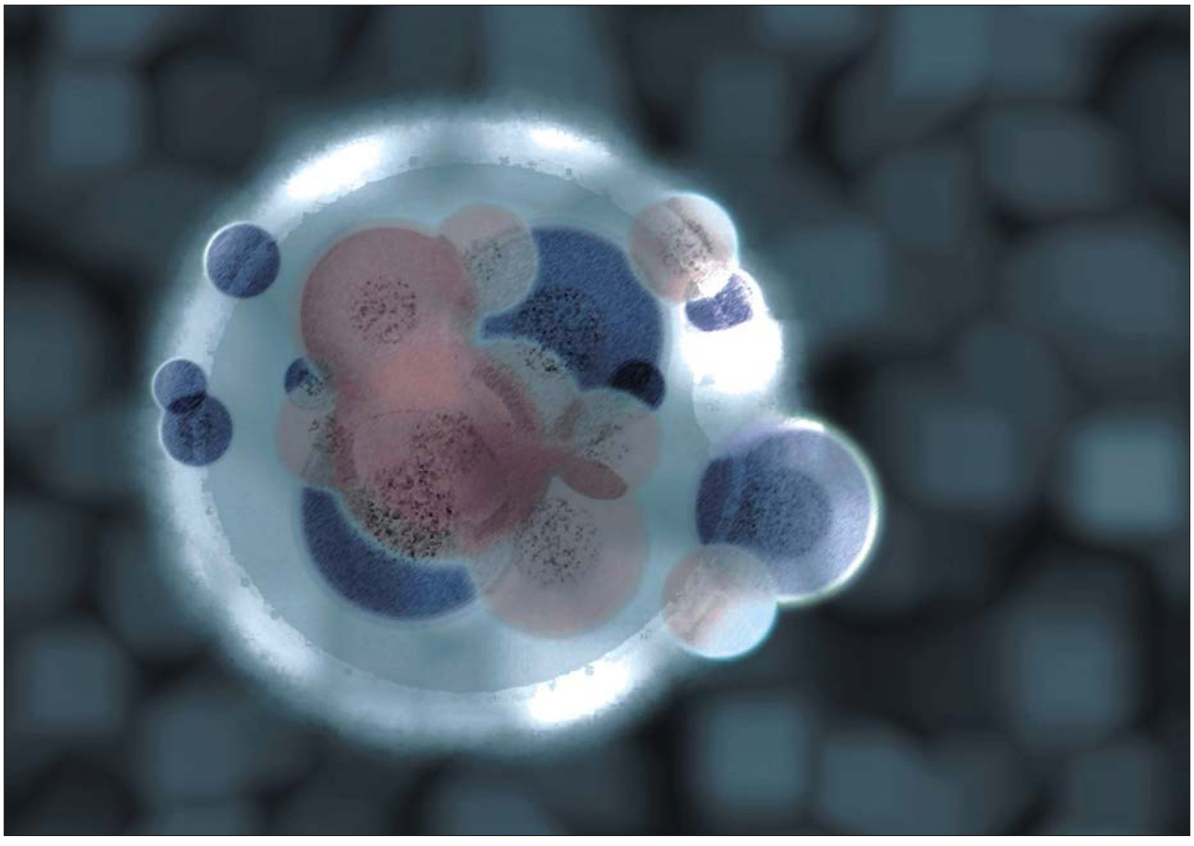

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A New Pyrano Xanthone from the Stem Barks of *Garcinia tetrandra* Pierre

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Abstract: In a search of bioactive constituents from Guttiferae plants, we have isolated, purified by combining chromatography methods (Gravitation column chromatography, flash column chromatography and preparative chromatography) and elucidated a new pyrano xanthone tetrandraxanthone [1,3-dihydroxy,2',2'-dimethyl pyrano (5',6',5,6) xanthone] (1) and seven known compounds cudraxanthone (2), lupeol (3), stigmasterol (4), thawaitesixanthone (5), 3-α-hopenol (6), isophrenyl benzophenones cambogin (7) and camboginol (8) from hexane and acetone extracts of the stem barks of *Garcinia tetrandra* Pierre. Their structures were established by spectroscopical data, including 1-D and 2-D NMR. These compounds are the first time reported from this plant.

Key words: *Garcinia tetrandra*, new pyrano xanthone [1,3-dihydroxy,2',2'-dimethyl pyrano (5',6',5,6) xanthone], tetrandraxanthone

INTRODUCTION

The genus Garcinia is wide spread in the world, most notably in the low lands tropical rain forest of South East Asia and West Africa (Willis, 1975) Plants of the Guttiferae family are used worldwide in traditional medicines for treatment of diseases and are well know to be rich sources of secondary metabolites including biflavonoids, xanthones and isophrenyl benzophenones (Gustafson *et al*., 1992; Williams *et al*., 2003; Bennet and Lee, 1989; Osmany *et al*., 2001; Allain Francois *et al*., 2006), many unique and novel compounds also found. Many compounds found in Garcinia species have bioactivity, such as antioxidant (Yamaguchi *et al*., 2000; Terashima *et al*., 2002; Anne *et al*., 2004; Liao *et al*., 2005), cytotoxic (Thoison *et al*., 2000; Xu *et al*., 1998, 2000; Kosela *et al*., 1999), antibacteria (Suksamrarn *et al*., 2003; Sundaram *et al*., 1982; Rukachaisirikul *et al*., 2003, 2005a, b), antimalaria (Likhitwitauwuid *et al*., 1998a, b). Many *Garcinia* species are found in Indonesian rain forest. One of them is *Garcinia tetrandra* Pierre (Cluciaceae) which is medium size three, found in west Kalimantan Island. No medicinal uses are recorded for this species. Although there have been phytochemical studies on more than 50 Garcinia species, no investigation on *G. tetrandra* has been reported. We have reported them thawaitesixanthone, 3-α-hopenol, cambogin and camboginol isolated from *G. tetrandra* have antioxidant, antibacterial activities (Hartati *et al*., 2000, 2001, 2002). In this study we are reported the isolation and structure elucidation of cudraxanton (2), lupeol (3) and stigmasterol (4) and established a new pyrano xanthone tetrandraxanthone [1,3-dihydroxy,2',2'-dimethyl pyrano (5',6',5,6) xanthone] (1) of steam barks of *G. tetrandra* Pierre. Their structures were established by 1 D and 2 D NMR spectrometers.

MATERIALS AND METHODS

General experimental procedures: Melting points were determined by using Fisher scientific melting point apparatus and were uncorrected. UV spectra were measured on a Hewlet-Packard 8453A diode array spectrophotometer. IR spectra were measured on Perkin-Elmer 16PC FT-IR as KBr discs. EIMS were determined on micromass VG 7035 spectrometer at 70 ev. NMR spectra were recorded on Bruker ACF 300 [100 MHZ and 300 MHZ (^{1}H) and (^{13}C) AMX 500 [500 MHZ] spectrometers with TMS as internal standard in $CDCl_3$ and D_2O for compound (1).

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CC: Silica gel (Merck 70-230 mesh and 230-400 mesh). Spots were visualized by UV (254 and 365 nm) and 5% H_2SO_4 in methanol.

Plant material: The stem barks of *Garcinia tetrandara* was collected in Bulungan Research Forest West Kalimantan Indonesia in 1999. A voucher specimen is deposited in Herbarium Bogoriense. Bogor Indonesia.

Extraction and isolation: The ground dried stem barks (835 g) was extracted with *n*-hexane (4×3 L) and the residue was extracted with acetone. The *n*-hexane and acetone extracts were concentrated to give *n*-hexane extract (14.6 g) and acetone extract (100 g). Nine gram of *n*-hexane extract subjected to column chromatography on silica-gel and eluted with *n*-hexane: EtOAc as gradient resulting 13.5 mg of yellow needles cudraxanthon (2), 14.8 mg of white needles lupeol (3), 35.0 mg of a gold-yellow needles of thawaitesixan thone (5) and 45 mg of a white needles 3-α- (22) (29) hopen-ol (6). A portion of acetone extract (50 g) was partitioned by *n*-hexane gave 1.37 g of extracts, a residue was partitioned with CH_2Cl_2 gave 6.4 g. A CH_2Cl_2 extracts were column chromatography on silica-gel elution with *n*-hexane-ethyl acetate and methanol gradient system, gave 8.5 mg of stigmasterol (4); 20 mg of thawaitesixanthone (5); 33 mg of cambogin (7); 150 mg of camboginol (8) and 4 mg of tetrandraxanthon (1).

RESULTS

The spectra, IR, ^{1}H, ^{13}C NMR and MS datadicribed as bellow: Compound (1) 4 mg: Is found from CH_2Cl_2 fraction as pale yellow oil, MS m/z (rel. int.): 310.2 [M^+] (53), 295.2 [M^+-15] (100), 253.1 (15), 212.1 (10), 187.1 (12), 147.6 (57), 83.1 (8), 57.1 (8). MS [M^+]. 312.2 molecular formula $C_{18}H_{14}O_5$. ^{1}H NMR ($CDCl_3$, 400 MHZ) δ 13.26 (1H, s, 1-OH), 6.31 (H-2, d, J = 2.63 Hz), 3.50 (1H, s, 3-OH), 6.23 (H-4, d, J = 2.63), 7.22 (H-7, d, J = 9.25 Hz), 7.16 (H-8, d, J = 9.25 Hz), 8.00 (H-3', d, J = 10.00 Hz), 5.82 (H-4', d, J = 10.00 Hz), 1.25 (3H, s, H-5'), 1.46 (3H, s, H-6'). ^{13}C NMR in $CDCl_3$: 165.65 (C-1), 98.36 (C-2), 163.07 (C-3), 93.63 (C-4), 157.60 (C-4a), 149.59 (C-5), 151.93 (5a) 90.82 (C-6), 117.80 (C-7), 124.59 (C-8) 101.56 (C-8a), 183.57 (C-9), 104.71 (C-9a), 75.71 (C-2'), 133.00 (C-3', 120.94) (C-4'), 29.89 (C-5'), 29.89 (C-6').

Compound (2) 13.5 mg: Isolated from *n*-hexane extract gold yellow needles, mp. 242-243°C, IR υ max cm^{-1} (KBr) 3330-3452 (brd. coj.-OH) 1720, 1611 (coj., keton). ^{1}HNMR ($CDCl_3$, 400 MHZ): 13.50 (1H, *s*,-OH, H-1), 6.62 (1H, *s*, H-2), 7.14 (1H, d, J = 9.25 Hz, H-5), 7.19 (1H, d, J = 9.25 Hz, H-6), 5.58 (1H, d, J = 10.75 Hz, H-3'), 5.81 (1H, d, J = 10.75 Hz, H-4'), 8.02 (1H, d, J = 10.15 Hz, H-3''), 6.73 (1H, d, J = 9.70 Hz, H-4''). 1.46 (s, 6 H) and 1.49 (s, 6 H).

Compound (3) 14.8 mg: Isolated from *n*-hexane extract, white solid, mp. 180-182°C, ^{1}HNMR ($CDCL_3$, 300 MHZ) δ_H 0.76 (s, 3H), 0.78 (s, 3H), 0.83 (s, 3 H), 0.92 (d, J = 3.7 Hz, 2H), 0.94 (s, 3 H), 0.96 (s, 3H), 0.98 (dd, J = 3.7;2.5 Hz, 1H) 1.01 (d, J = 2.5 Hz, 1H), 1,03 (s, 3H), 1,06 (dd, J = 3.7;4.9 Hz, 1H), 1.10-1.38 bulk signals of CH_2, 1.68 (s, 3 H), 2.05 (s, 1H), 2.37 (sextet, 1H), 3.19 (d,d J = 4.9; 4.9 Hz), 4.56 (dd, J = 1.2; 1.2 Hz, 1H), 4.68 (d, J = 2.5 Hz, 1H). ^{13}CNMR (APT, in $CDCL_3$, 125 MHZ) δ_C 14.72 (CH_3); 15.55 (CH_3); 16.15 (CH_3); 16.30 (CH_3); 18.18 (CH_3); 18.48 (CH_2); 19.48 (CH_3); 21.09 (CH_2); 25.28 (CH_2); 27.56 (CH_2); 28.16 (CH_3); 30.00 (CH_2); 34.42 (CH_2); 35.74 (CH_2); 37.33 (CH_2); 38.21 (CH); 38.86 (CH_2); 39.03 (C); 40.17 (CH); 40.98 (C); 42.99 (C); 43.17 (C), 48. 16 (CH), 48.44 (CH); 50.58 (CH); 50.58 (CH); 55;45 (CH); 78.95 (CH); 109.51 (CH_2); 151.19 (C).

Stigmasterol (4) 8.5 mg: Isolated from acetone extract as white solid, ^{1}HNMR ($CDCL_3$, 300 MHZ) δ 5.35 (d. J = 5.02 Hz), 5.16 (dd, J = 8.36Hz; 8.36Hz), 5.01 (dd, J = 8.36 Hz; 8.36 Hz), 3. 52 (m), 1.08 (s), 1.07 (s), 1.06 (s), 1.03 (s), 1.02 (s), 0.83 (s) and bulk signals of CH_2 at δ 1.11 -2.3 ppm.

Compound (5) 35 mg: Isolated from *n*-hexane and acetone extracts as bright-yellow needles, mp. 180-182°C, molecular formula $C_{23}H_2O_5$ ^{1}HNMR ($CDCl_3$, 400 MHZ): δ_H 8.02 (1H, d, J = 10 Hz, H-1), 5.82 (1H, d, J = 10 Hz, H-2), 7.18 (1H, d, J = 10 Hz), 7.16 (1H, d, J = 10 Hz, H-6), 6.27 (1 H, s, H-9), 5.59 (1H, d, J = 10 Hz, H-13), 6.73 (1H, d, J = 10 Hz, H-14), 13.50 (1H, s, 15-OH), 1.47 (6H, s, H-21/22), 1.46 (6H, s, H-22/23). ^{13}C NMR: δc 124.4 (C-1), 132.63 (C-2), 75.46 (C-3), 149.24 (C-4), 117.71 (C-5), 115.55 (C-6), 151.61 (C-7), 157.83 (C-8), 94.23 (C-9), 160.44 (C-10), 78.11 (C-11), 127.26 (C-12), 123.63 (C-13), 105.00 (C-14), 155.60 (C-15), 104.72 (C-16), 183.30 (C-17), 120.78 (C-18) 119.83 (C-19), 27.28 (C-20/21), 27.37 (C-22/23).

Compound (6): Isolated as white needles in *n*-hexane mp. 197-198°C, molecular formula $C_{30}H_{50}O$, EI-MS [M^+] 426 the δ ^{1}H NMR in $CDCl_3$: 4.66 (s.b. 1H), 4.55 (s.b. 1H), 3.16 (dd, 1H; 4,8; 5,2 Hz), 2.35 (m,1H), 1.89 (m, 1H), 1.69 (1H, d, J = 4Hz), 1.65 (s, 3H), 1.62 (2H; d.d, 3, 2; 4 Hz), 1.58 (1H, d, 4.8 Hz), 1.55. (2H, dd, 3.6, 6 Hz), 1.51 (2H, d. 3.2 Hz), 1.48 (2H, dd. 2.2, 4 Hz), 1.44 (2H; dd, 2.2; 4 Hz), 1.40 (2H, d, 2 Hz), 1.38 (s, 1H), 1.36 (s, 4H), 1.25 (s, 2H), 1.21 (2H, d, 3.2 Hz), 1.18 (s, 1H), 1.15 (s, 1H), 1.06 (2H, d, 4.4 Hz), 1.01 (s, 3H), 0.97 (1H, d, 4 Hz), 0.94 (s,3H), 0.92 (s, 3H), 0.88 (2H, dd, 4, 4 Hz), 0.85 (2H, d, 4. 4 Hz), 0.81 (s, 3H), 0.75 (s, 3H), 0.74 (s, 3H), 0. 66 (1H, d, 9. 2 Hz).

Cambogin (7): Isolated as white powder or crystal in $CHCl_3$ mp. 242 -243°C, molecular formula $C_{38}H_{50}O_6$, EI-MS

[M+] 602, ^{1}H NMR in $CDCl_3$: 1.66 (H-6, m), 1.63 (H-7, dd, J = 13.6; 0.66 Hz), 7.36 (H-12, d, J = 8 Hz), 6.84 (H-13, d, J = 8 Hz)), 8.74 (14-OH, s), 8.50 (15-OH, s), 7.11 (H-16, s), 2.29 (H-17, d, J = 14.8 Hz), 4.96 (H-18, t), 1,76 (H-20), 1.62 (H-21, s), 1.27 (H-22,), 0.99 (H-23, s), 2.06 (H-24, m), 4.96 (H-25, t), 1.69 (H-27, s), 1.54 (H-28, s), 1.43 (H-29, t), 1.66 (H-30, m), 0.93 (H-32, s), 1.15 (H-33, s), 2.06 (H-34), 5.20 (H-35, t), 1.68 (H-37, s), 1.54 (H-38, s); δ^{13}C NMR in $CDCl_3$: 171.0 (C-1), 87.8 (C-2), 194.3 (C-3), 68.86 (C-4), 46.54 (C-5), 46.96 (C-6), 28.88 (C-7), 51.97 (C-8), 207.33 (C-9), 192.22 (C-10), 131.15 (C-11), 115.78 (C-12), 145.84 (C-13), 151.20 (C-14), 115.6 (C-15), 123.65 (C-16), 29.22 (C-17), 121.43 (C-18), 133.18 (C-19), 25.93 (C-20), 18.80 (C-21), 21.57 (C-22), 26.07 (C-23), 30.19 (C-24), 126.29 (C-25), 133.8 (C-26), 26.24 (C-27), 17.98 (C-28), 29.06 (C-29), 30.36 (C-30), 87.04 (C-31), 22.67 (C-32), 26.91 (C-33), 30.34 (C-34), 125.59 (C-35), 134.0 (C-36), 26.28 (C-37), 18.45 (C-38).

Camboginol (8): A yellow-green needles, mp. 130-132° C, EI-MS [M+] 602.1 ^{1}H NMR in $CDCl_3$: 1.46 (H-6, m), 1.89 (H-7, dd, J = 4,2; 6.6 Hz), 7.26 (H-12, s), 6.61 (13-OH, *s*), 6.63 (14-OH, s), 6.69 (H-15, d, J = 4.3 Hz), 6.98 (H-16, d, J = 4.6 Hz), 2.74 (H-17, dd, J = 2.9, 3.6 Hz), 4.93 (H-18, t), 1,7 (H-20), 1.60 (H-21, s), 1.16 (H-22, s), 1.01 (H-23, s), 2.08 (H-24, m), 5.04 (H-25, t), 1.67 (H-27, s), 1.54 (H-28, s), 1.75 (H-28), 1.98 (H-20, m), 4.38; 4.42 (H-32, s), 1.74 (H-33, s), 2.08 (H-34, m), 4.94 (H-35, t), 1.67 (H-37, s), 1.54 (H-38, s). δ^{13}C NMR in $CDCl_3$: 194.9 (C-1), 118.5 (C-2), 193.9 (C-3), 69.4 (C-4), 49.6 (C-5), 46.9 (C-6), 42,6 (C-7), 57.9 (C-8), 209.1 (C-9), 198.8 (C-10), 132.0 (C-11), 116.2 (C-12), 148.1 (C-13), 149.4 (C-14), 114.4 (C-15), 124.2 (C-16), 26.4 (C-17), 120.2 (C-18), 129.0 (C-19), 26.1 (C-20), 18.5 (C-21), 22.8 (C-22), 27.1 (C-23), 29.0 (C-24), 127.9 (C-25), 133.0 (C-26), 25.9 (C-27), 18.2 (C-28), 36.2 (C-29), 43.6 (C-30), 143.7 (C-31), 112.7 (C-32), 18.0 (C-33), 32.7 (C-34), 123.9 (C-35), 135.2 (C-36), 25.8 (C-37), 18.0 (C-38).

DISCUSSION

Compound (1) 4 mg was obtained as a pale yellow oil, the molecular formula was deduced to be $C_{18}H_{14}O_5$ by EI-MS [M+] 310.2. The ^{1}H NMR spectrum in $CDCl_3$ and D_2O of (1) indicated the presence of two pair aromatic protons type AB signals at 7.76 (d, J = 9.25 Hz) and δ 7,20 (d, J = 9.25 Hz) and one pair of aromatic proton AX at 6.23 (d, J = 1.85 Hz), 5,82 (d, J = 1.85 Hz). The appearance of pair of doublets at 8.01 (d, J = 10.18 Hz) and 5.82 (d, J = 10.18 Hz), together with two singlets (each 3 H) at 1.25 and 1.46 indicated the presence of a dimethyl pyran ring system in the molecule. Two exchangeable hydroxyl signals at 3.5 (3-OH) and chelated hydroxyl signal at 13.26 (1-OH) (Table 1). The Fig. 1 was confirmed by ^{1}H-detected heteronuclear multiple quantum coherence (HMQC) and ^{1}H-detected multiple bond connectivity (HMBC) spectroscopies (Table 2). The presence of dimethyl pyran ring fused with the xanthone nucleolus at C-5 and C-6 were suggested by the appearance of long range coupling between aromatic proton at δ 8.0 (H-4', δc 120.20) on the dimethyl pyran ring with carbon δc 149.50 (C-5), aromatic carbon 117.80 (C-7, δ_H 7.22) on the xanthone of the ring B and carbon (δc 75.74) of dimethyl at pyran ring. The presence of hydroxyl group on C-3 (δc 163.67) suggested by appearance of proton aromatic type AX (correlation H-2 and H-4) with coupling constance doublet J = 1.85 Hz. One of meta-coupled proton at 6.72 ppm was correlated to the quartenery carbon at 104.71 ppm and O-function quartenery carbon at 164.65 ppm and the other also correlated to two quartenery carbon at 157.60 and O-function quartenery carbon at 163.67 ppm. Furthermore the presence of a hydroxyl group at C-1 13.26 ppm was supported by the presence of long range coupling carbon signal at 164.15, 104.31 and 98.36 ppm.

These results strongly support the proposed structure of 1 as a new pyranoxanthon tetrandraxanthon (1).

Table 1: ^{1}H NMR data of structure 1 in $CDCl_3$ and $CDCl_3$ + D_2O

Position	δ (ppm) in $CDCl_3$	Groups	δ (ppm) in $CDCl_3$ and D_2O
1	13.26; s; (1H)	OH	-
2	6.31; d; J = 2.6 Hz (1 H)	CH	6.31; d; J = 1.9 (1 H)
3	3.50, s; (1 H)	OH	-
3'	5.82; d; J = 10.1 Hz (1 H)	CH	5.82; d; J = 10.2 (1 H)
4	6.23; d; J = 2.6 (1 H)	CH	6.23; d; J = 1, 9 (1 H)
4'	8.00; d; J = 10.1 Hz (1 H)	CH	8.00; d; J = 10.2 (1 H)
7	7.22; d; J = 9.3 Hz (1 H)	CH	7.22; d; J = 9.3 (1 H)
7'	1.25; s (3 H)	CH_3	1.25; s (3 H)
8	7.16; d; J = 9.3 Hz (1 H)	CH	7.16; d; J = 9.3 (1 H)
8'	1.46; s (3 H)	CH_3	1.46; s (3 H)

s = Singlet, d = Doublet, J = Coupling constant

Table 2: ^{13}C NMR, HMQC and HMBC Data of compound 1

Position	δ_C (ppm)	δ_H	HMBC
1	164.2	/	H-1
2	98.4	6.31	H-1, H-5',H-8
3	163.1	/	/
4	93.6	6.23	H-8, H-7'
4a	157.6	/	H-4
5	149.6	/	H-7, H-8
6 or 3'	121.0	/	/
7	117.9	7.16	H-4
8	124.6	7.22	H-5'
8a	151.9	/	H-7, H-8
9	183.57	/	/
9a	107.7	/	H-1, H-4
4'	120.20	/	H-8
5'	133.0	5.82	H-7, H-7'
6'	75.7	/	H-5'
7'	27.5	1.46	H-7
8'	29.9	1.25	H-4

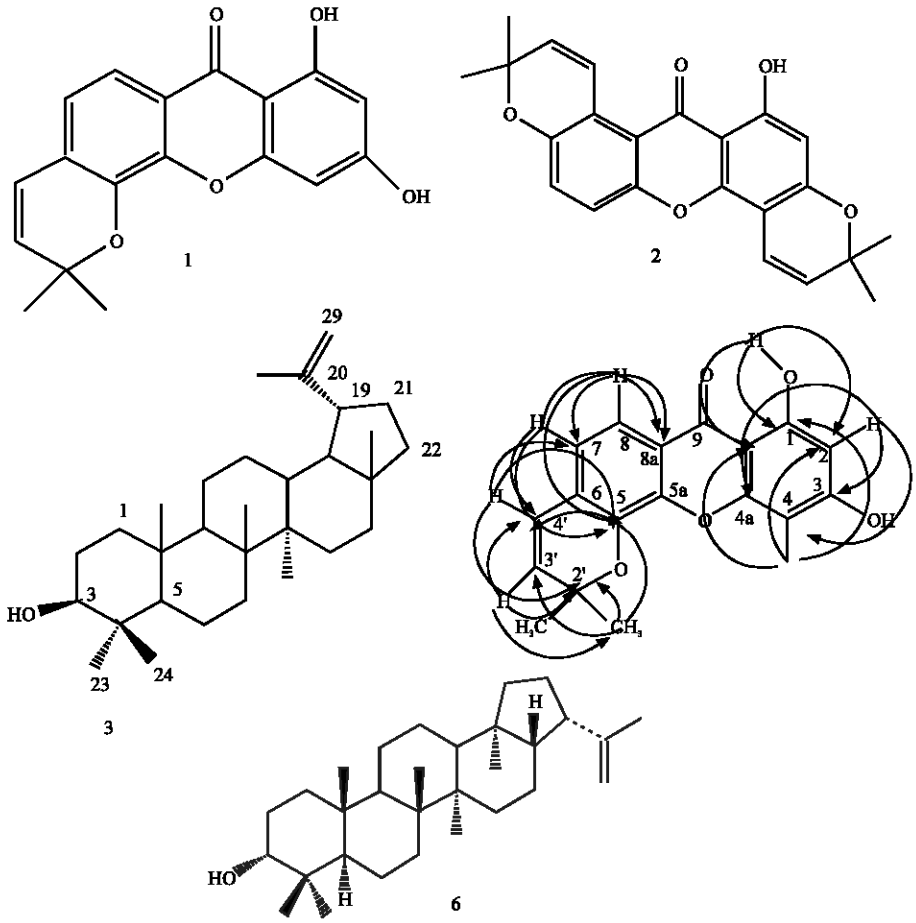

Fig. 1: HMBC correlation of compound 1

Compound (2) 13.5 mg: Isolated from *n*-hexane extract gold yellow needles, mp. 212-216°C, IR υmax cm^{-1} (KBr) 3330-3452 (brd. coj.-OH)1720, 1611 (coj., keton). The ^{1}HNMR ($CDCl_3$, 400 MHZ) showed a low field at δ 13.50 (1H, *s*) indicating the chelating hydroxyl group and suggested the presence of two 2,3-dymethylchromene ring as follow δ 1.46 s and 1.49 s (each 6 H), 5.58 (1H, d, J = 10.75 Hz, H-3'), 5.81 (1H, d, J = 10.75 Hz, H-4'), 7.19 (1H, d, J = 9.25 Hz, H-6), 8.02 (1H, d, J = 9.25 Hz. One aromatic proton epeared as a siglet at 6.62 (1H, s, H-2) and two doublet at 7.14 (1H, d, J = 9.25 Hz, H-5),, H-3''), 6.73 (1H, d, J = 9.70 Hz, H-4''). The compound and NMR spectra was compared with authentic sample and references (Pujimoto *et al*., 1984; Hano *et al*., 1990; Chang *et al*., 1994). So that compound 2 revealed as cudraxanthon.

Compound (3) 14.8 mg: white powder mp. 180-182°C, IR spectrum showed hydroxyl group at (3312-3285 cm^{-1}) and terminal metilen at 879.4 cm^{-1}. ^{1}H NMR spectrum displayed two secondary methyls at δ 0.96 and 1.03 ppm and four tertiary methyls at δ 0.76; 0.78; 0.83 and 0.94 ppm. Compound-3 also displayed a vinyl methylene at δ 4.56 and 4.68 ppm each integrating for one proton and appearance doublet-doublet at δ 3,52 ppm (J = 4,85; 4,85 Hz) was indicated an axial oxy methine proton, suggesting the usual equatorial (β) orientation for the hydroxyl group at C-3, this was supported by the ^{13}C NMR signal at δ 78.95 witch agreed closely with that recorded for the C-3 carbon with β hydroxyl group. The ^{13}C NMR showed two sp^2 carbon resonances at 151.19 and 109.51 confirming the presence of vinyl methylene.

CONCLUSIONS

From *n*-hexane and acetone extracts of stem barks of *Garcinia tetrandra* Pierre (Fig. 2) using silica gel column chromatography resulted a new pyranoxanthon (1) namely tetrandra xanthon and known xanthon cudraxanthon (2), stigmasterol (3), lupeol (4). These compounds are the first time reported from this plant.

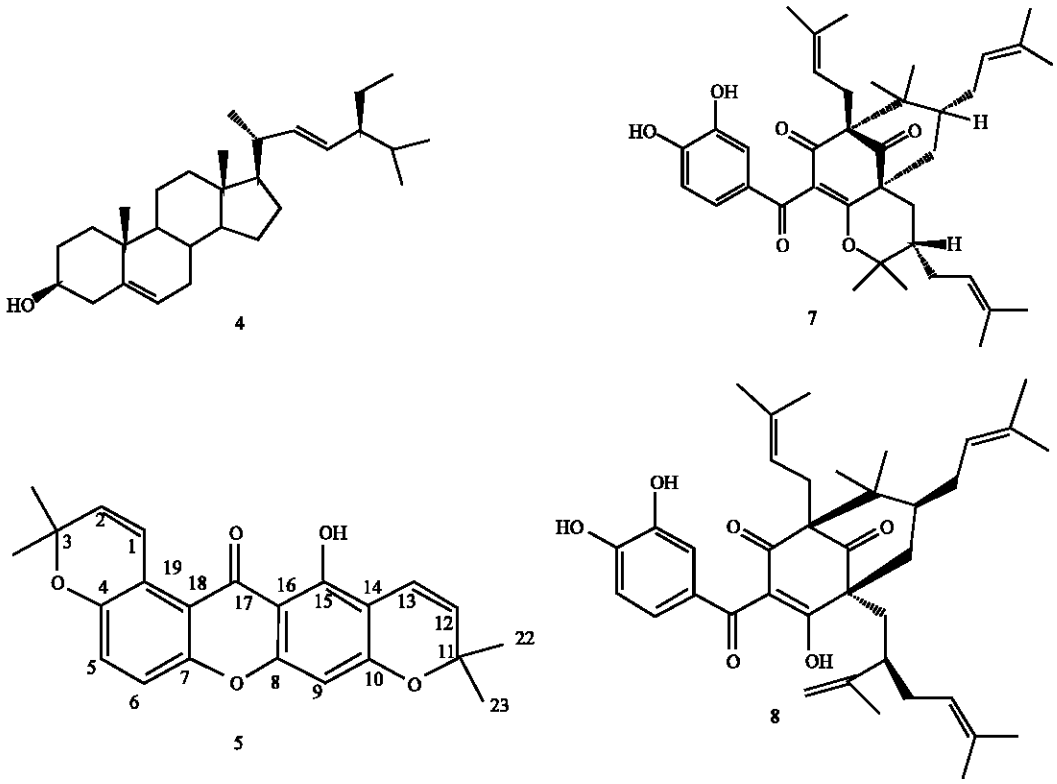

Fig. 2: Structure of compounds of *G. tetrandra* Pierre

REFERENCES

Allain Francois, K.W., M. Dulcie, W. Jean Duplex, M. Luc Meva'a, P. Robert, N.M. Theophile, F. Zacharias Tance, K. Wilfried and E.N. Agustin, 2006. Afzeliixanthones A and B, Two new prenylated xanthones from *Garcinia afzelii* Engl. (Guttiferae). Chem. Pharm. Bull., 54(4): 448-451.

Anne-Emmanuelle Hay, M.C. Aumon, S. Mallet, V. Dumontet, M. Litaudon, D. Rodeau and P. Richome, 2004. Antioxidant from *Garcinia vieilardii*. J. Nat. Prod., 67: 707-709.

Bennet, G.J. and H.H. Lee, 1989. Xanthones from Guttiferae. Phytochemistry, 28: 967-998.

Chang, C.H., C.C. Lin, M. Hattori and T. Namba, 1994. Effect on anti-lipid peroxidase of *Cudranian chochinensis* var. gerontogea. J. Etnopharmacol., 44(2): 75-79.

Gustafson, K.R., J.W. Blunt, H.G.M. Munro, R.W. Fuller, C.T. McKee, J.H. Cardelina, J.B. McMahon, G.M. Cragg and M.R. Boyd, 1992. HIV inhibitory natural products. The Guttiferones, HIV-inhibitory benzophenones from *Symphonia globulifera*, *Garcinia livingstonei*, *Garcinia ovalifolia* and *Clusia rosca*. Tetrahedron, 48: 10093-10102.

Hano, Y., Y. Matsumoto, J.Y. Sun and T. Nomura, 1990. Structure of four new isophrenylated xanthones, cudraxanthones H, I, J and K. Planta Med., 56(5): 479-481.

Hartati, S., S. Kosela, M. Hanafi and L.B.K. Leonardus, 2000. Isolation and elucidation structure of compounds of stem bark of *Garcinia tetrandra* piere. J. Applied Chem., 10(1): 6-10.

Hartati, S., S. Kosela, L.B.S. Kardono and K.Y. Sim, 2001. Chemical constituents of stem bark of *Garcinia tetrandra* pierre, proceeding international seminar on natural products chemistry and utilization of natural resources. UNESCO, Universitas Indonesia, June 5-7, UI DEPOK, pp: 344-349.

Hartati, S., L.B.S. Kardono and M. Hanafi, 2002. Bioactivity Cambogin and Camboginol (poly-isoprenyl benzophenones) from *Garcinia tetrandra* Pierre, Proceeding National Seminar on Chemical, Industry and environmental chemistry, Santika Hotel Yogyakarta, 22-23 December.

Kosela, S., S.G. Chao, I.H. Wu, Jagadese, J. Vittal, T. Sukri, Masdianto, S.H. Goh and K.Y. Sim, 1999. Laterifloron a cytotoxic spiroxalactone with a novel skeleton, from *Gracinia lateriflora*. Tetrahedron Lett., 40: 157-160.

Liao, C.H., C.T. Ho and J.K. Lin, 2005. Effects of garcinol on free radical generation and NO production in embryonic rat cortical neuron and astrocytes. Biochem. Biophys. Res. Commun., 329: 1306 -1314.

Likhitwitauwuid, K., T. Phadungcharoen and J. Krungkrai, 1998a. Antmalarial Xanthones From *Garcinia cowa*. Planta Med., 64: 70-72.

Likhitwitauwuid, K., W.C. Nijsiriruangrungsi and J. Krungkrai, 1998b. Xanton with antimalarial activity from *Garcinia dulchis*. Planta Med., 64: 281-282.

Osmany, C.R., P. Alexander, V.C. Herman, P. Casimo and R. Luac, 2001. Aristophenon A and B. A new tautomeric pair of polyisophrenylated benzophenone from *Garcinia aristata*. J. Nat. Prod., 64: 973-975.

Pujimoto, T., Y. Hano and T. Nomura, 1984. Components of root bark of *Cudrania tricuspidata* l. structure of four new isoprenylated xanthones, cudraxanthones A,B,C and D. Planta Med., 50(3): 218-221.

Rukachaisirikul, V., M. Kamkaew, D. Sukavisit and S. Phongpaichit, 2003. Antibactarial xanthon from the leaves of *Garcinia nigrolineata*. J. Nat. Prod., 66: 1531-1535.

Rukachaisirikul, V., K. Todpetch, A. Watthanaphamit, N. Saengsanae and S. Phongpaichit, 2005a. An antibectarial biphenyl derivative from *Garcinia bancana* miq. J. Nat. Prod., 68: 1218-1221.

Rukachaisirikul, V., W. Pharm Y. Sudpindama and S. Phongpaichit, 2005b. An antibacterial biphenyl derivative from *Garcinia bancana* miq. Chem. Pharm. Bull., 53: 342-343.

Suksamrarn, S., N. Suwananapoch, W. Phakhodee, J. Thauhiranlert, P. Ratananukul, N. Chimnoi and A. Suksamsarn, 2003. Antibacterial activity of prenylated xanthones from the fruits of *Garcinia mangostana*. Chem. Pharm. Bull., 51(7): 857 -859.

Sundaram, B.M., C. Gopalakishanan, S. Subramanian, D. Shankaranarayanan and L. Kameswaran, 1982. Antimicrobial activities of *Garcinia mangostana* Indian. J. Chem., 38: 59 -60.

Terashima, K., Y. Takaya and M. Niwa, 2002. Powerful antioxidative agent based on garcionic acid from *Garcinia kola*. Bioorganic and Med. Chem., 10: 1619-1625.

Thoison, O., J. Fahy, V. Dumotet, A. Chiaroni, C. Riche, M.V. Tri and T. Sivenet, 2000. Cytotoxic prenylxanthon from *Garcinia bractata*. J. Nat. Prod., 63(4): 441 -446.

Williams, R.B., J. Hoch, T.E. Glass, R. Evans, J.S. Miller, J.H. Wisse and D.G.I. Kingston, 2003. A novel cytotoxic guttiferone analogue from *Garcinia macrophylla* from the Suriname rainforest. Planta Med., 69: 864 -866.

Willis, J.C., 1975. A Dictionary of Lowering Pkants and Ferns Airy Shaw H.K. 8th Edn. Cambrige University Press Cambrige.

Xu, Y.J., S.G. Cao, X.H. Wu, Y.H. Lai, B.H.K. Tan, J.T. Pereira, S.H. Goh, G. Venkatraman, J. Leslie Harison and K.Y. Sim, 1998. Griffipavixanthone, a novel sitotoxic bixanton from *Garcinia grffithii* and *Garcinia pavifolia*. Tetrahedron Lett., 19: 9103-9106.

Xu, Y.J., S.C. Yip, S. Kosela, E. Fitri, M. Hanafi, S.H. Goh and K.Y. Sim, 2000. Novel cytotoxic, prenylated heptacyclic xanthonoids from indonesian *Garcinia gaudichaudii* (Guttiferae). Organic Lett., 2(24): 3945-3948.

Yamaguchi, F., M. Saito, T. Ariga, Y. Yoshimura and H. Nakazawa, 2000. Free Radical Scavenging activity and antinulcer activity from *Garcinia indica* fruit rind. J. Agric. Food Chem., 48: 320-322.