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山竺果壳的化学成分

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摘要: 从山竺 (*Garcinia mangostana*) 果壳中分离得到6个化合物, 通过 MS, 1D NMR 以及与文献对照鉴定它们为4个呫酮类化合物: α-mangostin (**1**), β-mangostin (**2**), γ-mangostin (**3**), 5, 9-dihydroxy-8-methoxy-2, 2-dimethyl-7-(3-methylbut-2-enyl)-2H, 6H-pyrano-[3, 2-b]-xanthen-6-one (**4**), 以及表儿茶素 (epicatechin, **5**) 和一个双苄类化合物 egonol (**6**)。其中化合物 **5** 和化合物 **6** 为首次从该植物中分离得到。对化合物 **1**~**5** 进行抗 HIV-1 RT 活性筛选结果表明, 化合物 **2** 和化合物 **5** 在浓度 200 μg/ml 的条件下, 其对 HIV-1 RT 抑制率分别为 41.97% 和 47.72%; 同一实验结果显示化合物 **1**, **3** 和 **4** 没有抑制 HIV-1 RT 作用。

关键词: 山竺; 呫酮; Egonol; 表儿茶素; 抗 HIV-1 RT 活性
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Chemical Constituents from Fruit Hulls of *Garcinia mangostana* (Cuttiferae)

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Abstract: From the fruit hulls of *Garcinia mangostana*, six known compounds were isolated and identified as α-mangostin (**1**), β-mangostin (**2**), γ-mangostin (**3**), 5, 9-dihydroxy-8-methoxy-2, 2-dimethyl-7-(3-methylbut-2-enyl)-2H, 6H-pyrano-[3, 2-b]-xanthen-6-one (**4**), epicatechin (**5**) and egonol (**6**) based on spectral analysis and by comparison with literature data. Compound **5** and **6** were isolated form this plant for the first time. Meanwhile, *In vitro* bioassay screening, the results indicated that β-mangostin (**2**) and epicatechin (**5**) showed inhibitory activities on recombinant HIV-1 RT with inhibitory percentage of 41.97 and 47.72 at 200 μg/ml. Compounds **1**, **3** and **4** showed no inhibitory activities at the same bioassay.

Key words: *Garcinia mangostana*; Xanthone; Egonol; Epicatechin; Inhibitory activities on recombinant HIV-1 RT

Garcinia mangostana L. is commonly cultivated throughout south and southeast Asia where it is the source of the mangosteen fruits as well as been used for heeling skin infections and wounds and for the relief of diarrhea. (Gopalakrishnan *et al*, 1997; Suksamrarn *et al*, 2002). The fruit hulls of *G. mangostana* L. (Guttiferae) are reported to be used as an anti-inflammatory agent and an astringent or used against diarrhea (Chairungsrilerd *et al*, 1996). The main metabolites are xanthones (Bennett and Lee, 1989) with α-man-

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gostin (**1**), β-mangostin (**2**) and γ-mangostin (**3**). In the course of screen on biologically active constituents, six known compounds (Fig. 1) were isolated from the fruit hulls of *G. mangostana* L. Their structures were identified based on spectral analysis and by comparison with literature data as α-mangostin (**1**) (Yates and Stout, 1958; Chen *et al*, 1996), β-mangostin (**2**) (Yates and Bhat, 1968), γ-mangostin (**3**) (Govindachari *et al*, 1971; Chen *et al*, 1996), 5, 9-dihydroxy-8-methoxy-2, 2-dimethyl-7-(3-methylbut-2-enyl)-2H, 6H-pyrano-[3, 2-b]-xanthen-6-one (**4**) (Sen *et al*, 1980), epicatechin (**5**) (Cui *et al*, 2005; Gen, 1983) and egonol (**6**) (Takanashi and Takizawa, 1988). Compounds **1**–**4** were obtained as yellow powders, compounds **5**–**6** as brown powders and were found in this plant for the first time. This paper describes the isolation and identification of this six compounds and the inhibitory activities on recombinant HIV-1 RT results of compounds **1**–**5**. The results provided chemical and biological evidences for the further investigation on this plant.

In vitro bioassay screening, the results indicated that β-mangostin (**2**) and epicatechin (**5**) showed definite inhibitory activities on recombinant HIV-1 RT with inhibitory percentage of 41.97 and 47.72 at 200 μg/ml, while α-mangostin (**1**), γ-mangostin (**3**) and 5, 9-dihydroxy-8-methoxy-2, 2-dimethyl-7-(3-methylbut-2-enyl)-2H, 6H-pyrano-[3, 2-b]-xanthen-6-one (**4**) showed no inhibitory activities at the same bioassay.

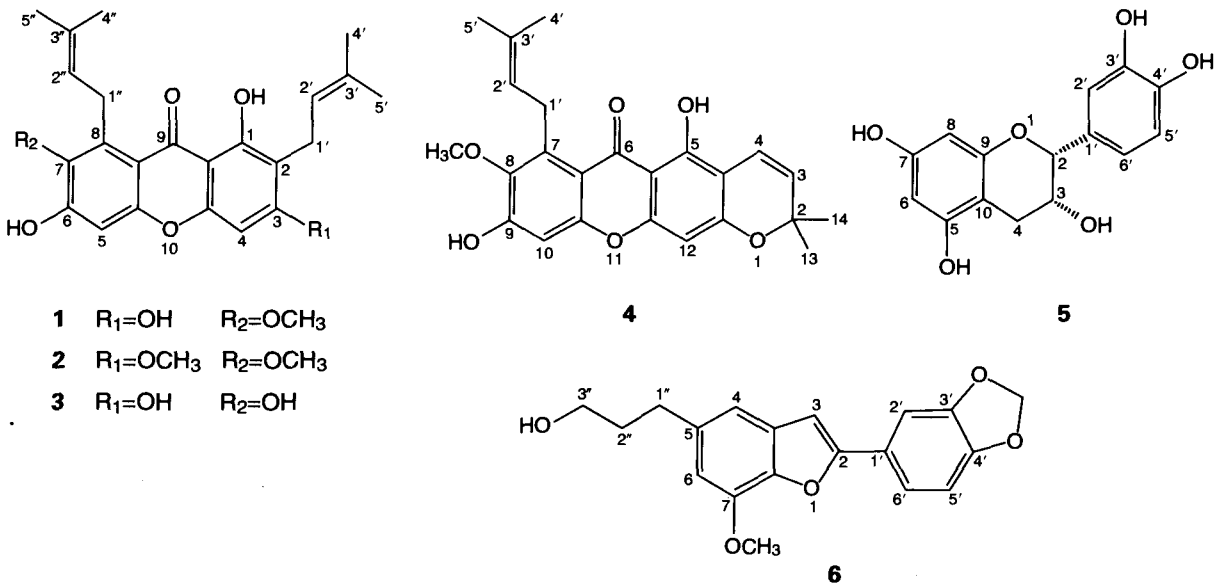

Fig. 1 Structures of compounds **1**–**6**

Experimental

General experimental procedures Melting point was measured on a XRC-1 micro-melting point apparatus and was uncorrected. EI-MS were obtained on a VG Auto Spec-3000 mass spectrometer, 1D NMR spectra were obtained on a Bruker AV-400 MHz and a DRX-500 MHz spectrometer with TMS as internal standard. Si gel (200–300 mesh) for column chromatography and silica gel G for TLC were obtained from the Qindao Marine Chemical factory.

Plant material The fruit hulls of *Garcinia mangostana* L. were bought in the market in June 2003, Kunming, Yunnan province. Identified by Dr. LEI Li-Gong, the main functionary of the herbarium, Kunming Institute of Botany, Chinese Academy of Sciences.

Extraction and Isolation The air-dried fruit hulls of *G. mangostana* L. (2.7 kg) were powdered and extracted with 80% EtOH (3 × 6 L) under reflux for 3 h each time. The extracted EtOH (18 L) was evaporated under reduced pressure and suspended in water (1500 ml), then fractionated by successive portions with $CHCl_3$ (3 × 1500 ml) and n-BuOH (3 × 1500 ml) to give $CHCl_3$-soluble (159.5 g) and n-BuOH-soluble (102.5 g) fractions. A portion (154.5 g) of the $CHCl_3$-soluble fraction was

subjected to Si-gel column chromatography (200 - 300 mesh, 1400 g) and eluted with $CHCl_3$-MeOH (100:0, 98:2, 95:5, 90:10, 80:20, 70:30, 0:100, v/v) gradient solvent system repeatedly to afford **1** (30 g), **2** (3 g), **3** (5 g), **4** (1 g) and **6** (30 mg). A portion (10 g) of the n-BuOH-soluble fractions was subjected to Si-gel column chromatography (200-300 mesh, 200 g) and eluted with petroleum ether-acetone (75:25, v/v) to afford compound **5** (100 mg).

α-mangostin (**1**), $C_{24}H_{26}O_6$, yellow powder, mp 182-183℃, EI-MS *m/z* (%): 410 ([M]$^+$, 51), 339 (100), 162 (23); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.71 (1H, s, H-5), 6.25 (1H, s, H-4), 5.28 (1H, t, *J* = 6.5 Hz, H-2′), 5.26 (1H, t, *J* = 5.8 Hz, H-2″), 4.10 (1H, d, *J* = 5.8 Hz, H-1″), 3.78 (3H, s, 7-OCH_3), 3.36 (2H, d, *J* = 6.5 Hz, H-1′), 1.83 (3H, s, H-5″), 1.81 (3H, s, H-5′), 1.69 (3H, s, H-4″), 1.69 (3H, s, H-4′); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 181.8 (s, C-9), 161.6 (s, C-3), 160.1 (s, C-6), 155.5 (s, C-10a), 155.3 (s, C-1), 154.7 (s, C-4a), 142.9 (s, C-7), 137.1 (s, C-8), 131.8 (s, C-3″), 131.4 (s, C-3′), 123.3 (d, C-2″), 122.2 (d, C-2′), 111.4 (s, C-8a), 109 (s, C-2), 102.9 (s, C-9a), 101.6 (d, C-5), 92.2 (d, C-4), 60.9 (q, C-7-OCH_3), 26.1 (t, C-1″), 25.5 (q, C-4″), 25.5 (q, C-4′), 21.2 (t, C-1′), 17.8 (q, C-5″), 17.5 (q, C-5′). (Yates and Stout, 1958; Chen *et al*, 1996).

β-mangostin (**2**), $C_{25}H_{28}O_6$, yellowpowder, mp 175-176℃, EI-MS *m/z* (%): 424 ([M]$^+$, 91), 381 (34), 353 (100); ^{1}H NMR (500 MHz, $CDCl_3$) δ: 6.60 (1H, s, H-5), 6.17 (1H, s, H-4), 5.11 (1H, t, *J* = 6.4 Hz, H-2″), 5.07 (1H, t, *J* = 7.1 Hz, H-2′), 3.95 (1H, d, *J* = 6.4 Hz, H-1″), 3.74 (3H, s, 3-OCH_3), 3.65 (3H, s, 7-OCH_3), 3.18 (2H, d, *J* = 7.1 Hz, H-1′), 1.69 (3H, s, H-5″), 1.64 (3H, s, H-5′), 1.54 (3H, s, H-4″), 1.53 (3H, s, H-4′); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 181.8 (s, C-9), 163.1 (s, C-3), 159.1 (s, C-6), 155.9 (s, C-10a), 155.3 (s, C-1), 155.0 (s, C-4a), 143.1 (s, C-7), 137.1 (s, C-8), 131.3 (s, C-3″), 131.3 (s, C-3′), 123.3 (d, C-2″), 122.1 (d, C-2′), 111.3 (s, C-8a), 110.9 (s, C-2), 103.5 (s, C-9a), 101.6 (d, C-5), 88.6 (d, C-4), 60.7 (q, C-7-OCH_3), 55.4 (q, C-3-OCH_3), 26.0 (t, C-1″), 25.4 (q, C-4″), 25.4 (q, C-4′), 21.0 (t, C-1′), 17.8 (q, C-5″), 17.3 (q, C-5′). (Yates and Bhat, 1968).

γ-mangostin (**3**), $C_{23}H_{24}O_6$, yellow powder, mp 207℃, EI-MS *m/z* (%): 396 ([M]$^+$, 91), 353 (59), 325 (100), 296 (91); ^{1}H NMR (500 MHz, $CDCl_3$) δ: 6.68 (1H, s, H-5), 6.23 (1H, s, H-4), 5.28 (1H, t, *J* = 5.8 Hz, H-2″), 5.24 (1H, t, *J* = 6.2 Hz, H-2′), 4.12 (1H, d, *J* = 5.8 Hz, H-1″), 3.31 (1H, d, *J* = 6.2 Hz, H-1′), 1.86 (3H, s, H-5″), 1.80 (3H, s, H-5′), 1.68 (3H, s, H-4″), 1.68 (3H, s, H-4′); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 183.5 (s, C-9), 163.3 (s, C-3), 161.5 (s, C-6), 156.2 (s, C-10a), 154.0 (s, C-1), 153.1 (s, C-4a), 142.0 (s, C-7), 131.7 (s, C-8), 131.6 (s, C-3″), 129.5 (s, C-3′), 124.8 (d, C-2″), 123.9 (d, C-2′), 112.2 (s, C-8a), 111.1 (s, C-2), 103.8 (s, C-9a), 100.9 (d, C-5), 92.9 (d, C-4), 26.6 (t, C-1″), 26.1 (q, C-4″), 26.0 (q, C-4′), 22.2 (t, C-1′), 18.3 (q, C-5″), 17.9 (q, C-5′). (Govindachari *et al*, 1971; Chen *et al*, 1996).

5, 9-dihydroxy-8-methoxy-2, 2-dimethyl-7-(3-methyl-but-2-enyl)-2H, 6H-pyrano-[3, 2-b]-xanthen-6-one (**4**), $C_{24}H_{24}O_6$, yellow powder, mp 156-157℃, EI-MS *m/z* (%): 408 ([M]$^+$, 51), 393 (100), 365 (44); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.64 (1H, d, *J* = 10 Hz, H-4), 6.62 (1H, s, H-10), 6.11 (1H, s, H-12), 5.47 (1H, d, *J* = 10 Hz, H-3), 5.16 (1H, d, *J* = 6.0 Hz, H-2′), 3.99 (2H, d, *J* = 6.0 Hz, H-1′), 3.69 (3H, s, 8-OCH_3), 1.74 (3H, s, H-5′), 1.58 (3H, s, H-4′), 1.37 (3H, s, H-13), 1.37 (3H, s, H-14); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 181.9 (s, C-6), 160.2 (s, C-12a), 157.7 (s, C-5), 156.1 (s, C-11a), 156.1 (s, C-9), 155.4 (s, C-10a), 143.2 (s, C-8), 137.2 (s, C-7), 131.6 (s, C-3′), 126.9 (d, C-3), 123.2 (d, C-2′), 115.5 (d, C-4), 112.8 (s, C-6a), 104.2 (s, C-4a), 103.5 (s, C-5a), 101.9 (d, C-10), 93.9 (d, C-12), 77.8 (s, C-2), 60.9 (q, C-8-OCH_3), 28.0 (q, C-13), 28.0 (q, C-14), 26.1 (q, C-1′), 25.6 (q, C-5′), 17.9 (q, C-4′). (Sen *et al*, 1980).

Epicatechin (**5**), $C_{15}H_{14}O_6$, white powder, mp 246-247℃, EI-MS *m/z* (%): 290 ([M]$^+$, 15), 152 (44), 139 (100), 123 (36); ^{1}H NMR (400 MHz, CD_3OD) δ: 6.97 (1H, d, *J* = 2.0 Hz, H-2′), 6.80 (1H, d, *J* = 8.0 Hz, H-5′), 6.76 (1H, dd, *J* = 8.0, 2.0 Hz, H-6′), 5.95 (1H, d, *J* = 2.0 Hz, H-8), 5.93 (1H, d, *J* = 2.0 Hz, H-6), 4.80 (1H, brs, H-2), 4.17 (1H, m, H-3), 2.85 (1H, dd, *J* = 17.0, 4.5 Hz, H-4), 2.75 (1H, dd, *J* = 17.0, 3.0 Hz, H-4); ^{13}C NMR (100 MHz, CD_3OD) δ: 158.0 (s, C-5), 157.6 (s, C-7), 157.3 (s, C-9), 145.9 (s, C-3′), 145.7 (s, C-4′), 132.3 (s, C

-1′), 119.5 (d, C-6′), 116.0 (d, C-2′), 115.3 (d, C-5′), 100.2 (s, C-10), 96.6 (d, C-6), 96.0 (d, C-8), 79.8 (d, C-2), 67.5 (d, C-3), 29.2 (t, C-4). (Cui *et al*, 2005; Gen, 1983).

Egonol (**6**), $C_{14}H_{18}O_5$, white powder, mp 117.5-118℃, EI-MS *m/z* (%): 326 ($[M]^+$, 62.5), 281 (100); ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.59 (1H, dd, *J* = 8.1, 1.5 Hz, H-6′), 7.51 (1H, s, H-3), 7.15 (1H, d, *J* = 1.5 Hz, H-2′), 7.11 (1H, s, H-4), 7.08 (1H, d, *J* = 8.1 Hz, H-5′), 6.90 (1H, s, H-6), 6.18 (2H, s, O-CH_2-O), 3.48 (3H, s, 7-OCH_3), 3.77 (2H, t, *J* = 6.4 Hz, H-3″), 2.92 (2H, t, *J* = 8.0 Hz, H-1″), 2.06 (2H, m, H-2″); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 157.2 (s, C-2), 149.7 (s, C-3′), 149.5 (s, C-4′), 146.2 (s, C-7), 139.3 (s, C-7a), 139.3 (s, C-5), 132.4 (s, C-3a), 126.2 (s, C-1′), 120.0 (d, C-6′), 113.5 (d, C-4), 109.6 (d, C-5′), 108.7 (d, C-6), 106.1 (d, C-2′), 102.8 (t, O-CH_2-O), 101.5 (d, C-3), 62.3 (t, C-3″), 56.0 (q, 7-OCH_3), 36.0 (t, C-1″), 33.4 (t, C-2″). (Takanashi and Takizawa, 1988).

Bioactive Assay Procedure

The inhibition of recombinant HIV-1 RT activity was performed with a commercially available ELISA kit (Boehringer Mannheim, Germany) according to the instructions of the manufacturer. Five serial dilutions of samples in DMSO (6 μl) in duplicate were added to the reaction mixture. The final DMSO concentration used was 10%. The highest concentration of compounds was 200 μg/ml. The compounds-free but contained an equivalent volume of DMSO were performed as control assays. Foscarnet was used as positive a control compound, it inhibited 100% of the HIV-1 RT activity at 100 μg/ml. The inhibition percentage of the compounds was calculated.

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References:

Bennett GJ, Lee HH, 1989. Xanthones from guttiferae [J]. *Phytochemistry*, **28**: 967—998

Chairungsrilerd N, Takeuchi K, Ohizumi Y, *et al*, 1996. Mangostanol, a prenyl xanthone from *Garcinia mangostana* [J]. *Phytochemistry*, **43**: 1099—1102

Chen SX, Wan M, Loh BN, 1996. Active constituents against HIV-1 protease from *Garcinia mangostana* [J]. *Planta Med*, **62**: 381—382

Cui YJ (崔艳君), Liu P (刘屏), Chen RY (陈若芸), 2005. Studies on the active constituents in vine stem of patholobus suberectus [J]. *China Journal of Chinese Materia Medica* (中国中药杂志), **30** (2): 121—123

Gen-ichiro N, 1983. A new class of dimeric flavan-3-ol gallates, theasinensins A and B, and proanthocyanidin gallates from green tea leaf [J]. *Chem Pharm Bull*, **31** (11): 3906—3914

Gopalakrishnan G, Banumathi B, Suresh G, 1997. Evaluation of the antifungal activity of natural xanthones from *Garcinia mangostana* and synthetic derivatives [J]. *J Nat Prod*, **60**: 519—524

Govindachari TR, Kalyanaraman PS, Muthukumaraswamy N, *et al*, 1971. Isolation of three new xanthone from *Garcinia mangostana* [J]. *Indian J Chem*, **9**: 505—506

Sen AK, Sarkar KK, Mazumder PC, *et al*, 1980. A xanthone from *Garcinia mangostana* [J]. *Phytochemistry*, **19**: 2223—2225

Suksamram S, Suwannapoch N, Ratananukul P, *et al*, 2002. Xanthones from the green fruit hulls of *Garcinia mangostana* [J]. *J Nat Prod*, **65**: 761—763

Takanashi M, Takizawa Y, 1988. New benzofurans related to egonol from immature seeds of *Styrax obassia* [J]. *Phytochemistry*, **27** (4): 1224—1226

Yates P, Bhat HB, 1968. Structure of β-mangostin [J]. *Can J Chem*, **46**: 3770—3772

Yates P, Stout GH, 1958. The structure of mangostin [J]. *J Am Chem Soc*, **80**: 1691—1699