INITIAL RESEARCH ON CHEMICAL CONSTITUENTS OF CURCUMA SINGULARIS RHIZOMES

Nguyen Manh Cuong¹*, Doan Thi Van¹, Ninh The Son¹, To Dao Cuong¹, Pham Ngoc Khanh¹, Vu Thi Ha¹, Tran Thu Huong¹, Nguyen Phuong Hanh², Nguyen Quoc Binh³

¹Institute of Natural Products Chemistry, VAST, 18 Hoang Quoc Viet, Caugiay, Hanoi
²Institute of Ecology and Biological Resources, VAST, 18 Hoang Quoc Viet, Caugiay, Hanoi
³Vietnam National Museum of Nature, VAST, 18 Hoang Quoc Viet, Caugiay, Hanoi

*Email: nmcuong_inpc@yahoo.com.vn

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ABSTRACT

From the rhizomes of Curcuma singularis Gagnep (Zingiberaceae family), six compounds, including three terpenoids, p-menthane-1,2,4-triol (1), amoxantin A (2), rugosic acid B (3); two diols, 2,3-butanediol (4) [2R,3R-butanediol (4a) and 2S,3S-butanediol (4b)], and meso-2,3-butanediol (5), along with 3-hydroxy-4-methoxy benzoic acid (6) were isolated. All of six compounds were obtained for the first time from the Curcuma genus. The structures of those compounds were determined by 1D and 2D-NMR spectroscopic data.

Keywords: Curcuma singularis Gagnep., Zingiberaceae, rhizomes, terpenoid, labdadien, butanediol, benzoic acid.

1. INTRODUCTION

Curcuma is a large genus belonging to Zingiberaceae family, comprise of 147 species over the world [1] and 15 species in Vietnam [2]. Several Curcuma species were used in traditional medicine for the treatment of gastrointestinal disorders, abdominal pain, jaundice, and hepatitis [3]. Curcuma singularis Gagnep., local name “cây khôe” were used by ethnic people in Tay Nguyen provinces as medicinal remedy for increasing vitality, boosting health, treating rheumatism and fortifying kidney.

Around the world, so far there have been many publications on the chemical compositions and biological activity of the Curcuma species such as Curcuma longa L. [4, 5], C. wenyujin [6], and C. comosa [7]. Compounds mainly found in this genus were terpenoids and diaryl phenyls [4 - 7]. However, to the best of our knowledge, there are not any studies announced on the chemical compositions and biological activity of C. singularis. In this paper, we present some our initial findings on the chemical compositions of the rhizomes of Curcuma singularis Gagnep.
2. MATERIALS AND METHODS

2.1. Plant material

The rhizomes of *C. singularis* were collected in Kon Pne commune, K’bang district, Gialai province, Vietnam in April 2015. The plant was identified by botanist Dr. Nguyen Quoc Binh, Institute of Ecology and Biological Resources (VAST), Vietnam. A voucher specimen (C-557) is deposited in the Herbarium of the Institute of Natural Products Chemistry (VAST), Hanoi, Vietnam.

2.2. General experimental procedures

$^1$H-NMR (500 MHz) and $^{13}$C-NMR (125 MHz) were measured on a Bruker Avance 500 MHz spectrometer, Institute of Chemistry. ESI-MS were obtained from an Agilent 1100 Series LC/MSD Trap SL, Institute of Chemistry. Chromatographic separation was carried out on silica gel (Si 60 F$_{254}$, 40-63 mesh, Merck) and RP-C$_{18}$ column. All solvents were redistilled before use. Pre-coated TLC plates (Si 60 F$_{254}$) were used for analytical purposes.

2.3. Extraction and isolation

Dried powdered rhizomes of *C. singularis* (3.2 kg) were extracted with ethanol 80° (3 × 7L) at room temperature and concentrated under reduced pressure to yield a black crude ethanol extract (300 g). The crude ethanol extract was suspended in hot ethanol-water (1:1, v/v) and successively partitioned with chloroform, ethyl acetate and water. The resulting fractions were concentrated under reduced pressure to give the corresponding solvent-soluble fractions chloroform (198 g, CS-C), ethyl acetate (6.0 g, CS-E) and water (96 g, CS-W).

The chloroform fraction (CS-C, 198 g) was chromatographed on a silica gel column, using solvent gradient of $n$-hexane : ethyl acetate (6:1, v/v) to afford 8 fractions (C1-C8). The fraction C1 (15 g) was chromatographed on a silica gel column, eluting with $n$-hexane : ethyl acetate (100:1, v/v) to afford 4 subfractions (C1A-C1D). Precipitate from C1C subfraction (3.5 g) was filtered and washed to yield compound 2 (100 mg). The fraction C5 (1.59 g) was chromatographed on a silica gel column, eluting with dichloromethane : acetone (20/1, v/v) to afford 7 subfractions (C5A-C5G). The subfraction C5E (243 mg) was eluted with isocratic solvent system of $n$-hexane : acetone (5:1, v/v) on a silica gel column to yield compound 1 (4 mg).

The ethyl acetate fraction (CS-E, 6.0 g) was subjected for chromatography column (CC) on a flash silica gel column (400-630 mesh), eluting with chloroform-acetone (10:1, v/v) to afford 11 fractions (E1-E11). The fraction E2 (110 mg) was chromatographed on a silica gel column, eluting with chloroform : ethyl acetate (10:1, v/v) to afford 2 subfractions (E2A-E2B). Precipitate from E2A (80 mg) was filtered and washed with chloroform to yield compound 6 (10.0 mg). The fraction E10 (220 mg) was chromatographed on a silica gel column, eluting with ethyl acetate : methanol (5:1, v/v) to afford 5 subfractions (E10A-E10E). The subfraction E10B (25 mg) was rechromatographed over a RP-18 column eluting with methanol : water (1:1, v/v) to yield compound 3 (6 mg).

The water fraction (CS-W, 96 g) was subjected to a Diaion CC, eluting with gradient solvent mixture of water-methanol (1.0→0:1) to produce 5 fractions (W1-W5). The fraction W1 (70 g) was purified on a silica gel CC using chloroform : methanol : water (6:1:0.1, v/v) to
afford 11 fractions (W1A-W1J). The subfraction W1A (1.6 g) was chromatographed on a silica gel column, eluting with chloroform : acetone (6:1, v/v) to afford 5 subfractions and yield compound 4 (100 mg) and compound 5 (80 mg).

**p-menthane-1,2,4-triol** (1): White needle crystals (C₁₀H₂₀O₃). ¹H-NMR (500 MHz, MeOD), δ_H (ppm): 0.93 (3H, d, J = 7.0 Hz, H-9), 0.94 (3H, d, J = 7.0 Hz, H-8), 1.26 (3H, s, 1-CH₃), 1.44 (2H, m, H-6), 1.60 (1H, dd, J = 13.0, 6.5 Hz, H-7), 1.63 (1H, dt, J = 14.0, 3.0 Hz, H₆-3), 1.85 (1H, dd, J = 13.5, 4.0 Hz, H₆-5), 1.93 (1H, dd, J = 13.5, 3.5 Hz, H₆-5), 1.96 (1H, dt, J = 14.0, 3.5 Hz, H₆-3), 3.53 (1H, brs, H-2). ¹³C-NMR (125 MHz, MeOD), δ_C (ppm): 17.1 (q, C-9), 17.2 (q, C-8), 27.1 (q, 1-CH₃), 30.3 (t, C-6), 30.4 (t, C-5), 34.9 (t, C-3), 39.0 (d, C-7), 72.1 (s, C-1), 75.7 (s, C-4), 75.7 (d, C-2).

**Amoxantin A** (2): Yellowish needle crystals (C₁₈H₂₈O). ¹H-NMR (500 MHz, CDCl₃), δ_H (ppm): 0.85 (3H, s, H-19), 0.89 (6H, s, H-18, H-20), 1.02 (1H, ddd, J = 3.0, 13.0, 13.0 Hz, Ha-1), 1.10 (1H, dd, J = 2.5, 12.5 Hz, H-5), 1.19 (1H, ddd, J = 4.5, 13.5, 14.0 Hz, H₆-1), 1.37 (1H, m, H₆-1), 1.39 (1H, m, H₆-6), 1.41 (1H, m, H₆-2), 1.44 (1H, m, H₆-3), 1.54 (1H, m, H₆-2), 1.72 (1H, m, H₆-6), 2.09 (1H, ddd, J = 5.0, 12.5, 13.5 Hz, H₆-7), 2.27 (3H, s, H-14), 2.44 (1H, m, H₆-7), 2.47 (1H, m, H-9), 4.41 (1H, d, J = 1.0 Hz, H-17), 4.79 (1H, d, J = 1.0 Hz, H₆-17), 6.07 (1H, d, J = 16.0 Hz, H-12), 6.87 (1H, dd, J = 6.0, 16.0 Hz, H-11). ¹³C-NMR (125 MHz, CDCl₃), δ_C (ppm): 15.1 (q, C-20), 19.0 (t, C-2), 21.9 (q, C-19), 23.3 (t, C-6), 27.2 (q, C-14), 33.5 (s, C-4), 33.6 (q, C-18), 36.6 (t, C-7), 39.3 (s, C-10), 40.9 (t, C-3), 54.5 (d, C-5), 60.8 (d, C-9), 108.6 (t, C-17), 133.6 (d, C-12), 146.6 (d, C-11), 148.6 (s, C-8), 198.1 (s, C-13).

**Rugosic acid B** (3): Colorless crystals (C₁₅H₂₂O₅). ¹H-NMR (500 MHz, MeOD), δ_H (ppm): 0.94 (3H, d, J = 7.0 Hz, H-13), 1.02 (3H, d, J = 6.5 Hz, H-12), 1.15 (3H, s, 7-CH₃), 1.68 (1H, m, H₆-8), 1.71 (1H, m, H-9), 1.78 (1H, m, H₆-8), 1.92 (1H, d, J = 12.0 Hz, H₆-6), 2.02 (1H, d, J = 12.0 Hz, H₆-6), 2.06 (1H, m, H₆-9), 2.14 (1H, dd, J = 7.5, 3.0 Hz, H-10), 2.41 (1H, m, H-11), 4.02 (1H, d, J = 5.0 Hz, H-2), 6.63 (1H, d, J = 5.0 Hz, H-3). ¹³C-NMR (125 MHz, MeOD), δ_C (ppm): 20.7 (q, C-13), 24.4 (t, C-9), 24.8 (q, 7-CH₃), 25.8 (q, C-12), 26.1 (d, C-11), 45.3 (t, C-8), 49.7 (s, C-7), 54.0 (d, C-10), 57.1 (t, C-6), 66.4 (d, C-2), 97.8 (s, C-1), 103.2 (s, C-5), 134.2 (d, C-3), 141.4 (s, C-4), 173.5 (s, CO).

**2,3-butanediol** (4): Yellowish oil (C₄H₁₀O₂). ¹H-NMR (500 MHz, MeOD), δ_H (ppm): 0.94 (3H, d, J = 6.0 Hz, H-13), 1.02 (3H, d, J = 6.5 Hz, H-12), 1.15 (3H, s, 7-CH₃), 1.68 (1H, m, H₆-8), 1.71 (1H, m, H-9), 1.78 (1H, m, H₆-8), 1.92 (1H, d, J = 12.0 Hz, H₆-6), 2.02 (1H, d, J = 12.0 Hz, H₆-6), 2.06 (1H, m, H₆-9), 2.14 (1H, dd, J = 7.5, 3.0 Hz, H-10), 2.41 (1H, m, H-11), 4.02 (1H, d, J = 5.0 Hz, H-2), 6.63 (1H, d, J = 5.0 Hz, H-3). ¹³C-NMR (125 MHz, MeOD), δ_C (ppm): 20.7 (q, C-13), 24.4 (t, C-9), 24.8 (q, 7-CH₃), 25.8 (q, C-12), 26.1 (d, C-11), 45.3 (t, C-8), 49.7 (s, C-7), 54.0 (d, C-10), 57.1 (t, C-6), 66.4 (d, C-2), 97.8 (s, C-1), 103.2 (s, C-5), 134.2 (d, C-3), 141.4 (s, C-4), 173.5 (s, CO).

**meso-2,3-butanediol** (5): Yellowish oil (C₄H₁₀O₂). ¹H-NMR (500 MHz, MeOD), δ_H (ppm): 1.14 (6H, d, J = 6.5 Hz, H-1, H-4), 3.53 (2H, m, H-2, H-3). ¹³C-NMR (125 MHz, MeOD), δ_C (ppm): 18.6 (q, C-1), 18.7 (q, C-4), 26.2 (d, C-2), 72.7 (d, C-3).

**3-Hydroxy-4-methoxybenzoic acid** (6): White needle crystals (C₈H₈O₄). ¹H-NMR (500 MHz, MeOD), δ_H (ppm): 3.91 (3H, s, H-8), 6.86 (1H, d, J = 8.5 Hz, H-5), 7.57 (1H, d, J = 2.5 Hz, H-2), 7.58 (1H, d, J = 2.5, 8.5 Hz, H-5). ¹³C-NMR (125 MHz, MeOD), δ_C (ppm): 56.4 (q, 4-OCH₃), 113.8 (d, C-5), 115.8 (d, C-2), 123.1 (s, C-1), 123.5 (d, C-6), 148.7 (s, C-3), 152.7 (s, C-4), 170.0 (s, CO).
Initial research on chemical constituents of *Curcuma singularis* rhizomes

Figure 1. Compounds (1-6) from rhizomes of *Curcuma singularis* species.

3. RESULT AND DISCUSSION

Compound 1 was obtained as white needle crystals. The $^1$H-NMR of 1 showed characteristic signals for a monoterpene, including two methyl protons of isopropyl group at [$\delta_H$ 0.93 ($J = 7.0$ Hz, H-9), $\delta_H$ 0.94 ($J = 7.0$ Hz, H-8)], one methyl group at $\delta_H$ 1.26 (1-CH$_3$), three methylene groups at [$\delta_H$ 1.44 (m, H-6), $\delta_H$ 1.85 (dd, $J = 13.5$, 4.0 Hz, H$_2$-5), $\delta_H$ 1.93 (dd, $J = 13.5$, 3.5 Hz, H$_3$-5), $\delta_H$ 1.63 (dt, $J = 14.0$, 3.0 Hz, H$_2$-3) and $\delta_H$ 1.96 (dt, $J = 14.0$, 3.5 Hz, H$_3$-3)], and two methine protons at [$\delta_H$ 1.60 (dd, $J = 13.0$, 6.5 Hz, H-7), $\delta_H$ 3.53 (brs, H-2)]. In agreement with those, $^{13}$C-NMR/DEP of 1 showed 10 carbon signals, assignable to three methyl carbons at [$\delta_C$ 17.1 (q, C-9), $\delta_C$ 17.2 (q, C-8), $\delta_C$ 27.1 (q, 1-CH$_3$)], three methylene carbons at [$\delta_C$ 30.3 (t, C-6), $\delta_C$ 30.4 (t, C-5), $\delta_C$ 34.9 (t, C-3)], two methine carbons at [$\delta_C$ 39.0 (d, C-7), $\delta_C$ 75.7 (d, C-2)], and two quaternary carbons at [$\delta_C$ 72.1 (s, C-1), $\delta_C$ 75.7 (s, C-4)]. Analysis of HMBC spectra, methyl proton 1-CH$_3$ correlated to C-1, C-2 and C-6, which confirmed the position of methyl group at C-1. Similarly, isopropyl side chain at C-4 was confirmed by the HMBC correlations between H-8/H-9 and C-4/C-7. From 1D, 2D-NMR data, together with a comparison with spectral data in published literature, the chemical structure of 1 was elucidated as a polyoxygen-monoterpene with trivial name *p*-menthane-1,2,4-triol [8].

Compound 2 was isolated as yellowish needle crystals. The $^1$H-NMR spectrum of 2 displayed patterns of diterpenoid, bicyclic skeleton of bisnorlabdane, with characteristic signals of three methyl groups at $\delta_H$ 0.85 (s, H-19), $\delta_H$ 0.89 (s, H-18, H-20), one exomethylene group at [$\delta_H$ 4.41 (d, $J = 1.0$ Hz, H$_2$-17), $\delta_H$ 4.79 (d, $J = 1.0$ Hz, H$_2$-17)], one $\alpha$, $\beta$-unsaturated ketone side chain at [$\delta_H$ 6.80 (dd, $J = 10.0$, 16.0 Hz, H-11), $\delta_H$ 6.07 ($J = 16.0$ Hz, H-12), $\delta_H$ 2.27 (s, H-14)]. $^{13}$C-NMR/DEPT spectra of 2 contained 18 carbon signals, composed of four methyl groups at [$\delta_C$ 27.2 (q, C-14), $\delta_C$ 33.6 (q, C-18), $\delta_C$ 21.9 (q, C-19), $\delta_C$ 15.1 (q, C-20)], six methylene carbons at [$\delta_C$ 40.9 (t, C-1), $\delta_C$ 19.0 (t, C-2), $\delta_C$ 42.1 (t, C-3), $\delta_C$ 23.3 (t, C-6), $\delta_C$ 36.6 (t, C-7), $\delta_C$ 108.6 (t, C-17)], four methine carbons at [$\delta_C$ 54.5 (d, C-5), $\delta_C$ 60.8 (d, C-9), $\delta_C$ 146.6 (d, C-11), $\delta_C$ 133.6 (d, C-12)], three quaternary carbons at [$\delta_C$ 33.5 (s, C-4), $\delta_C$ 148.6 (s, C-8), $\delta_C$ 39.3 (s, C-10)], and
carbonyl group at $\delta_c$ 198.1 (s, C-13). The chemical structure of 2 was also confirmed by COSY and HMBC spectroscopies. In the COSY spectra, the presence of a skeletal bisnorlabdane was determined, due to cross peaks of three consecutive methylene protons H-1/H-2/H-3, two methylene protons H-6/H-7, two olefinic protons H-11/H-12. In the HMBC spectra, selective key correlations between H-18 and H-19/C-4, H-20/C-10, and H-14/C-13, have assigned the positions of methyl groups (Figure 1). In addition, the connectivity of exomethylene group and ring at C-8, which was observed by correlations of H-17/C-7, C-8 and C-9. In the same manner, the linkage between the $\alpha$, $\beta$-unsaturated ketone side chain and the ring at C-9 was improved by correlations of H-11/C-8, C-9, and C-10. By comparison of the spectroscopic data with those in published literature, compound 2 was identified as amoxantin A [9].

Compound 3 was isolated as colourless crystals. The $^1$H-NMR of 3 showed the presence of a sesquiterpene of carotane skeleton, including, one methyl group at $\delta_h$ 1.15 (s, 7-CH$_3$), and two methyl protons of isopropyl group at [$\delta_h$ 0.94 (d, $J = 7.0$ Hz, H-13), $\delta_h$ 1.02 (d, $J = 6.5$ Hz, H-12)], three methylene protons at [$\delta_h$ 1.68 (m, H$_2$-8), $\delta_h$ 1.71 (m, H$_2$-9), $\delta_h$ 1.78 (m, H$_2$-8), $\delta_h$ 1.92 (d, $J = 12.0$ Hz, H$_2$-6), $\delta_h$ 2.02 (d, $J = 12.0$ Hz, H$_2$-6), $\delta_h$ 2.06 (m, H$_2$-9)], three methine protons at [$\delta_h$ 2.14 (dd, $J = 7.5$, 3.0 Hz, H-10), $\delta_h$ 2.41 (m, H-11), $\delta_h$ 4.02 (d, $J = 5.0$ Hz, H-2)], and olefinic proton at $\delta_h$ 6.63 (d, $J = 5.0$ Hz, H-3). The $^{13}$C-NMR/DEPT data indicated a total number of 15 carbons, comprising characteristic signals of a sesquiterpene, due to three methyl carbons at [$\delta_c$ 20.7 (q, C-13), $\delta_c$ 24.8 (q, 7-CH$_3$), $\delta_c$ 25.8 (q, C-12)], three methylene carbons at [$\delta_c$ 45.3 (t, C-8), $\delta_c$ 57.1 (t, C-6)], four methine carbons at [$\delta_c$ 26.1 (d, C-11), $\delta_c$ 54.0 (d, C-10), $\delta_c$ 66.4 (d, C-2), $\delta_c$ 134.2 (d, C-3)], and five quaternary carbons at [$\delta_c$ 49.7 (s, C-7), $\delta_c$ 97.8 (s, C-1), $\delta_c$ 103.2 (s, C-5), $\delta_c$ 141.4 (s, C-4), $\delta_c$ 173.5 (s, CO)]. The observed correlations of methyl proton 7-CH$_3$/C-1, C-6, C-7, and C-8 in the HMBC spectra have determined the position of 7-CH$_3$ group at C-7, whereas the linkage position of isopropyl group at C-10 was determined by correlations between H-12 and H-13/C-10 and C-11. Furthermore, the linkage of carboxyl group and olefinic carbon C-4 was determined from the correlations of H-3/C-1, C-2, and C-5. From 1D, 2D-NMR and literature data, compound 3 was identified to be rugosic acid B [10].

Compound 4 (the mixture of 4a and 4b) was isolated as a yellowish oil. Based on the $^1$H-NMR and $^{13}$C-NMR/DEPT spectral data, compound 4 was identified as a vicinal-diols. In the $^1$H-NMR spectrum, superimpose doublet signal at $\delta_h$ 1.16 ($J = 6.0$ Hz) was due to two methyl groups H-1 and H-4, whereas superimpose multiple signal at $\delta_h$ 3.56 was of two hydroxylated-methylene protons H-2 and H-3. Furthermore, the $^{13}$C-NMR spectra clearly showed the appearances of four carbon signals at [$\delta_c$ 18.6 (q, C-1), $\delta_c$ 18.7 (q, C-4), $\delta_c$ 72.6 (d, C-2), and $\delta_c$ 72.7 (d, C-3)]. By comparison of the NMR data with those reported in the publication, compound 4 was determined as a mixture of enatiomers [(2R, 3R)-2,3-butanediol (4a) and (2S, 3S)-2,3-butanediol (4b)] [11].

Compound 5 was isolated as a yellowish oil. The $^1$H-NMR data of 5 was similar to those of 4, showing the existence of a symmetric polyalcohol. Two symmetric methyl groups H-1 and H-4 was founded at $\delta_h$ 1.14 ($J = 6.5$ Hz, d), while two hydroxylated-methylene protons H-2 and H-3 were characterized with multiple signals, at $\delta_h$ 3.53. Unlike compounds 4a and 4b, only two signals with strong intensity were observed in the $^{13}$C-NMR/DEPT spectra of 5, at $\delta_c$ 18.7 (q, C-1, C-4), and $\delta_c$ 72.7 (d, C-2, C-3)]. Those data suggest compound 5 having an internal plane of symmetry. Therefore, from above mention and literature research, the chemical structure of 5 was confirmed as meso-2,3-butanediol [12].

Compound 6 was obtained as white needle crystals. The $^1$H-NMR spectrum data clearly indicated that this compound displayed as a pattern of 3,4-disubstituted benzoic acid, including ABX aromatic protons at [$\delta_h$ 6.86 (d, $J = 8.5$ Hz, H-5), $\delta_h$ 7.58 (d, $J = 2.5$, 8.5 Hz, H-6) and $\delta_h$
7.57 (d, J = 2.5 Hz, H-2)], one methoxy group at $\delta_{\text{H}}$ 3.91 (4-OCH$_3$, s). In accordance with $^1$H-NMR spectrum data, $^{13}$C-NMR/DEPT spectrum data of 6 exhibited eight carbons, comprising one methoxy carbon at $\delta_{\text{C}}$ 56.4 (4-OCH$_3$), three aromatic carbons at $\delta_{\text{C}}$ 113.8 (d, C-5), $\delta_{\text{C}}$ 125.3 (d, C-6) and $\delta_{\text{C}}$ 115.8 (d, C-2)], three quaternary carbons at $\delta_{\text{C}}$ 123.1 (s, C-1), $\delta_{\text{C}}$ 148.7 (s, C-3) and $\delta_{\text{C}}$ 152.7 (s, C-4), and a carbonyl group in the downfield, at $\delta_{\text{C}}$ 170.0 ppm. From above mentions and a comparison with literature data, compound 6 was determined as a derivative of benzoic acid, named 3-hydroxy-4-methoxybenzoic acid [13].

4. CONCLUSION

From the rhizomes of Curcuma singularis Gagnep. (Zingiberaceae), six compounds, including 3 terpenoids, p-menthane-1,2,4-triol (1), amoxantin A (2), rugosic acid B (3), 2 diols, 2,3-butanediol (4) [2R,3R-butanediol (4a) and 2S,3S-butanediol (4b)], meso-2,3-butanediol (5), along with 3-hydroxy-4-methoxybenzoic acid (6) were obtained. All of six compounds were isolated for the first time from the Curcuma genus. The structures of those compounds were determined by 1D and 2D-NMR spectroscopic data.

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TÔM TÁT

BUỘC ĐẦU NGHIÊN CỨU THÀNH PHÁN HÓA HỌC THÂN RỄ CÂY CURCUMA SINGULARIS

Nguyễn Mạnh Cuong1,*, Đoàn Thị Vân1, Ninh Thế Sơn1, Tô Đạo Cương1, Phạm Ngọc Khanh1, Vũ Thị Hà1, Trần Thu Hương1, Nguyễn Phương Hạnh2, Nguyễn Quốc Bình3

1Viện Hỏa học các Hợp chất TN, Viện HLKHCNVN, 18 Hoàng Quốc Việt, Cầu Giấy, Hà Nội
2Viện Sinh thái và TN sinh vật, Viện HLKHCNVN, 18 Hoàng Quốc Việt, Cầu Giấy, Hà Nội
3Bảo tàng thiên nhiên Việt Nam, Viện KLKHCNVN, 18 Hoàng Quốc Việt, Cầu Giấy, Hà Nội

*Email: nmcuong_inpc@yahoo.com.vn

Từ thân rễ loài Curcuma singularis Gagnep. (Zingiberaceae), sáu hợp chất bao gồm ba hợp chất terpenoit, p-menthane-1,2,4-triol (1), amoxantin A (2), axit rugosic B (3), nhóm hợp hai diol, 2,3-butanediol (4) [2R,3R-butanediol (4a) và 2S,3R-butanediol (4b)], meso-2,3-butanediol (5) và một dẫn xuất của axit benzoic 3-hydroxy-4-methoxybenzoic acid (6) đã được phân lập. Sáu hợp chất trên được phân tích lần đầu tiên từ Curcuma. Cấu trúc hóa học của các hợp chất 1-6 được xác định dựa trên các dữ kiện phô 1D và 2D-NMR.

Từ khóa: Curcuma singularis Gagnep., Zingiberaceae, thân rễ, terpenoit, labdadien, butanediol, axit benzoic.