LJMU Research Online

Salleh, WMNHW, On, S, Ahmad, F, Sirat, HM, Taher, M, Sarker, SD and Nahar, L

A new xanthone and a new benzophenone from the roots of Garcinia hombroniana

http://researchonline.ljmu.ac.uk/id/eprint/11954/

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

Salleh, WMNHW, On, S, Ahmad, F, Sirat, HM, Taher, M, Sarker, SD and Nahar, L (2019) A new xanthone and a new benzophenone from the roots of Garcinia hombroniana. Phytochemistry Letters, 35. pp. 216-219. ISSN 1874-3900

A new xanthone and a new benzophenone from the roots of *Garcinia hombroniana*

Wan Mohd Nuzul Hakimi Wan Salleh[a], Shamsul On[b,c,], Farediah Ahmad[b], Hasnah Mohd Sirat[b], Muhammad Taher[d], Satyajit Dey Sarker[e], Lutfun Nahar[e.f]

[a] Department of Chemistry, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris (UPSI), 35900 Tanjong Malim, Perak, Malaysia

[b] Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia (UTM), 81310 Skudai, Johor, Malaysia

[c] Faculty of Applied Sciences, Universiti Teknologi MARA, Pasir Gudang Campus, Jalan Purnama, Bandar Seri Alam, 81750 Masai, Johor, Malaysia

[d] Kulliyah of Pharmacy, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia

[e] Centre for Natural Products Discovery (CNPD), School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, James Parsons Building, Byrom Street, Liverpool L3 3AF, United Kingdom

[f] Laboratory of Growth Regulators, Institute of Experimental Botany ASCR & Palacký University, Šlechtitelů 27, 78371 Olomouc, Czech Republic

*Corresponding author.

E-mail addresses: wmnhakimi@fsmt.upsi.edu.my (W.M.N.H.W. Salleh)

ABSTRACT

In this study, the roots of *Garcinia hombroniana* were chemically investigated, in which novel derivatives of xanthone and benzophenone, known as garcihomxanthone (**1**) and garcihombrianone (**2**), respectively, together with garceduxanthone (**3**), cheffouxanthone (**4**), norathyriol (**5**), and 2,3′,4,5′-tetrahydroxy-6-methoxybenzophenone (**6**) were isolated.. The structures of these compounds were elucidated by extensive spectroscopic techniques and evaluated based on references with previous literature data.

Keywords:
Garcinia hombroniana
Clusiaceae
Xanthone
Benzophenone
Garcihomxanthone
Garcihombrianone

1. Introduction

The genus *Garcinia* (Clusiaceae) is distributed in tropical and subtropical countries of South East Asia, West and East Africa as well as in Central and South America. It comprises over 400 species in Asia, in which 49 species have been identified in Malaysia (Whitmore, 1973; Li et al., 1990). The chemical analyses of *Garcinia* species revealed the presence of bioactive molecules such as xanthones, benzophenones, biflavonoids, and triterpenoids (Muriithi et al., 2016; Thepthong et al., 2017; Salleh et al., 2017; Abdullah et al., 2018; Ibrahim et al., 2018;), which were previously shown to possess antioxidant as well as antibacterial, antimalarial, anti-inflammatory, and cytotoxic activities (Seruji et al., 2013; Oluwatosin et al., 2014; Dzoyem et al., 2015; Pailee et al., 2017; Tian et al., 2017).

Garcinia hombroniana Pierre is a small evergreen tree commonly known as '*seashore mangosteen*', which is native to the tropical rainforests in Southeast Asian countries such as Vietnam, Cambodia, Malaysia and Thailand (Lim, 2012). The root is widely used in folk medicine as an anti-infective agent after birth and to relieve itchiness. Besides, the ethanolic extracts of this species have been shown to exhibit cytotoxicity, antitrypanosomal, antioxidation and antiplatelet aggregation activities (Saputri and Jantan, 2012; Dyary et al., 2015; Jamila et al., 2017). Although phytochemical analyses were performed on the pericarp, leaves, and twigs of *G. hombroniana* yielding compounds such as lanostanes, friedolanostanes, xanthones, biflavonoids and triterpenes (Klaiklay et al., 2013; Jamila et al., 2014a, 2014b, 2016), no phytochemical investigation has ever been performed on the roots of the *G. hombroniana*. Thus, as a continuation of the phytochemical studies on this species (On et al., 2017; Salleh et al., 2017), we now report on the isolation and identification of novel derivatives of xanthone and benzophenone, known as garcihomxanthone (**1**) and garcihombrianone (**2**), (**Figure 1**), respectively, from the roots of *G. hombroniana*.

2. Results and discussion

Compound **1** was obtained as yellow needles and the HREIMS spectrum revealed a molecular ion peak at *m/z* 342.2212 (calculated as *m/z* 342.2215) with the molecular formula deduced as $C_{19}H_{18}O_6$. The IR spectrum showed the presence of absorption bands at 3297 cm^{-1}, 1627 cm^{-1}, 1603 cm^{-1}, 1583 cm^{-1}, and 1552 cm^{-1} assigned to hydroxyl, carbonyl group, conjugated double bonds, and aromatic functional groups, respectively. The NMR spectral data for compound **1** are listed in **Table 1**. The ^1H NMR spectrum exhibited signals characteristic for the 1,1-dimethylprop-2-enyl group, which was represented by a singlet of six protons at δ_H 1.61 assigned to methyl groups, H-4′ and H-5′. In addition, mutually coupled vinylic protons were observed as two doublets of doublets at δ_H 5.10 (J = 10.8 and 1.2 Hz) and δ_H 5.29 (J = 17.6 and 1.2 Hz) assigned to H-3′α and H-3′β, respectively. Similarly, another doublet of doublets signal of one proton was observed at δ_H 7.03 (J = 17.6 and 10.4 Hz) and assigned to H-2′, while a singlet signal at δ_H 6.40 was assigned to the aromatic proton of H-2. The spectrum also revealed the presence of a methoxy group which was indicated by a singlet at δ_H 3.89. Besides, an AB pattern was observed with J values of 8.5 Hz at δ_H 6.70 and 6.71, respectively, which were assigned to *ortho*-coupled aromatic protons, H-6 and H-5. Two singlets with one proton each resonated at δ_H 7.12 and 7.28 and were assigned to two hydroxyl groups at C-7 and C-3, respectively. The deshielded singlet signal at δ_H 10.75 was attributed to the chelated hydroxyl group, 1-OH. The COSY spectrum of compound **1** supported the couplings between the protons in the structure. The signal of H-2′ at δ_H 7.03 was coupled with H-3′α (δ_H 5.10) and H-3′β (δ_H 5.24). The presence of cross-peaks validated the assignments between H-5 (δ_H 6.71) and H-6 (δ_H 6.70) as *ortho*-coupled protons. The ^{13}C NMR and DEPT spectra revealed eighteen peaks attributable to nineteen carbons in the structure. These peaks were characterised as a carbonyl, three methyl, one methylene, four methine, and ten quaternary carbons. The HMQC spectrum further confirmed the direct attachment between the protons and carbons as indicated by the cross-peaks between H-4′/H-5′ (δ_H 1.61) with C-4′/C-5′ (δ_C 26.3), H-3′α/H-3′β (δ_H 5.10/5.29) with C-3′ (δ_C 103.7), H-2′ (δ_H 7.03) with C-2′ (δ_C 155.5), H-2 (δ_H 6.40) with C-2 (δ_C 97.6), H-5 (δ_H 6.71) with C-5 (δ_C 111.6), and H-6 (δ_H 6.70) with C-6 (δ_C 110.8). The HMBC spectrum supported the correlation between the protons and carbons, in which the side chain 1,1-dimethylprop-2-enyl was substituted at C-4 by exhibiting long-range correlations between H-4′ and H-5′ with C-4 (δ_C 119.3). Additionally, both methyl protons, H-4′ and H-5′, showed a correlation with C-2′ (δ_C 155.5), while the aromatic proton, H-2 (δ_H 6.40), showed long-range correlations with C-9a (δ_C 99.5) and C-4 (δ_C 119.3). The placement of the methoxy group was also confirmed by the correlation of its proton (δ_H 3.89) with C-8 (δ_C 165.4). Likewise, the aromatic proton, H-6 (δ_H 6.70) showed correlations with C-10a (δ_C 142.9) and C-8 (δ_C 165.4), whereas H-5 (δ_H 6.71) was correlated with C-7 (δ_C 137.3) and C-8a (δ_C 135.7). A summary of these correlations is shown in **Figure 2**. Based on the data obtained from the detailed spectral analyses, compound **1** was determined as a new derivative of xanthone, identified as 1,3,7-trihydroxy-4-(1,1-dimethylprop-2-enyl)-8-methoxyxanthone, and given the trivial name,garcihomxanthone.

Compound **2** was also obtained as yellow needles and its molecular formula, $C_{20}H_{14}O_8$, was determined from the HREIMS spectrum, which revealed a corresponding molecular ion peak at *m/z* 382.1258 (calculated as *m/z* 382.1254). The IR spectrum exhibited the presence of hydroxyl, carbonyl, and aromatic functional groups at 3250 cm^{-1}, 1676 cm^{-1}, 1579 cm^{-1}, and 1470 cm^{-1}, respectively. The NMR spectral data of compound **2** are tabulated in **Table 2**. The ^1H NMR spectrum showed two singlets integrated for each proton at δ_H 5.97 and 5.98, which were assigned to H-6 and H-3, respectively. Signals representing the symmetrical resorcinol in the system were observed as an A_2B spin system at δ_H 6.60 (d, *J* = 2.4 Hz) and δ_H 6.48 (t, *J* = 2.4 Hz) which were assigned to H-2′/H-6′ and H-4′, respectively. The spectrum also displayed the presence of an ABX coupling system as indicated by signals representing a doublet of doublets at δ_H 7.17 (*J* = 8.0 and 2.4 Hz, H-6″) as well as a doublet at δ_H 6.86 (*J* = 8.0 Hz, H-5″) and δ_H 7.25 (*J* = 2.4 Hz, H-2″). In addition, three broad singlets with two protons each, were resonated at δ_H 8.62, 10.14, and 10.42, respectively, and assigned to six hydroxyl groups at C-4″/C-3″, C-3′/C-5′, and C-5/C-2. The COSY spectrum supported the couplings between the protons in the structure. The signal observed for H-4′ at δ_H 6.48 was coupled with H-2′/H-6′ (δ_H 6.60), while the signal of the proton, H-5″ (δ_H 6.86), showed a cross-peak with H-6″ (δ_H 7.17) which was also found to be coupled with H-2″ (δ_H 7.25). Analysis of the ^{13}C NMR, DEPT and HMQC spectra revealed the presence of eight methine carbons which resonated at δ_C 95.0 (C-3), 105.2 (C-4′), 106.4 (C-2′/C-6′), 114.1 (C-5″), 116.2 (C-2″), and 122.5 (C-6″), ten quaternary carbons at δ_C 132.9 (C-1″), 144.2 (C-3″), 149.1 (C-4″), 143.7 (C-1′), 158.0 (C-3′/C-5′), 161.8 (C-1), 162.8 (C-4), 163.5 (C-5), and 164.4 (C-2), and two carbonyl groups at δ_C 197.0 and 198.7. Moreover, the HMBC spectrum showed long-range correlations between H-6 (δ_H 5.97) with C-4 (δ_C 162.8) and C-2 (δ_C 164.4), while H-3 (δ_H 5.98) displayed correlations with C-1 (δ_C 161.8) and C-5 (δ_C 163.5). Cross-peaks were also observed between H-4′ (δ_H 6.48) with C-2′ (δ_C 106.4) and H-2′/H-6′ (δ_H 6.60) with carbonyl carbon (δ_C 198.7) and the neighbouring carbons. Besides, correlations were observed between H-5″ (δ_H 6.86) with C-1″ (δ_C 132.9) and C-3″ (δ_C 144.2), while H-6″ (δ_H 7.17) showed cross-peaks with carbonyl carbon (δ_C 197.0), C-4″ (δ_C 149.1), and C-2″ (δ_C 116.2). In addition, H-2″ (δ_H 7.25) showed correlations with carbonyl carbon (δ_C 197.0) and C-4″ (δ_C 149.1). The HMBC connectivities are summarised in **Figure 2**. Based on the data obtained in this study, the structure of compound **2** was established as [4-(3′,5′-dihydroxybenzoyl)-2,5-dihydroxyphenyl]-(3″,4″-dihydroxyphenyl)methanone, and given the trivial name, garcihombrianone.

In addition to the these new compounds, several other known compounds including garceduxanthone (**3**) (Zakaria et al., 2006), cheffouxanthone (**4**) (Vanessa et al., 2012), norathyriol (**5**) (Chappell, 1995) and 2,3′,4,5′-tetrahydroxy-6-methoxybenzophenone (**6**) (Ran et al., 2004) were identified based on the comparison of their spectroscopic data with respective published data. Based on the NMR data, the purity of all the isolated compounds was well over 90%.

3. Experimental

3.1. General experimental procedures

Mass spectra measurements were performed on a Agilent Technologies 6530 accurate-mass e-TOF LC/MS, with a ZORBAX Eclipse XDB-CI8 rapid resolution HT (4.6 mm×50 mm×1.8 mm column) and electron impact ionization set at 70 eV. The UV spectra were recorded using a Shimadzu UV 1601PC spectrophotometer. Melting points were determined using a Leica Gallen III hot-stage melting point apparatus and were reported uncorrected. The IR spectra were recorded on a Perkin-Elmer 1600 FTIR spectrophotometer. The 1D and 2D NMR spectra were recorded in deuterated acetone-d_6 on a Bruker Avance 400 MHz spectrometer, in which chemical shifts (δ) were reported in ppm on δ scale and the coupling constants (J) were measured in Hz. Merck silica gels were used for vacuum liquid chromatography (VLC) (230-400 mesh) and column chromatography (CC) (70-230 mesh). Thin-layer chromatography (TLC) aluminium sheets pre-coated with silica gel 60 F_{254} (0.2 mm thickness) were used to detect and monitor components present in the crude samples or fractions. The TLC plates were sprayed with 5% H_2SO_4 and 1% vanillin in MeOH, and heated at 120°C for 5 min, prior to the visualisation of spots under UV light (254 and 366 nm). All solvents were of analytical grade.

3.2. Plant material

The roots of *Garcinia hombroniana* Pierre was collected from Kuantan, Pahang, Malaysia in November 2009. The species was identified by Muhammad Taher from the International Islamic University Malaysia (IIUM) and the voucher specimen (MT20) deposited at the Herbarium of Kulliyyah of Pharmacy, IIUM.

3.3. Extraction and isolation

The dried and powdered roots of *G. hombroniana* (200 g) were sequentially extracted using Soxhlet extraction for 18 hours with *n*-hexane (2.5 L) and acetone (2.5 L) at room temperature. The extracts were concentrated under reduced pressure to produce *n*-hexane (3.12 g) (GHRH) and acetone (4.86 g) (GHRA) extracts, which were observed as a gummy dark brown liquid. The *n*-hexane extract (GHRH, 3.12 g) was subjected to silica gel VLC (*n*-hexane: $CHCl_3$: EtOAc), in which nine fractions were obtained. Each fraction was subjected to TLC analysis. Fractions with similar patterns observed on TLC were combined to produce four major fractions: GHRH1 (0.15 g), GHRH2 (0.35 g), GHRH3 (0.17 g), and GHRH4 (0.43 g). Fraction GHRH2 (0.35 g), and GHRH4 (0.43 g) were further subjected to silica gel CC (150 g; *n*-hexane: $CHCl_3$) to produce garceduxanthone (**3**) (5.6 mg) (yellow spot; R_f 0.32; *n*-hexane: EtOAc, 6:4) and cheffouxanthone (**4**) (6.7 mg) (orange spot; R_f 0.40; *n*-hexane: EtOAc, 4:6), respectively, which were both obtained as yellow needles. The acetone extract of the roots of *G. hombroniana* was subjected to silica gel VLC (200 g, *n*-hexane: $CHCl_3$: EtOAc), in which eight fractions were obtained and subjected to TLC analysis. Similarly, as performed for *n*-hexane extracts, fractions with similar patterns on the TLC plate were combined to produce four major fractions: GHRA1 (0.21 g), GHRA2 (0.25 g), GHRA3 (0.35 g), and GHRA4 (0.57 g). Fraction GHRA3 (0.35 g) was subjected to silica gel CC (*n*-hexane:$CHCl_3$) to produce norathyriol (**5**) (4.2 mg) (yellow spot; R_f 0.50; *n*-hexane: EtOAc, 3:7), which was obtained as yellow needles, while fraction GHRA2 (0.25 g) was subjected to silica gel CC (150 g, *n*-hexane:$CHCl_3$) to produce 2,3′,4,5′-tetrahydroxy-6-methoxybenzophenone (**6**) (7.4 mg) (orange spot; R_f 0.45; *n*-hexane: EtOAc, 4:6), which was obtained as pale yellow needles. Fractions GHRA4 (0.57 g) and GHRA1 (0.21 g) were subjected to silica gel CC (150 g, *n*-hexane: $CHCl_3$) to produce compound (**1**) (5.7 mg) and compound (**2**) (5.3 mg), respectively, which were obtained as yellow needles.

Garcihomxanthone (**1**): yellow needles, m.p 152-154°C; R_f 0.52 (yellow spot; *n*-hexane: EtOAc, 6:4); IR (KBr): 3297, 1627, 1603, 1583, 1552 cm^{-1}; UV_{max} (MeOH) nm (log ε) 220 (4.50), 258 (5.70), 275 (4,15), 342 (2.14); HREIMS *m/z* 342.2212 (calculated 342.2215 for $C_{19}H_{18}O_6$); ^1H NMR (CD_3COCD_3, 400 MHz) and ^{13}C NMR (CD_3COCD_3, 100 MHz) data see **Table 1**.

Garcihombrianone (**2**): yellow needles, m.p 170-174°C; R_f 0.25 (yellow spot *n*-hexane: EtOAc, 4:6); IR (KBr): 3250, 1676, 1579, 1470 cm^{-1}; UV_{max} (MeOH) nm (log ε) 220 (3.75), 230 (4.12), 304 (4.35); HREIMS *m/z* 382.1258 (calculated 382.1254 for $C_{20}H_{14}O_8$); ^1H NMR (CD_3COCD_3, 400 MHz) and ^{13}C NMR (CD_3COCD_3, 100 MHz) data see **Table 2**.

4. Conclusion

In the present study, the isolation and chemical characterization of a new xanthone (**1**) and a new benzophenone (**2**) from the roots of *G. hombroniana* were achieved. The structures of these isolates were accomplished using comprehensive spectroscopic means. Various xanthones and benzophenones have previously been reported from other *Garcinia* species, and the current findings expand and reinforce the existence of chemical diversity in the genus *Garcinia*. The presence of xanthones and benzophenones in the genus *Garcinia* might have some chemotaxonomic implications.

Appendix A. Supplementary data

Supplementary data including 1D/2D NMR, IR, and MS for compound (**1-2**) are available as supporting information.

Acknowledgements

The authors thank the Research University Grant (GUP) for financial support under vote Q.J130000.2526.03H93 and the Faculty of Science, Universiti Teknologi Malaysia for research facilities. L Nahar gratefully acknowledges the financial support of the European Regional Development Fund - Project ENOCH (No. CZ.02.1.01/0.0/0.0/16_019/0000868)

References

Abdullah, I., Phongpaichit, S., Voravuthikunchai, S.P., Mahabusarakam, W. 2018. Prenylated biflavonoids from the green branches of *Garcinia dulcis*. Phytochem. Lett. 23, 176-179.

Chappell, J., 1995. The biochemistry and molecular biology of isoprenoid metabolism. Plant Physiol. 107, 1-6.

Dyary, H.O., Arifah, A.K., Sharma, R.S., Rasedee, A., Mohd Aspollah, M.S., Zakaria, Z.A., Zuraini, A., Somchit, M.N. 2015. *In vivo* antitrypanosomal activity of *Garcinia hombroniana* aqueous extract. Res. Vet. Sci. 100, 226-231.

Dzoyem, J.P., Lannang, A.M., Fouotsa, H., Mbazoa, C.D., Nkengfack, A.E., Sewald, N., Eloff, J.N. 2015. Anti-inflammatory activity of benzophenone and xanthone derivatives isolated from *Garcinia* (Clusiaceae) species. Phytochem. Lett. 14, 153-158.

Ibrahim, S.R.M., Abdallah, H.M., El-Halawany, A.M., Radwan, M.F., Shehata, I.A., Al-Harshany, E.M., Zayed, M.F., Mohamed, G.A. 2018. Garcixanthones B and C, new xanthones from the pericarps of *Garcinia mangostana* and their cytotoxic activity. Phytochem. Lett. 25, 12-16.

Jamila, N., Khairuddean, M., Yaacob, N.S., Kamal, N.N., Osman, H., Khan, S.N., Khan, N., 2014a. Cytotoxic benzophenone and triterpene from *Garcinia hombroniana*. Bioorg. Chem. 54, 60-67.

Jamila, N., Khairuddean, M., Khan, S.N., Khan, N. 2014b. Complete NMR assignments of bioactive rotameric ($3 \rightarrow 8$) biflavonoids from the bark of *Garcinia hombroniana*. Magn. Reson. Chem. 52(7), 345-352.

Jamila, N., Khan, N., Khan, I., Khan, A.A., Khan, S.N. 2016. A bioactive cycloartane triterpene from *Garcinia hombroniana*. Nat. Prod. Res. 30(12), 1388-1389.

Jamila, N., Khan, N., Khan, A.A., Khan, I., Khan, S.N., Zakaria, Z.A., Khairuddean, M., Osman, H., Kim, K.S. 2017. In vivo carbon tetrachloride-induced hepatoprotective and in vitro cytotoxic activities of *Garcinia hombroniana* (seashore mangosteen). Afr. J. Tradit. Complement. Altern. Med. 14(2), 374-382.

Klaiklay, S., Sukpondma, Y., Rukachaisirikul, V., Phongpaichit, S. 2013. Friedolanostanes and xanthones from the twigs of *Garcinia hombroniana*. Phytochemistry 85, 161-166.

Li, X., Li, J., Norman, K.B.R., Peter F.S. 1990. Flora of China. Missouri Botanical Garden Press, St. Louis, and Science Press Beijing.

Lim, T.K. 2012. Edible Medicinal and Non-Medicinal Plants, Vol.2, Springer, Netherlands.

Muriithi, E., Bojase-Moleta, G., Majinda, R.R.T. 2016. Benzophenone derivatives from *Garcinia livingstonei* and their antioxidant activities. Phytochem. Lett. 18, 29-34.

Oluwatosin, A., Tolulope, A., Ayokulehin, K., Patricia, O., Aderemi, K., Catherine, F., Olusegun, A. 2014. Antimalarial potential of kolaviron, a biflavonoid from *Garcinia kola* seeds, against *Plasmodium berghei* infection in Swiss albino mice. Asian Pac. J. Trop. Med. 1, 97-104.

On, S., Salleh, W.M.N.H.W., Ahmad, F., Sirat, H.M., Taher, M. 2017. Cytotoxicity of triterpenes from the leaves of *Garcinia prainiana* King (Guttiferae). Marmara Pharm. J. 21(1), 127-131.

Pailee, P., Kruahong, T., Hongthong, S., Kuhakarn, C., Jaipetch, T., Pohmakotr, M., Jariyawat, S., Suksen, K., Akkarawongsapat, R., Limthongkul, J., Panthonge A., Kongsaeree, P., Prabpai, S., Tuchinda, P., Reutrakula, V. 2017. Cytotoxic, anti-HIV-1 and anti-inflammatory activities of lanostanes from fruits of *Garcinia speciosa*. Phytochem. Lett. 20, 111-118.

Ran, X., Gia, C.F., Seiichi, P.T.M., 2004. On the origins of triterpenoid skeletal diversity. Phytochemistry 65, 261-291.

Salleh, W.M.N.H.W., Sazali, N.S.A.N., Ahmad, F. 2017. Biflavonoids from the leaves and stem bark of *Garcinia griffithii* and their biological activities. Marmara Pharm. J. 21(4), 889-897.

Saputri, F.C., Jantan, I. 2012. Inhibitory activities of compounds from the twigs of *Garcinia hombroniana* Pierre on human low-density lipoprotein (LDL) oxidation and platelet aggregation. Phytother. Res. 26(12), 1845-1850.

Seruji, N.M.U., Khong, H.Y., Kutoi, C.J. 2013. Antioxidant, anti-Inflammatory, and cytotoxic activities of *Garcinia nervosa* (Clusiaceae). J. Chem. 913406, 1-5.

Thepthong, P., Phongpaichit, S., Carroll, A.R., Voravuthikunchai, S.P., Mahabusarakam, W. 2017. Prenylated xanthones from the stem bark of *Garcinia dulcis*. Phytochem. Lett. 21, 32-37.

Tian, D.S., Gu, W., Wang, L.P., Huang, L.J., Rao, Q., Huang, T., Fu, Y.H., Zhang, J.X., Yuan, C.M., Hao, X.J. 2017. Cytotoxic and anti-oxidant biphenyl derivatives from the leaves and twigs of *Garcinia multiflora*. Phytochem. Lett. 19, 132-135.

Vanessa, S.G., Thiago, C.S., Isael, A.R., Marisi, G.S., Marcelo, A.S., Wagner, V., Cláudio, V.J., Marcelo, H.S., 2012. Isolation and evaluation of the antioxidant activity of phenolic constituents of the *Garcinia brasiliensis* epicarp. Food Chem. 132, 1230-1235.

Whitmore, T.C. 1973. Tree Flora of Malaya 2: A Manual for Foresters. Longman Malaysia, Kuala Lumpur.

Zakaria, H., Mbwambo, M.C., Kapingu, M.J., Moshi, F.M., Sandra, A., Paul, C., Daneel, F., Jannie, P.J.M., Dirk, V., Louis, M., Arnold, V., Luc, P., 2006. Antiparasitic activity of some xanthones and biflavonoids from the root bark of *Garcinia livingstonei*. J. Nat. Prod. 69, 369-372.

Table 1.

NMR spectral data of compound **1**

Table 2.

NMR spectral data of compound **2**

Figure 1. Chemical structures of the isolated compounds (**1-6**)

Figure 2. Selected HMBC correlations of compounds (**1-2**)

Table 1

No.	δ_H (m, *J* in Hz)	δ_C
1	-	164.0
2	6.40 (s)	97.6
3	-	137.9
4	-	119.3
4a	-	158.6
5	6.70 (d, 8.5)	111.6
6	6.71 (d, 8.5)	110.8
7	-	137.3
8	-	165.4
8a	-	135.7
9	-	168.6
9a	-	99.5
10a	-	142.9
1′	-	41.6
2′	7.03 (dd, 17.6, 10.4)	155.5
3′α	5.10 (dd, 10.8, 1.2)	103.7
3′β	5.29 (dd, 17.6, 1.2)	
4′	1.61 (s)	26.3
5′	1.61 (s)	26.3
1-OH	10.75 (s)	-
3-OH	7.28 (s)	-
7-OH	7.12 (s)	-
8-OCH_3	3.89 (s)	55.6

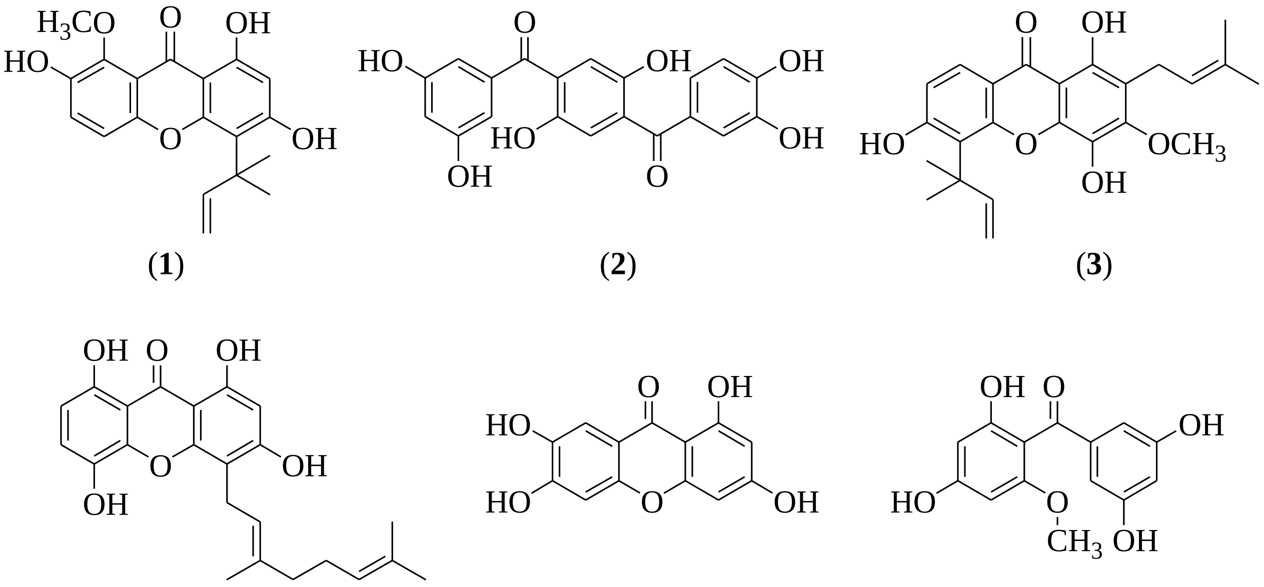
^{1}H (400 MHz) and ^{13}C (100 MHz) in CD_3COCD_3

Table 2

No.	δ_H (m, *J* in Hz)	δ_C
1	-	161.8
2	-	164.4
3	5.98 (s)	95.0
4	-	162.8
5	-	163.5
6	5.97 (s)	95.0
1′	-	143.7
2′	6.60 (d, 2.4)	106.4
3′	-	158.0
4′	6.48 (t, 2.4)	105.2
5′	-	158.0
6′	6.60 (d, 2.4)	106.4
1″	-	132.9
2″	7.25 (d, 2.4)	116.2
3″	-	144.2
4″	-	149.1
5″	6.86 (d, 8.0)	114.1
6″	7.17 (dd, 8.0, 2.4)	122.5
C=O	-	197.0
C=O	-	198.7
3,6-OH	10.42 (br s)	-
3′,5′-OH	10.14 (br s)	-
4″,5″-OH	8.62 (br s)	-

^{1}H (400 MHz) and ^{13}C (100 MHz) in CD_3COCD_3

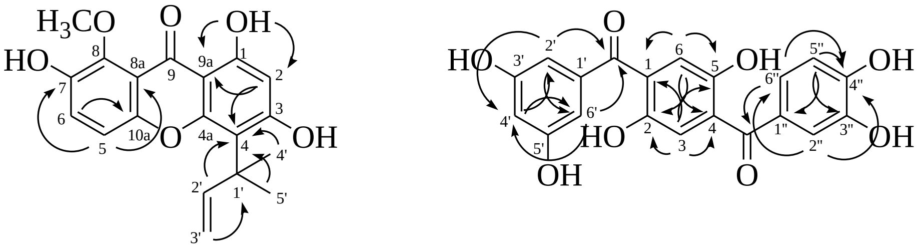
Figure 1.



(**1**) (**2**) (**3**)

(**4**) (**5**) (**6**)

Figure 2.



(**1**) (**2**)