

1 INTRODUCTION

1.1 Introduction

Cratoxylum is a plant belonging to a small genus of the family Guttiferae, which can be found in several Southeast Asian countries. The genus *Cratoxylum* has about six species, which are all found in Thailand (Smitinand, 2001): *Cratoxylum arboresens*, *Cratoxylum cochinchinense*, *Cratoxylum maingayi*, *Cratoxylum sumatranum* ssp. *neriifolium*, *Cratoxylum formosum* ssp. *formosum* (Jack) Dyer and *Cratoxylum formosum* (Jack) Dyer ssp. *pruniflorum* (Kurz) Gogel. The last two species, which are subspecies of *C. formosum* can be differentiated through the young twigs, leaves, pedicels, and sepals. Those of *C. formosum* ssp. *formosum* are glabrous, whereas *C. formosum* ssp. *pruniflorum* are densely villous (Veesommai *et al.*, 2004). The local name of *C. formosum* ssp. *pruniflorum* is Tuikhon (Smitinand, 2001). It is a shrub or tree, deciduous to evergreen, 3-8 m tall, whose barks are brown or dark-grey, and barks and spines are attached on stem or old branch. The resin is red-yellow. Special young twigs, leaves, pedicels and sepals are densely villous. Leaves are simple, opposite, oblong lanceolate, entire, acute, attenuate, 3-5 cm by 6-8 cm. Young leaves are usually red and the mature ones densely villous. Flowers are complete, sepal 5, deep red or scarlet, petal 5, pink or white, 0.3-0.5 by 2-3 cm. Some species of this genus have been used for the treatment of diuretic, stomachic and tonic effects, as well as for diarrhea and flatulence, and for food poisoning and internal bleeding (Kitanov *et al.*, 1988).

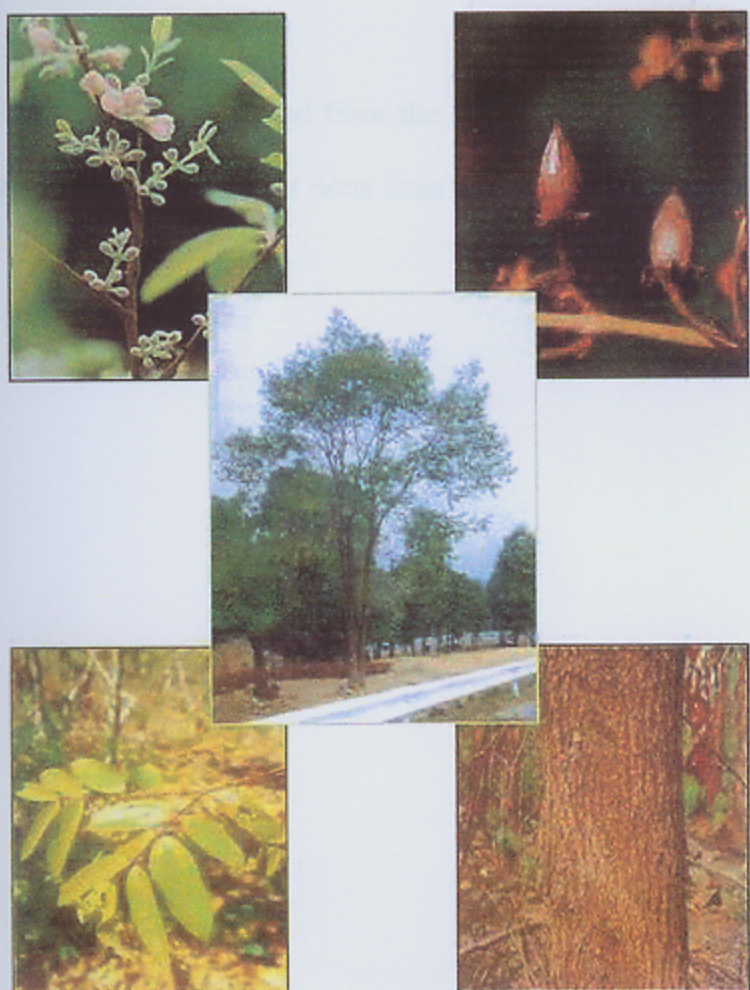


Figure 1 Different parts of *Cratogeomys formosus* ssp. *pruniflorum*

1.2 Review of Literatures

Chemical constituents isolated from the *Cratoxylum* genus were summarized in Table 1. The literature survey was done from NAPRALERT and Scifinder scholar data bases.

Species Name	Part	Compounds	Bibliography
<i>Cratoxylum</i>	Leaves	Quercetin, 1a	Siamonv et al., 1981
		Hyperoside, 2a	
		1,3,6,7-Tetrahydroxy-	
		androsin, 3b	
		Mangiferin, 4b	
<i>Cratoxylum</i>	Barks	Polypoda-9(26), 13, 17, 21-	Dumont et al., 1981
		erectin-3, 5a, 6a	
		Mangrocin, 5b	
		β -Mangrocin, 5c	
		Castanoside D, 10b	
		Taniglycoside A, 11b	
		2-O-methyl-1,3,7-trihydroxy-	
		4-O-2,6-dihydroxyphenyl-	
		androsin, 12b	
		Chloroxylin, 13b	
Friedelin, 62b			

Table 1 Chemical Constituents from the *Cratoxylum* genus.

- | | |
|-------------------------------|---------------------------|
| a. Flavonoids | e. Quinonoids |
| b. Xanthones | f. Bicyclic triterpenoids |
| c. Bixanthones | g. Tocotrienols |
| d. Caged-prenylated xanthones | h. Triterpenoids |

Scientific name	Part	Compounds	Bibliography
<i>C. formosum</i> ssp. <i>pruniflorum</i>	Leaves	Quercetin, 1a Hyperoside, 2a 1,3,6,7-Tetrahydroxy-xanthone, 5b Mangiferin, 6b Isomangiferin, 7b	Kitanov <i>et al.</i> , 1988
<i>C. cochinchinense</i>	Barks	Polypoda-8(26),13,17,21-tetraen-3 β -ol, 60f Mangostin, 8b β -Mangostin, 9b Garcinone D, 10b Torophyllin A, 11b 2-Geranyl-1,3,7-trihydroxy-4-(3,3dimethylallyl)-xanthone, 12b Cratoxylone, 13b Friedelin, 65h	Bennett <i>et al.</i> , 1993

Table 1 (Continued)

Scientific name	Part	Compounds	Bibliography
<i>C. cochinchinense</i>	Barks	δ -Tocotrienol, 62g δ -Tocotrienol dimer, 63g 5-(γ -Tocotrienyl)- γ -tocotrienol, 64g 11-Hydroxy-1-iso-mangostin, 14b 1,3,5,6-Tetrahydroxy-xanthone, 15b 5'-Demethoxycadensin G, 16b Cratoxyxanthone, 49c	Sia <i>et al.</i> , 1995
<i>C. formosum</i>	Roots	2,7-Dihydro-1,8-dimethyl-xanthone, 17b 1,4,7-Trihydroxy-8-methoxy-xanthone, 18b 1,4,7-Trihydroxyxanthone, 19b 1,7-Dihydroxy-4-methoxy-xanthone, 20b 1,7-Dihydroxyxanthone, 21b 1,2,3,4,8-Pentamethoxy-xanthone, 22b	Ilnuma <i>et al.</i> , 1996

Table 1 (Continued)

Scientific name	Part	Compounds	Bibliography
<i>C. formosum</i>	Roots	3,8-Dihydroxy-1,2-dimethoxyxanthone, 23b Macluraxanthone, 24b 1,7-Dihydroxy-8-methoxyxanthone, 25b (-)-Epicatechin, 3a Astilbin, 4a	Ilnuma <i>et al.</i> , 1996
<i>C. maingayi</i>	Wood	1,7-Dihydroxyxanthone, 21b 1,7-Dihydroxy-4-methoxyxanthone, 20b 2,8-Dihydroxy-1-methoxyxanthone, 26b 7-Hydroxy-1,2,3,8-tetramethoxyxanthone, 27b	Kijjoa <i>et al.</i> , 1998
<i>C. cochinchinense</i>	Barks	(13 <i>E</i> ,17 <i>E</i>)-Polypoda-7,13,17,21-tetraen-3 β -ol, 61f 2-Geranyl-1,3,7-trihydroxy-4-(3-methylbut-2-enyl)-xanthone, 28b	Nguyen, 1998

Table 1 (Continued)

Scientific name	Part	Compounds	Bibliography
<i>C. cochinchinense</i>	Barks	1,3,7-Trihydroxy-2,4-di-(3-methyl-but-2-enyl)-xanthone, 29b 7-Geranyloxy-1,3-dihydroxyxanthone, 30b Lupeol, 66h β -Mangostin, 9b	Nguyen, 1998
<i>C. sumatranum</i>	Leaves Twigs and Stem barks	Cratoxyarborenone A, 31b Cratoxyarborenone B, 32b Cratoxyarborenone C, 33b Cratoxyarborenone D, 34b Cratoxyarborenone E, 35b Cratoxyarborenone F, 36b Cratoxyarborequinone A, 53e Cratoxyarborequinone B, 54e Vismione B, 55e δ -Tocotrienol, 62g Betulinic acid, 67h	Seo <i>et al.</i> , 2002

Table 1 (Continued)

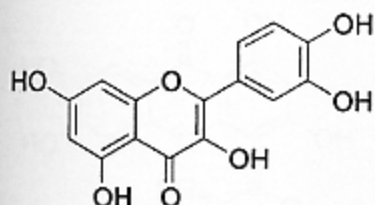
Scientific name	Part	Compounds	Bibliography
<i>C. arborescens</i>	Stem barks	1,3-Dihydroxy-6,7-dimethoxy-2,8-diprenyl-xanthone, 37b Fuscaxanthone C, 38b 1,7-Dihydroxyxanthone, 21b 3-Geranyloxy-6-methyl-1,8-dihydroxy-anthraquinone, 56e 2-Geranylmodin, 57e	Pattanaprateeb <i>et al.</i> , 2005
<i>C. formosum</i>	Roots	Gerontoxanthone, 39b Formoxanthone A, 40b Formoxanthone B, 41b Formoxanthone C, 42b Xanthone V ₁ , 43b Macluraxanthone, 24b 3-Geranyloxy-6-methyl-1,8-dihydroxyanthraquinone, 56e Vismiaquinone, 57e Madagascin, 58e	Boonsri <i>et al.</i> , 2006

Table 1 (Continued)

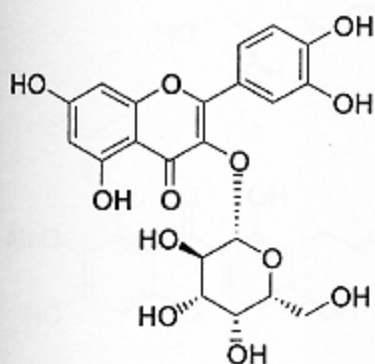
Scientific name	Part	Compounds	Bibliography
<i>C. cochinchinense</i>	Roots	Cochinchinone A, 44b Cochinchinone B, 45b Cochinchinone C, 50d Cochinchinone D, 51d Caged prenylated-xanthone, 52d β -Mangostin, 9b 1,3,7-Trihydroxy-2,4-bis-(3-methyl-2-butenyl)-xanthone, 46b Mangostin, 8b Macluraxanthone, 24b Garcinone B, 47b Celebixanthone, 48b Garcinone D, 10b	Mahabusarakam <i>et al.</i> , 2006

Structures

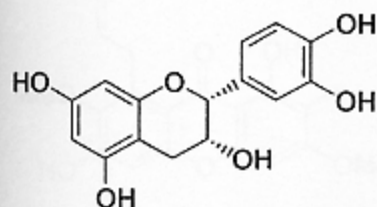
a. Flavonoids



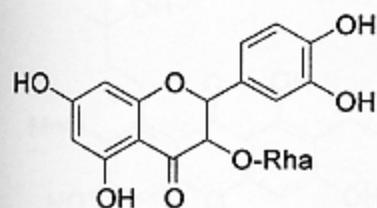
1a: Quercetin



2a: Hyperoside

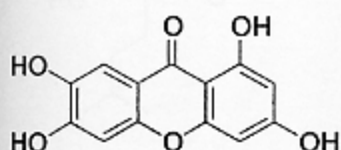


3a: (-)-Epicatechin

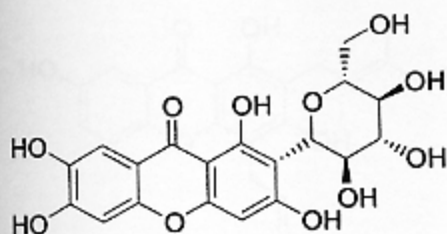
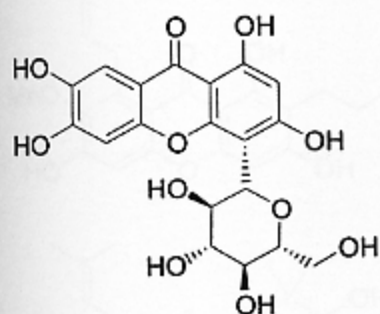
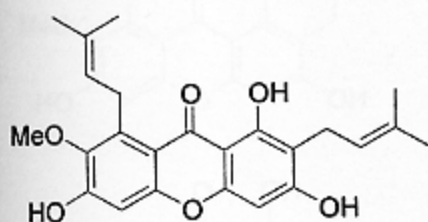
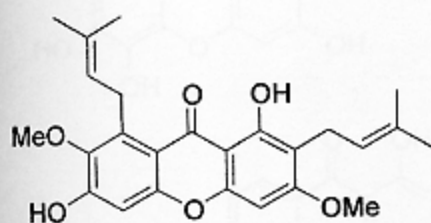
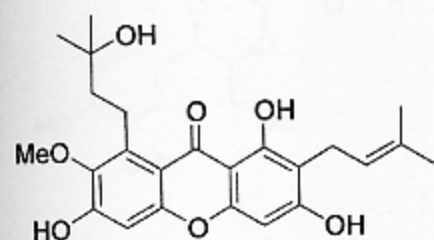
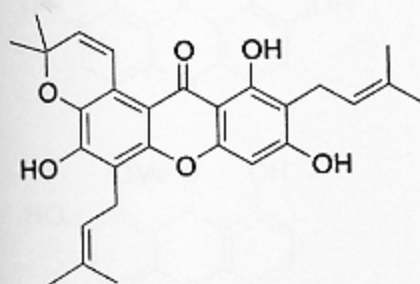


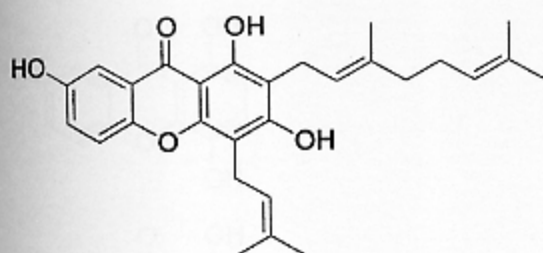
4a: Astilbin

b. Xanthenes

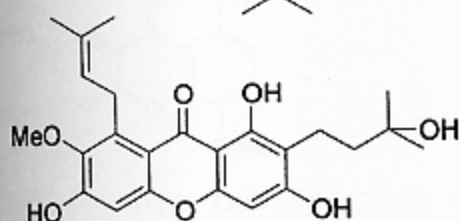


5b: 1,3,6,7-Tetrahydroxy-xanthone

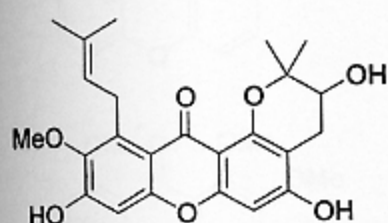
**6b:** Mangiferin**7b:** Isomangiferin**8b:** Mangostin**9b:** β -Mangostin**10b:** Garcinone D**11b:** Torophyllin A



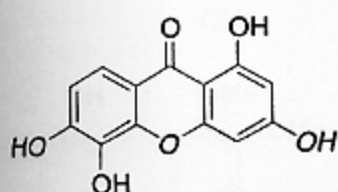
12b: 2-Geranyl-1,3,7-trihydroxy-4-(3,3-dimethylallyl)-xanthone



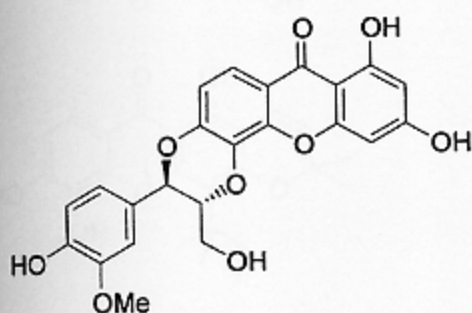
13b: Cratoxylone



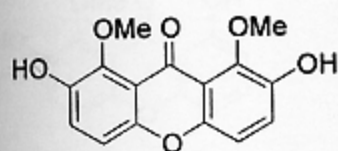
14b: 11-Hydroxy-1-isomangostin



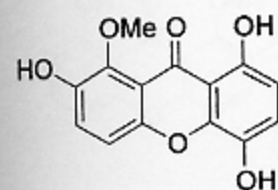
15b: 1,3,5,6-Tetrahydroxyxanthone



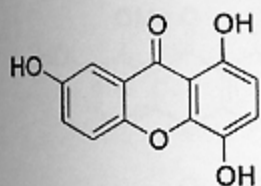
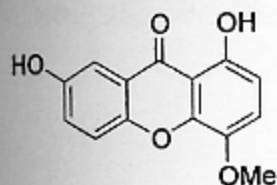
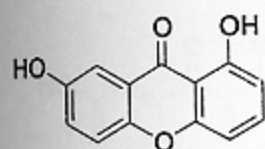
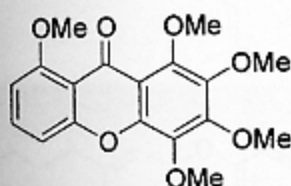
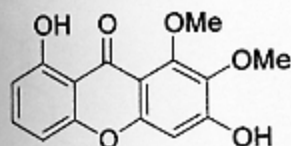
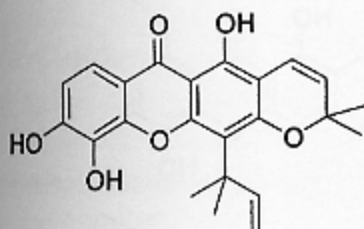
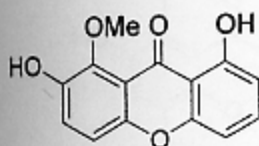
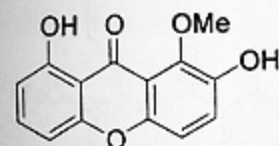
16b: 5'-Demethoxycadensin G

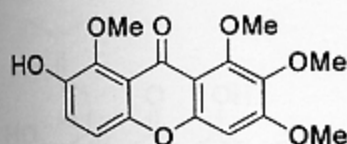


17b: 2,7-Dihydro-1,8-dimethyl-xanthone

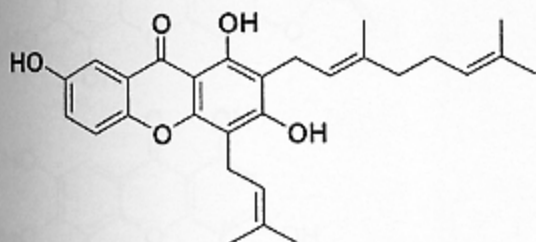


18b: 1,4,7-Trihydroxy-8-methoxy-xanthone

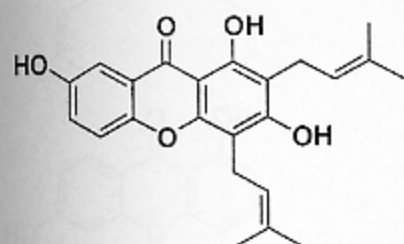
**19b:** 1,4,7-Trihydroxyxanthone**20b:** 1,7-Dihydroxy-4-methoxyxanthone**21b:** 1,7-Dihydroxyxanthone**22b:** 1,2,3,4,8-Pentamethoxyxanthone**23b:** 3,8-Dihydroxy-1,2-dimethoxyxanthone**24b:** Macluraxanthone**25b:** 1,7-Dihydroxy-8-methoxyxanthone**26b:** 2,8-Dihydroxy-1-methoxyxanthone



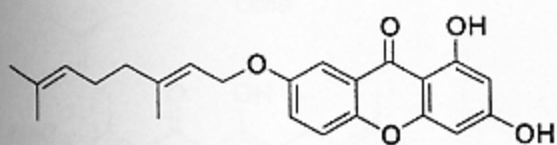
27b: 7-Hydroxy-1,2,3,8-tetra-methoxyxanthone



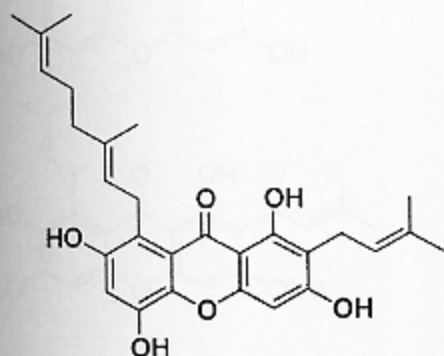
28b: 2-Geranyl-1,3,7-trihydroxy-4-(3-methyl-but-2-enyl)-xanthone



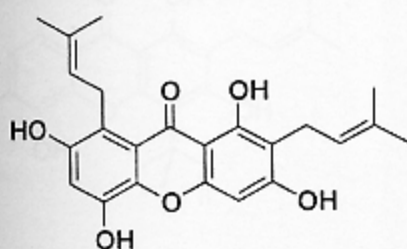
29b: 1,3,7-Trihydroxy-2,4-di-(3-methyl-but-2-enyl)-xanthone



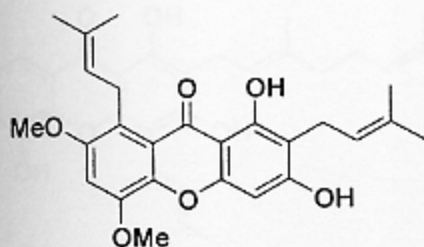
30b: 7-Geranyloxy-1,3-dihydroxy-xanthone



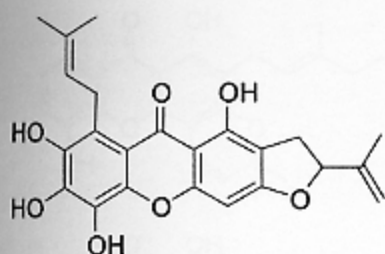
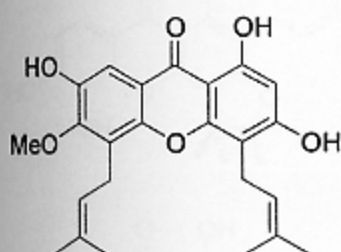
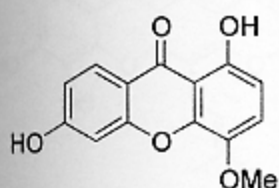
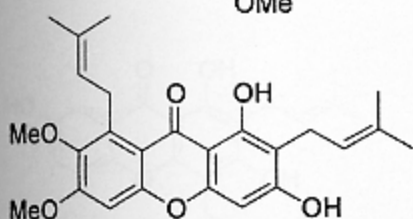
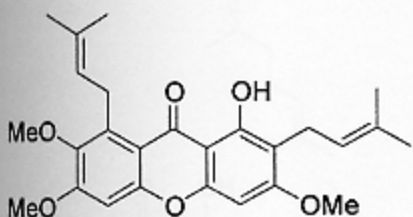
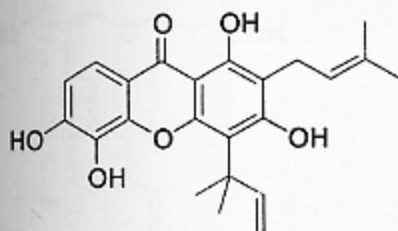
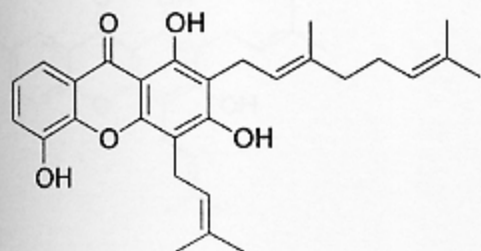
31b: Cratoxyarborenone A

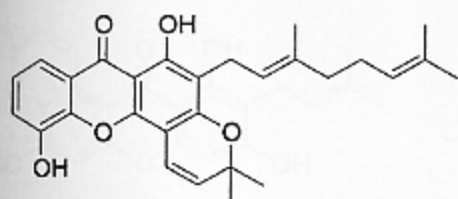


32b: Cratoxyarborenone B

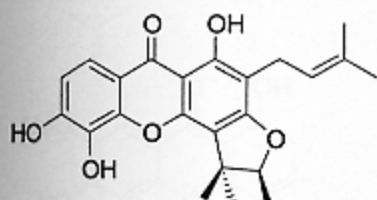


33b: Cratoxyarborenone C

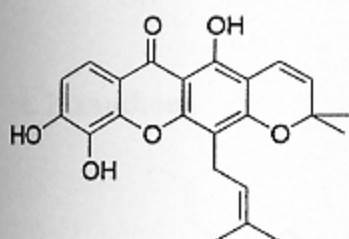
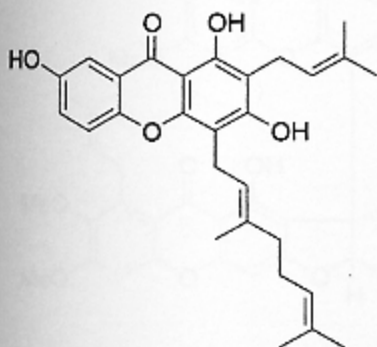
**34b:** Cratoxyarborenone D**35b:** Cratoxyarborenone E**36b:** Cratoxyarborenone F**37b:** 1,3-Dihydroxy-6,7-dimethoxy-2,8-diprenylxanthone**38b:** Fuscaxanthone C**39b:** Gerontoxanthone I**40b:** Formoxanthone A



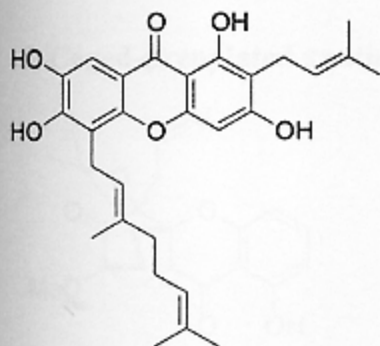
41b: Formoxanthone B



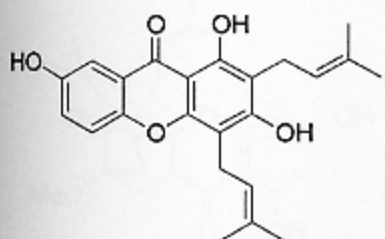
42b: Formoxanthone C

43b: Xanthone V₁

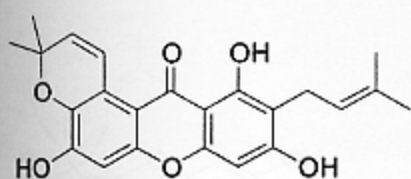
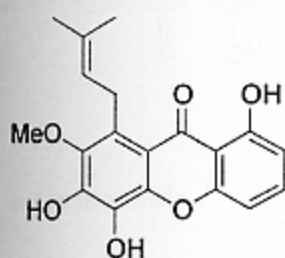
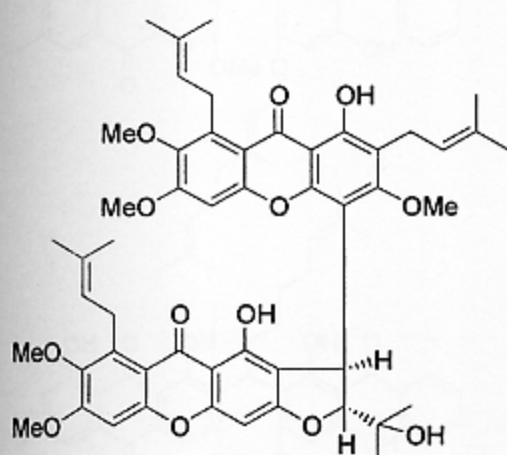
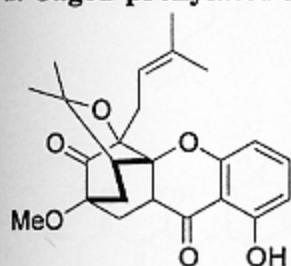
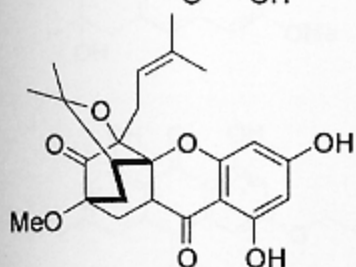
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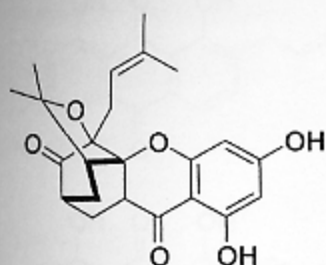


45b: Cochinchinone B



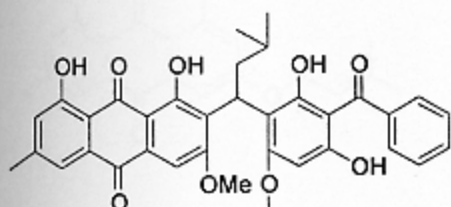
46b: 1,3,7-Trihydroxy-2,4-bis-(3-methyl-2-butenyl)-xanthone

**47b:** Garcinone B**48b:** Celebixanthone**c. Bixanthone****49c:** Cratoxyxanthone**d. Caged-prenylated xanthenes****50d:** Cochinchinone C**51d:** Cochinchinone D

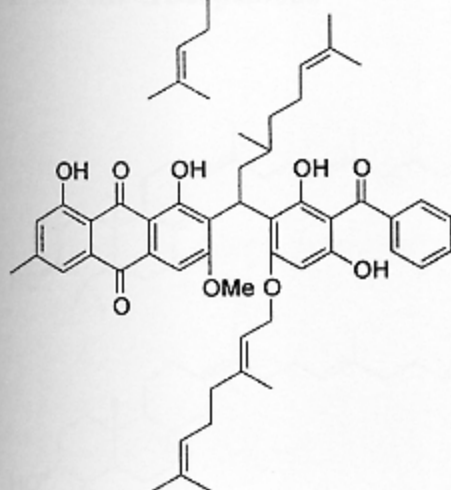


52d: Caged-prenylated xanthone

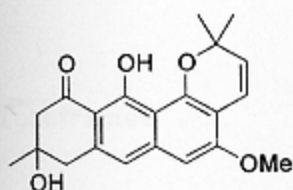
e. Quinonoids



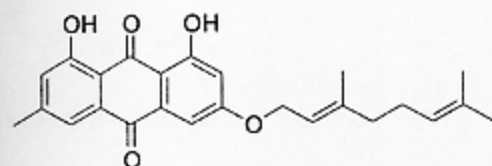
53e: Cratoxyarborequinone A



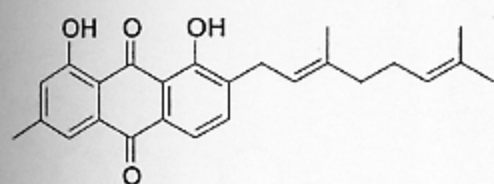
54e: Cratoxyarborequinone B



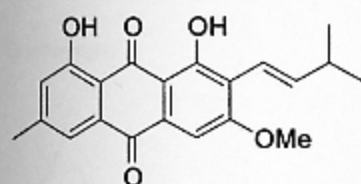
55e: Vismione B



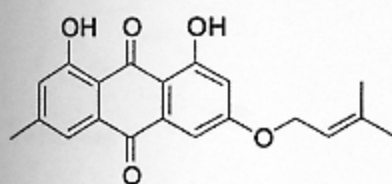
56e: 3-Geranyloxy-6-methyl-1,8-dihydroxyanthraquinone



57e: 2-Geranylemodin

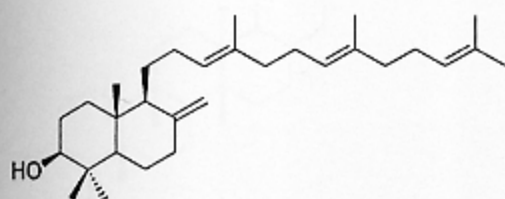
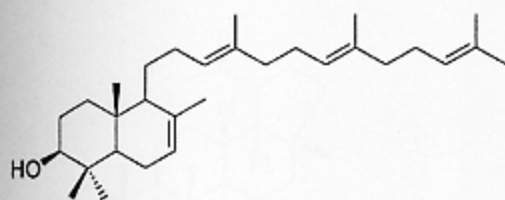


58e: Vismiaquinone

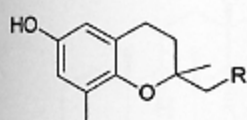


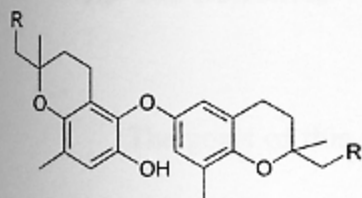
59e: Madagascin

f. Bicyclic triterpenoids

60f: Polypoda-8(26),13,17,21-tetraen-3 β -ol61f: (13*E*,17*E*)-Polypoda-7,13,17,21-tetraen-3 β -ol

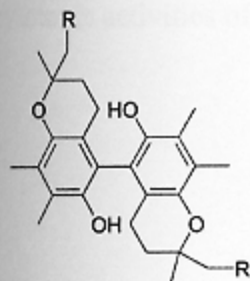
g. Tocotrienols

62g: δ -Tocotrienol



63g: δ -Tocotrienol dimer

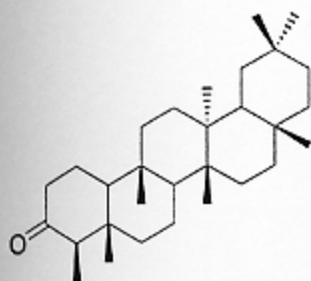
R = Farnesyl



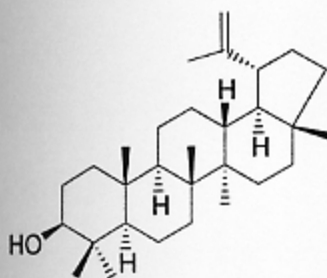
64g: 5-(γ -Tocotrienyl)- γ -Toco-trienol

R = Farnesyl

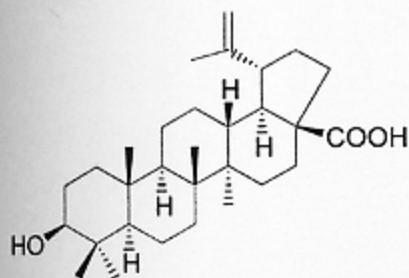
h. Triterpenoids



65h: Friedelin



66h: Lupeol



67h: Betulinic acid

2 EXPERIMENTAL

1.3 The Objectives

The goals of this work were to investigate the chemical constituents from the barks of *C. formosum* ssp. *pruniflorum* and to evaluate the antibacterial and cytotoxic activities of the isolated compounds.