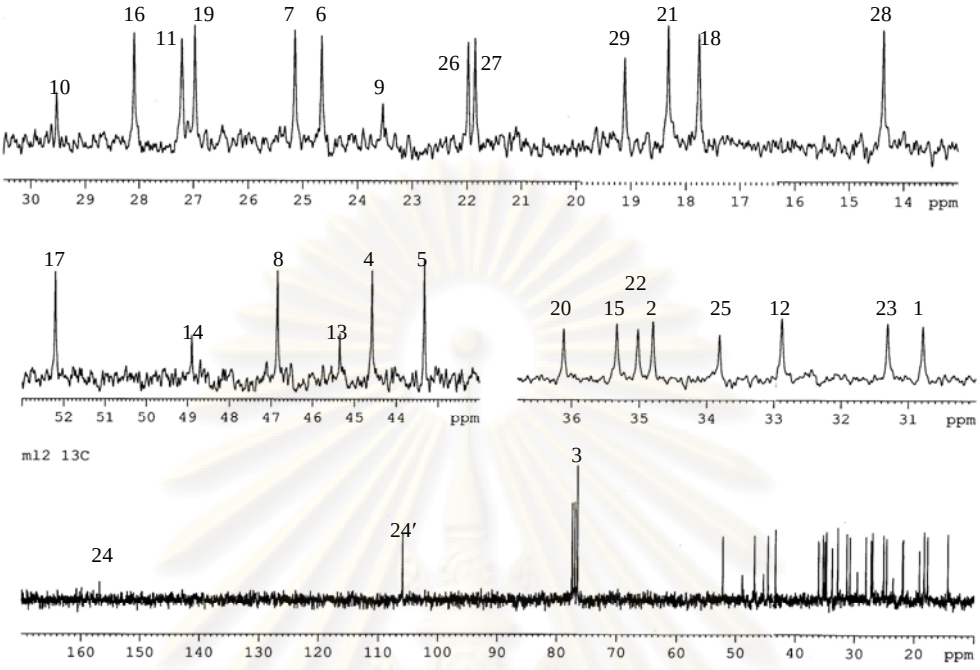


Figure 4 ^{13}C-NMR (75 MHz) Spectrum of compound ML1 ($CDCl_3$)

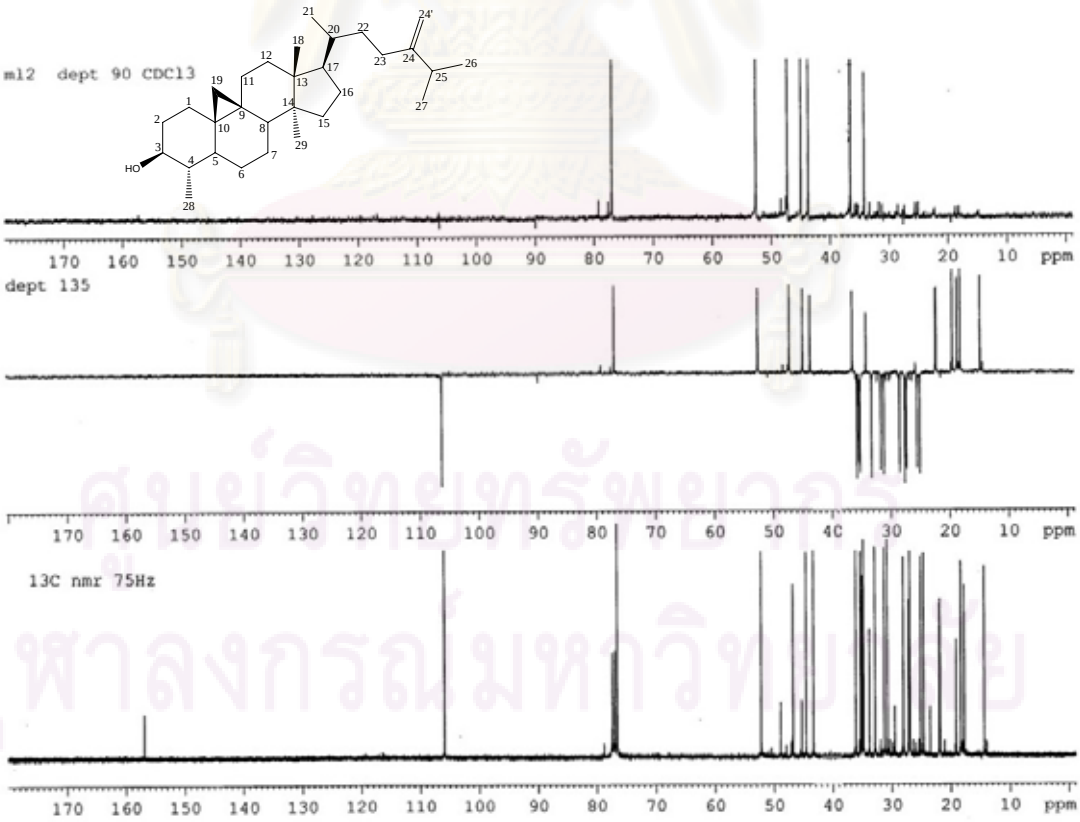


Figure 5 ^{13}C-NMR and DEPT Spectra of compound ML1 ($CDCl_3$)

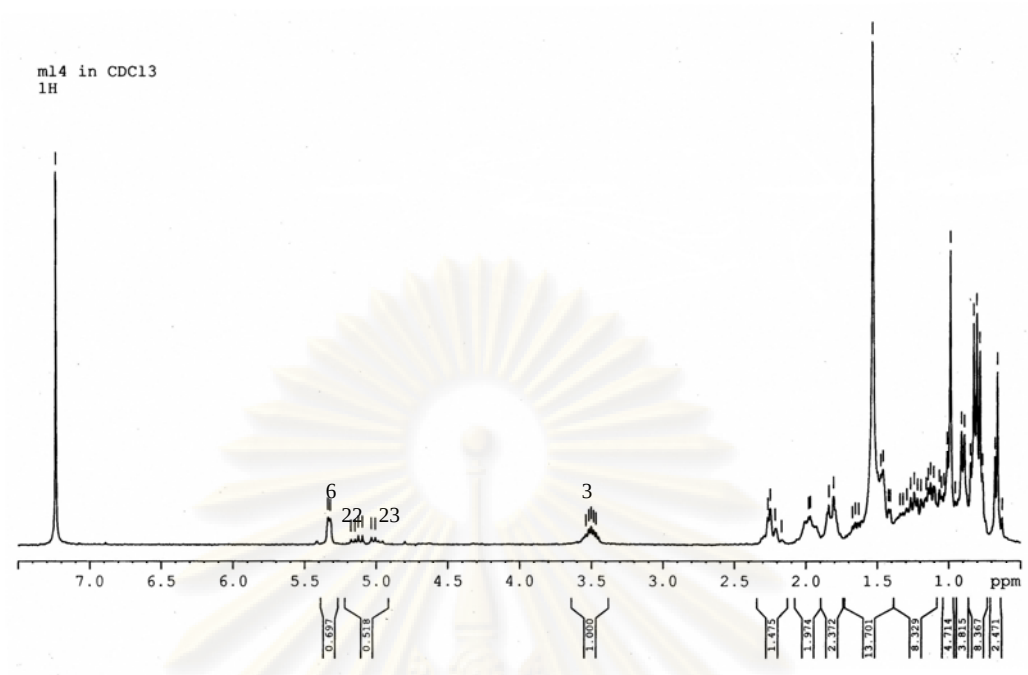


Figure 6 ^{1}H-NMR (300 MHz) Spectrum of compound ML2 ($CDCl_3$)

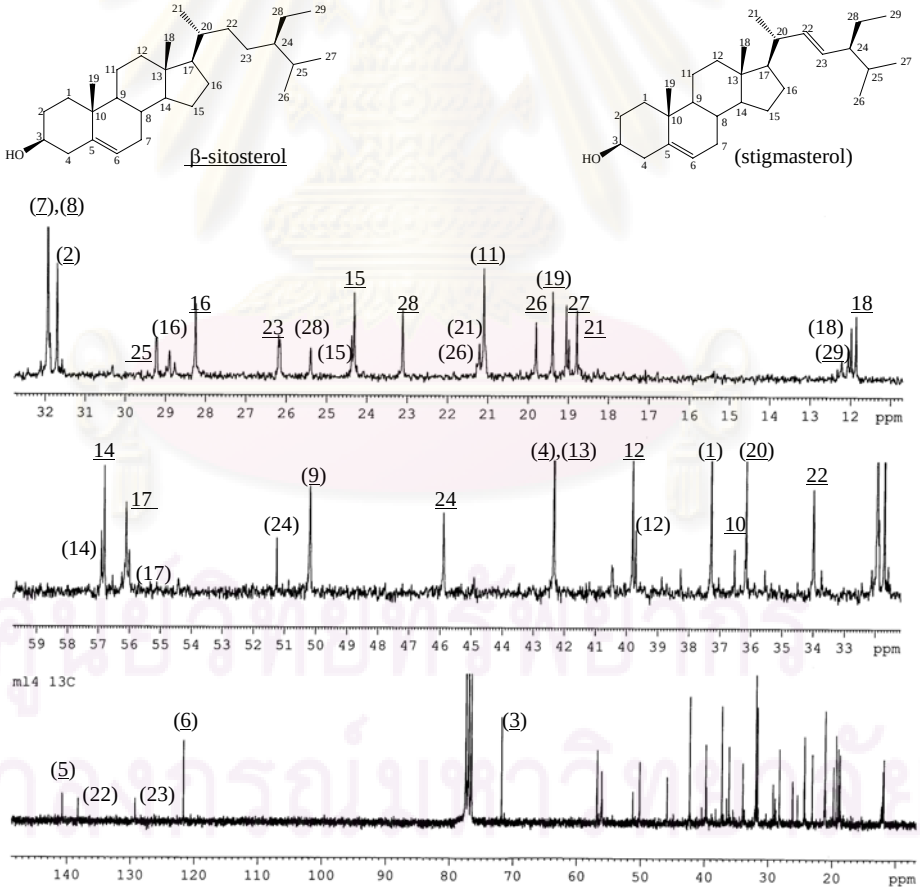


Figure 7 ^{13}C-NMR (75 MHz) Spectrum of compound ML2 ($CDCl_3$)

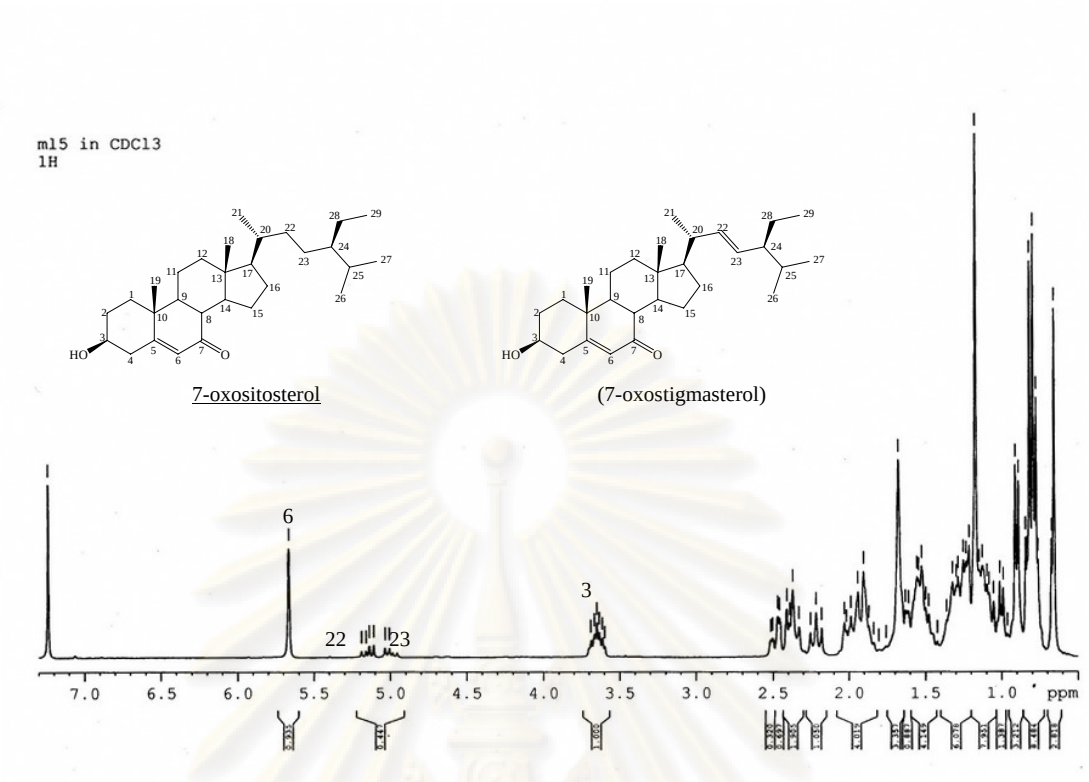


Figure 8 ^{1}H-NMR (300 MHz) Spectrum of compound ML3 ($CDCl_3$)

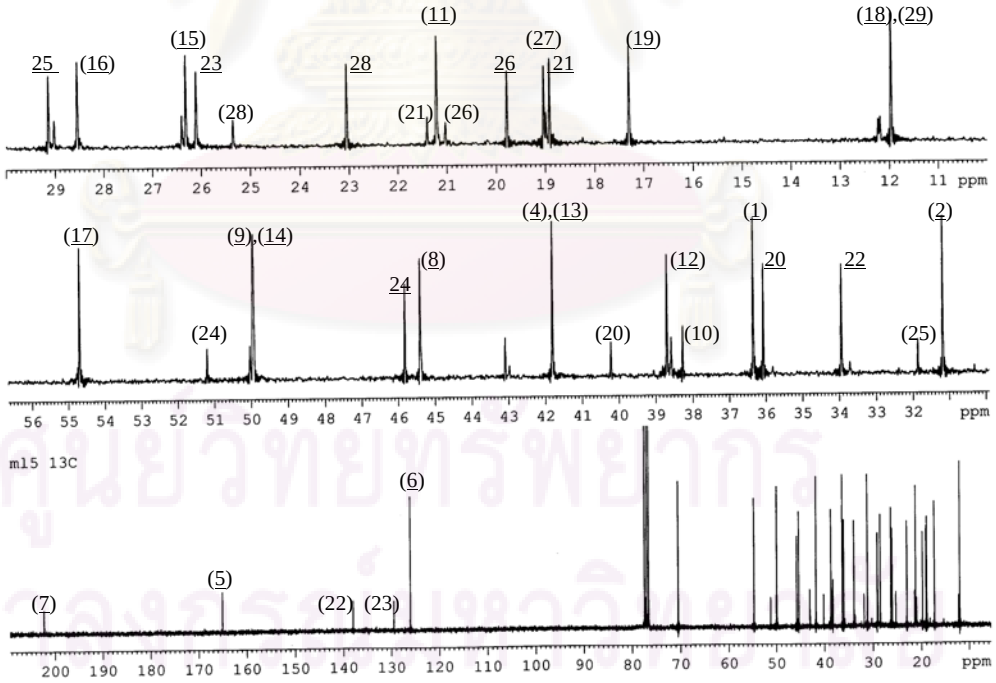


Figure 9 ^{13}C-NMR (75 MHz) Spectrum of compound ML3 ($CDCl_3$)

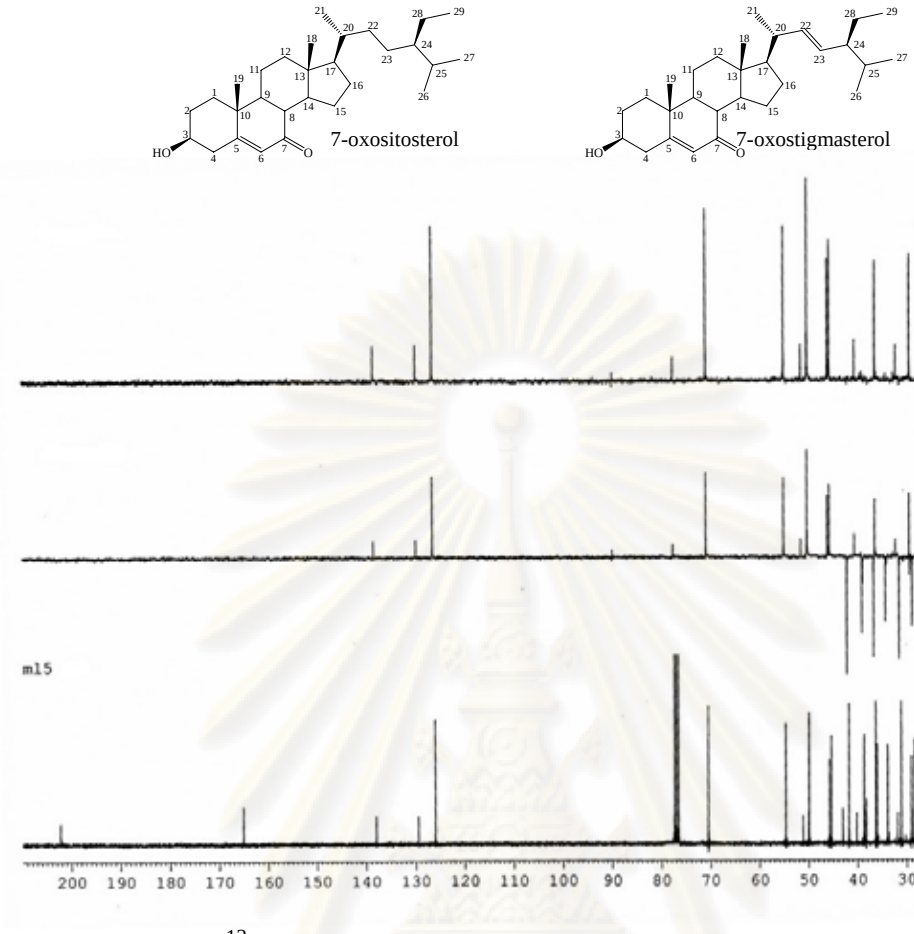


Figure 10 ^{13}C-NMR and DEPT Spectra of compound ML3 ($CDCl_3$)

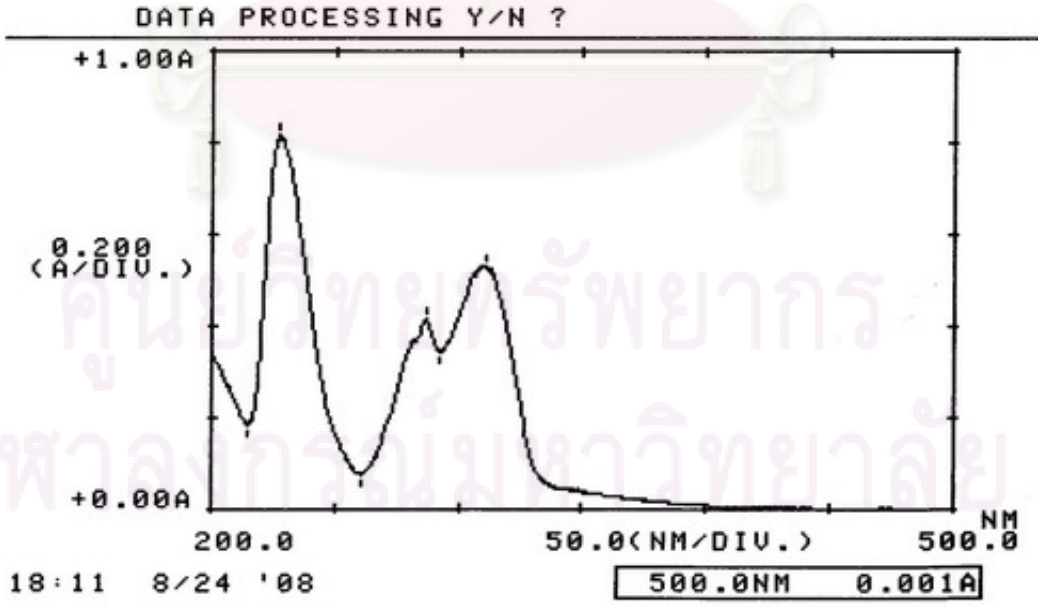


Figure 11 UV spectrum of compound ML4

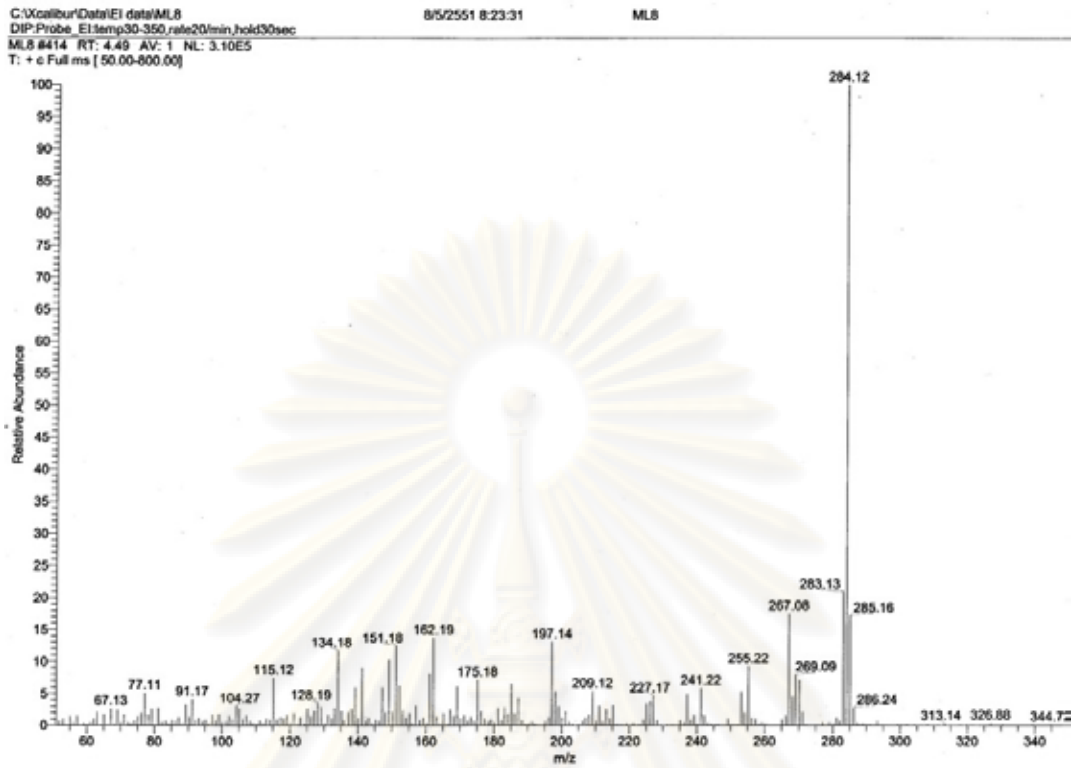


Figure 12 Mass spectrum of compound ML4

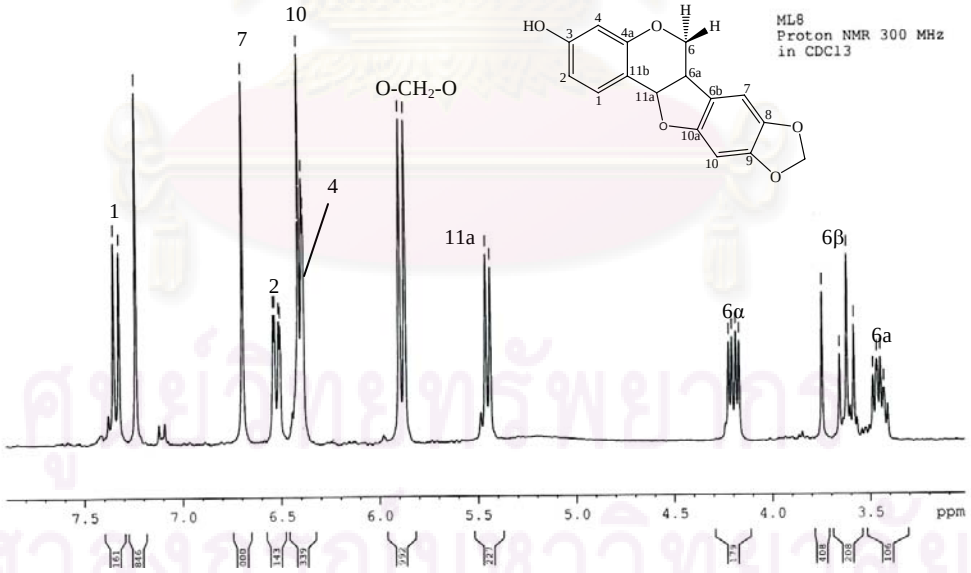


Figure 13 ^{1}H-NMR (300 MHz) Spectrum of compound ML4 ($CDCl_3$)

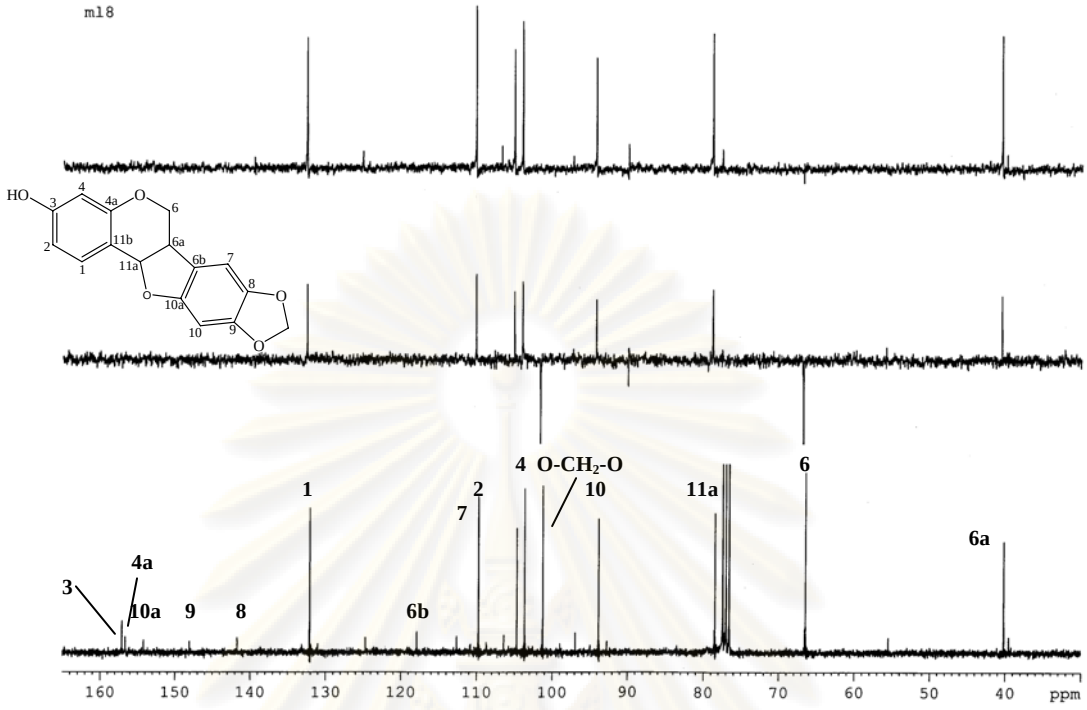


Figure 14 ^{13}C-NMR and DEPT Spectra of compound ML4 ($CDCl_3$)

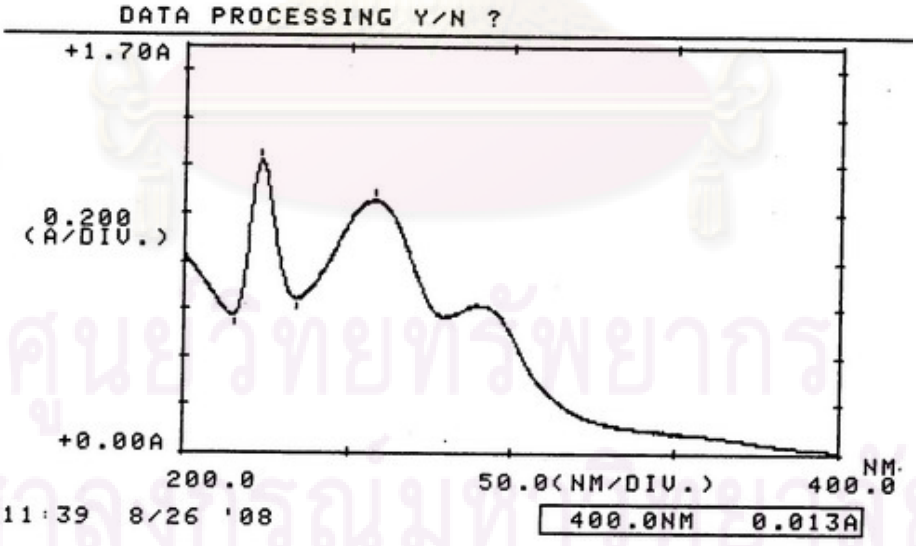


Figure 15 UV spectrum of compound ML5

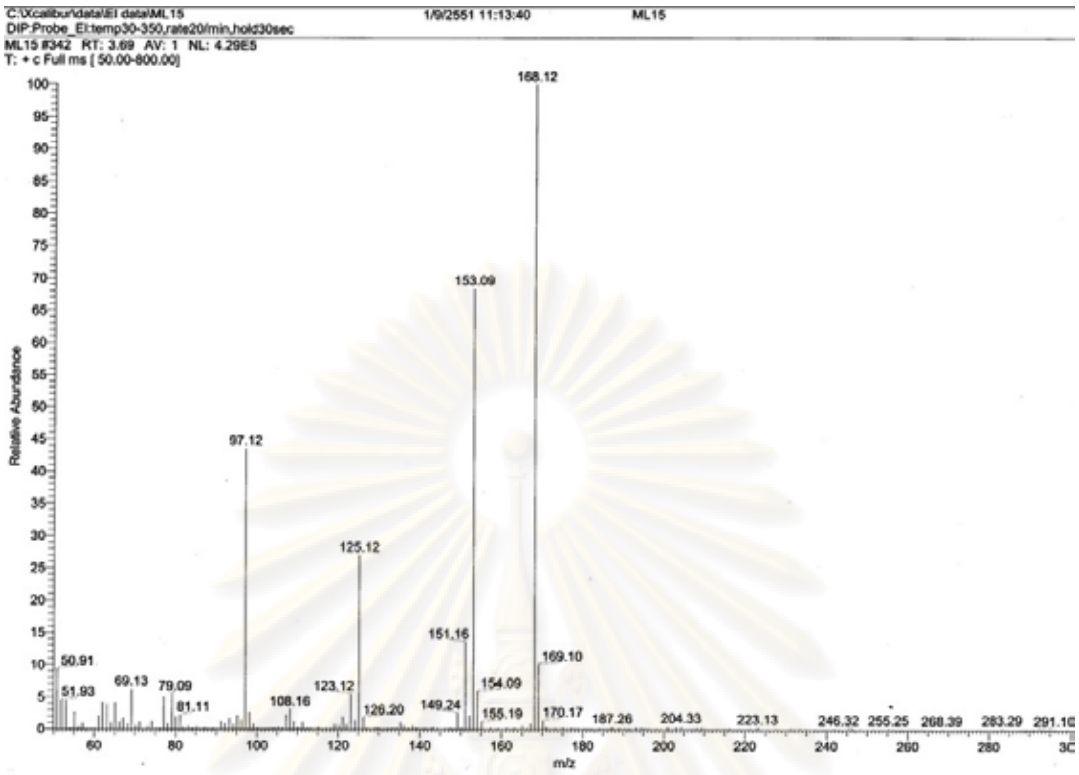


Figure 16 Mass spectrum of compound ML5

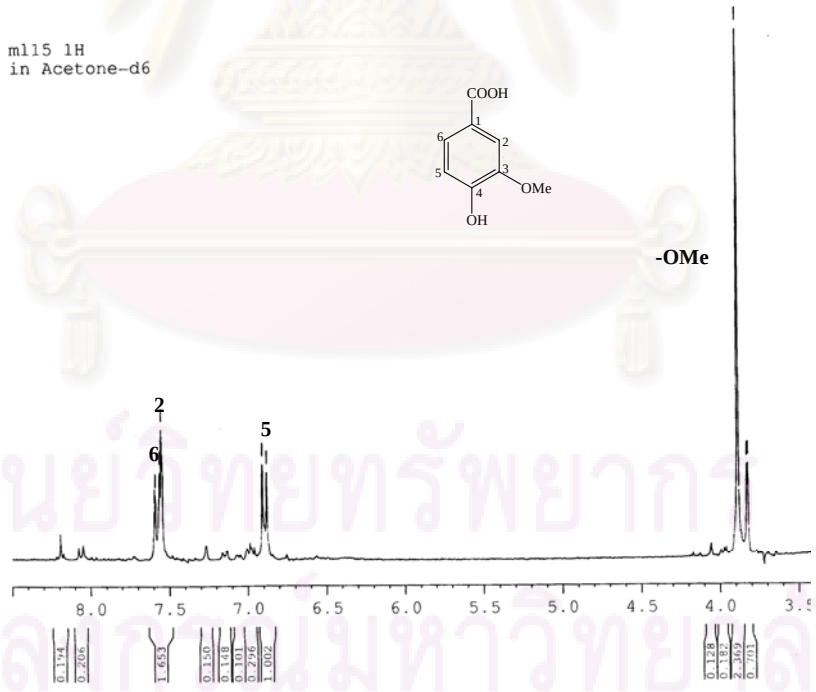


Figure 17 ^{1}H-NMR (300 MHz) Spectrum of compound ML5 (acetone-d_6)

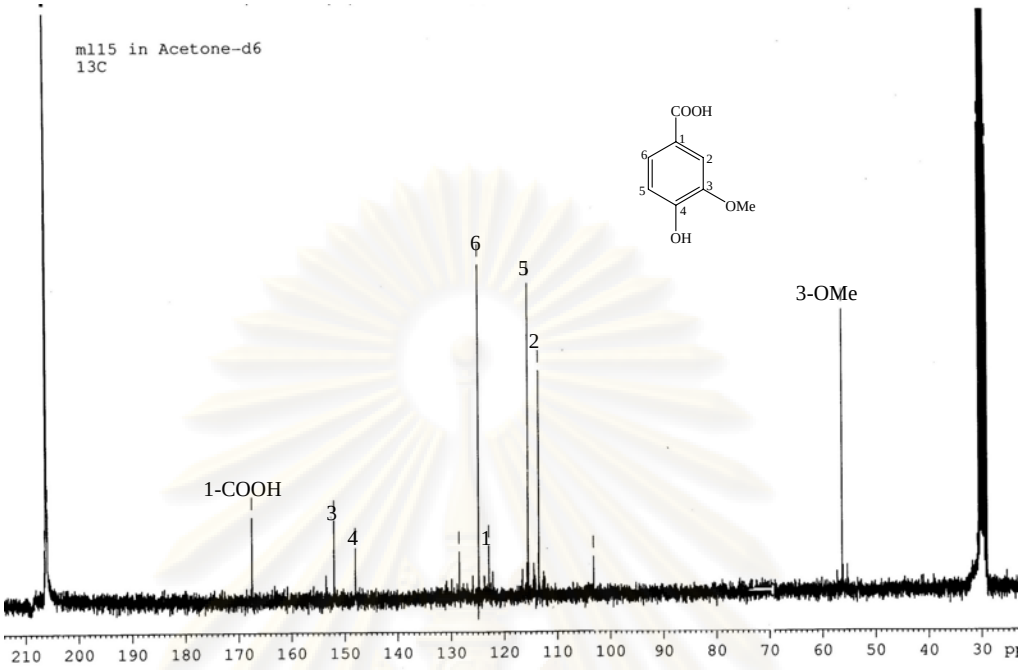


Figure 18 ^{13}C-NMR (75 MHz) Spectrum of compound ML5 (acetone-d_6)

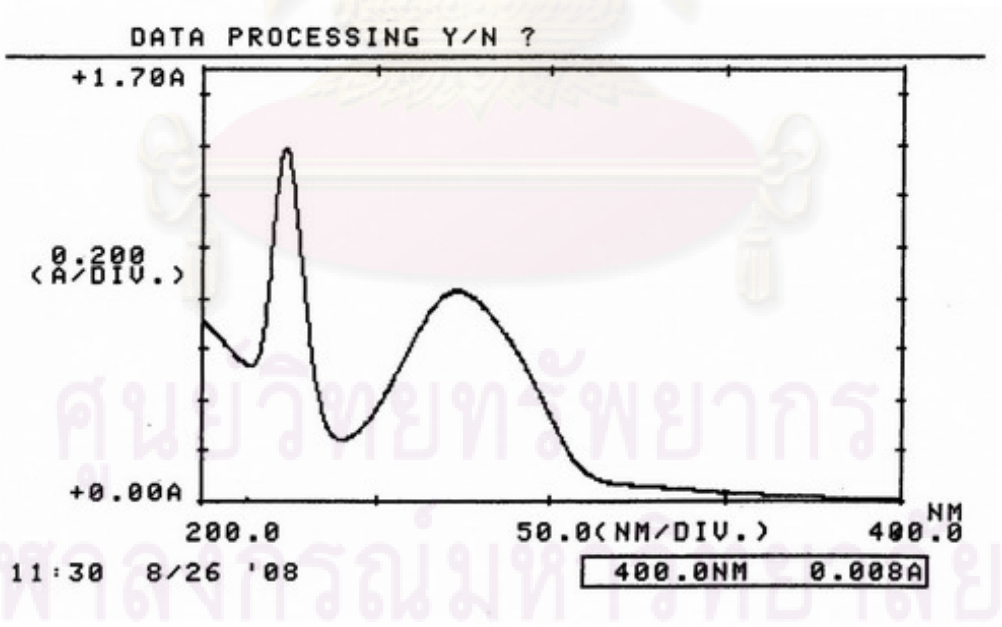


Figure 19 UV spectrum of compound ML6

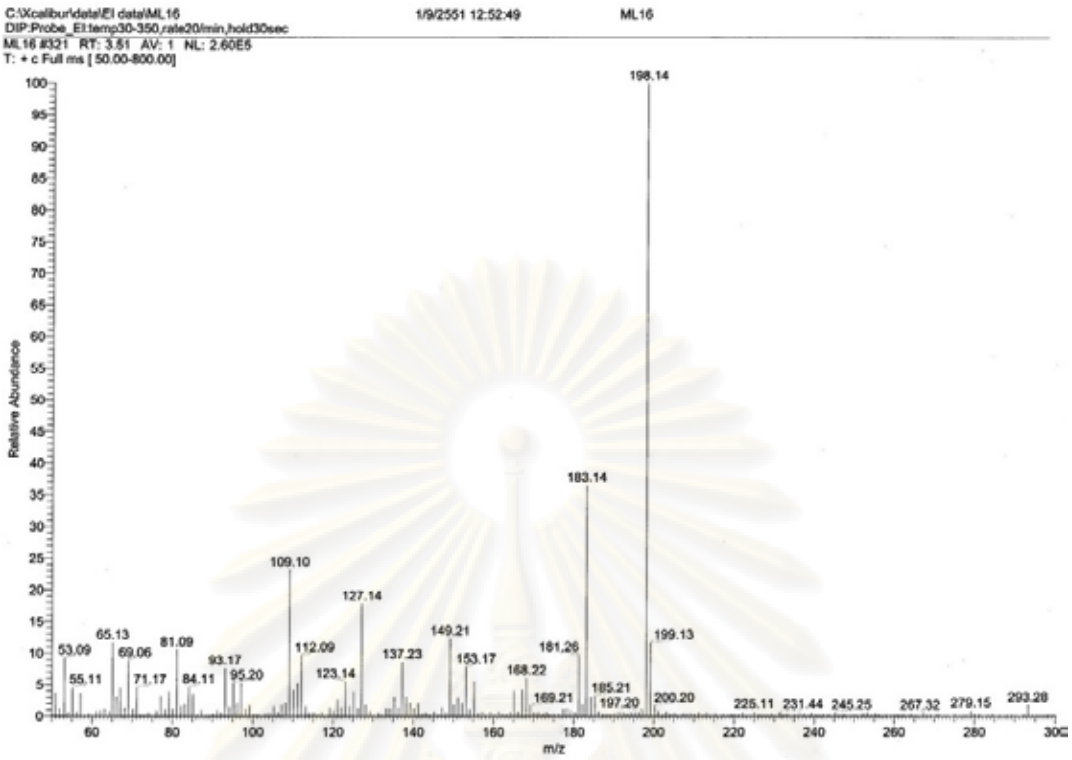


Figure 20 Mass spectrum of compound ML6

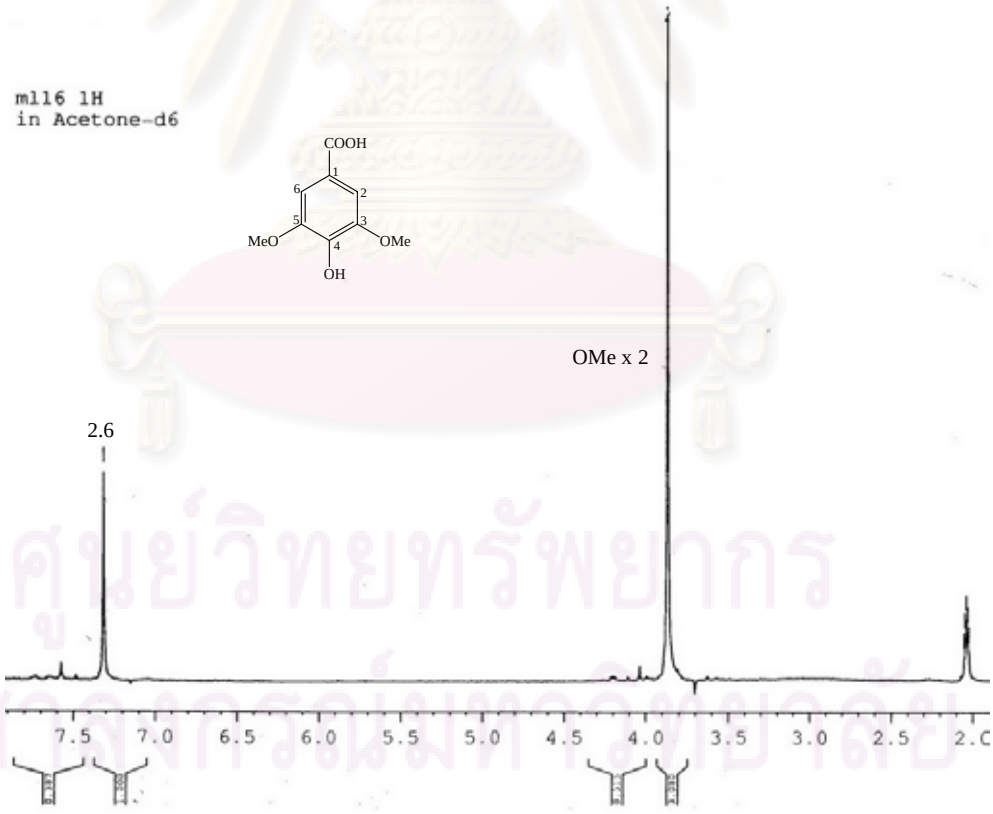


Figure 21 ^{1}H-NMR (300 MHz) Spectrum of compound ML6 (acetone-d_6)

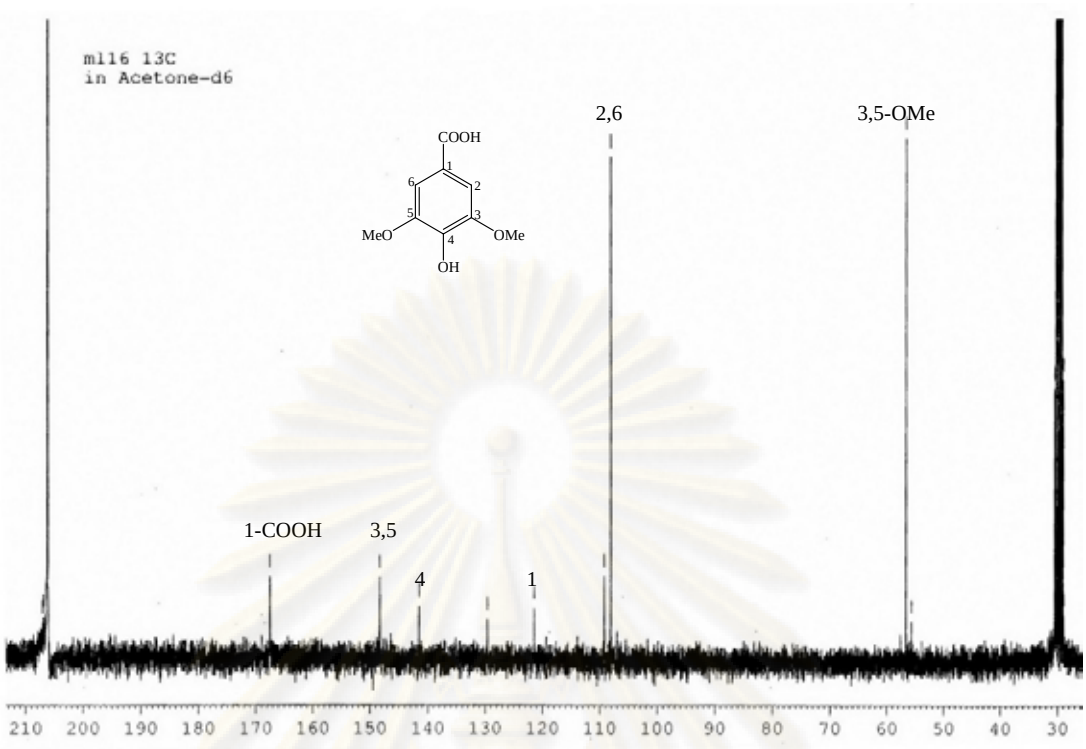


Figure 22 ^{13}C-NMR (75 MHz) Spectrum of compound ML6 (acetone-d_6)

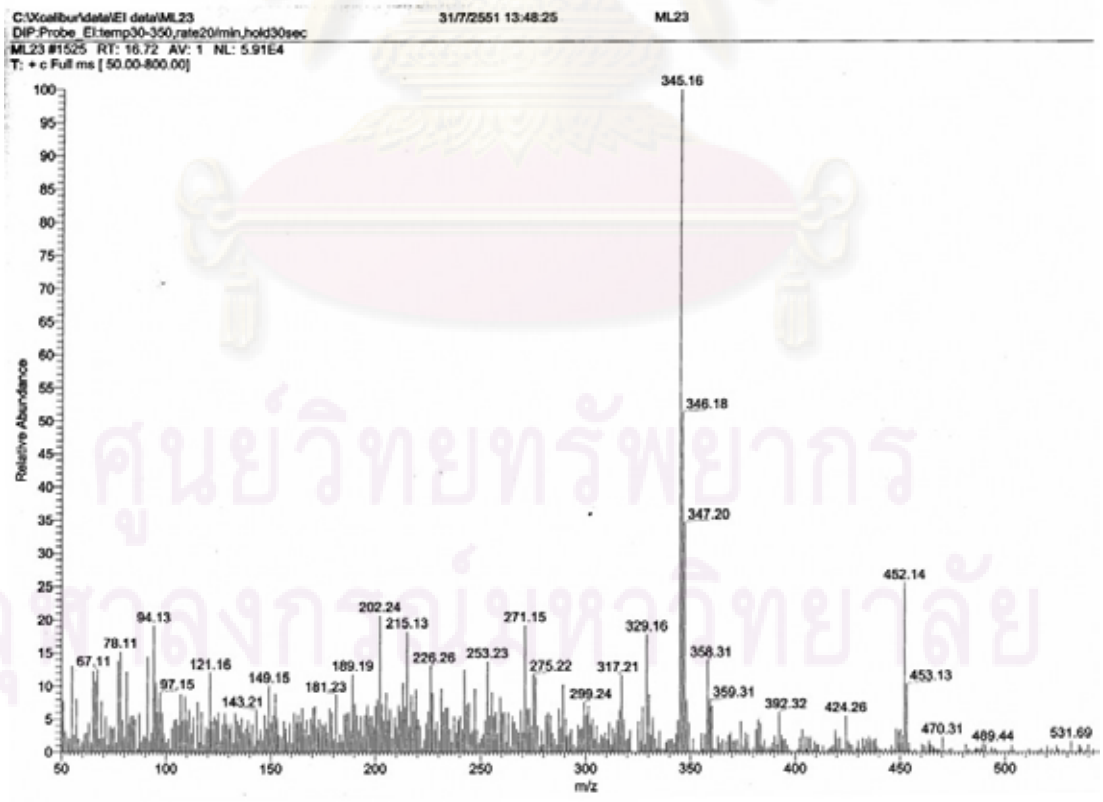


Figure 23 Mass spectrum of compound ML7

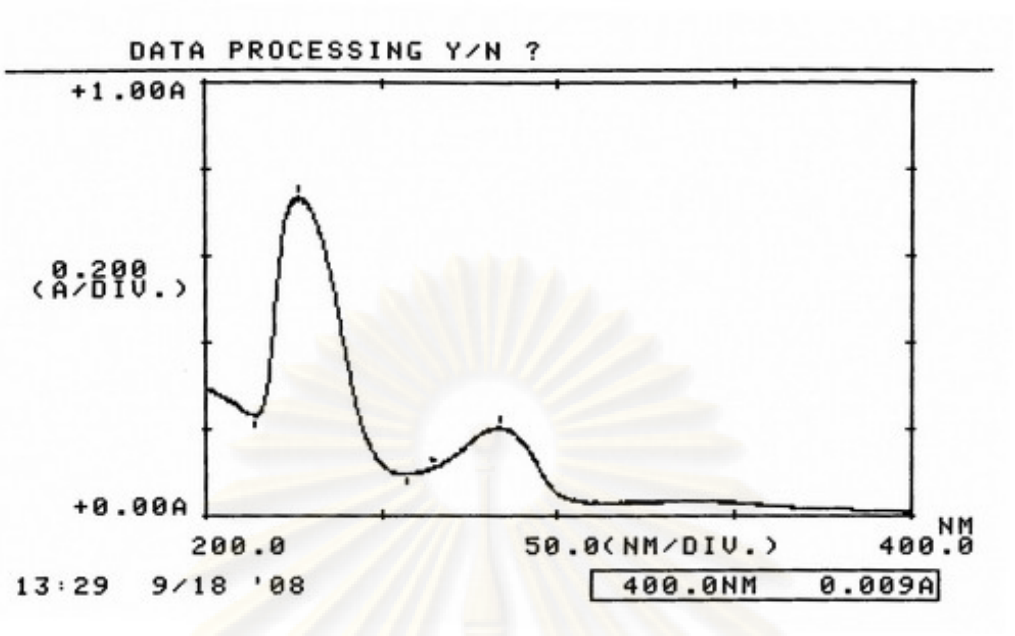


Figure 24 UV spectrum of compound ML7

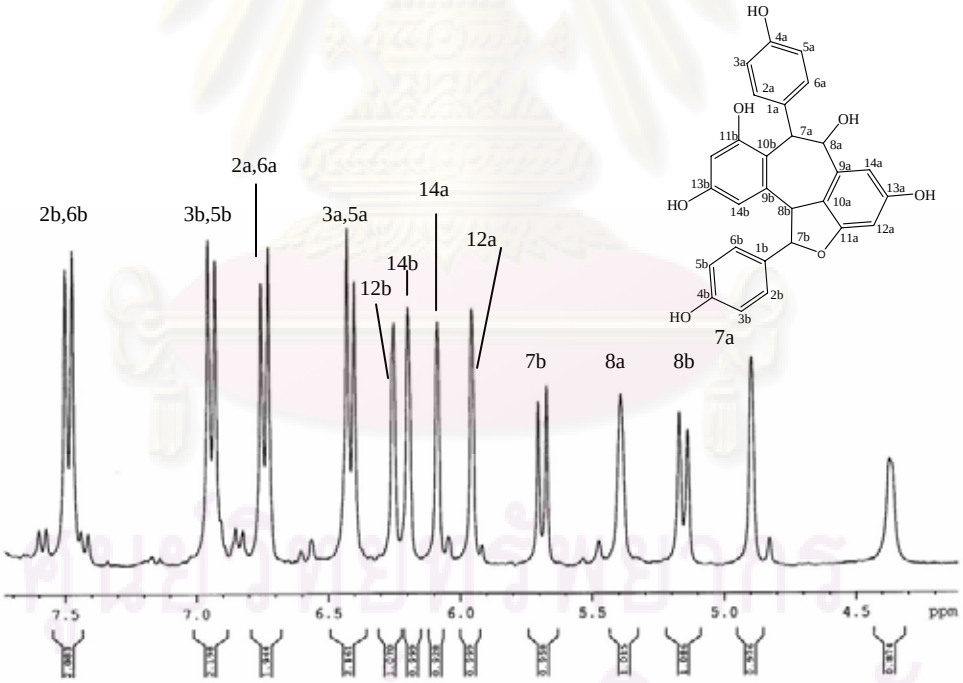


Figure 25 ^{1}H-NMR (300 MHz) Spectrum of compound ML7 (acetone-d_6)

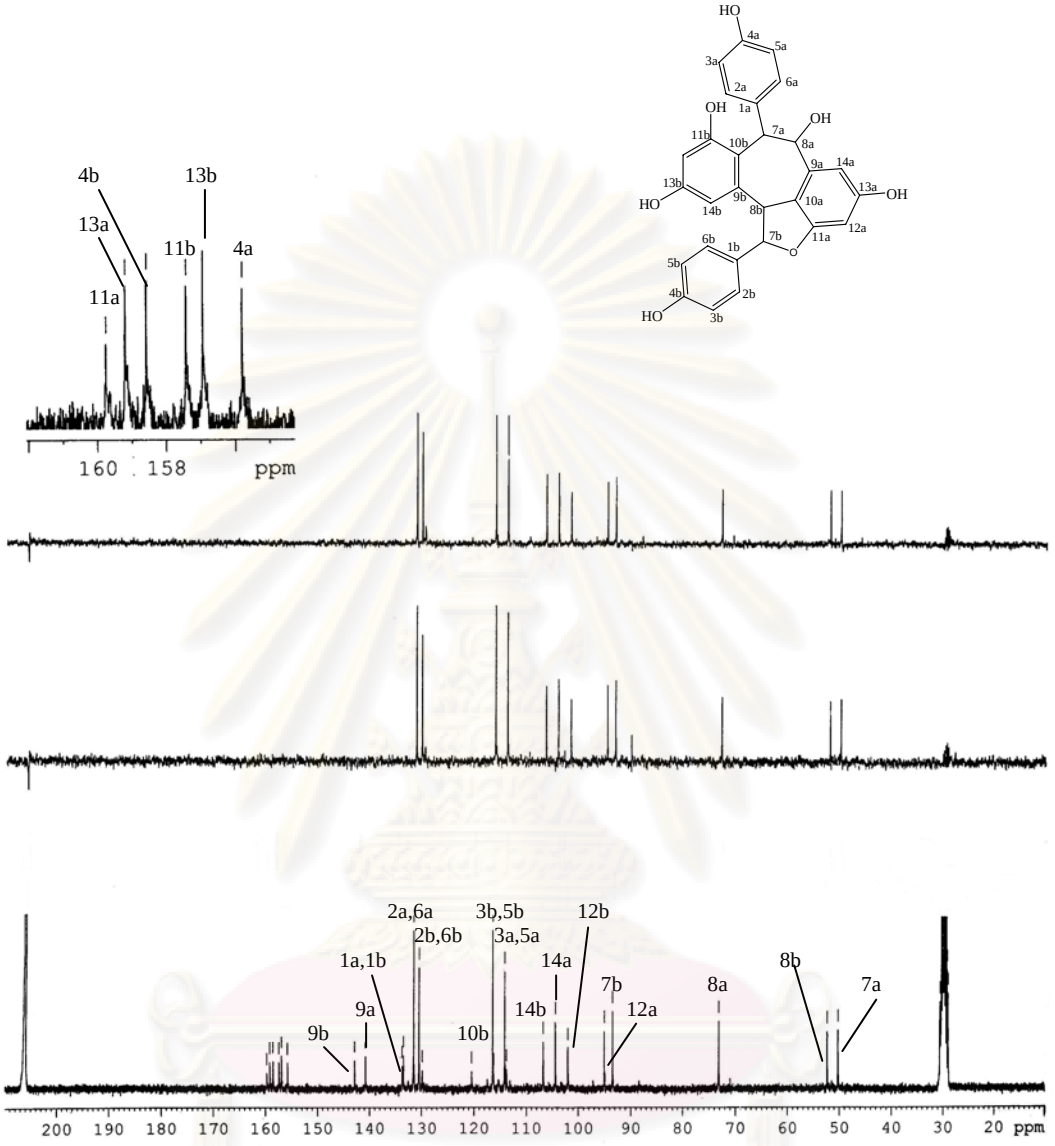


Figure 26 ^{13}C-NMR (75 MHz) and DEPT Spectra of compound ML7 (acetone-d_6)

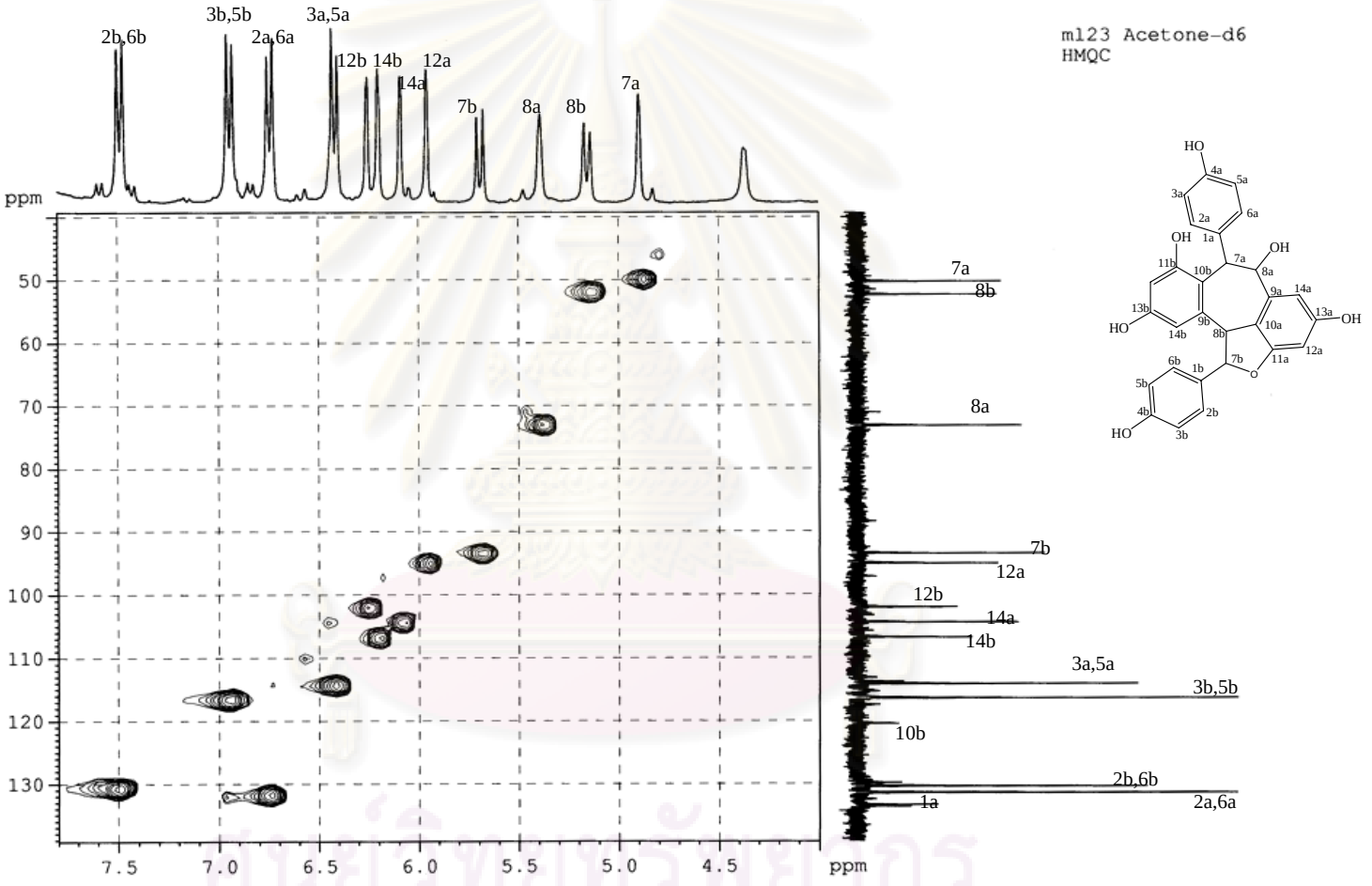


Figure 27 HMQC Spectrum of compound ML7 (acetone-d_6)

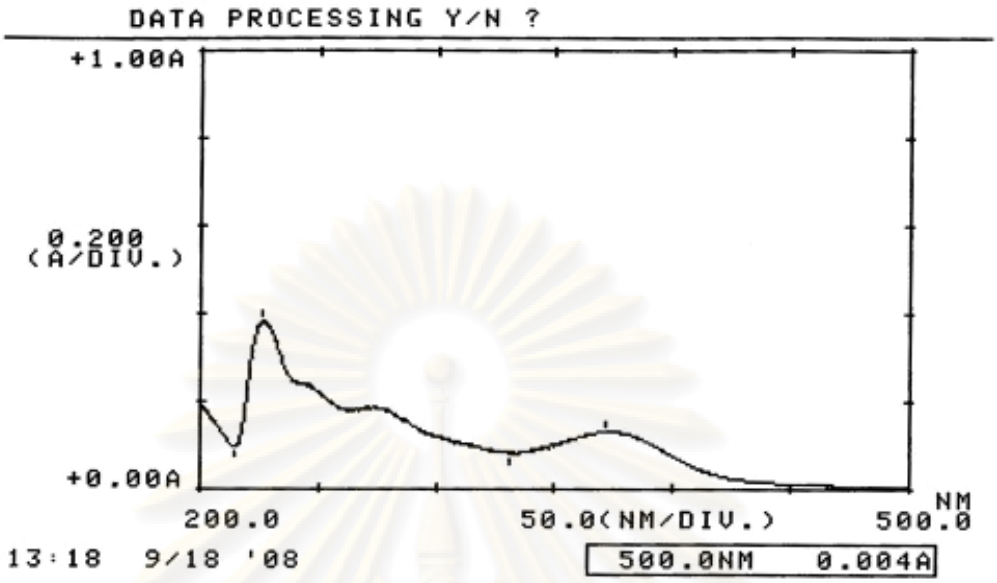


Figure 28 UV spectrum of compound ML8

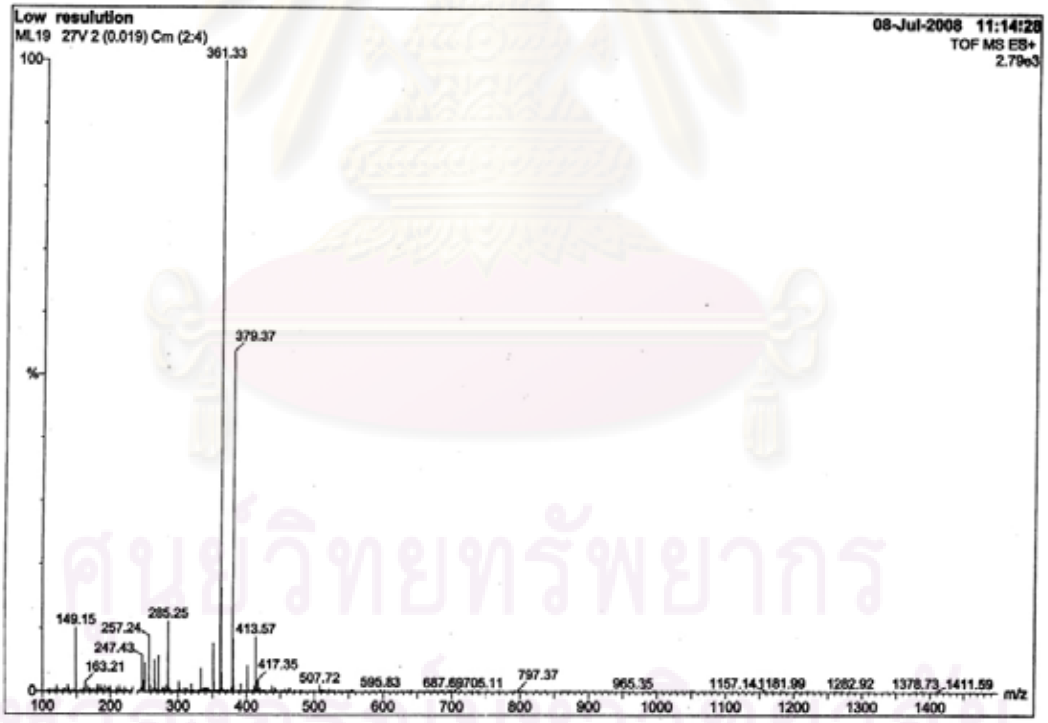


Figure 29 Mass spectrum of compound ML8

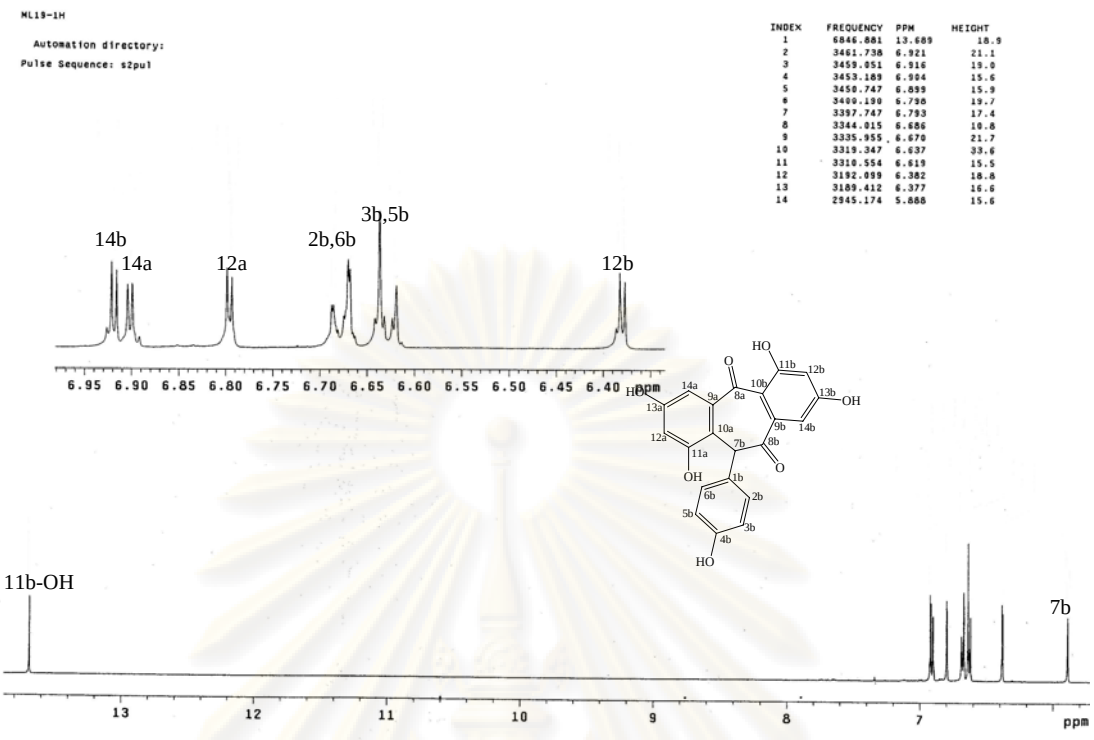


Figure 30 ^{1}H-NMR (500 MHz) Spectrum of compound ML8 (acetone-d_6)

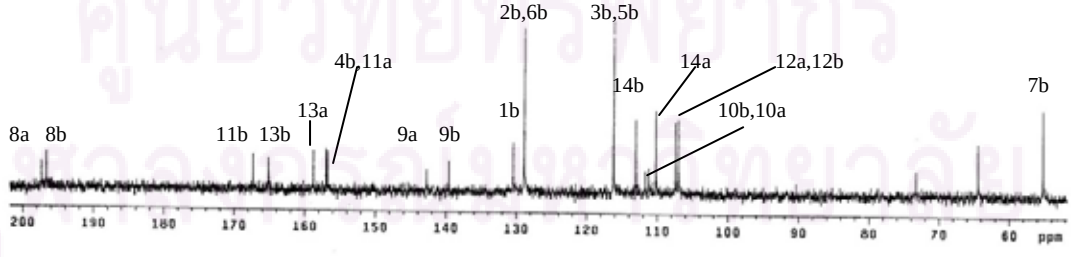


Figure 31 ^{13}C-NMR (125 MHz) Spectrum of compound ML8 (acetone-d_6)

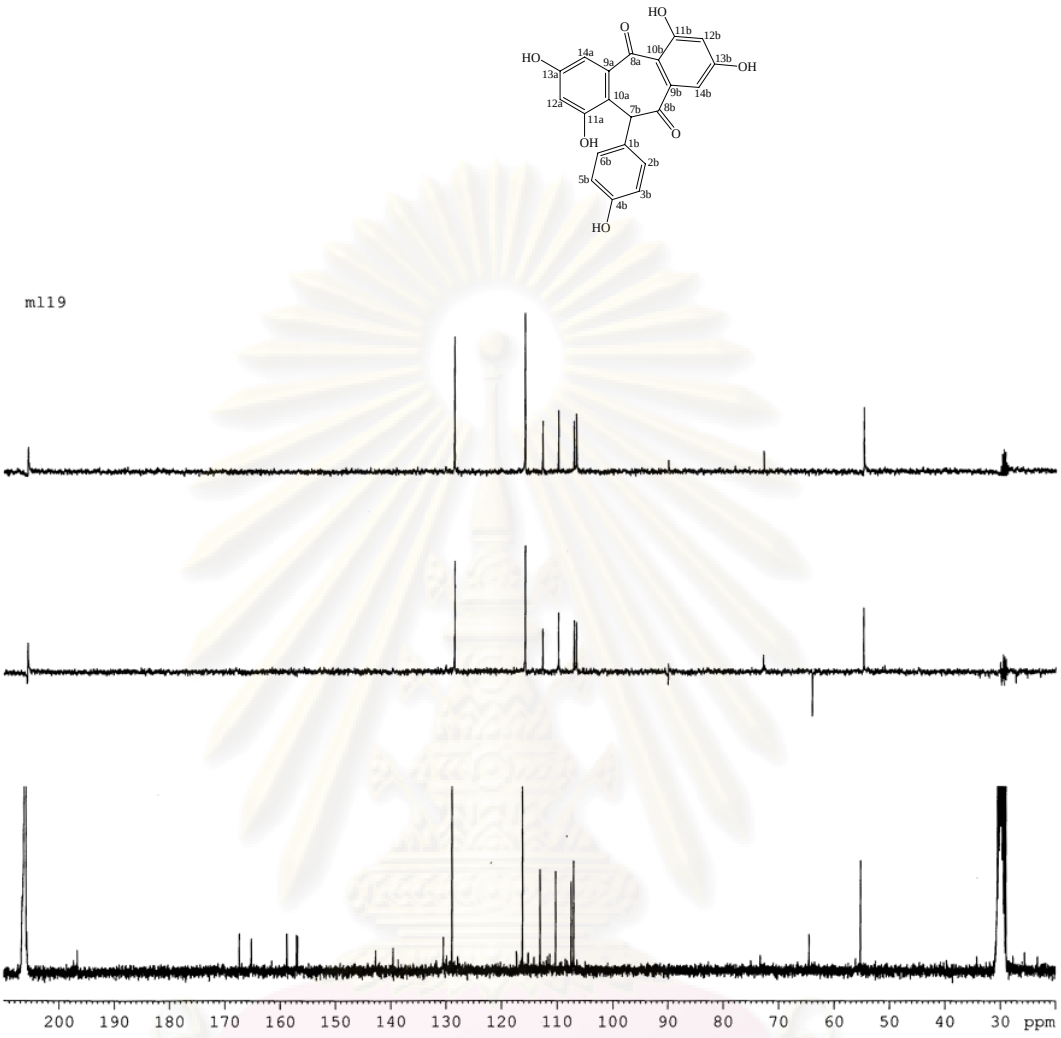


Figure 32 DEPT Spectra of compound ML8 (acetone-d_6)

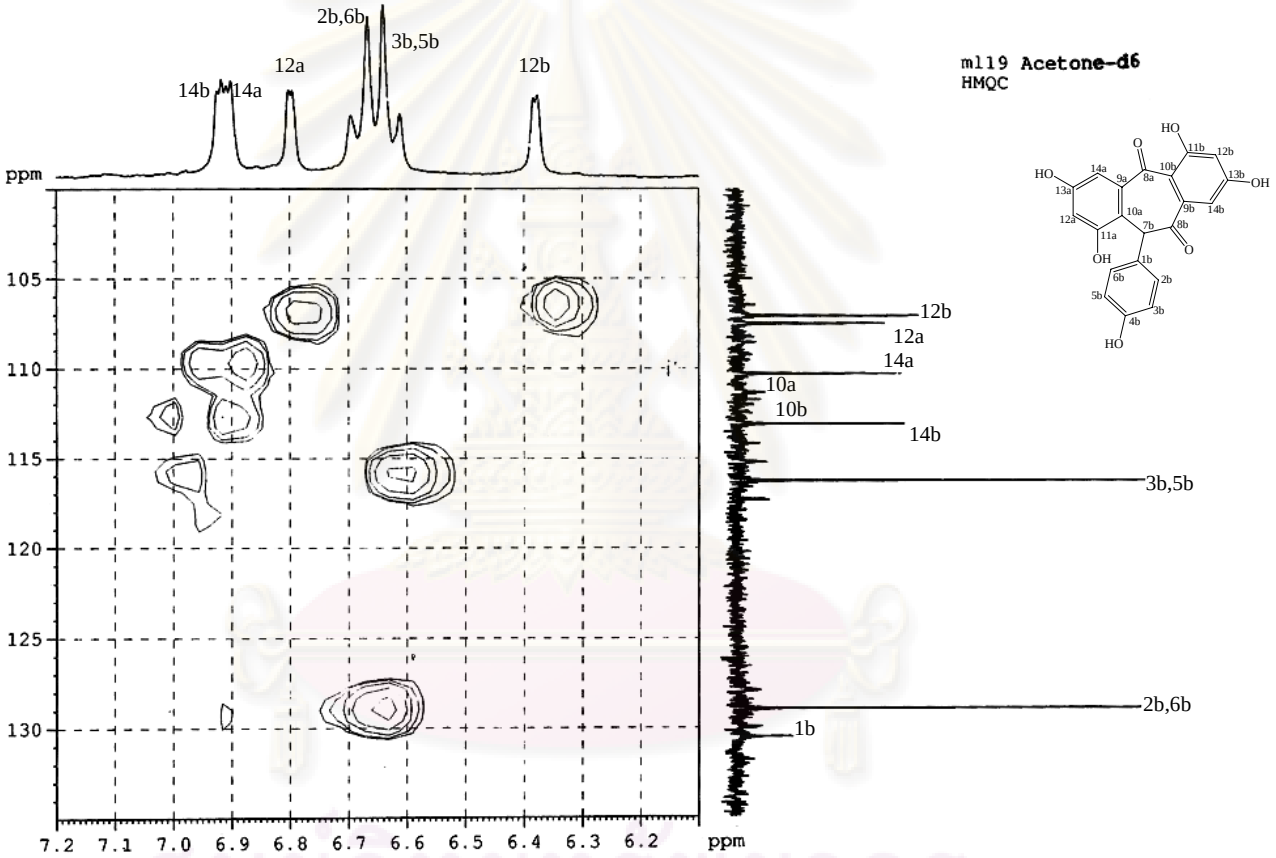


Figure 33 HMQC Spectrum of compound ML8 (acetone-d_6)

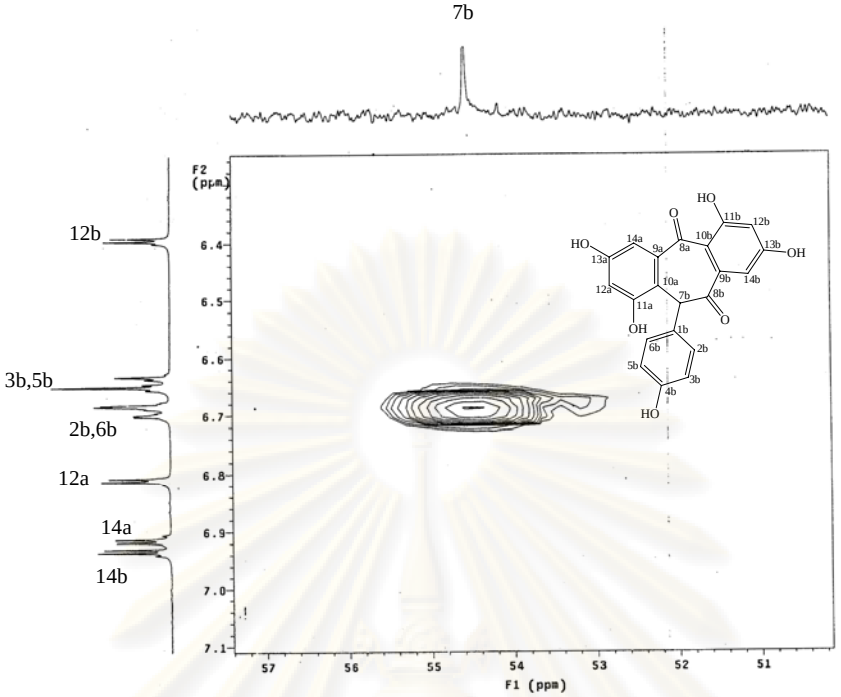


Figure 34 HMBC Spectrum of compound ML8 (acetone-d_6)

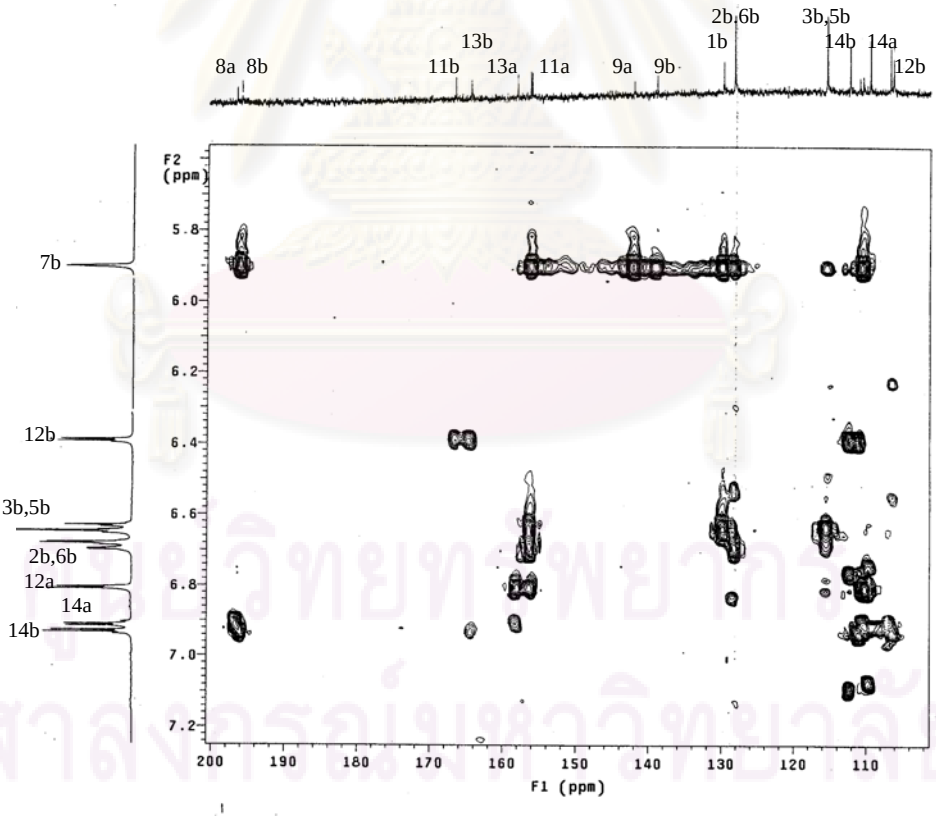


Figure 35 HMBC Spectrum of compound ML8 (acetone-d_6)

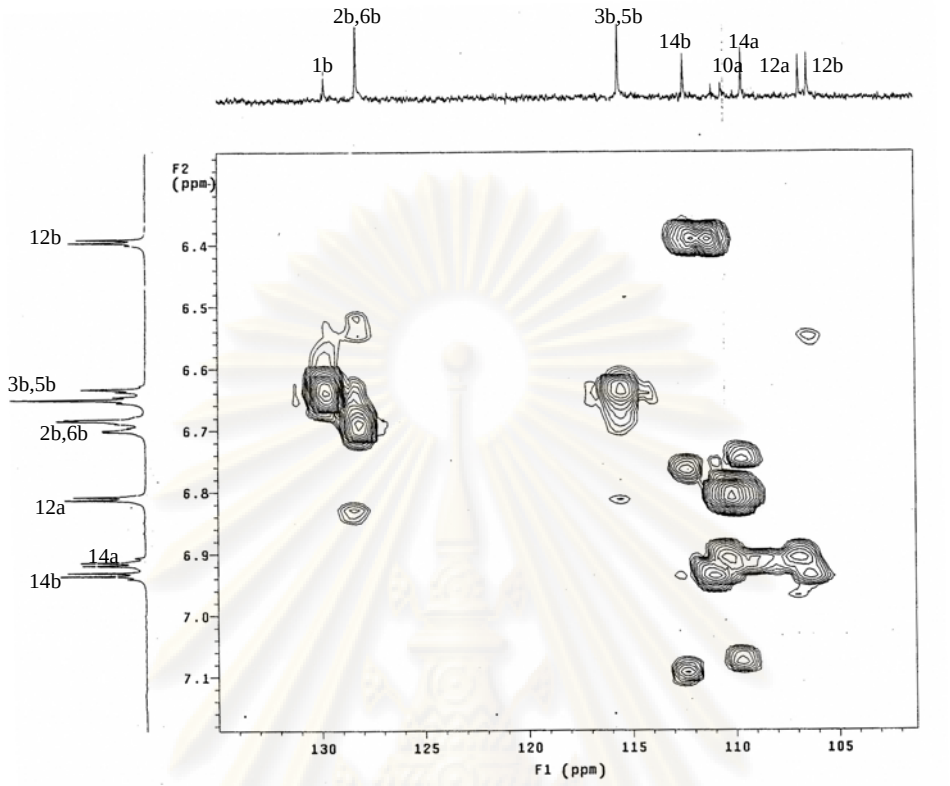


Figure 36 HMBC Spectrum of compound ML8 (acetone-d_6)

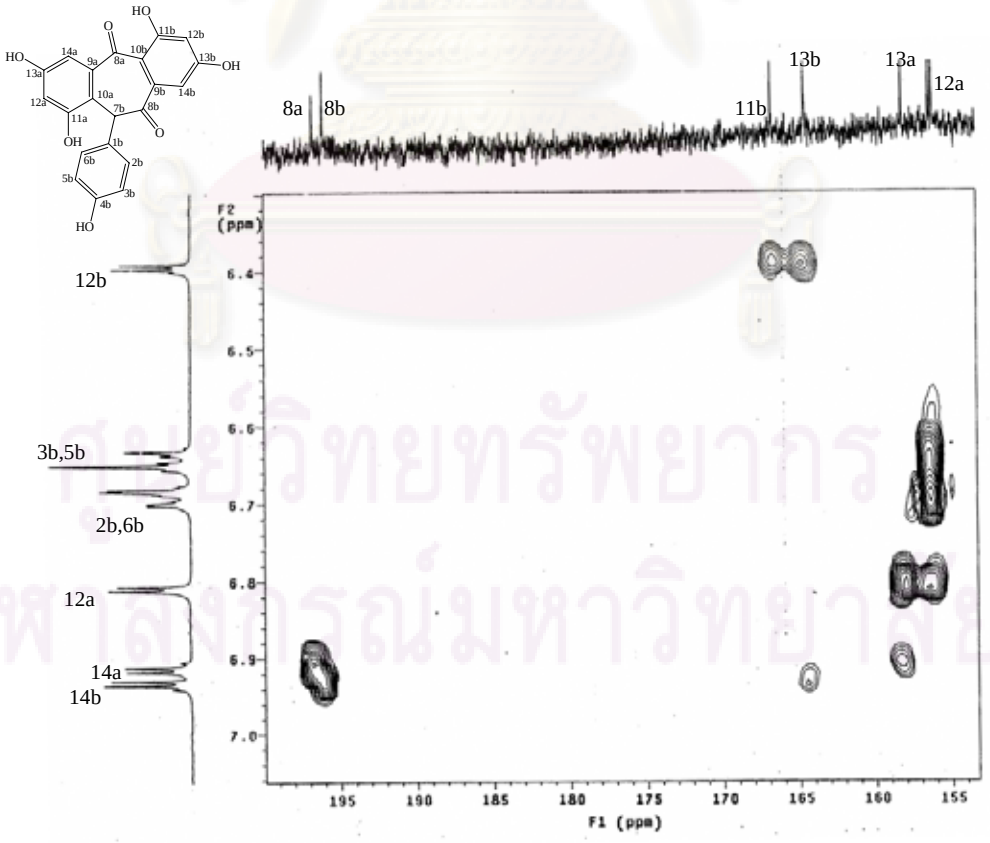


Figure 37 HMBC Spectrum of compound ML8 (acetone-d_6)

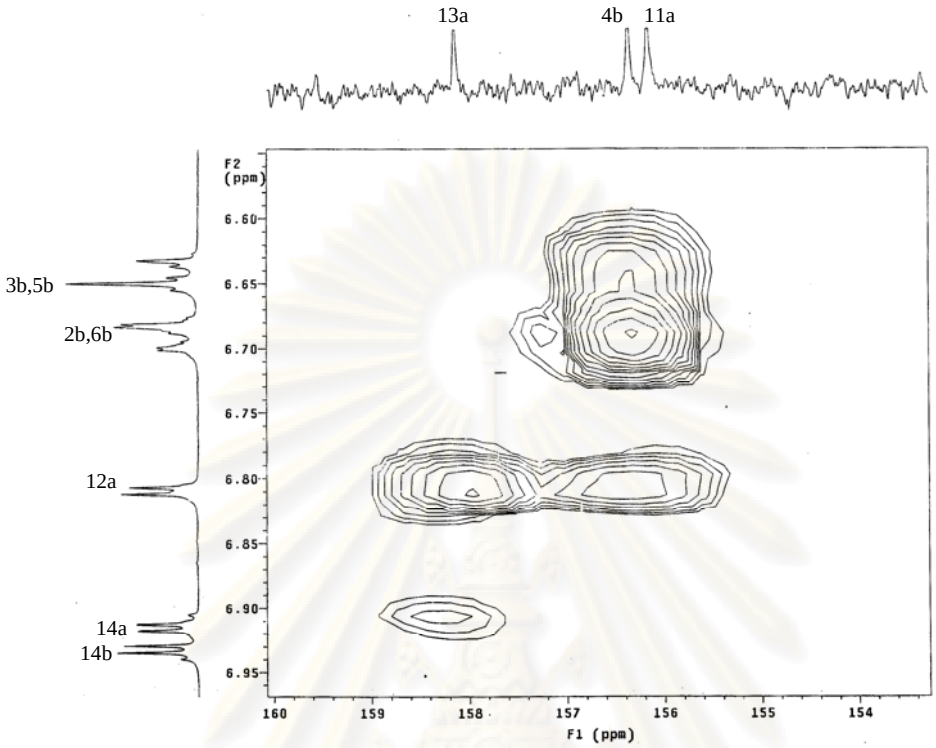


Figure 38 HMBC Spectrum of compound ML8 (acetone-d_6)

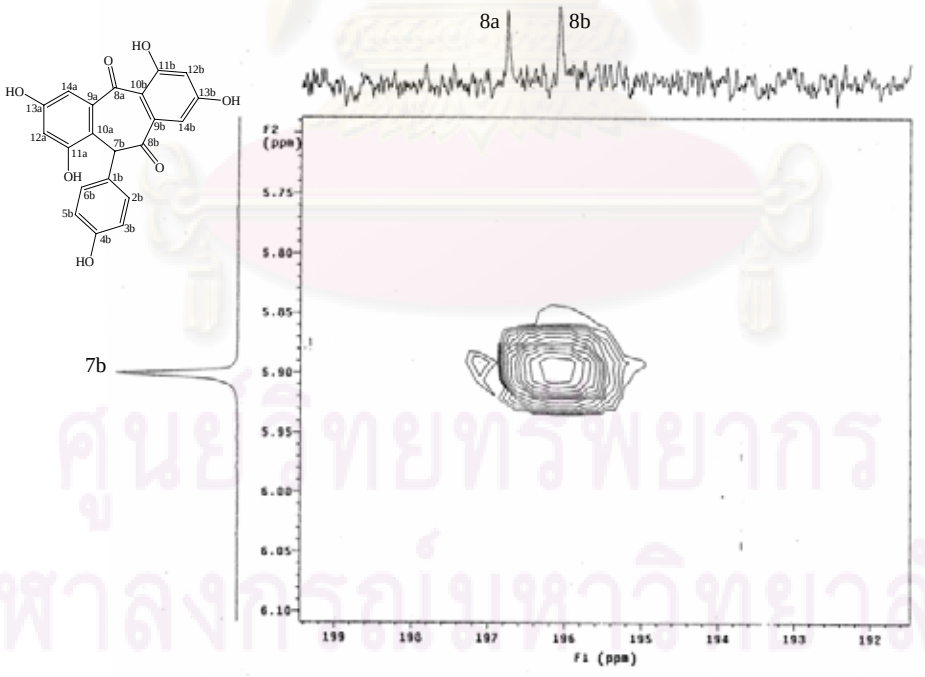


Figure 39 HMBC Spectrum of compound ML8 (acetone-d_6)

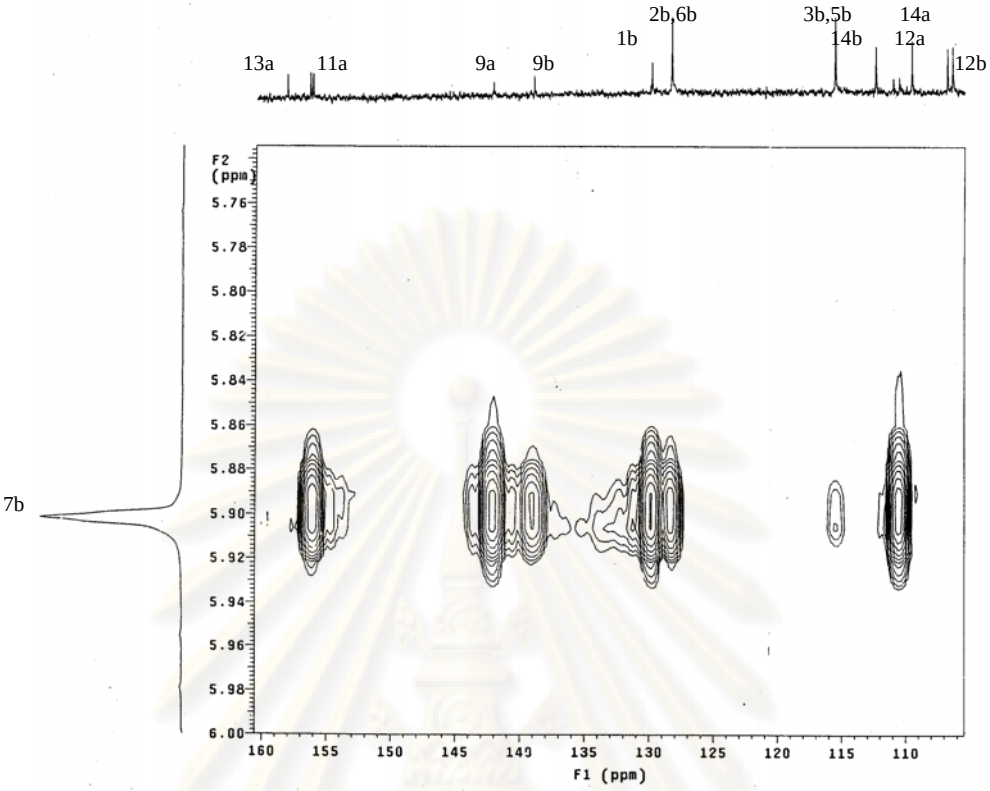


Figure 40 HMBC Spectrum of compound ML8 (acetone-d_6)

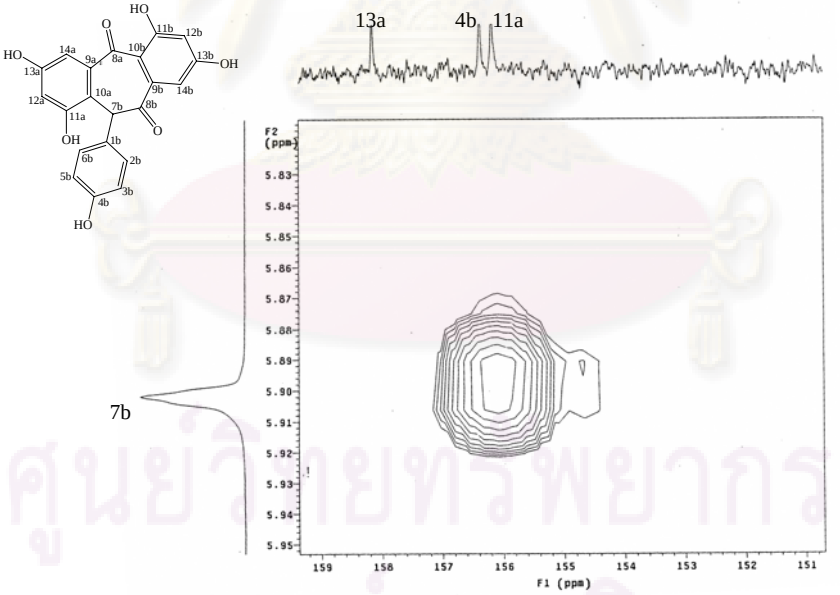


Figure 41 HMBC Spectrum of compound ML8 (acetone-d_6)

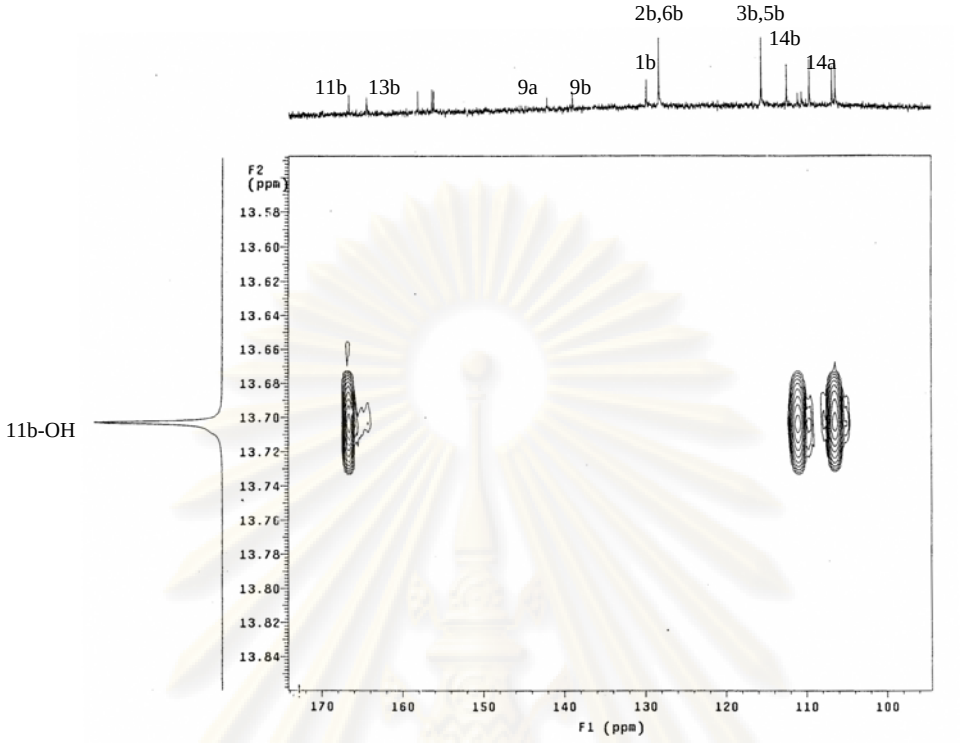


Figure 42 HMBC Spectrum of compound ML8 (acetone-d_6)

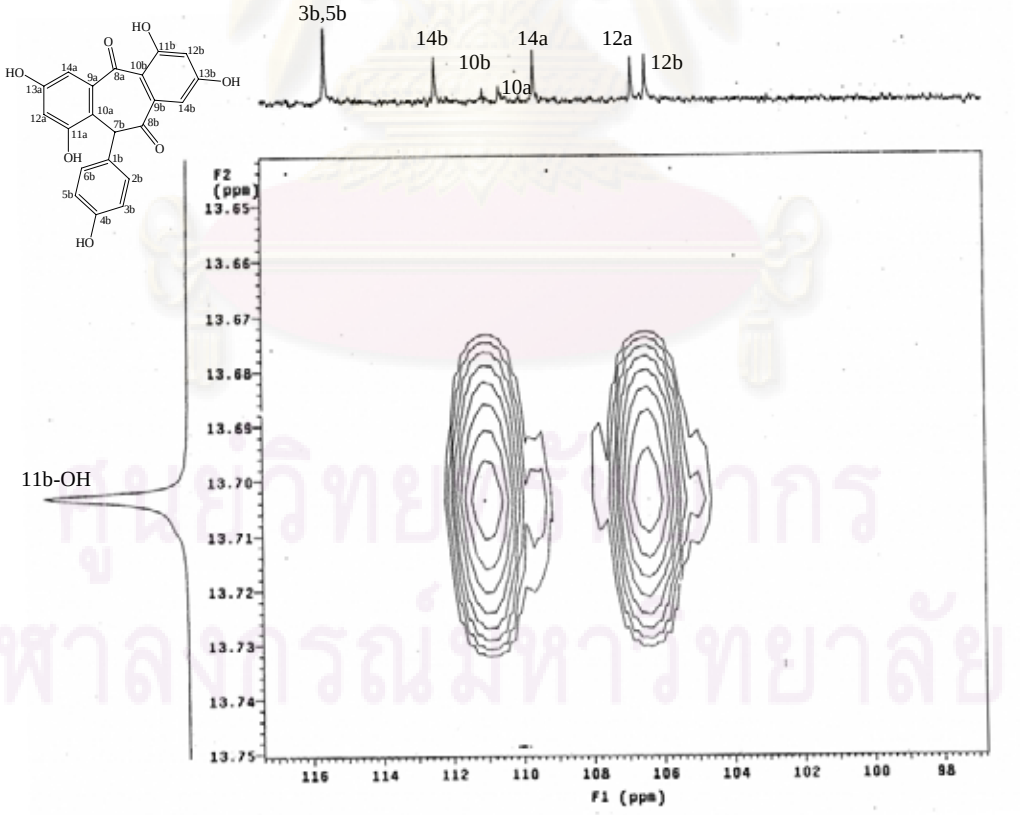


Figure 43 HMBC Spectrum of compound ML8 (acetone-d_6)

VITA

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Poster Presentation

Chatsumpun, M., Sritularak, B., and Likhitwitayawuid, K. Chemical constituents of *Millettia leucantha* stemwood. Abstract of The 10th National Graduate Research Conference, September 11-12, 2008. Sukhothai Thammathirat Open University, Nonthaburi, p. 321.