1 INTRODUCTION

1.1 Introduction

***Cratoxylum cochinchinense* (Lour.) Blume** are shrubs or trees, deciduous, 1.5 - 18 or 25 m tall, glabrous. Trunk is with tufted long spines on lower part. Bark is gray-yellow or gray-brown, smooth or finely striate. Twigs are somewhat compressed, glabrous and pink when young, interpetiolar scars not always continuous. Petioles are 2-3 mm, glabrous; leaf blades elliptic to oblong or lanceolate, 3-10.5 X 1-4 cm, papery, both surfaces glabrous, abaxially gray-green and with pellucid or dark glands, adaxially green, base obtuse to cuneate, apex abruptly acute or acuminate; midvein abaxially elevated, adaxially impressed; lateral veins 8-12 pairs, oblique, free; veins and veinlets reticulate, elevated on both surfaces. Cymes are axillary or extra-axillary and terminal, 1 or 2 or 3-flowered, pedunculate; peduncles 3-10 mm or longer. Pedicel 2-3 mm. Flowers are 1-1.5 cm in diameter. Sepals are oblong, 5-7 X 2-5 mm, apex rounded, with dark linear glands on entire surface, accrescent. Petals are deep crimson to pink or pinkish yellow, obovate, 5-10 X 2.5-5 mm, with dark linear glands between veins, without a petal-scale, base cuneate, apex rounded. Stamen fascicles are 4-8 mm, stalk broad to slender. Fasciclodes are oblong to obovate, cucculate, to 3 X 1-1.5 mm, apex thickened and recurved. Ovary conical, is ca. 3 mm, glabrous; styles linear, ca. 2 mm, divaricate from base. Capsule is brown, ellipsoid, 0.8-1.2 cm X 4-5 mm, glabrous, to 2/3 covered by persistent calyx. Seeds 5 or 6 - 8 in each cell, obovoid, 6-8 X 2-3 mm (Blume, 1852).

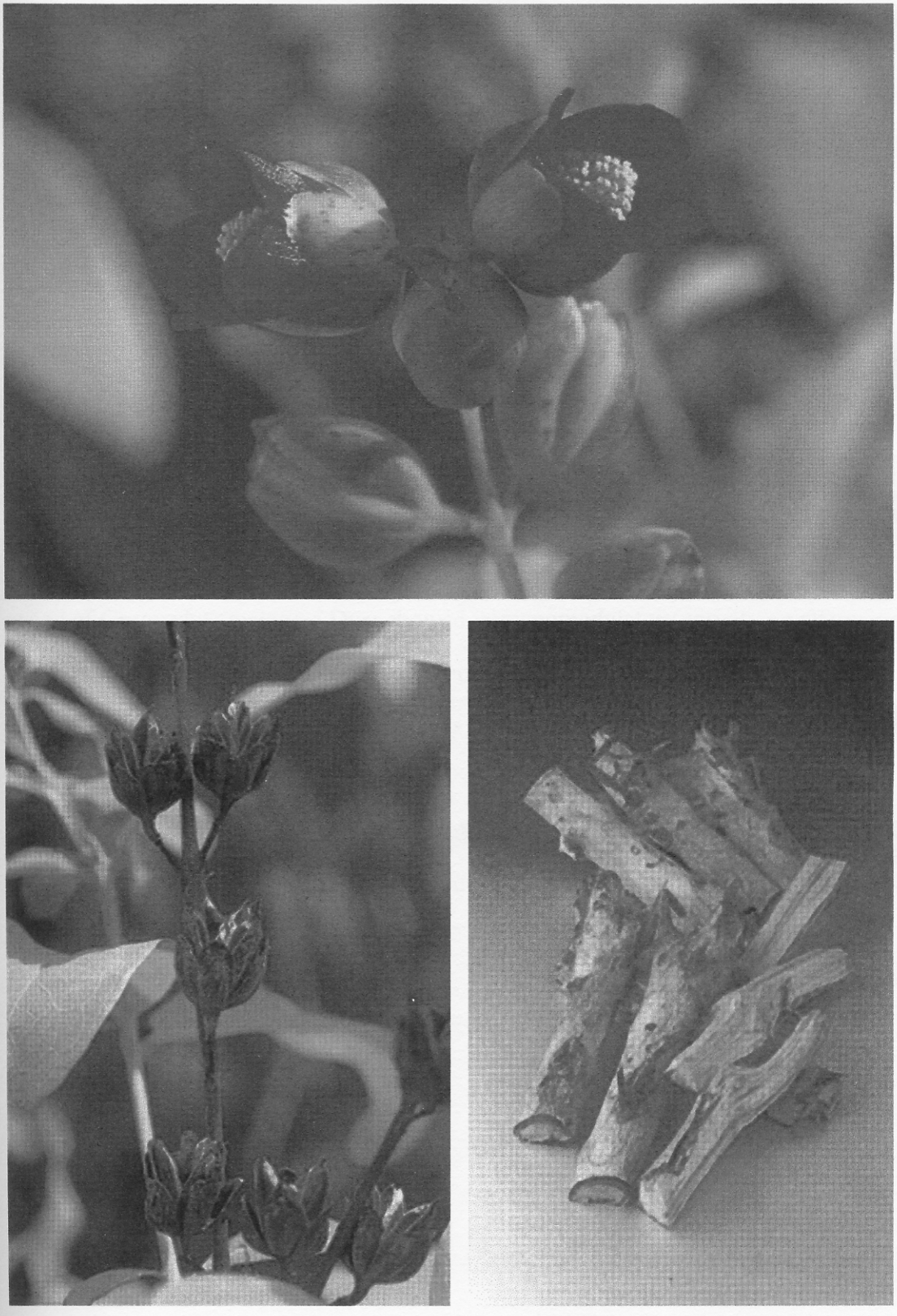


Figure 1 *Cratoxylum cochinchinense* (Lour.) Blume (วงศ์สถิตย์, 2542)

1.2 Review of Literatures

Cratoxylum is in the family Hypericaceae or sometimes placed in the Guttiferae (Bennett, 1993). It is a small genus, about six species (*Cratoxylum arborescens* (Vahl) Blume, *Cratoxylum cochinchinense* (Lour.) Blume, *Cratoxylum formosum* (Jack) Dyer, *Cratoxylum glaucum* Korth, *Cratoxylum maingayi* Dyer and *Cratoxylum sumatranum* (Jack) Blume) are distributed mainly in Southeast Asia (Bennett and Lee, 1989). They are the occurrence of triterpenoids, flavonoids and xanthones (Iinuma, 1996). The compounds isolated from genus *Cratoxylum* are shown in Table 1.

Xanthones from *Cratoxylum sumatranum* Blume was reported to act as active constituents by bioassay-directed fractionation using the KB human cancer cell line cytotoxicity assay (Seo, 2002). In addition, biological activity of xanthones from the wood of *Cratoxylum maingayi* Dyer showed immunomodulatory activity on alternative and classical pathway of the human complement system (Pinto, 1997).

C. cochinchinense (Lour.) Blume was first investigated in 1993 by Bennett *et al* and was further studied by Sia, *et al.*, 1995 and Nguyen, *et al.*, 1998. Triterpenes, xanthones and tocopherols were found in this plant (Table 1). In folk medicines *C. cochinchinense* was used to treat fevers, coughs, diarrhea, itches, ulcers and abdominal complaints (Vo, 1997).

Table 1 Compounds isolated from the *Cratoxylum* genus

Scientific name (Investigated part)	Compound	Structure	Reference
C. cochinchinense			
(Bark)	Cratoxyxanthone	1	Sia, *et al.*, 1995
	11-Hydroxy-1-isomangostin	2	
	1,3,5,6-Tetrahydroxyxanthone	3	
	Xanthonolignoid	4	
(Stem bark)	2-Geranyl-1,3,7-trihydroxy-4-(3-methylbut-2-enyl)xanthone	5	Nguyen and Harrison, 1998
	3-Geranyloxy-6-methyl-1,8-dihydroxyanthraquinone	6	
	7-Geranyloxy-1,3-dihydroxyxanthone	7	
	Lupeol	8	
	β-Mangostin	9	
	(13*E*,17*E*)-Polypoda-7,13,17,21-tetraen-3β-ol	10	
	1,3,7-Trihydroxy-2,4-di(3-methylbut-2-enyl)xanthone	11	
(Trunk bark)	Cratoxylone	12	Bennett, *et al.*, 1993
	Friedelin	13	
	Garcinone D	14	
	2-Geranyl-1,3,7,-trihydroxy-4-(3,3-dimethylallyl)xanthone	5	

Table 1 (Continued)

Scientific name (Investigated part)	Compound	Structure	Reference
(Trunk bark)	Mangostin	15	Bennett, *et al.*, 1993
	β-Mangostin	9	
	Polypoda-8(26),13,17,21-tetraen-3β-ol	16	
	δ-Tocotrienol	17	
	δ-Tocotrienol dimer	18	
	5-(γ-Tocotrienyl)-γ- tocotrienol	19	
	Tovophyllin A	20	
C. formosum (Root)	Astilbin	21	Iinuma, *et al.*, 1996
	1,7-Dihydroxy-4-methoxyxanthone	22	
	1,7-Dihydroxy-8-methoxyxanthone	23	
	2,7-Dihydroxy-1,8-dimethoxyxanthone	24	
	3,8-Dihydroxy-1,2-dimethoxyxanthone	25	
	(-)-Epicatechin	26	
	Euxanthone	27	
	Macluraxanthone	28	
	1,2,3,4,8-Pentamethoxyxanthone	29	

Table 1 (Continued)

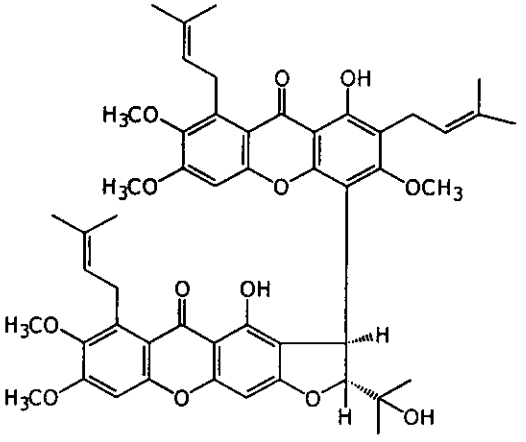
Scientific name (Investigated part)	Compound	Structure	Reference
(Root)	1,4,7-Trihydroxy-8-methoxyxanthone	30	Iinuma, *et al.*, 1996
	1,4,7-Trihydroxy-8-methoxyxanthone	30	
	1,4,7-Trihydroxyxanthone	31	
C. maingayi (Wood)	1,5-Dihydroxy-8-methoxyxanthone	32	Pinto, *et al.*, 1997
	1,7-Dihydroxy-4-methoxyxanthone	22	Kijjoa, *et al.*, 1998
	2,8-Dihydroxy-1-methoxyxanthone	23	
	Euxanthone	27	Pinto, *et al.*, 1997
	5-Hydroxy-2,3,4,8-tetramethoxyxanthone	33	
	7-Hydroxy-1,2,3,8-tetramethoxyxanthone	34	Kijjoa, *et al.*, 1998
C. pruniflorum (Leaves)	(-)-Epicatechin	26	Van, *et al.*, 1988
	Hyperoside	35	Kitanov, *et al.*, 1988; Van, *et al.*, 1988
	Isomangiferin	36	

Table 1 (Continued)

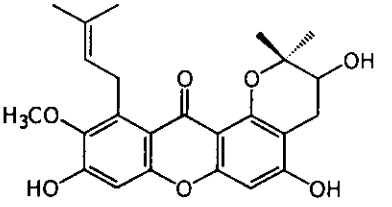
Scientific name (Investigated part)	Compound	Structure	Reference
(Leaves)	Mangiferin	37	Kitanov, *et al.*, 1988; Van, *et al.*, 1988
	Quercetin	38	Kitanov, *et al.*, 1988
	1H-xanthen-2(3H)-one,6,7-dihydro	39	
(Stem)	(-)-Epicatechin	26	Van, *et al.*, 1988
	Hyperoside	35	Van, *et al.*, 1988
	Isomangiferin	36	
	Mangiferin	37	
(Not specified)	Isomangiferin	36	Bennett and Lee, 1989
(Not specified)	Mangiferin	37	Bennett and Lee, 1989
	Norathyriol	40	
C. prunifoluim (Leaves)	Epicatechin 3-*O*-gallate	41	Cao, *et al.*, 2000
	Epigallocatechin 3-*O*-gallate	42	
C. sumatranum (Leaves)	Cratoxyarborenone A	43	Seo, *et al.*, 2002
	Cratoxyarborenone B	44	
	Cratoxyarborenone D	45	
	Cratoxyarborenone E	46	

Table 1 (Continued)

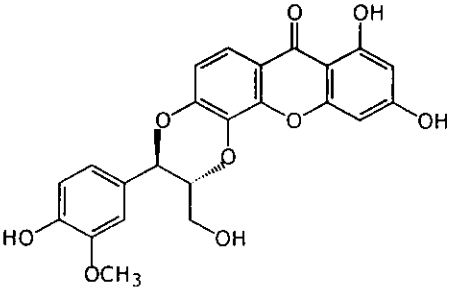
Scientific name (Investigated part)	Compound	Structure	Reference
(Stem bark)	Betulinic acid	47	Seo, *et al.*, 2002
	Cratoxyarborenone C	48	
	Cratoxyarborequinone A	49	
	Cratoxyarborequinone B	50	
	2,4,6-Trihydroxybenzophenone 4-*O*-geranyl ether	51	
	δ-Tocotrienol	17	
	Vismione B	52	
(Twigs)	Cratoxyarborenone F	53	



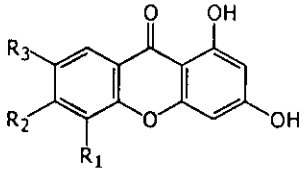
1: Cratoxyxanthone



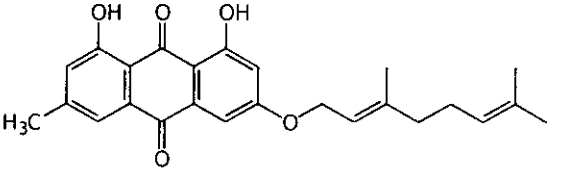
2: 11-Hydroxy-1-isomangostin



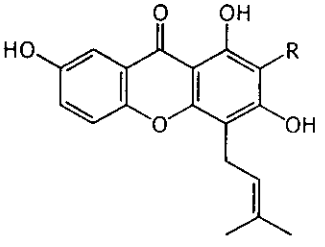
4: Xanthonolignoid



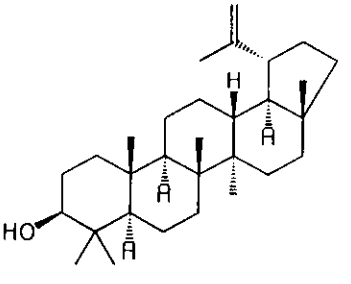
3: $R_1 = OH, R_2 = OH, R_3 = H$:
1,3,5,6-Tetrahydroxyxanthone
7: $R_1 = H, R_2 = H, R_3 =$ *O*-geranyl :
7-Geranyloxy-1,3-dihydroxyxanthone



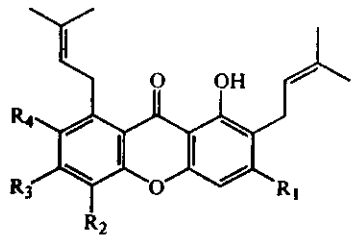
6: 3-Geranyloxy-6-methyl-1,8-dihydroxyanthraquinone



5: R = geranyl : 2-Geranyl-1,3,7-trihydroxy-4-(3-methylbut-2-enyl)xanthone
11: R = prenyl : 1,3,7-Trihydroxy-2,4-di(3-methylbut-2-enyl)xanthone



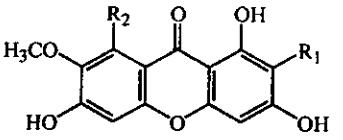
8: Lupeol



9 : $R_1 = OCH_3$, $R_2 = H$, $R_3 = OH$, $R_4 = OCH_3$: β-Mangostin

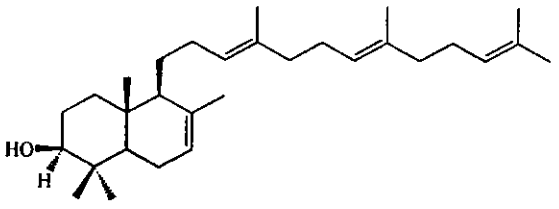
15 : $R_1 = OH$, $R_2 = H$, $R_3 = OH$, $R_4 = OCH_3$: Mangostin

48 : $R_1 = OH$, $R_2 = OCH_3$, $R_3 = H$, $R_4 = OCH_3$: Cratoxyarborenone C

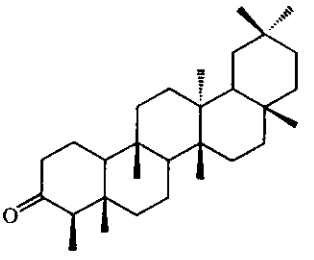


12 : R_1 = 3-hydroxy-3-methylbutyl, R_2 = prenyl : Cratoxylone

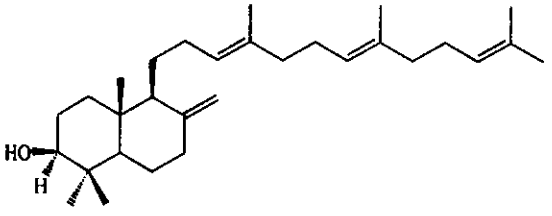
14 : R_1 = prenyl, R_2 = 3-hydroxy-3-methylbutyl : Garcinone D



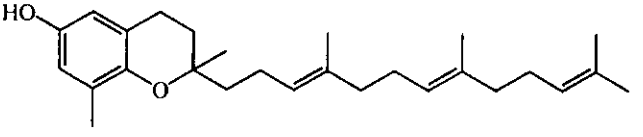
10 : (13*E*,17*E*)-Polypoda-7,13,17,21-tetraen-3β-ol



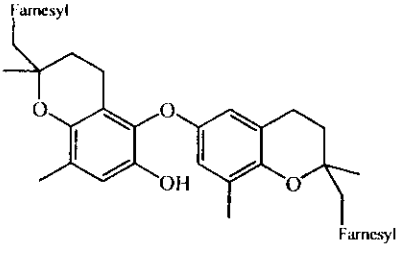
13 : Friedelin



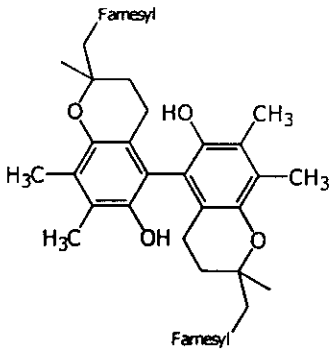
16 : Polypoda-8(26),13,17,21-tetraen-3β-ol



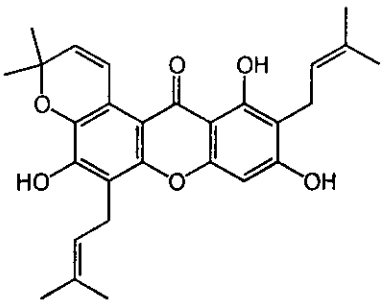
17 : δ-Tocotrienol



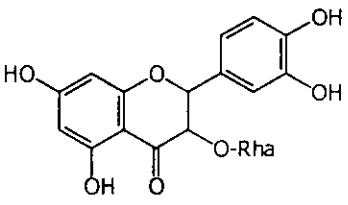
18 : δ-Tocotrienol dimer



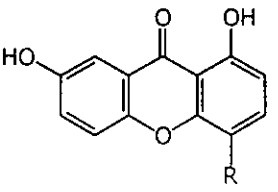
19 : 5-(γ-Tocotrienyl)-γ- tocotrienol



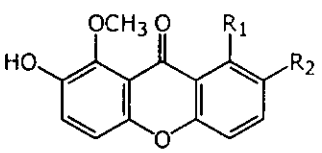
20 : Tovophyllin A



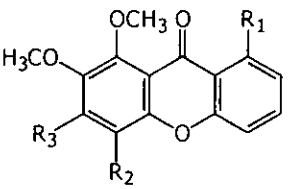
21 : Astilbin



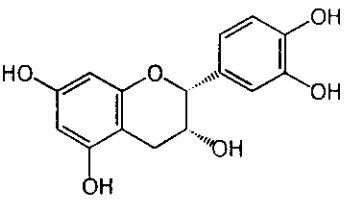
22 : R = OCH_3 **:** 1,7-Dihydroxy-4-methoxyxanthone
27 : R = H **:** Euxanthone
31 : R = OH **:** 1,4,7-Trihydroxyxanthone



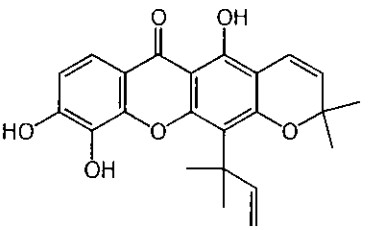
23 : R_1 = OH, R_2 = H **:** 1,7-Dihydroxy-8-methoxyxanthone
24 : R_1 = OCH_3, R_2 = OH **:** 2,7-Dihydroxy-1,8-dimethoxyxanthone



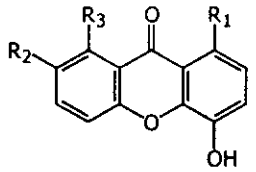
25 : R_1 = OH, R_2 = H, R_3 = OH **:** 3,8-Dihydroxy-1,2-dimethoxyxanthone
29 : R_1 = OCH_3, R_2 = OCH_3, R_3 = OCH_3 **:** 1,2,3,4,8-Pentamethoxyxanthone



26 : (-)-Epicatechin

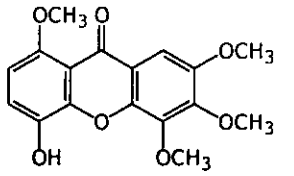


28 : Macluraxanthone

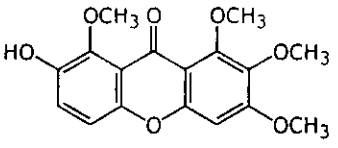


30 : $R_1 = OH, R_2 = OH, R_3 = OCH_3$:
1,4,7-Trihydroxy-8-methoxyxanthone

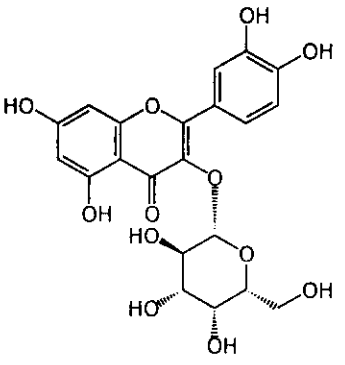
32 : $R_1 = OCH_3, R_2 = H, R_3 = OH$:
1,5-Dihydroxy-8-methoxyxanthone



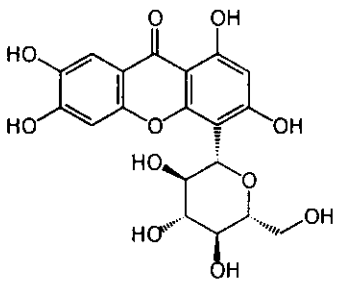
33 : 5-Hydroxy-2,3,4,8-tetramethoxyxanthone



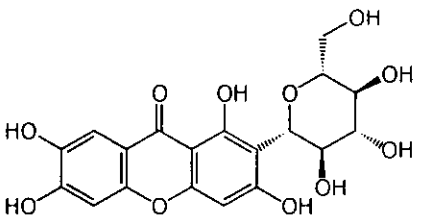
34 : 7-Hydroxy-1,2,3,8-tetramethoxyxanthone



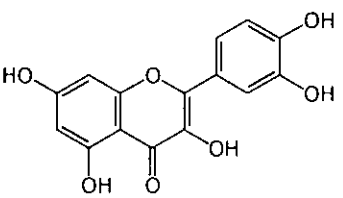
35 : Hyperoside



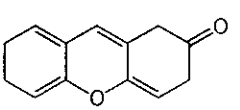
36 : Isomangiferin



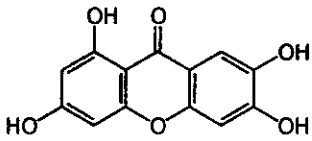
37 : Mangiferin



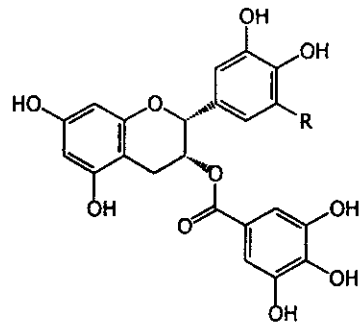
38 : Quercetin



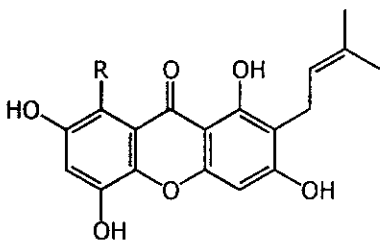
39 : 1H-xanthen-2(3H)-one,6,7-dihydro



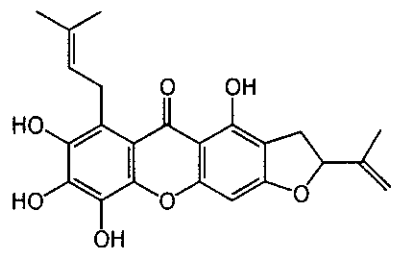
40 : Norathyriol



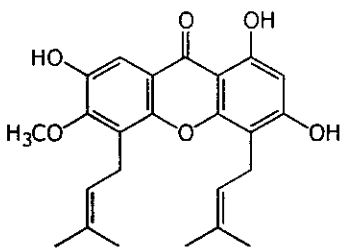
41 : R = H : Epicatechin 3-*O*-gallate
42 : R = OH : Epigallocatechin 3-*O*-gallate



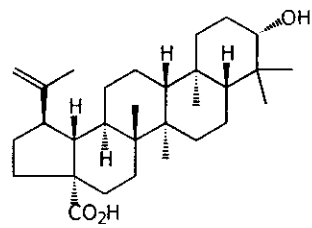
43 : R = geranyl : Cratoxyarborenone A
44 : R = prenyl : Cratoxyarborenone B



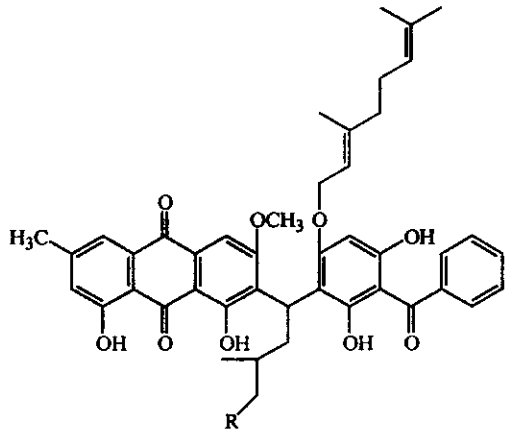
45 : Cratoxyarborenone D



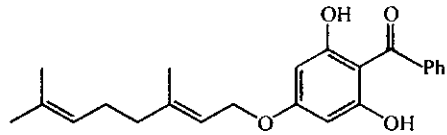
46 : Cratoxyarborenone E



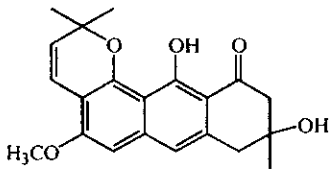
47 : Betulinic acid



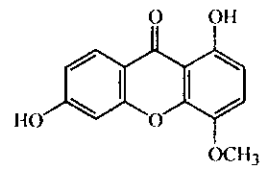
49 : R = H : Cratoxyarborequinone A
50 : R = prenyl : Cratoxyarborequinone B



51 : 2,4,6-Trihydroxybenzophenone 4-*O*-geranyl ether



52 : Vismione B



53 : Cratoxyarborenone F

1.3 The Objective

The objectives of this work were to investigate the chemical constituents of the roots of *C. cochinchinense* and to study on the antioxidation properties of crude extracts and pure compounds by 2,2-diphenyl-1-picrylhydrazyl free radical assay.