CHAPTER 1
INTRODUCTION

_Garcinia_ is a plant genus of the family Gutiferae, sub-family Clusiaceae native to Asia, Australia, tropical and southern Africa, and Polynesia. The genus, with between 150-300 species of evergreen trees and shrubs, is dioecious and several of its elements are apomictic. The genus _Garcinia_ is mainly grown in lowland rain forests of the tropical world and found from sea level to the tops of the highest mountains.

_Garcinia hanburyi_ Hook. f. (Guttiferae) or Gamboge tree grows widely in the tropical rain forest area. Gamboge tree is a native of Cambodia, Southern Vietnam and Thailand. Its common name is Rongthong and Gamboge.

_G. hanburyi_ is a small to medium-sized tree, up to 15 m tall, with short and straight trunk, up to 20 cm. in diameter, grey bark, smooth and 4-6 mm. thick, exuding a yellow gum-resin. Leaves are opposite, leathery, elliptic or ovate-lanceolate, 10-25 cm. x 3-10 cm., cuneate at base, acuminate at apex and short stalk. Flowers are in clusters or solitary in the axils of fallen leaves, 4-merous, pale yellow and fragrant, unisexual or bisexual. Fruits are a globose berry, 2-3 cm. in diameter, smooth, with recurved sepals at the base and crowned by the persistent stigma, 1-4 seeded. Seeds are 15-20 mm long, surrounded by a pulpy aril. Normally it flowers in November and December and fruits from February to April.
The species are closely related to *G. morella* and *G. hanburyi* has been considered in the past as a variety of *G. morella*.

**Figure 1** *Garcinia hanburyi* Hook. f.
Figure 2 Gamboge of *G. hanburyi*.

The gum-resin (gamboge), obtained from incisions of the bark of *G. hanburyi*, is used as a golden-yellow colouring matter for varnishes, lacquer, paints and ink. Gamboge is used in traditional medicine as a drastic purgative, an emetic and a vermifuge for treating tape worm. Gamboge is a powerful hydragogue cathartic, causing in large doses much irritation and griping. It is employed in dropsical conditions and in cerebral congestion when it is desirable to lower blood-
pressure rapidly, but is rarely used alone on account of its drastic action. Sometimes it is given to cows as purgative. For external use, the resin, mixed with coconut milk, is applied for treatment of chronic dermatitis. It is well known that gamboge is rich in a variety of compounds such as xanthones, benzophenones, flavonoids, biflavonoids, chalcones and triterpenes.

Gambogic acid (12) is the major principal of G. hanburyi. Due to the complexity of this type of xanthone derivatives, chemical studies have been carried out on gambogic acid and a related compound, morellin (6) [1-5]. The structure of p-bromo-benzenesulphonyl ester of morellin has been established by X-ray crystallographic study [3] and structure of gambogic acid was deduced inferentially [2].

\[
\begin{align*}
\text{12 (gambogic acid)} & \\
\text{6 (morellin)}
\end{align*}
\]
In 1993, Cordell et al. isolated three xanthone derivatives, gambogenic acid (12), isogambogenic acid (13) and isomorellinol (10) from the dry latex of *G. hanburyi* [6]. Determination of the structures and stereochemistry were achieved by high-field NMR experiments including COSY, ROESY, HMQC, HMBC and selective INEPT. Cytotoxic evaluation revealed that all three derivatives were active against KB and drug-resistant KB-V1 cell lines.
In 1996, Tada et al. isolated eleven novel cytotoxic caged-polyrenylated xanthones, gambogin (11), morellin dimethyl acetal (18), isomoreollin B (19), moreollic acid (20), gambogenin (14), isogambogenin (15), desoxygambogenin (21), gambogenin dimethyl acetal (22), gambogenic acid (16), gambogellic acid (23) and hanburin (24) together with four known xanthones, desoxymorellin (5) [7], isomorellin (7) [8], morellic acid (8) [9] and gambogenic acid (12) [6], from the dry latex of G. hanburyi [10]. The structures were elucidated by spectroscopic analysis and comparison of the NMR spectral data with those reported previously. Cytotoxicity against HeLa and HEL cells of the compounds was reported.

5: \( R_1 = \text{Me}, R_2 = \text{Me} \) (desoxymorellin)

7: \( R_1 = \text{Me}, R_2 = \text{CHO} \) (isomorellin)

8: \( R_1 = \text{CO}_2\text{H}, R_2 = \text{Me} \) (morellic acid)

9: \( R_1 = \text{Me}, R_2 = \text{CO}_2\text{H} \) (isomorellic acid)

18: \( R_1 = \text{CH(OMe)}_2, R_2 = \text{Me} \) (morellin dimethyl acetal)
19: \( R_1 = \text{Me}, R_2 = \text{CHO} \) (isomoreollin B)

20: \( R_1 = \text{CO}_2\text{H}, R_2 = \text{Me} \) (moreollic acid)

14: \( R_1 = \text{CHO}, R_2 = \text{Me} \) (gambogenin)

15: \( R_1 = \text{Me}, R_2 = \text{CHO} \) (isogambogenin)

16: \( R_1 = \text{CO}_2\text{H}, R_2 = \text{Me} \) (gambogenic acid)

17: \( R_1 = \text{Me}, R_2 = \text{CO}_2\text{H} \) (isogambogenic acid)

21: \( R_1 = \text{Me}, R_2 = \text{Me} \) (desoxygambogenin)

22: \( R_1 = \text{CH(OMe)}_2, R_2 = \text{Me} \) (gambogenin dimethyl acetal)
11 (gambogin)

23 (gambogelic acid)

24 (hanburin)
In 2005, Rukachaisirikul et al. reported the isolation of a new caged-tetraprenylated xanthone, hanburinone (25), from the fresh fruits of *G. hanburyi* together with four known xanthones, isomoreollin B (19), morellin (6), moreollic acid (20) and morellic acid (8) [11]. The structures were elucidated by spectroscopic analysis and comparison of their spectral data with those reported previously. Compounds 20 and 8 showed moderately antibacterial activity against methicillin-resistant *Staphylococcus aureus* with a MIC value of 25 \( \mu \text{g/mL} \).

\[ \text{25 (hanburinone)} \]

In 2006, Hong-Xi et al. found two new compounds, gaudichaudic acid (26) and isogambogenic acid (17), and one new natural product, deoxygaudichaudione A (27) [13] from the resin of *G. hanburyi* together with ten known xanthones, gambogoic acid A (28) [12], gambogoic acid B (29) [12], gambogic acid (12), isogambogic acid (13), gambogenic acid (16), desoxygambogenin (21), desoxymorellin (5), morellic acid (8), isomorellic acid (9) and isomorellinol (10) [14]. The structures were elucidated by spectroscopic analysis. Ten of these xanthones were test for cytotoxicity against human leukemia K562 (K562/S) and doxorubicin-resistant K562 (K562/ADR) cell lines.
26 : \( R_1 = \text{CO}_2\text{H}, \ R_2 = \text{Me} \) (gaudichaudic acid)

27 : \( R_1 = \text{Me}, \ R_2 = \text{Me} \) (deoxygaudichaudione A)

28 : \( R = \text{CH}_3 \) (gambogoic acid A)

29 : \( R = \text{CH}_2\text{CH}_3 \) (gambogoic acid B)
In 2006, Xu et al. have set up a recycling counter-current chromatographic system with a high-speed counter-current chromatography instrument, coupled with a column switching valve. This method has been successfully applied in the preparative separation of epimers, gambogic acid (12) and epigambogic acid (12’) from *G. hanburyi* using *n*-hexane/methanol/water as the two-phase solvent system. From 50 mg of the mixture, 28.2 mg gambogic acid and 18.4 mg epigambogic acid were separated and their purities were both above 97% as determined by HPLC. The chemical structures were identified by $^1$H-NMR and $^{13}$C-NMR spectra [15].
In 2000, Rukachaisirikul et al. isolated three new caged-tetraprenylated xanithones, scortechinone A (30), scortechinone B (31) and scortechinone C (32) from the twigs of *G. scortechinii* together with friedelin (33) and stigmasterol (34) [16]. The structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously.

![Molecular structures of 30, 31, 32, 33, 34](image)

- **30** $R = \text{Me}$ (scortechinone A)
- **31** $R = \text{CO}_2\text{H}$ (scortechinone B)
- **32** (scortechinone C)
- **33** (friedelin)
- **34** (stigmasterol)
In 2001, Permana et al. reported the isolation of two new prenylated compounds, the benzoquinone atrovirinone (35) and the depsidone atrovirisidone (36) from the MeOH extract of the roots of G. atroviridis [17]. Their structures were determined on the basis of spectroscopic analysis. Compound 36 showed some cytotoxicity against HeLa cells, and both compounds 35 and 36 were only mildly inhibitory against Bacillus circus and Staphylococcus aureus.

\[
\begin{align*}
\text{35 (atrovirinone)} & \quad \text{36 (atroviridisone)}
\end{align*}
\]

In 2001, Goh et al. isolated a novel degraded and rearranged tetraprenylated xanthone, gaudispirolactone (37) from the bark of G. gaudichaudii together with 7-isoprenylmorellic acid (38) [18]. The structures were elucidated by analysis of spectroscopic data. A plausible biosynthetic route for 37 involving morellic acid, which is the major natural product from the bark, was given.

\[
\begin{align*}
\text{37 (gaudispirolactone)} & \quad \text{38 (7-isoprenylmorellic acid)}
\end{align*}
\]
In 2001, Goh et al. isolated nine new xanthones, parvixanthone A (39), parvixanthone B (40), parvixanthone C (41), parvixanthone D (42), parvixanthone E (43), parvixanthone F (44), parvixanthone G (45), parvixanthone H (46) and parvixanthone I (47) from the dried bark of *G. parvifolia* [19]. The structures were determined on the basis of spectroscopic analysis.
In 2003, Itoigawa et al. studied the chemical constituents of *G. assigu* and isolated two new benzophenones, garcinol 13-\(O\)-methyl ether (48) and isogarcinol 13-\(O\)-methyl ether (49) from the EtOH extract of dried stem bark together with four known benzophenones, clusianone (50), garcinol (51), isogarcinol (52) and maclurin (53) [20]. The structures were elucidated by spectroscopic analysis and comparison of their spectral data with those reported previously. The cyclized polyprenylbenzophenones (48-52) showed stronger potential cancer chemopreventive activity when compared to glycyrrhetinic acid, a known anti-tumor promoter.
51: R = H (garcinol)
48: R = Me (garcinol 13-O-methyl ether)

52: R = H (isogarcinol)
49: R = Me (isogarcinol 13-O-methyl ether)

50 (clusianone)
53 (maclurin)
In 2003, Lajis et al. isolated a new prenylated hydroquinone, 4-methylhydroatrovirinone (54) together with six known compounds, atrovirinone (35), atrovirisidone (36), 14-cis-docosenoic acid (55), morelloflavone (56), morelloflavone 7-O-β-D-glucopyranoside (57) and fukugiside (58) from the MeOH extract of the roots of *G. atroviridis* [21]. The structures were determined on the basis of the analysis of spectroscopic data and mass spectroscopy.
In 2003, Itoigawa et al. investigated the chemical constituents of the stem bark of *G. fusca*, eight new xanthones, fuscaxanthone A (59), fuscaxanthone B (60), fuscaxanthone C (61), fuscaxanthone D (62), fuscaxanthone E (63), fuscaxanthone F (64), fuscaxanthone G (65) and fuscaxanthone H (66) were isolated together with eight known xanthones, cowanin (67), cowanol (68), cowaxanthone (69), rubraxanthone (70), α-mangostin (71), β-mangostin (72), 7-O-methylgarcinone (73) and norcowanin (74) [22]. Their structures were determined on the basis of spectroscopic analysis. A primary screening of eleven xanthones, 64-74, were examined for their possible inhibitory effect on EBV-EA activation.

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59 \quad \text{(fuscaxanthone A)}
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\[
60 \quad \text{(fuscaxanthone B)}
\]

\[
61 : R_1 = \text{---}, R_2 = \text{Me} \quad \text{(fuscaxanthone C)}
\]

\[
62 : R_1 = \text{---OH}, R_2 = \text{H} \quad \text{(fuscaxanthone D)}
\]
63: $R_1 = \text{branch}, R_2 = H$ (fuscaxanthone E)
64: $R_1 = H, R_2 = \text{branch}$ (fuscaxanthone F)
65 (fuscaxanthone G)
66: $R_1 = \text{branch} \text{OH}, R_2 = \text{branch}$ (fuscaxanthone H)
67: $R_1 = \text{branch}, R_2 = \text{branch}$ (cowanin)
68: $R_1 = \text{branch} \text{OH}, R_2 = \text{branch}$ (cowanol)
69: $R_1 = \text{branch} \text{branch}, R_2 = H$ (cowaxanthone)
70: $R_1 = H, R_2 = \text{branch}$ (rubraxanthone)
In 2003, Williams et al. reported the isolation of guttiferone G (75), a new guttiferone analogue from the EtOAc extract of the twigs of *G. macrophylla* together with guttiferone A (76) and friedelin (33) [23]. Their structures were determined on the basis of spectroscopic analysis.
In 2003, Nguyen et al. isolated a new xanthone, merguenone (77) and nine known xanthones, 6-deoxyjacareubin (78), 8-deoxygartanin (79), 1,3,5-trihydroxy-4,8-di(3-methylbut-2-enyl)-xanthone (80), morusignin G (81), rheediachromenoxanthone (82), 1,5-dihydroxy-6’-methyl-6’-(4-methyl-3-pentenyl)-pyran (2’,3’:3,2)-xanthone (83), 6-deoxyisojacareubin (84), rheediaxanthone A (85) and subelliptenone H (86) from a petroleum ether extract of the bark of G. merguensis [24]. Their structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously.

![Chemical structures](image.png)

77 (merguenone)  
78 (6-deoxyjacareubin)

79 : \( R_1 = \text{alkene}, R_2 = \text{H} \) (8-deoxygartanin)

80 : \( R_1 = \text{H}, R_2 = \text{alkene} \) (1,3,5-trihydroxy-4,8-di(3-methylbut-2-enyl)-xanthone)
81 (morusignin G)

82 (rheidiachromenoxanthone)

83 (1,5-dihydroxy-6'-methyl -6'-[(4-methyl-3-pentenyl)-pyrano(2',3':3,2)-xanthone)

84 (6-deoxyisojacareubin)

85 (rheediaxanthone A)

86 (subelliptenone H)
In 2003, Kuo et al. reported the isolation of two new xanthone derivatives, garcinianones A (87) and garcinianones B (88), two new benzophenone derivatives, 4,6,4'-trihydroxy-2,3'-dimethoxy-3-prenylbenzophenone (89) and 4,6,3',4'-tetrahydroxy-2-methoxybenzophenone (90) and a new inseparable mixture of (1E,22Z)-1,22-diferuloyloxydocosane (91) and (1E,24Z)-1,24-diferuloyloxyteracosane (92), together with the previously known 3,8-dihydroxy-2,4,6-trimethoxyxanthone (93), 6,3'-dihydroxy-2,4-dimethoxybenzophenone (94), maclurin (95), 2,4,6,3'-tetrahydroxylbenzophenone (96) and naringenin (97) were isolated from the stems of G. multiflora [25]. The structures were elucidated by a detailed spectroscopic analysis and comparison of their spectral data with those reported previously. The compounds were evaluated in the brine shrimp lethality test and in the DPPH antioxidant assay.

87 (garcinianones A)  
88 (garcinianones B)  
89 (4,6,4'-trihydroxy-2,3'-dimethoxy-3-prenylbenzophenone)
90: $R_1 = \text{OH}, R_2 = \text{Me}, R_3 = \text{H}$ (4,6,3',4'-tetrahydroxy-2-methoxybenzophenone)

94: $R_1 = \text{H}, R_2 = R_3 = \text{Me}$ (6,3'-dihydroxy-2,4-dimethoxybenzophenone)

95: $R_1 = \text{OH}, R_2 = R_3 = \text{H}$ (maclurin)

96: $R_1 = R_2 = R_3 = \text{Me}$ (2,4,6,3'-tetrahydroxybenzophenone)

91: $n = 22$ ((1$E$,22$Z$)-1,22-diferuloyloxydocosane)

92: $n = 24$ ((1$E$,24$Z$)-1,24-diferuloyloxyteracosane)

93 (3,8-dihydroxy-2,4,6-trimethoxyxanthone)

97 (naringenin)
In 2003, Rukachaisirikul et al. isolated nine new xanthones, nigrolineaxanthone A (98), nigrolineaxanthone B (99), nigrolineaxanthone C (100), nigrolineaxanthone D (101), nigrolineaxanthone E (102), nigrolineaxanthone F (103), nigrolineaxanthone G (104), nigrolineaxanthone H (105) and nigrolineaxanthone I (106) together with nine known xanthones, 1,3,5-trihydroxy-4-(3-hydroxy-3-methylbutyl)xanthone (107), 1,3,7-trihydroxy-2-(3-hydroxy-3-methylbutyl)xanthone (108), 6-deoxyjacreubin (78), morusignin C (109), rheediachromenoxanthone (82), tovoxanthone (110), latisxanthone D (111), rheediaxanthone A (85) and brasillixanthone (112) from the methanol extract of the stem bark of *G. nigrolineata* [26]. The structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously. The xanthones isolated from the stem bark were evaluated for antibacterial activity against methicillin-resistant *Staphylococcus aureus*. Compounds 103, 111 and 112 showed significant activity with the MIC value of 2 μg/mL.
99 : $R_1 = H$, $R_2 = \text{Me}$, $R_3 = \text{OH}$ (nigrolineaxanthone B)

111 : $R_1 = \text{OH}$, $R_2 = R_3 = H$ (latisxanthone D)

101 : $R_1 = H$, $R_2 = \text{OH}$ (nigrolineaxanthone D)

108 : $R_1 = \text{OH}$, $R_2 = H$ (1,3,7-trihydroxy-2-(3-hydroxy-3-methylbutyl)xanthone)

103 : $R_1 = R_3 = H$, $R_2 = \text{OH}$ (nigrolineaxanthone F)

109 : $R_1 = R_3 = \text{OH}$, $R_2 = H$ (morusignin C)

110 (tovoxanthone)
102 nigrolineaxanthone E

104 nigrolineaxanthone G

105 nigrolineaxanthone H

106 nigrolineaxanthone I

110 (tovoxanthone)

112 brasillixanthone
In 2003 Rukachaisirikul *et al.* isolated eight new caged-polyrenylated xanthones, scortechinone D (113), scortechinone E (114), scortechinone F (115), scortechinone G (116), scortechinone H (117), scortechinone I (118), scortechinone J (119) and scortechinone K (120) from the latex of *G. scortechinii* [27]. The structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously.
In 2003, Ishibashi, \textit{et al.} reported the isolation of a new prenylated xanthone, 1,3,5,6-tetrahydroxy-4,7,8-tri(3-methyl-2-butenyl)xanthone (121) from the wood of \textit{G. xanthochymus} together with a known xanthone, garciniaxanthone E (122) [28]. The structures were determined by spectroscopic analysis. Compounds 121 (3 mM) and 122 (10 mM) elicited marked enhancement of nerve growth factor-mediated neurite outgrowth in PC12D cells.

\begin{center}
\textbf{121} (1,3,5,6-tetrahydroxy-4,7,8-tri(3-methyl-2-butenyl)xanthone)
\end{center}

\begin{center}
\textbf{122} (garciniaxanthone E)
\end{center}
In 2004, Richomme et al. isolated two xanthones, virgataxanthone A (123) and virgataxanthone B (124), along with two formylated tocotrienols and the known δ-tocotrienol, griffipavixanthone and cotoin from the stem bark of G. virgata [29]. The structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously.

In 2004, Lin et al. reported the isolation of three new phloroglucinols, garcinielliptone K (125), garcinielliptone L (126) and garcinielliptone M (127), and two new terpenoids, garcinielliptone N (128) and garcinielliptone O (129) from the seeds of G. subelliptica [30]. Compounds 126 and 127 showed potent inhibitory effects on the release of β-glucuronidase and histamine, respectively, from peritoneal mast cells stimulated with p-methoxy-N-methylphenethylamine in a concentration-dependent manner and showed potent effects on NO production in culture media of RAW 264.7 cells in response to lipopolysaccharide (LPS).
Compound 126 also showed a potent effect on NO production in culture media of N9 cells in response to LPS/interferon-ε (IFN-ε).

In 2005 a new benzophenone, garcinielliptone FA (130) and a new benzoylphloroglucinol, garcinielliptone FB (131) were isolated from the pericarp of the same plant [31]. Compound 131 exhibited cytotoxic activity against several human cancer cell lines. The structures including their relative configurations were elucidated by spectroscopic methods and supported by computer-generated molecular modeling.

125 (garcinielliptone K)  
126 : R = H (α) (garcinielliptone L)  
127 : R = H (β) (garcinielliptone M)  
128 : R = H (garcinielliptone N)  
129 : R = CO₂CH₃ (garcinielliptone O)
In 2005, Mahabusarakam et al. isolated five new xanthones, cowagarcinone A (132), cowagarcinone B (133), cowagarcinone C (134), cowagarcinone D (135) and cowagarcinone E (136) from the acetone extract of the latex of *G. cowa* Roxb together with six known xanthones, cowanin (67), cowanol (68), cowaxanthone (69) and 1,3,6-trihydroxy-7-methoxy-2,5-bis(3-methyl-2-butenyl)xanthone (137), mangostinone (138) and fuscaxanthone A (59) [32]. The structures were elucidated by a detailed spectroscopic analysis and comparison of their spectral data with those reported previously. The crude latex and the isolated compounds were investigated for their radical scavenging activities.
132 (cowagarcinone A)

133: $R_1 = H, R_2 = OCH_3$ (cowagarcinone B)

134: $R_1 = OCH_3, R_2 = H$ (cowagarcinone C)

135 (cowagarcinone D)

136 (cowagarcinone E)

137 (1,3,6-trihydroxy-7-methoxy-2,5-bis(3-methyl-2-butenyl)xanthone)

138 (mangostinone)
In 2005, Mahabusarakam et al. reported the isolation and structural elucidation of dulcinoside (139), dulcisisoflavone (140), dulcisxanthone A (141) and sphaerobioside acetate (142) together with 22 known compounds from the green fruit of *G. dulcis*. Dulcisflavan (143), dulcisxanthone B (144) and isonormangostin (145) together with 22 known compounds were isolated from the ripe fruit of the same plant [33]. The structures were elucidated by a detailed spectroscopic analysis and comparison of their spectral data with those reported previously. The radical scavenging and antibacterial activities of some of the compounds were investigated.
In 2005, Rukachaisirikul et al. reported the isolation of one new benzopyran, nigrolineabenzopyran A (146), two new biphenyls, nigrolineabiphenyl A (147) and nigrolineabiphenyl B (148), and four new tetraoxygenated xanthones, nigrolineaxanthone T (149), nigrolineaxanthone U (150), nigrolineaxanthone V (151) and nigrolineaxanthone W (152) from the methanol extract of the twigs of *G. nigrolineata* along with eleven known xanthones [34]. Their structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously. The xanthones isolated from the twig as well as those from the stem bark were evaluated for antibacterial activity against methicilin-resistant *Staphylococcus aureus*. 
146 (nigrolineabenzopyran A)

147 : R = OH  (nigrolineabiphenyl A)

148 : R = OMe  (nigrolineabiphenyl B)

149 : R₁ = H, R₂ = OH, R₃ = R₄ = OMe  (nigrolineaxanthone T)

150 : R₁ = R₄ = OH, R₂ = H, R₃ = R₄ = OH  (nigrolineaxanthone U)

151 (nigrolineaxanthone V)

152 (nigrolineaxanthone W)
In 2005, Lannang et al. isolated two xanthones, bangangxanthone A (153) and bangangxanthone B (154), along with two known xanthones, 1,5-dihydroxyxanthone (155), 2-hydroxy-1,7-dimethoxyxanthone (156) and the pentacyclic triterpenoids, friedelin (33), oleanolic acid and lupeol from the chloroform extract of the stem bark of *G. polyantha* [35]. Their structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously. Compound 153-156 showed antioxidant DPPH radical scavenging activity.
In 2005, Rukachaisirikul et al. reported the isolation of ten new compounds, eight caged-tetraprenylated xanthones, scortechinone Q (157), scortechinone R (158), scortechinone S (159), scortechinone T (160), scortechinone U (161), scortechinone V (162), scortechinone W (163) and scortechinone X (164), and two sesquiterpene derivatives, scortechterpene A (165) and scortechterpene B (166), together with fourteen known compounds from the fruits of *G. scortechinii* [36]. Their structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously. All xanthone derivatives were evaluated for antibacterial activity against methicillin-resistant *Staphylococcus aureus*.

![Chemical structures](image)

157 (scortechinone Q)  
158 (scortechinone R)

159: $R_1 = \text{OH}, R_2 = \text{OMe}, R_3 = \text{CO}_2\text{H}$ (scortechinone S)  
160: $R_1 = \text{OH}, R_2 = \text{OMe}, R_3 = \text{CHO}$ (scortechinone T)
161 (scortechinone U)  
162 (scortechinone V)  
163 (scortechinone W)  
164 (scortechinone X)  
165 (scortechterpene A)  
166 (scortechterpene B)
In 2006, Waffo et al. isolated two new prenylated xanthones, afzeliixanthones A (167) and afzeliixanthones B (168), together with three known xanthones, 1,5-dihydroxyxanthone (155), 1,7-dihydroxyxanthone (169) and 1,3,7-trihydroxy-2-(3-methylbut-2-enyl) xanthone (170) and two phytosterols, β-sitosterol (171) and stigmasterol (34) from the CH$_2$Cl$_2$/MeOH extract of the stem bark of G. afzelii [37]. The structures were established using one and two-dimensional NMR and mass spectroscopy. The antioxidant activities of the crude extracts as well as of the new compounds 167 and 168 were evaluated.
In 2006, Panthong et al. isolated five new tetraoxygenated xanthones, cowaxanthones A (172), cowaxanthones B (173), cowaxanthones C (174), cowaxanthones D (175) and cowaxanthones E (176), together with 10 previously reported tetraoxygenated xanthones, 1,6-dihydroxy-3,7-dimethoxy-2-(3-methyl-2-buteryl)xanthone (177), 7-O-methylgarcinone E (178), mangostanin (179), 6-O-methylmangostanin (180), fuscaxanthone C (61), cowaxanthone (69), cowanin (67), cowanol (68), α-mangostin (71) and β-mangostin (72) from the hexane extract of the fruits of *G. cowa* [38]. Two new xanthones, 1,5,6-trihydroxy-3-methoxy-4-(3-hydroxyl-3-methylbutyl)xanthone (181) and 1,5-dihydroxy-3-methoxy-6′,6′-dimethyl-2H-pyrano(2′,3′:6,7)-4-(3-methylbut-2-enyl)xanthone (182), were isolated together with six known xanthones, 1,3,5-trihydroxy-6′,6′-dimethyl-2H-pyrano(2′,3′:6,7) xanthone (183), dulxanthone A (184), 1,5,6-trihydroxy-3,7-dimethoxyxanthone (185), 1,7-dihydroxyxanthone (186), 1,3,5-trihydroxy-6-methoxyxanthone (187) and 1,3,6,7-tetra-hydroxyxanthone (188) from the 95% EtOH extract of the stems of *G. cowa* by Yang et al. [39]. Their structures were elucidated by analysis of spectroscopic data and comparison of the NMR data with those reported previously.
172 : $R_1 = \text{OMe}, R_2 = \text{H}$ (cowaxanthone A)

177 : $R_1 = \text{H}, R_2 = \text{OMe}$ (1,6-dihydroxy-3,7-dimethoxy-2-(3-methyl-2-butenyl)xanthone)

173 : $R_1 = \text{OH}, R_2 = \text{H}, R_3 = R_4 = \text{OMe}$ (cowaxanthone B)

178 : $R_1 = R_3 = \text{OH}, R_2 = \text{H}, R_4 = \text{OMe}$ (7-O-methylgarcinone E)

174 : $R_1 = \text{H}, R_2 = \text{OH}$ (cowaxanthone C)

179 : $R_1 = \text{H}, R_2 = \text{OH}$ (mangostanin)

180 : $R_1 = \text{H}, R_2 = \text{OMe}$ (6-O-methylmangostanin)
175 (cowaxanthone D)

176 (cowaxanthone E)

184 : $R = \frac{3}{2}$ (dulxanthone A)

181 : $R = \frac{3}{2}$ (1,5,6-trihydroxy-3-methoxy-4-(3-hydroxyl-3-methylbutyl) xanthone)

182 : $R_1 = \text{OMe}, R_2 = \frac{3}{2}$ (1,5-dihydroxy-3-methoxy-6',6'-dimethyl-2H-pyran (2',3':6,7)-4-(3-methylbut-2-enyl)xanthone)

183 : $R_1 = \text{OH}, R_2 = \text{H}$ (1,3,5-trihydroxy-6',6'-dimethyl-2H-pyran(2',3':6,7) xanthone)
In 2006, Mahabusarakam et al. reported the isolation and structural of five new xanthones, dulcisxanthone C (189), dulcisxanthone D (190), dulcisxanthone E (191), dulcisxanthone F (192) and dulcinone (193) together with 22 known compounds from the acetone extract of the flowers of *G. dulcis* [40]. Their structures were elucidated by analysis of spectroscopic data. The radical scavenging and antibacterial activities of some of the compounds were investigated.
191 (dulcisxanthone E)

192 (dulcisxanthone F)

193 (dulcinone)