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CHEMICAL CONSTITUENTS FROM METHANOLIC EXTRACT OF *GARCINIA MACKEANIANA* LEAVES AND THEIR ANTIOXIDANT ACTIVITY

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Abstract. The phytochemical investigation of the methanolic extract of *Garcinia mackeaniana* Craib. leaves led to the isolation and determination of five known compounds, including one benzophenone 4,3',4'-trihydroxy-2,6-dimethoxybenzophenone (**1**), two flavone *C*-glucosides, vitexin (**2**) and 2''-*O*-acetylvitexin (**3**), one biflavone, amentoflavone (**4**), and one phenolic compound, methyl protocatechuate (**5**). The chemical structures of compounds **1**-**5** were characterized by the NMR-spectral methods. All isolated compounds were separated from *G. mackeaniana* for the first time. Benzophenone derivative **1** has shown the IC_{50} value of 14.97 ± 0.8 µg/mL in the DPPH-antioxidantexamination.

Keywords: Garcinia mackeaniana, leaves, phytochemistry, antioxidant activity.

Classification numbers: 1.1.1, 1.2.1.

1. INTRODUCTION

Genus *Garcinia* is a large genus of the flowering plants which belong to the family Clusiaceae. Plants of this genus with about 450 species are now native to Asia, Australia, America, and Southern Africa [1]. *Garcinia* species have always contributed valuable properties as traditional medicines to the food chemistry and pharmacology. For instance, the decoction of *G. cambogia* fruit rind was employed for rheumatism treatment, and bowel complaints [2]. The fruit of mangosteen (*G. mangostana*) is now well-known in food chemistry because of its distinctive and pleasant taste [3]. Polyisoprenylated benzophenone derived from some *Garcinia* species, namely garcinol, was recommended for the antioxidant therapeutic targets [4]. Phytochemical investigations of *Garcinia* plants indicated that xanthones, flavonoids, and benzophenones were major components [1]. Among about 30 *Garcinia* species distributed in

Viet Nam, *G. mackeaniana* was selected for phytochemical investigation and antioxidant examination [5]. As part of phytochemical investigation [6], we now describe the isolation, structural elucidation of five known compounds from *G. mackeaniana* and their DPPH-radical quenching activity.

2. MATERIALS AND METHODS

2.1. General experimental procedures

ESI-MS spectra were recorded on Thermo Scientific LTQ Orbitrap XL spectrometer (USA). NMR spectra were obtained from Bruker 500 MHz spectrometer (125 MHz for ^{13}C and at 500 MHz for ^{1}H). Silica gel (40 - 63 μm), Sephadex LH-20 (25 - 100 μm), and RP-18 (150 μm, Kyoto-Japan) were applied for column chromatography (CC), while silica gel 60 F_{254} (Merck) was used for TLC analysis. Compounds were detected by UV lamp (254 and 365 nm), and by spraying plates with indicators (10 % H_2SO_4 and vanillin).

2.2. Plant materials

The leaves of *Garcinia mackeaniana* Craib. were collected in Son La, Viet Nam in January 2018, and were identified by Dr. Nguyen Quoc Binh, Institute of Ecology and Biological Resources. A voucher specimen (VN-1641) was deposited in Department of Applied Biochemistry, Institute of Chemistry.

2.3. Extraction and isolation

The dried leaves powder of *G. mackeaniana* (1.3 kg) was immersed with MeOH (10 L × 3 times) for 1 h at 50 °C. The MeOH solution was then concentrated under decreased pressure to give a crude MeOH residue (89.1 g). This part was chromatographed on a silica gel column (10 × 50 cm, 182.0 g), eluting with a stepwise gradient of *n*-hexane-CH_2Cl_2 (1:1→0:1, v/v) and CH_2Cl_2-MeOH (9:1→0:1, v/v), to afford 15 fractions (MF.1-MF.15). Fraction MF.9 (0.9 g) was subjected to silica gel CC [CH_2Cl_2-EtOAc (3:1, v/v)], to afford 4 fractions (MF.91-MF.94). Fraction Fr.91 (40 mg) was continued to separate by a RP-18 column [MEOH-H_2O (1:1, v/v)], to give compound **1** (8.0 mg). Compound **4** (7.0 mg) was separated from fraction MF.92 (0.3 g) by washing with MeOH. Fraction MF.11 (0.5 g) was further chromatographed on a silica gel column [CH_2Cl_2-CH_3COCH_3 (1:1, v/v)], to give compounds **5** (2.5 mg) and **3** (15.0 mg). Finally, fraction MF.12 (0.7 g) was re-chromatographed on a silica gel column [CH_2Cl_2-MeOH (30:1, v/v)], to obtain compound **2** (15.0 mg).

4,3',4'-Trihydroxy-2,6-dimethoxybenzophenone (1): Yellow amorphous powders; ESI-MS: *m/z* 291 $[M+H]^+$ (calcd for $C_{15}H_{15}O_6$, 291); ^{1}H-NMR (500 MHz, CD_3OD, δ_H ppm): 6.17 (2H, s, H-3, H-5), 7.27 (1H, d, 2.5 Hz, H-2'), 7.17 (1H, dd, 2.5, 8.0 Hz, H-6'), 6.77 (1H, d, 8.0 Hz, H-5'), and 3.67 (6H, s, 2-OCH_3, 6-OCH_3); ^{13}C-NMR (125 MHz, CD_3OD, δ_C ppm): 197.0 (CO), 161.8 (C-4), 160.1 (C-2, C-6), 152.4 (C-4'), 146.2 (C-3'), 132.2 (C-1'), 124.7 (C-6'), 117.3 (C-2'), 115.7 (C-5'), 111.1 (C-1), 92.9 (C-3, C-5), and 56.11 (2-OCH_3, 6-OCH_3).

Vitexin (2): Yellow amorphous powders; ESI-MS: *m/z* 433 $[M+H]^+$ (calcd for $C_{21}H_{21}O_{10}$, 433); ^{1}H-NMR (DMSO-d_6, 500 MHz, δ_H ppm): 13.14 (1H, s, 5-OH), 8.00 (2H, brd, 8.5 Hz, H-2', H-6'), 6.90 (2H, d, 8.5 Hz, H-3', H-5'), 6.74 (1H, s, H-3), 6.23 (1H, s, H-6), 4.72 (1H, d, 9.5 Hz, H-1"), 3.85 (1H, t, 9.0 Hz, H-2"), 3.76 (1H, brd, 11.0 Hz, H_a-6"), 3.52 (1H, dd, 6.0, 12.0 Hz, H_b-6"), and 3.25-3.36 (2H, m, H-4", H-5"); ^{13}C-NMR (DMSO-d_6, 125 MHz, δ_C ppm): 181.9 (C-4),

163.8 (C-2), 162.8 (C-7), 161.2 (C-4'), 160.4 (C-5), 156.0 (C-8a), 129.0 (C-2', C-6'), 121.6 (C-1'), 115.8 (C-3', C-5'), 104.6 (C-4a, C-8), 102.4 (C-3), 98.4 (C-6), 81.8 (C-5"), 73.5 (C-1"), 70.9 (C-2"), 78.7 (C-3"), 70.6 (C-4"), and 61.3 (C-6").

2''-*O*-Acetylvitexin (3): Yellow amorphous powders; ESI-MS: *m/z* 475 $[M+H]^+$ (calcd for $C_{23}H_{23}O_{11}$, 475); ^{1}H-NMR (500 MHz, CD_3OD, δ_H ppm): 8.05 (2H, d, 8.5 Hz, H-2', H-6'), 6.98 (1H, d, 8.5 Hz, H-3', H-5'), 6.62 (1H, s, H-3), 6.24 (1H, s, H-6), 5.56 (1H, m, H-2"), 5.10 (1H, d, 10.0 Hz, H-1"), 4.02 (1H, dd, 2.0, 12.0 Hz, H_a-6"), 3.83 (1H, dd, 5.5, 12.0 Hz, H_b-6"), 3.72 (1H, m, H-3"), 3.52 (1H, m, H-5"), and 1.80 (3H, s, $C\underline{H}_3CO$); ^{13}C-NMR (CD_3OD, 125 MHz, δ_C ppm): 184.1 (C-4), 172.0 ($CH_3\underline{C}O$), 166.7 (C-2), 164.1 (C-7), 163.0 (C-5), 162.7 (C-4'), 158.6 (C-8a), 130.1 (C-2', C-6'), 123.7 (C-1'), 117.0 (C-3', C-5'), 105.7 (C-4a), 103.7 (C-3, C-8), 99.1 (C-6), 83.1 (C-5"), 77.8 (C-3"), 74.1 (C-2"), 73.0 (C-1"), 72.3 (C-4"), 63.0 (C-6"), and 20.5 ($\underline{C}H_3CO$).

Amentoflavone (4): Yellow amorphous powders; ESI-MS: *m/z* 539 $[M+H]^+$ (calcd for $C_{30}H_{19}O_{10}$, 539); ^{1}H-NMR (DMSO-d_6, 500 MHz, δ_H ppm): 13.10 (1H, s, 5"-OH), 12.98 (1H, s, 5-OH), 8.02 (1H, d, 2.5 Hz, H-2'), 7.99 (1H, d, 2.5, 9.0 Hz, H-6'), 7.58 (2H, d, 8.5 Hz, H-2"', H-6"'), 7.12 (1H, d, 9.0 Hz, H-5'), 6.82 (1H, s, H-3), 6.77 (1H, s, H-3"), 6.70 (2H, d, 8.5 Hz, H-3"', H-5"'), 6.44 (1H, d, 2.0 Hz, H-8), 6.37 (1H, s, H-6"), and 6.18 (1H, d, 2.0 Hz, H-6); ^{13}C-NMR (DMSO-d_6, 125 MHz, δ_C ppm): 182.1 (C-4"), 181.8 (C-4), 164.2 (C-7), 164.0 (C-2), 163.7 (C-2"), 162.9 (C-7"), 161.5 (C-5), 161.0 (C-4"'), 160.6 (C-5"), 160.1 (C-4'), 157.4 (C-8a), 154.6 (C-8"a), 131.5 (C-2'), 128.2 (C-2"', C-6"'), 127.7 (C-6'), 121.5 (C-1"'), 120.7 (C-1'), 120.4 (C-3'), 116.5 (C-5'), 115.8 (C-3"', C-5"'), 104.3 (C-8"), 103.8 (C-4a), 103.5 (C-4"a), 102.9 (C-3), 102.6 (C-3"), 99.0 (C-6"), 98.9 (C-6), and 94.1 (C-8).

Methyl protocatechuate (5): Yellow amorphous powder; ESI-MS: *m/z* 169 $[M+H]^+$ (calcd for $C_8H_9O_4$, 169); ^{1}H-NMR (CD_3OD, 500 MHz, δ_H ppm): 7.43 (1H, dd, 2.0, 8.0 Hz, H-6), 7.42 (1H, d, 2.0 Hz, H-2), 6.82 (1H, d, 8.0 Hz, H-5), and 3.85 (3H, s, OCH_3); ^{13}C-NMR (CD_3OD, 125 MHz, δ_C ppm): 167.5 (CO), 150.0 (C-4), 144.8 (C-3), 122.2 (C-1),121.2 (C-6), 116.0 (C-5), 114.5 (C-2), and 50.8 (OCH_3).

2.4. DPPH-antioxidant assay

Free radical quenching assay of the isolated compounds **1-5** has been carried out by 1,1-diphenyl-2-picryl hydrazyl (DPPH) [7-9]. Briefly, DPPH (0.1 mM) was diluted in methanol. 200 µL of this solution was added to 1.3 µL of various concentrations of **1-5** in DMSO (128.0, 32.0, 8.0, and 2.0 µg/mL). The mixture was performed by a 96-well plate at 25 ^oC in 30 min. Then, absorbance was determined by Biotek tool (at 517 nm). The percentage of DPPH quenching activity was computed by the following formula:

$$\text{Inhibitory percentage SC (\%)} = [(Ao - A_1)/Ao] \times 100.$$

where A_O was defined as the absorbance of control reaction, and A_1 represented for the absorbance in the presence of test or standard sample.

Each experiment was repeated three times, while resveratrol was used as a reference compound. The EC_{50} value, also known as the concentration of tested samples that induced half maximal response has been calculated from linear regression of the serial SC values versus the concentrations by using Table Curve 2Dv4.

3. RESULTS AND DISCUSSION

3.1. The NMR-structural elucidation

Compound **1** was separated as yellow amorphous powders. The ^{1}H, and ^{13}C-NMR spectral data of **1** revealed a pattern of a benzophenone derivative. In detail, the ^{1}H-NMR spectrum was composed of two superimposed singlet proton signals H-3 and H-5 (δ_H 6.17), one ABX spin system of δ_H 6.77, d, 8.0 Hz, 7.17, dd, 2.5, 8.0 Hz, and 7.27, d, 2.5 Hz, and two superimposed singlet methoxy groups at δ_H 3.67. It suggested that the chemical structure **1** included a symmetrically 1,2,4,6-tetrasubstituted phenyl unit, and another 1,3,4-trisubstituted phenyl unit. The ^{13}C-NMR data contained two methoxy groups at δ_C 56.11, five aromatic methines at δ_C 92.9-124.7 ppm, six aromatic carbons at δ_C 146.2-160.1 ppm, and a carbonyl group at δ_C 197.0. The structure of **1** was supported by 2D-NMR evidence, in which the key HBMC correlations H-3 (δ_H 6.17)/C-1 (δ_C 111.1), C-2 (δ_C 160.1), and C-4 (δ_C 161.8), H-5 (δ_H 6.17)/C-1, C-4, and C-6 (δ_C 160.1), 2-OCH_3/C-2, 6-OCH_3/C-6 confirmed the appearance of 2,6-dimethoxy-4-hydroxyphenyl unit. Similarly, the remaining 1,3,4-substituted phenyl moiety was highlighted with the key HMBC cross-peaks H-5'/C-1', and C-3', H-2' and H-6'/C-4'. The key HMBC correlations H-2' and H-6'/CO implied that two phenyl units were connected through the carbonyl group. From these findings and comparing with literature [10], compound **1** was determined to be 4,3',4'-trihydroxy-2,6-dimethoxybenzophenone.

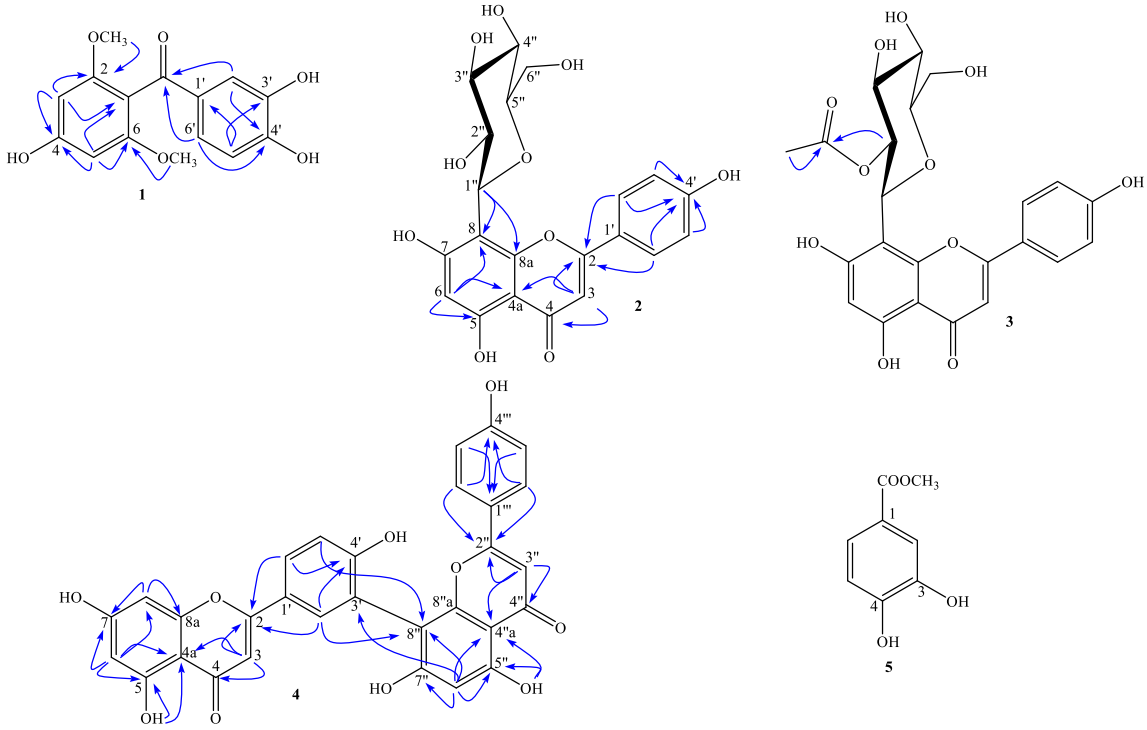

Figure 1. Isolated compounds from *G. mackeaniana* leaves and their key HMBC correlations.

Compound **2** was isolated as yellow amorphous powders. The positive ESI-MS spectrum showed the proton adduct ion at *m/z* 433 $[M+H]^+$, which alongside the ^{13}C-NMR data were consistent with the molecular formula of $C_{21}H_{20}O_{10}$. The ^{1}H-NMR spectral data of **2** were characteristic of a flavone *C*-glycoside, in which two singlet signals resonating at δ_H 6.74 and δ_H 6.23 were assigned to aromatic methine protons H-3 and H-6, respectively. A symmetric phenyl unit (B ring of flavone) was found to appear at δ_H 8.00 (2H, brd, 8.5 Hz, H-2', H-6'), and δ_H 6.90

(2H, d, 8.5 Hz, H-3', H-5'). The sugar unit of **2** with chemical shifts at δ_H 3.25-4.72 ppm, and coupling constant J = 9.0 Hz of the anomeric proton have demonstrated a β-D-glucopyranosyl unit [11-13]. The 2D-NMR spectroscopies were in agreement with the findings in the 1D-NMR (Figure 1). The chromene ring was formulated with HMBC correlations H-3 (δ_H 6.74)/C-2 (δ_C 163.8), C-4 (δ_C 181.9), and C-4a (δ_C 104.6), H-6 (δ_H 6.23)/C-4a, C-5 (δ_C 160.4), and C-8 (δ_C 104.6), whereas ring B was established and linked to carbon C-2 due to the key HMBC correlations between H-2' and H-6' (δ_H 8.00), H-3' and H-5' (δ_H 6.90)/C-4, and H-2' and H-6'/C-2. The important HBMC cross peaks H-1"/C-8, and C-8a confirmed that anomeric C-1" directly connected to C-8. Based on these findings and comparing with literature, compound **2** was elucidated as vitexin [14].

Compound **3** was isolated as yellow amorphous powders. The ^{1}H and ^{13}C-NMR spectral data of **3** were very similar to those of **2**, except for the presence of acetyl group at δ_H 1.80 (3H, s, C<u>H</u>$_3$CO) in the ^{1}H-NMR, and at δ_C 172.0 (CH$_3$<u>C</u>O) and δ_C 20.5 (<u>C</u>H$_3$CO) in the ^{13}C-NMR. The connectivity between the acetoxy group and carbon C-2" was determined by the HMBC correlation H-2"/CO (Figure 1). The chemical structure of **3** was further confirmed by the positive ESI-MS spectrum. The adduct ion at *m/z* 475 $[M+H]^+$ in the ESI-MS assigned to the molecular formula of **3** was to be $C_{23}H_{22}O_{11}$. Based on these findings, and comparing with literature data, compound **3** was identified to be 2"-*O*-acetylvitexin [15].

Compound **4** was separated as yellow amorphous powders, and had the molecular formula $C_{30}H_{18}O_{10}$ due to the observation of the proton adduct ion at *m/z* 539 $[M+H]^+$ in the positive ESI-MS spectrum. The ^{1}H-NMR data of **4** showed the characteristics of a biflavone. In comparison with compounds **2-3**, glycoside units of compounds **2-3** were replaced by a flavone unit [three aromatic protons at δ_H 6.82 (H-3), δ_H 6.18 (H-6), and 6.44 (H-8), and a ABX spin system at δ_H 7.12 (1H, d, 9.0 Hz, H-5'), δ_H 7.99 (1H, d, 2.5, 9.0 Hz, H-6'), and δ_H 8.02 (1H, d, 2.5 Hz, H-2')] in **4**. The ^{13}C-NMR data of **4** contained 30 carbon signals, which were assigned to twelve aromatic methine carbons, sixteen aromatic carbons, and two carbonyl carbons. The chemical structure of **4** was further confirmed by the 2D-NMR data (HSQC, and HMBC) (Figure 1). Especially, the connectivity between two monomeric flavone units was identified by the key HMBC J^3-correlation from H-2' to C-8", as well as the key HMBC W-shape correlations from H-5' to C-8", and from H-6" to C-3'. In comparison with literature data, isolated compound **4** was determined to be a biflavone, which was trivially named amentoflavone [16]. Secondary metabolite **4** has ever been isolated from various *Garcinia* species, such as *G. brevipedicellata* stem heartwoods, or *G. livingstonei* leaves, however, it was now found in *G. mackeaniana* [17, 18] for the first time.

Compound **5** was obtained as yellow amorphous powders. The ^{1}H-NMR spectrum of **5** established an ABX spin system of H-5 (δ_H 6.82, d, 8.0 Hz), H-6 (δ_H 7.43, dd, 2.0, 8.0 Hz), and H-2 (δ_H 7.42, d, 2.0 Hz), and one methoxy singlet signal at δ_H 3.85. Therefore, it can be concluded that isolated compound **5** was to be a phenolic compound type of 1,3,4-trisubstituted benzene. Based on the ^{13}C-NMR/DEPT data [three methines at δ_C 114.5 (C-2), δ_C 116.0 (C-5), and δ_C 122.2 (C-6), four carbons at δ_C 121.2 (C-1), δ_C 144.8 (C-3), δ_C 150.0 (C-4), and δ_C 167.5 (CO), together with one methoxy group at δ_C 50.8 (OCH_3)], and comparison with literature compound [19], compound **5** was unambiguously determined to be methyl 3,4-dihydroxybenzoate, which was trivially named methyl protocatechuate. Despite its availability in nature, this is the first time this compound was found in genus *Garcinia*.

3.2. DPPH-antioxidant assay

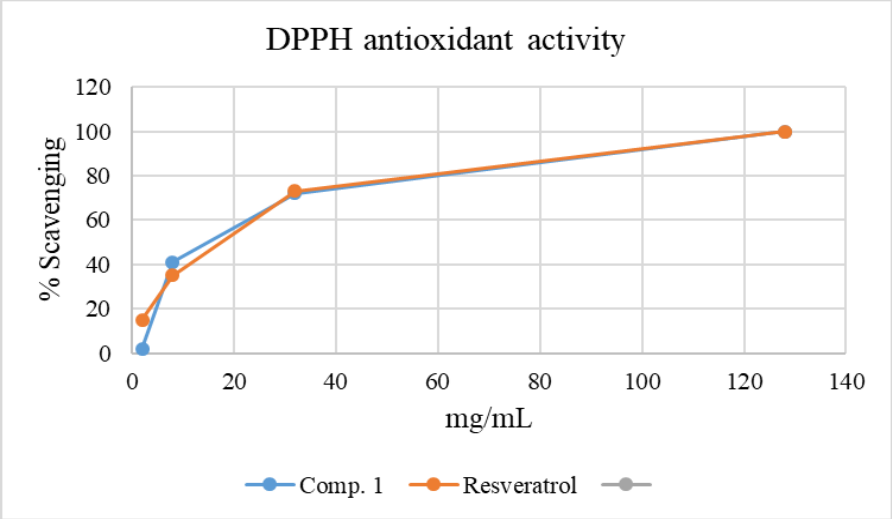

Figure 2. Radical quenching percent (% SC) of compound **1** and standard compound resveratrol. Data are described as Mean ± SD (n = 3), $P < 0.05$.

All isolated compounds **1-5** were subjected to antioxidative examination with the target of DPPH-radical scavenging assessment. Compounds **2-5** failed to capture DPPH radicals at any concentrations (data not shown). In contrast, compound **1** showed the strong EC_{50} value of 14.97±0.8 µg/mL, as compared with that of the positive control (IC_{50} 11.61 ± 0.09 µg/mL). As shown in Figure 2, at the concentration of 128.0 mg/mL, benzophenone **1** completely controlled DPPH with SC = 100%. It is noticeable that benzophenones (compound **1**) derived from *Garcinia* plants are better than flavone glycosides and biflavones (compounds **2-4**), and phenols (compound **5**) in antioxidant treatments.

4. CONCLUSIONS

The present results provide information on the phytochemical investigation and DPPH-antioxidative assay relating to Vietnamese *Garcinia mackeaniana* species. From methanolic extract, five known compounds, comprising of one benzophenone 4,3',4'-trihydroxy-2,6-dimethoxybenzophenone (**1**), two flavone *C*-glucosides vitexin (**2**) and its 2''-*O*-acetyl derivative (**3**), one biflavone amentoflavone (**4**), and one *mono*-phenol methyl protocatechuate (**5**) were isolated. This is the first time we report the isolation of these compounds from *G. mackeaniana*. Given strong IC_{50} value in DPPH assay, benzophenone **1** and analogs derived *Garcina* plants can become promising agents for antioxidant problems.

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REFERENCES

1. Yang H., Tian D., Zeng Y., Huang L., Gu W., Hao X., Yuan C. - Phenolic derivatives from *Garcinia multiflora* Champion ex Bentham and their chemotaxonomic significance, Biochem. Syst. Ecol. **88** (2020) 103981.

2. Jena B. S., Jayrakasha G. K., Singh R. P., Sakariah K. K. - Chemistry and biochemistry of (−)-hydroxycitric acid from Garcinia, J. Agric. Food Chem. **50** (2002) 10-22.
3. Ovalle-Magallanes B, Eugenio-Pérez D, Pedraza-Chaverri J. - Medicinal properties of mangosteen (*Garcinia mangostana* L.): A comprehensive update, Food Chem. Toxicol. **109** (2017) 102-122.
4. Hemshekhar M., Sunitha K., Sebastin Santhosh M., Devaraja S., Kemparaju K., Vishwanath B. S., Niranjana S. R., Girish K. S. - An overview on genus *Garcinia*: phytochemical and therapeutic aspects, Phytochem. Rev. **10** (2011) 325-351.
5. Ho P. H. - An illustrated flora of Vietnam, Youth Publisher, Ho Chi Minh City, Vietnam, **1** (1999) 457-461.
6. Ha N. T. T., Cuong P. V., Anh L. T. T., Tra N. T., Cham B. T., Son N. T. – Antimicrobacterial xanthones from *Garcinia mackeaniana* leaves, Vietnam J. Chem. **58** (2020) 343-348.
7. Son N. T., Kamiji M., Huong T. T., Kubo M., Cuong N. M., Fukuyama Y. - Chemical constituents of the Vietnamese plants *Dalbergia tonkinensis* Prain and *Cratoxylum formosum* (Jack) Dyer in Hook and their antioxidative activities, Med. Chem. Res. **28** (2019) 1441-1447.
8. Elshamy A. I., Hama M., Trang N. V., Son N. T., Okamoto Y., Noji M., Ban S., Umeyama A. - A new cerebroside from the endophytic fungus *Ophiocordyceps longiissima*: Structural-electronic and antioxidant relations. Experimental and DFT calculated studies, J. Mol. Struct. **1200** (2020) 127061.
9. Tram N. C. T., Son N. T., Nga N. T., Phuong V. T. T., Cuc N. T., Phuong D. T., Truan G., Cuong N. M., Thao D. T. - The hepatoprotective activity of a new derivative kaempferol glycoside from the leaves of Vietnamese *Phyllanthus acidus* (L.) Skeels, Med. Chem. Res. **26** (2017) 2057-2064.
10. Muriithi E., Bojase-Moleta G., Majinda R. R. T. - Benzophenone derivatives from *Garcinia livingstonei* and their antioxidant activities, Phytochem. Lett. **18** (2016) 29-34.
11. Huong Tran T., Ha Vu T., Cuong To D., Son Ninh T., Toan Tran Q., Anh Hoang T. N., Tram Nguyen T. T., Woo Sun H., Kim Y. H., Cuong N. M. - New constituents from the roots and stems of *Paramignya trimera*, Nat. Prod. Commun. (2019) 1-5.
12. Huong Tran T., Son Ninh T., Cuong Nguyen M., Van Doan T., Cuong To D., Khanh Pham N., Ha Vu T. - Morinlongosides A-C, two new isoprenylated naphthoquinone glucosides and a new iridoid glucoside from the roots of *Morinda longissima*, Chem. Pharm. Bull. **64** (2016) 1230-1234.
13. Cuong Nguyen M., Huong Tran T., Khanh Pham N., Tai Nguyen V., Ha Vu T., Son Ninh T., Tai Bui H., Kim Young H. - Paratrimerins A and B, two new dimeric monoterpene-linked coumarin glycosides from the roots and stems of *Paramignya trimera*, Chem. Pharm. Bull. **63** (2015) 945-949.
14. Cuong L. C. V., Trang D. T., Cuc N. T., Nhiem N. X., Yen P. H., Anh H. L. T., Huong L. M., Minh C. V., Kiem P. V. - Flavonoid glycosides from *Antidesma ghasembilla*, Vietnam J. Chem. **53** (2e) (2015) 94-97.
15. Kashnikova M. V., Sheichenko V. I., Glyzin V. I., Samylina I. A. - Acetylvitein – A new flavonoid from the flowers of *Crataegus sanguinea*, Chem. Nat. Compd. **106** (1984) 108-109.

16. Devkota H. P., Miyazaki S., Yahara S. -Amentoflavone and kaempferol glycosides from the aerial parts of *Cissampelos pareira*, Nepal J. Biotechnol. **5** (2017) 1-4.
17. Abdermane B., Tih A. E., Ghogomu R. T., Blond A., Bodo B. - New flavonoid C-O-C dimers and other chemical constituents from *Garcinia brevipedicellata* stem heartwood, Z. Naturforsch. C **71** (2016) 233-241.
18. Kaikabo A. A., Eloff J. N. - Antibacterial activity of two biflavonoids from *Garcinia livingstonei* leaves against *Mycobacterium smegmatis*, J. Ethnopharmacol. **138** (2011) 252-255.
19. Ha N. T. T., Tra N. T., Cham B. T., Anh L. T. T., Cuong P. V. - Chemical constituents from *Diospyros fleuryana* (genus *Diospyros*), Vietnam J. Chem. **57** (6E12) (2019) 22-26.