FLAVONOIDS ISOLATED FROM THE FLOWERS OF 
CAMELLIA CHRYSANtha

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Abstract. Camellia chrysantha (Hu) Tuyama (the golden camellia, golden tea) is a species of evergreen shrub or small tree belonging to the family Theaceae. The flowers and the leaves of this plant are used as tea due to their health benefits. The aim of this study was to investigate the chemical constituents of the flowers of Camellia chrysantha (Hu) Tuyama. Five flavonoids were isolated from the flowers of Camellia chrysantha (Theaceae), including (+)-catechin (1), (-)-epicatechin (2), quercetin (3), quercetin-3-O-methyl ether (4) and kaempferol (5). Their chemical structures were elucidated by spectroscopic data analysis and by comparison with those reported in the literature. Among five compounds, compound 4 was isolated for the first time from this species.

Keywords: Camellia chrysantha (Hu) Tuyama, Theaceae, catechin, epicatechin, quercetin, quercetin-3-O-methyl ether, kaempferol.

Classification numbers: 1.1.3; 1.3.1.

1. INTRODUCTION

Camellia chrysantha (Hu) Tuyama (the golden camellia) is a species of evergreen shrub or small tree belonging to the family Theaceae and restricted to wet areas of forest below 500 m. It is found in China and Vietnam. In Vietnam, this species was found in Ba Che (Quang Ninh) [1]. It is noticed that Camellia chrysantha contains many trace elements such as germanium, selenium, manganese, molydenuem, vanadium, and zinc; the bioactive compounds found in this species have the ability to inhibit the growth of tumors up to 33.8 % and help reduce up to 35 % of cholesterol in the blood [2]. The plant is also able to relieve the symptoms of atherosclerosis caused by blood fats, control blood pressure and treat cardiovascular diseases and diabetes. Camellia chrysantha was included in The IUCN Red List of Threatened Species 1998: e.T32315A9695863 [3]. Although this is a precious medicinal plant and has many uses, the knowledge about its chemical constituents is still limited. There are some studies about this plant but almost all studies focused on its botanical characteristics and values for bonsai. Recently,
Luong Phu Hoang et al. have studied on preparation and characterization of chitosan/alginate film loading Golden Flower Tea (*Camellia chrysantha*) extract [4]. In the previous study [5], we have presented five flavonoid glycosides isolated from the flowers of *Camellia chrysantha* (Hu) Tuyama, collected at Ba Che (Quang Ninh province). In the current study, we continue to report the isolation and elucidation of chemical structures of five flavonoids from this plant.

2. MATERIALS AND METHODS

2.1. Materials

*Camellia chrysantha* (Hu) Tuyama was collected in December 2016 at Ba Che, Quang Ninh province. Plants were identified by Dr. Nguyen Quoc Binh of the Viet Nam National Museum of Nature, Vietnam Academy of Science and Technology (VAST). A voucher specimen (THV01/BC-QN) was deposited in the Institute of Natural Product Chemistry (INPC), VAST.

2.2. Chemicals and equipments

**Chemicals:** Thin layer chromatography (TLC) used a pre-coated silica-gel 60 F<sub>254</sub> (0.25 mm, Merck) and RP-18 F<sub>254</sub> plates (0.25 mm, Merck). Column chromatography (CC) was performed using a silica gel 60 (70 - 230 mesh or 230 - 400 mesh, Merck, Germany) or YMC RP-18 resins (30 - 50 μm, Fujisilisa Chemical Ltd., Japan).

**Equipments:** The nuclear magnetic resonance (NMR) spectra were recorded on a Bruker AM500 FT-NMR Spectrometer using tetramethylsilane as internal standard (ppm). The mass spectra (ESI-MS) were obtained from an AGILENT 1100 LC-MSD Trap spectrometer.

2.3. Extraction and isolation of compounds

The dried flowers of *Camellia chrysantha* (Hu) Tuyama (1.0 kg) were extracted with ethanol by the sonication three times at temperature 50°C to yield 200.0 g of a dark solid extract, which was then suspended in water and successively partitioned with hexane, chloroform and ethyl acetate (EtOAc) (each, 2.0 L) to obtain the hexane (THV/A), the chloroform (THV/B) and the EtOAc (THV/C) layers after removal solvent *in vacuo*. The aqueous phase was chromatographed on a Diaion HP-20P column (7 × 20 cm) eluting with water and then methanol; the methanolic fraction was evaporated *in vacuo* to yield THV/D. THV/C (35 g) was chromatographed on a silica gel column and eluted with gradient elution of dichloromethane:methanol (100% CH<sub>2</sub>Cl<sub>2</sub>, 9:1, 8:2, 7:3, 6:4, 5:5 and 100% MeOH) to obtain seven sub-fractions, signed from THV/C-1 to THV/C-7. The fraction THV/C-2 (1.5 g) was chromatographed on a silica gel column eluting with hexane:ethyl acetate (4:1, v:v) to give five smaller fractions (signed from THV/C2/1 to THV/C2/5). The fraction THV/C2/3 was chromatographed on a silica gel column eluting with hexane:ethyl acetate (3:1, v:v) to yield 4. The fraction THV/C2/5 was chromatographed on an YMC RP-18 column eluting with methanol:water (5:1, v:v) to yield 3 and 5.

The fraction THV/C-5 (1.5 g) was chromatographed on a silica gel column eluting with dichloromethane:methanol (8:1, v:v) to give eight smaller fractions (signed from THV/C5/1 to THV/C5/8). The fraction THV/C5/3 was continuously chromatographed on a silica gel column eluting with hexane:acetone (2.5:1, v:v) to yield 1 and 2.
Flavonoids isolated from the flowers of Camellia chrysantha

**Compound 1: (+)-catechin**
Yellowish powder;
ESI-MS: m/z 289 [M-H], C_{15}H_{14}O_6

^1^H-NMR (CD_3OD, 500 MHz) δ (ppm): 4.58 (1H, d, J = 7.0 Hz, H-2), 3.99 (1H, m, H-3), 2.52 (dd, J = 8.0 Hz, 16.25 Hz, H_4-4), 2.87 (dd, J = 5.5Hz, 16.5Hz, H_b-4), 5.95 (d, J = 2.0 Hz, H-6), 5.88 (d, J = 2.0 Hz, H-8), 6.86 (d, J = 2.0 Hz, H-2'), 6.78 (d, J = 8.0 Hz, H-5'), 6.74 (dd, J = 2.0 Hz, 8.0 Hz, H-6').

^1^3^C-NMR (CD_3OD, 100 MHz) δ (ppm): 82.87 (C-2), 68.82 (C-3), 28.52 (C-4), 157.58 (C-5), 96.32 (C-6), 157.85 (C-7), 95.53 (C-8), 156.93 (C-9), 100.84 (C-10), 132.25 (C-1'), 115.28 (C-2'), 146.24 (C-3'), 146.26 (C-4'), 116.10 (C-5'), 120.04 (C-6').

**Compound 2: (-)-epicatechin**
Yellow solid;
ESI-MS: m/z 289 [M-H], C_{15}H_{14}O_6

^1^H-NMR (CD_3OD, 500 MHz) δ (ppm): 4.83 (1H, s, H-2), 4.20 (1H, m, H-3), 2.75 (dd, J = 3.0 Hz, 17.0 Hz, H_4-4), 2.88 (dd, J = 4.5Hz, 16.5Hz, H_b-4), 5.96 (d, J = 2.5 Hz, H-6), 5.94 (d, J = 2.0 Hz, H-8), 6.99 (d, J = 1.5 Hz, H-2'), 6.78 (d, J = 8.0 Hz, H-5'), 6.84 (dd, J = 2.0 Hz, 8.1 Hz, H-6').

^1^3^C-NMR (CD_3OD, 100 MHz) δ (ppm): 79.88 (C-2), 67.48 (C-3), 29.24 (C-4), 157.67 (C-5), 96.42 (C-6), 157.99 (C-7), 95.91 (C-8), 157.37 (C-9), 100.10 (C-10), 132.29 (C-1'), 115.33 (C-2'), 145.94 (C-3'), 145.78 (C-4'), 115.91 (C-5'), 119.41 (C-6').

**Compound 3: quercetin**
Yellow solid;
ESI-MS: m/z 303 [M +H]^+, C_{15}H_{14}O_7.

^1^H-NMR (500 MHz, CD_3OD) δ (ppm): 6.20 (1H, d, J = 2.0 Hz, H-6), 6.41 (1H, d, J = 2.0 Hz, H-8), 7.75 (1H, d, J = 2.0 Hz, H-2'), 6.90 (1H, d, J = 8.5 Hz, H-5'), 7.65 (1H, dd, J = 8.5 Hz, 2.0 Hz, H-6').

^1^3^C-NMR (125 MHz, CD_3OD) δ (ppm): 148.6 (C-2), 137.2 (C-3), 177.3 (C-4), 162.6 (C-5), 99.1 (C-6), 165.6 (C-7), 94.4 (C-8), 158.2 (C-9), 104.5 (C-10), 124.1 (C-1'), 116.0 (C-2'), 146.2 (C-3'), 148.0 (C-4'), 116.2 (C-5'), 121.7 (C-6').

**Compound 4: quercetin-3-O-methyl ether**
Yellow powder;
ESI-MS: m/z 315 [M-H], C_{16}H_{12}O_7.

^1^H-NMR (500MHz, DMSO) δ (ppm): 3.77 (3H, s, -OCH_3), 6.18 (1H, d, J = 2.0 Hz, H-6), 6.39 (1H, d, J = 2.0 Hz, H-8), 6.90 (1H, d, J = 8.0 Hz, H-5'), 7.44 (1H, dd, J = 8.0, 2.0 Hz, H-6'), 7.61 (1H, d, J = 2.0 Hz, H-2').

^1^3^C-NMR (125 MHz, DMSO) δ (ppm): 59.6 (OCH_3), 93.5 (C-8), 98.5 (C-6), 104 (C-10), 115.4 (C-5'), 115.7 (C-2'), 120.5 (C-1'), 120.7 (C-6'), 137.6 (C-3), 145.2 (C-3'), 148.7 (C-4'), 155.5 (C-2), 156.3 (C-9), 161.2 (C-5), 164.2 (C-7), 177.9 (C-4).

**Compound 5: kaempferol**
Yellow solid;
ESI-MS: m/z 285 [M-H], C_{13}H_{10}O_5.
\[1^H\text{-NMR (500 MHz, CD}_3\text{OD), } \delta (\text{ppm}): 8.08 (2H, dd, } J = 2.0 \text{ Hz, 9.0 Hz, H-2'}, 6'), 6.90 (2H, dd, } J = 2.0 \text{ Hz, 9.0 Hz, H-3', 5')}, 6.39 (1H, d, } J = 2.0 \text{ Hz, H-8}), 6.19 (1H, d, } J = 2.0 \text{ Hz, H-6}).\]

\[13^C \text{ NMR (125 MHz, CD}_3\text{OD), } \delta (\text{ppm}) 177.32 (C-4), 165.53 (C-7), 160.51 (C-4'), 158.23 (C-5), 156.50 (C-9), 130.66 (C-2'), 130.66 (C-6'), 148.01 (C-2), 137.09 (C-3), 123.72 (C-1'), 116.29 (C-3'), 116.29 (C-5'), 104.5 (C-10), 99.26 (C-6), 94.47 (C-8).\]

3. RESULTS AND DISCUSSION

Compound 1 was isolated as yellowish powder. The 1D-NMR and 2D-NMR spectra of compound 1 suggested that this compound is a flavan-3-ol. The \(^1\text{H-NMR spectrum of 1}\) showed five aromatic proton signals, including two doublet signals with meta-coupling (\(J = 2.0 \text{ Hz}\)) at \(\delta_{H} 5.95\) and 5.88 ppm characteristic for the presence of two protons at position 6 and 8 of A ring, three signals of an ABX type at \(\delta_{H} 6.86 (1H, d, } J = 2.0 \text{ Hz, H-2'}), 6.78 (1H, d, } J = 8.0 \text{ Hz, H-5'}) and 6.74 (1H, dd, } J = 2.0 \text{ Hz and 8.0 Hz, H-6'}) characteristic for the presence of three protons of B ring substituted at three positions 1, 3 and 4. The basic structure of this compound was therefore deduced as 3,5,7,3',4'-pentahydroxyflavan of catechin. At the higher magnetic field, it also displayed two methylene proton signals at \(\delta_{H} 2.52 (dd, } J = 8.0 \text{ Hz, 16.25 Hz, H-4') and 2.87 (dd, } J = 5.5 \text{ Hz, 16.5 Hz, H-4'})\) typical of position 4 of catechin; another signals at \(\delta_{H} 4.58 (1H, d, } J = 7.0 \text{ Hz, H-2})\) of oximethin group and at \(\delta_{H} 3.99 (1H, m, H-3')\) of carbinol proton characteristic of a flavan nucleus. The coupling constant (\(J_{2,3} = 7.0 \text{ Hz, H-2})\) supports trans-2,3 stereochemistry for the structure of 1.

The \(^{13}\text{C-NMR and DEPT spectra of 1}\) showed the presence of 15 carbon signals, including one methylene, seven methins and seven nonprotonated aromatic carbons. The HMBC spectrum of 1 showed the correlations between proton H-2 and carbons C-1', C-2', C-6' and C-9, between proton H-4 and C-2, C-3, C-5, C-9 and C-10, between proton H-8 and C-6 and C-10, and also between proton H-6 and C-8 and C-10.

Based on the above mentioned data, and based on the comparison with the data of literature [6], compound 1 was confirmed to be (++)-catechin. Catechin has been isolated from \textit{Camellia sinensis} [7] and known to possess a variety of biological activities, such as anti-inflammatory [8], antimicrobial [9] and antioxidant [10].

Compound 2 was isolated as yellow solid. The 1D-NMR and 2D-NMR spectra of compound 2 are similar with those of compound 1, suggesting that this compound is also a flavan-3-ol. The \(^1\text{H-NMR spectrum of compound 2}\) showed a multiplet signal at \(\delta_{H} 4.20 \text{ ppm (1H, m, H-3})\) resulting from the splitting of H-3 by H-2 and H-4; two doublet doublet signals at \(\delta_{H} 2.75 (1H, dd, } J = 3.0 \text{ Hz, 17 Hz})\) and 2.88 (1H, dd, } J = 4.5 \text{ Hz, 16.5 Hz})\) typical of methylene protons at position 4 which were split by H-3; three aromatic proton signals characteristic for the presence of an ABX type of B-ring at \(\delta_{H} 6.99 (1H, d, } J = 1.5 \text{ Hz}), 6.78 (1H, d, } J = 8.0 \text{ Hz})\) and 6.83 (1H, dd, } J = 2.0 \text{ Hz and 8.5 Hz})\); two other aromatic proton signals characteristic for the presence of A-ring at \(\delta_{H} 5.96 (d, } J = 2.5 \text{ Hz, H-6})\) and \(\delta_{H} 5.94 (d, } J = 2.5 \text{ Hz, H-8})\). The difference between compound 2 and compound 1 is that: while the position of the proton H-2 chemical shift of compound 1 was observed as doublet signal at \(\delta_{H} 4.58 (1H, d, } J = 7.0 \text{ Hz, H-2})\), this position of compound 2 appeared as a broad singlet at \(\delta_{H} 4.83\), suggesting that the flavan structure of 2 possesses a \textit{cis}-2,3 configuration and typically of epicatechin [11].

The \(^{13}\text{C-NMR and DEPT spectra of 2}\) showed fifteen carbon signals, which consisted of one methylene at \(\delta_{C} 29.24 (C-4))\), seven methins at \(\delta_{C} 79.88 (C-2), 67.48 (C-3), 96.42 (C-6),\)
95.91 (C-8), 115.33 (C-2), 115.91 (C-5), 119.41 (C-6), and seven quaternary carbons at δC 157.67 (C-5), 157.99 (C-7), 157.37 (C-9), 100.10 (C-10), 132.29 (C-1’), 145.94 (C-3’), 145.78 (C-4’). The HMBC spectrum of 2 showed the correlations between proton H-2 and C-1’, C-2’, C-6’, between proton H-4 and C-2, C-3, C-5, C-9, C-10, between proton H-8 and C-6, C-10, also between proton H-6 and C-8, C-10.

The above data of compound 2 was compared with those reported in the literature [12], so compound 2 was identified as (-)-epicatechin. Epicatechin has been isolated from the Camellia sinensis [13], and reported to have antimicrobial [13], anti-inflammatory [14], and antioxidant activities [15].

The compound 3 was isolated as yellow powder. The NMR spectra of compound 3 suggested that this compound is a flavonoid. The 1H-NMR showed two doublet signals with meta-coupling (J = 2.0 Hz) at δH 6.20 and 6.41 that were assigned to H-6 and H-8 in the A-ring, three distinctive signals of aromatic protons of an ABX type ring B found at δH 7.75 (1H, d, J = 2.0 Hz, H-2’), 6.90 (1H, d, J = 8.5 Hz, H-5’) and 7.65 (1H, dd, J = 8.5 Hz, 2.0 Hz, H-6’). The 13C-NMR and DEPT spectra of 3 showed fifteen carbon signals, which consisted of one carbonyl carbon (δC 177.3), five methines (δC 99.1, 94.4, 116.0, 116.2, 121.7), and nine other quaternary carbons (δC 148.6, 137.2, 162.6, 165.6, 158.2, 104.5, 124.1, 146.2, 148.0). The obtained results for compound 3 were in agreement with the spectral data of quercetin previously reported in the literature [16]. Thus, compound 3 was identified as quercetin.

The compound 4 was isolated as yellow powder. The 1D-NMR and 2D-NMR spectra of compound 4 are similar with those of compound 3, suggesting that it is also a flavonoid: the 1H-NMR showed meta coupled signals at δH 6.18 (1H, d, J = 2.0 Hz) and 6.39 (1H, d, J = 2.0 Hz) corresponding with two carbon signals at δC 98.5 and 93.5 ppm in HSQC spectrum characteristic for the presence of two protons at position 6 and 8 of A ring; three characteristic aromatic proton signals for one B ring started at the three positions 1, 3 and 4 at δH 7.61 (1H, d, Jmeta = 2.0 Hz, H-2’), 6.90 (1H, d, Jortho = 8.0 Hz, H-5’) and 7.44 (1H, dd, Jortho and meta = 8.0 and 2.0 Hz, H-6’) corresponding with three carbon signals at δC 115.7, 115.4 and 120.7 ppm in HSQC spectrum. The presence of a methoxy group was indicated by the presence of a singlet signal at 3.77 (3H, s, -OCH3) in the 1H-NMR spectrum corresponding with a carbon signal at δC 59.6 ppm in the 13C-NMR spectrum. The 13C-NMR spectrum shown also the presence of one carbonyl group at δC 177.8 (C-4). The HMBC spectrum showed a clearly correlation between protons of methoxy group (δH 3.77 ppm) and carbon C-3 (δC 137.6 ppm). The molecular formula of 4 was established as C16H12O7 based on spectral data obtained by ESI-MS (m/z 315 [M-H]+) together 1H and 13C NMR analysis, including DEPT. The above data of 4 were consistent with the literature data of quercetin-3-O-methyl ether [17].

The compound 5 was isolated as yellow solid. The NMR spectra of compound 5 are similar with those of compound 3, suggesting that this compound is a flavonoid with the 3,3’,4,5,7-pentahydroxy substitution pattern. The 1H-NMR spectrum of 5 showed two doublet signals at δH 6.19 (1H, d, J = 2.0 Hz) and 6.39 (1H, d, J = 2.0 Hz), corresponding with two carbon signals at δC 99.26 and 94.47 ppm in HSQC spectrum, were attributed to aromatic protons H-6 and H-8 of the ring A; two doublet doublet signals at 8.08 (J = 2.0 Hz, 9.0 Hz) and 6.90 (J = 2.0 Hz, 9.0 Hz), with integration of 2 protons each, which confirm the presence of a A2B2 system in the ring B. The 13C-NMR spectrum of 5 indicates the presence of fifteen carbon signals at δC 177.32 (C-4), 165.53 (C-7), 160.51 (C-4’), 158.23 (C-5), 156.50 (C-9), 130.66 (C-2’), 130.66 (C-6’), 148.01 (C-2), 137.09 (C-3), 123.72 (C-1’), 116.29 (C-3’), 116.29 (C-5’), 104.5 (C-10), 99.26 (C-6) and 94.47 (C-8). The 1H-NMR and 13C-NMR spectral data confirm that compound 5 is kaempferol. The results are identical to those obtained by the literature [16].
Five flavonoids were isolated from the flowers of *Camellia chrysantha* (Hu) Tuyama, including catechin, epicatechin, quercetin, quercetin-3-O-methyl ether and kaempferol. Their chemical structures were elucidated by spectroscopic data analysis and by comparison with those reported in the literatures. Among five compounds, quercetin-3-O-methyl ether 4 was isolated for the first time from this species.

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**REFERENCES**

1. Camellia chrysantha. Available online: [https://en.wikipedia.org/wiki/Camellia_chrysantha](https://en.wikipedia.org/wiki/Camellia_chrysantha) (accessed on 1 March 2019).
2. Trà_hoa_vàng. Available online: [https://vi.wikipedia.org/wiki/Trà_hoa_vàng](https://vi.wikipedia.org/wiki/Trà_hoa_vàng) (accessed on 1 March 2019).
3. The IUCN Red List of Threatened Species 1998: e.T32315A9695863 - *Camellia chrysantha*. Available online: [https://www.iucnredlist.org/species/32315/9695863](https://www.iucnredlist.org/species/32315/9695863) (accessed on 1 March 2019).
4. Luong Phu Hoang, Nguyen Thuy Chinh, Vu Quoc Trung, Thai Hoang - Alginate/chitosan film loading golden flower tea (*Camellia chrysantha*) extract: preparation and characterization, Vietnam Journal of Science and Technology 56 (3B) (2018) 209-218.
5. Nguyen Thi Hong Van, Cam Thi Inh, Pham Cao Bach, Tran Thi Tuyen, Nguyen Thi Thanh, Nguyen Huong Quynh, Pham Quoc Long - Flavonoid glycosides isolated from the flowers of *Camellia chrysantha*, Journal of Chemistry 56 (3) (2018) 335-340.
6. Hye M.A., Taher M.A., Ali M.Y., Ali M.U., Shahed Zaman - Isolation of (+)-catechin from *Acacia catechu* (Cutch tree) by a convenient method, Journal of Scientific Research 1 (2) (2009) 300-305.
7. Huang Q., Wu L. J., Tashiro S., Gao H. Y., Onodera S., Ikejima T. - (+)-Catechin, an ingredient of green tea, protects murine microglia from oxidative stress-induced DNA damage and cell cycle arrest, J. Pharmacol. Sci. 98 (1) (2005) 16-24.

8. Syed Hussein S. S., Kamarudin M. N., Kadir H. A. - (+)-Catechin attenuates NF-kB activation through regulation of Akt, MAPK, and AMPK signaling pathways in LPS-induced BV-2 microglial cells, Am. J. Chin. Med. 43 (5) (2015) 927-952.

9. Gomes F. M. S., da Cunha Xavier J., Dos Santis J. F., de Matos Y. M. L. S., Tintino S. R., de Freitas T. S., Coutinho H. D. M. - Evaluation of antibacterial and modifying action of catechin antibiotics in resistant strains, Microb. Pathog. 115 (2018) 175-178.

10. Xie H., Li X., Ren Z., Qiu W., Chen J., Jiang Q., Chen B., Chen D. - Antioxidant and cytoprotective effects of tibetan tea and its phenolic components, Molecules 23 (2) (2018) doi: 10.3390/molecules23020179.

11. Chen-Chang Shen, Yuan-Shiun Chang, Likang Hots - Nuclear magnetic resonance studies of 5,7-dihydroxyflavonoids, Phytochemistry 34 (3) (1993) 843-845.

12. Adrienne L. Davis, Ya Cai, Alan P. Davies, Lewis J. R. - 1H and 13C-NMR assignments of some green tea polyphenols, Magnetic resonance in chemistry 34 (1996) 887-890.

13. Reygaert W. C. - The antimicrobial possibilities of green tea, Front. Microbiol. 5 (2014) 434-438.

14. Bettaieb A., Cremonini E., Kang H., Kang J., Haj F. G., Oteiza P. I. - Anti-inflammatory actions of (-)-epicatechin in the adipose tissue of obese mice, Int. Biochem. Cell Biol. 81 (Pt B) (2016) 383-392.

15. Scott B. C., Butler J., Halliwell B., Aruoma O. I. - Evaluation of the antioxidant actions of ferulic acid and catechins, Free Radic. Res. Commun. 19 (4) (1993) 241-53.

16. Dorothee Alfonso, Ilias Kapetanidis - Flavonoids from Iochroma gesnerioides, Pharmaceutica Acta Helvetiae 68 (1994) 211-214.

17. Smolarz H. D., Surdacka A., Roliński J. - Influence of ethyl acetate extract and quercetin-3-methyl ether from Polygonum amphibium on activation lymphocytes from peripheral blood of healthy donor in vitro, Phytother Res. 17 (7) (2003) 744-747.