

苦楝化学成分及抗糖尿病活性研究

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摘要:为研究苦楝皮的化学成分及其抗糖尿病活性, 采用正相、反相及 Sephadex LH-20 凝胶柱色谱等方法分离纯化化合物, 通过波谱数据和理化性质分别鉴定为 12 β , 20(*S*)-dihydroxydammar-24-en-3-one (**1**), dammarendiol II 3-*O*-caffeate (**2**), 24-methylenecycloartenone (**3**), meliavolin (**4**), 3, 20-diacetyl-11-methoxy-1-tigloylmeliacarpinin (**5**), methyl 3-formyl-2, 4-dihydroxy-6-methyl benzoate (**6**), usnic acid (**7**), *epi*-catechin (**8**)。其中化合物 **1**~**3**, **6**, **7** 均为首次从该植物中分离得到。采用酶偶联、液闪接近测定等技术测试化合物 **2**~**5** 体外抗糖尿病活性。研究表明, 受试化合物 **2**~**5** 均未表现出 GK、SIRT1 体外激动活性和 DPPIV 抑制活性, 但化合物 **2** 对人 11 β -HSD1 具有显著的抑制作用 (IC₅₀ = 94.15 nmol/L)。

关键词: 苦楝; 三萜; 葡萄糖激酶; SIRT1; 二肽基肽酶 IV; 11 β -羟基类固醇脱氢酶

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Chemical Constituents from *Melia azedarach* and Their Anti-diabetes Activities

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Abstract: The chemical constituents from the barks of *Melia azedarach* were isolated by silica gel, reverse phase silica gel and Sephadex LH-20 column chromatography, and their anti-diabetes activities were subsequently evaluated. Eight compounds were obtained and elucidated as 12 β , 20(*S*)-dihydroxydammar-24-en-3-one (**1**), dammarendiol II 3-*O*-caffeate (**2**), 24-methylenecycloartenone (**3**), meliavolin (**4**), 3, 20-diacetyl-11-methoxy-1-tigloylmeliacarpinin (**5**), methyl 3-formyl-2, 4-dihydroxy-6-methyl benzoate (**6**), usnic acid (**7**) and *epi*-catechin (**8**) based on their spectra and physico-chemical characteristics. Among these, compounds **1**, **3**, **6**, and **7** were isolated from this species for the first time. All the tested compounds **2**~**5** were inactive against GK, SIRT1 and DPPIV, but compounds **2** showed significant inhibitory activity against human 11 β -HSD1 with IC₅₀ value of 94.15 nmol/L.

Key words: *Melia azedarach*; triterpenoids; GK; SIRT1; DPPIV; 11 β -HSD

苦楝 (*Melia azedarach* L.) 为楝科 (Meliaceae) 楝属 (*Melia*) 植物, 其树皮因良好的药理活性曾载于 2010 年《中国药典》一部^[1]。研究表明, 苦楝叶提取物能使糖尿病小鼠的血糖水平显著下降且呈量效关系^[2], 为了深入研究苦楝皮的化学成分及抗糖尿病活性, 本实验对苦楝皮乙醇提取物的化学成分进行了研究, 共分离得到 5 个三萜类成分和 3 个酚性化合物, 并对分离得到的部分化合物进行了体外抗糖

尿病活性测试。研究表明, 化合物 **1**~**3**, **6**, **7** 为首次从该植物中分离得到。受试化合物 **2**~**5** 均未表现出葡萄糖激酶 (glucokinase, GK)、组蛋白去乙酰化酶 (sirtuin1, SIRT1) 体外激动活性和二肽基肽酶 IV (dipeptidyl peptidase IV, DPPIV) 抑制活性, 其中化合物 **2** 对人 11 β -羟基类固醇脱氢酶 1 (11 β -hydroxysteroid dehydrogenase 1, 11 β -HSD1) 具有显著的抑制作用, 并对人 11 β -HSD2 有良好的选择性。

1 仪器与材料

FAB-MS 用 VG Auto Spec-3000, EI-MS 用 VG ZAB-SH 质谱仪 (英国 VG 公司); NMR 用 Bruker AM-400 或 DRX-500 核磁共振仪测定 (德国 Bruker 公司, TMS 为内标); 酶标仪 (SpectraMax 190, 美国 Molecular Device 公司); PHS-3TC 型精密数显 pH 计

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(上海天达仪器有限公司);薄层层析检测用 UV-210 紫外分光光度计(上海元析仪器有限公司)。

柱层析硅胶(200~300目),GF₂₅₄薄层板为青岛海洋化工厂生产;Rp-18(40~65 μm)为德国 Merck 公司产品;Sephadex LH-20(40~70 μm)为瑞典 Pharmacia 公司产品;分离纯化用试剂为分析纯,10%的硫酸-乙醇溶液(加热)检测;阳性对照物 PSN-GK1、MK0431(FW:505)、白黎芦醇(RSV)、甘草次酸购自 Sigma 公司,小鼠或人 11β-HSD 基因购自 NIH Mammalian Gene Collection。

样品购自云南昆明,由中国科学院昆明植物研究所曾春霞博士鉴定为苦楝(*Melia azedarach* L.)的皮。

2 实验方法

2.1 提取与分离

苦楝皮干燥品(10 kg)粉碎,用95%的乙醇加热回流提取3次,滤液减压回收得提取物570 g,水分散后用乙酸乙酯萃取3次,得乙酸乙酯萃取物260 g,上硅胶柱层析,用氯仿:丙酮(1:0~1:1)系统梯度洗脱,得到七个组分(Fr. I-VII)。Fr. III经硅胶柱层析,以石油醚-丙酮(6:1~3:1)洗脱,再经甲醇结晶得化合物**1**(73.0 mg),**6**(5.8 mg)。Fr. IV经Rp-18柱层析,以甲醇-水(7:3~10:0)洗脱,以Sephadex LH-20(氯仿-甲醇=1:1)过滤,甲醇结晶得化合物**2**(56.1 mg),**3**(24.8 mg),**4**(29.5 mg)。Fr. V经Rp-18柱层析,以甲醇-水(5:5~10:0)洗脱,甲醇结晶得化合物**5**(383.2 mg)。Fr. VI经Rp-18柱层析,以甲醇-水(4:6~10:0)洗脱,甲醇结晶得化合物**7**(5.0 mg),丙酮结晶得化合物**8**(9.3 mg)。

2.2 体外抗糖尿病活性研究

糖尿病发病原因复杂,某些酶与其发生发展密切相关,如GK在糖尿病患者血糖平衡控制中有减少肝脏葡萄糖生成和促胰岛素分泌的双重作用^[3],SIRT1激动剂可改善肥胖糖尿病大鼠的胰岛素敏感性^[4],DPPIV的活性增高与糖尿病的发生存在相关性^[5],抑制11β-HSD的活性可使糖尿病患者的代谢作用正常等^[6]。

采用文献^[7]描述的酶偶联分析法,测定化合物2-5对GK和SIRT1的激动活性;按文献^[8]方法构建体外筛选模型并测定上述化合物抑制DPPIV的活性;按文献^[9]方法,测定上述化合物对小鼠和人11β-HSD的抑制作用。

3 实验结果

3.1 化合物结构鉴定

化合物1 无色针状结晶(MeOH),mp. 194~195 °C;FAB-MS(negative):*m/z* 457 [M-1]⁻;分子式C₃₀H₅₀O₃;¹H NMR(CDCl₃, 500 MHz) δ:5.10(1H,t,*J*=6.9 Hz,H-24),3.56(1H,m,H-12),1.66(3H,s,H-26),1.61(3H,s,H-27),1.15(3H,s),1.06(3H,s),1.02(3H,s),1.00(3H,s),0.96(3H,s),0.87(3H,s);¹³C NMR(CDCl₃, 125 MHz) δ:39.7(t,C-1),34.0(t,C-2),217.9(s,C-3),47.7(s,C-4),55.2(d,C-5),19.6(t,C-6),34.0(t,C-7),39.5(s,C-8),49.3(d,C-9),36.7(s,C-10),30.9(t,C-11),70.4(d,C-12),48.6(d,C-13),51.9(s,C-14),31.5(t,C-15),26.2(t,C-16),49.9(d,C-17),15.9(q,C-18),15.3(q,C-19),74.5(s,C-20),21.7(q,C-21),30.9(t,C-22),21.9(t,C-23),124.5(d,C-24),132.0(s,C-25),25.7(q,C-26),17.8(q,C-27),26.6(q,C-28),20.9(q,C-29),16.9(q,C-30)。以上数据与文献^[10]报道一致,故该化合物鉴定为12β,20(S)-dihydroxydammar-24-en-3-one。

化合物2 无色针状结晶(MeOH),mp. 205~206 °C;ESI-MS(negative):*m/z* 605 [M-1]⁻;分子式C₃₉H₅₈O₅;¹H NMR(DMSO-*d*₆, 400 MHz) δ:9.58(1H,d,*J*=4.1 Hz,3'-OH),9.15(1H,d,*J*=6.9 Hz,4'-OH),7.43(1H,d,*J*=15.9 Hz,H-8'),7.02(1H,s,H-2'),6.98(1H,d,*J*=8.2 Hz,H-6'),6.73(1H,d,*J*=8.2 Hz,H-5'),6.22(1H,d,*J*=15.9 Hz,H-7'),5.05(1H,t,*J*=7.2 Hz,H-24),4.47(1H,dd,*J*=10.6,4.1 Hz,H-3),4.65(1H,d,*J*=11.8 Hz,H-1),3.86(1H,s,20-OH),1.60(3H,s,H-26),1.51(3H,s,H-27),1.00(3H,s),0.91(3H,s),0.87(3H,s),0.84(3H,s),0.83(3H,s),0.81(3H,s);¹³C NMR(DMSO-*d*₆, 100 MHz) δ:38.9(t,C-1),24.3(t,C-2),79.8(d,C-3),38.1(s,C-4),55.2(d,C-5),17.8(t,C-6),35.2(t,C-7),39.9(s,C-8),50.0(d,C-9),36.6(s,C-10),21.9(t,C-11),24.9(t,C-12),41.6(d,C-13),49.9(s,C-14),31.3(t,C-15),27.3(t,C-16),49.9(d,C-17),16.4(q,C-18),16.1(q,C-19),73.0(s,C-20),25.3(q,C-21),41.3(t,C-22),22.3(t,C-23),125.3(d,C-24),130.1(s,C-25),25.6(q,C-26),17.5(q,C-27),27.8(q,C-28),15.3(q,C-29),16.6(q,C-30),125.5(s,C-1'),

114.4 (d, C-2'), 144.9 (s, C-3'), 148.4 (s, C-4'), 114.8 (d, C-5'), 121.3 (d, C-6'), 145.6 (d, C-7'), 115.7 (d, C-8'), 166.4 (s, C-9')。以上数据与文献^[11]报道一致,故该化合物鉴定为 dammarendiol II 3-*O*-caffeate。

化合物 3 片状结晶 (MeOH), mp. 110 ~ 112 °C; EI-MS: m/z 438 [M]⁺; 分子式 C₃₁H₅₀O; ¹H NMR (CDCl₃, 500 MHz) δ : 4.71 (1H, br s, H-31), 4.65 (1H, br s, H-31), 1.09 (3H, s, H-30), 1.03 (3H, s, H-29), 1.02 (3H, d, $J = 6.5$ Hz, H-27), 1.02 (3H, d, $J = 6.5$ Hz, H-26), 1.00 (3H, s, H-18), 0.98 (3H, s, H-28), 0.89 (3H, d, $J = 6.0$ Hz, H-21); ¹³C NMR (CDCl₃, 100 MHz) δ : 33.4 (t, C-1), 37.4 (t, C-2), 216.5 (s, C-3), 50.2 (s, C-4), 48.4 (d, C-5), 21.5 (t, C-6), 28.1 (t, C-7), 47.8 (d, C-8), 21.0 (s, C-9), 25.9 (s, C-10), 25.8 (t, C-11), 35.5 (t, C-12), 45.3 (s, C-13), 48.7 (s, C-14), 32.7 (t, C-15), 26.7 (t, C-16), 52.2 (d, C-17), 18.3 (q, C-18), 29.5 (q, C-19), 36.1 (d, C-20), 18.0 (q, C-21), 34.9 (t, C-22), 31.2 (t, C-23), 156.7 (s, C-24), 33.7 (d, C-25), 21.9 (q, C-26), 21.8 (q, C-27), 19.3 (q, C-28), 22.1 (q, C-29), 20.7 (q, C-30), 105.9 (t, C-31)。以上数据与文献^[12]报道一致,故该化合物鉴定为 24-methylene-cycloartenone。

化合物 4 无色粉末, FAB-MS (negative): m/z 709 [M-1]⁻; 分子式 C₄₁H₅₈O₁₀; ¹H NMR (CDCl₃, 500 MHz) δ : 8.04 (2H, d, $J = 7.7$ Hz, H-3' and H-7'), 7.52 (1H, m, H-5'), 7.38 (2H, t, $J = 7.5$ Hz, H-2' and H-6'), 5.30 (1H, br. d, $J = 2.1$ Hz, H-15), 5.13 (1H, br. s, H-7), 4.83 (1H, s, H-3), 4.65 (1H, d, $J = 11.8$ Hz, H-1), 3.92 (br. s, W_{1/2}, $J = 3.5$ Hz), 3.54 (1H, m, H-21), 2.12 (3H, s, COCH₃), 1.60 (3H, s, COCH₃), 1.35 (3H, s, H-27), 1.24 (3H, s, H-26), 1.08 (3H, s, H-30), 1.06 (3H, s, H-29), 0.96 (3H, s, H-18), 0.95 (3H, s, H-19), 0.86 (3H, s, H-28); ¹³C NMR (CDCl₃, 125 MHz) δ : 72.6 (d, C-1), 25.3 (t, C-2), 77.0 (d, C-3), 36.4 (s, C-4), 37.3 (d, C-5), 23.0 (t, C-6), 75.4 (d, C-7), 41.9 (s, C-8), 35.2 (d, C-9), 40.1 (s, C-10), 16.0 (t, C-11), 34.6 (t, C-12), 46.3 (s, C-13), 158.8 (s, C-14), 119.2 (d, C-15), 33.7 (t, C-16), 56.8 (d, C-17), 19.9 (q, C-18), 16.1 (q, C-19), 29.7 (d, C-20), 65.2 (t, C-21), 32.6 (t, C-22), 67.4 (d, C-23), 96.5 (s, C-24), 76.3 (s, C-25),

23.1 (q, C-26), 24.1 (q, C-27), 27.9 (q, C-28), 21.3 (q, C-29), 26.7 (q, C-30), 165.2 (s, C-1'), 130.5 (s, C-2'), 129.4 (d, C-3'), 128.2 (d, C-4'), 132.9 (d, C-5'), 128.2 (d, C-6'), 129.4 (d, C-7'), 169.7, 170.1 (s, COCH₃), 20.9, 21.3 (q, COCH₃)。以上数据与文献^[13]报道一致,故该化合物鉴定为 meliavinol。

化合物 5 无色针状结晶 (MeOH), mp. 215 ~ 217 °C; FAB-MS (positive): m/z 733 [M+1]⁺; 分子式 C₃₇H₄₈O₁₅; ¹H NMR (CDCl₃, 400 MHz) δ : 6.91 (1H, dd, $J = 13.7, 6.3$ Hz, H-3'), 6.40 (1H, d, $J = 3.0$ Hz, H-23), 5.65 (1H, s, H-21), 5.38 (1H, d, $J = 2.9$ Hz, H-22), 4.89 (1H, s, H-3), 4.75 (1H, s, H-1), 4.23 (1H, d, $J = 2.3$ Hz, H-7), 4.14 and 3.84 (2H, d, $J = 9.1$ Hz, H-19), 4.11 (1H, s, H-15), 3.93 (1H, dd, $J = 12.9, 2.7$ Hz, H-6), 3.68 (3H, s, 12-OMe), 3.54 and 3.46 (2H, d, $J = 2.5$ Hz, H-28), 3.34 (3H, s, 11-OMe), 3.03 (1H, d, $J = 12.8$ Hz, H-5), 2.91 (1H, d, $J = 4.5$ Hz, H-17), 2.10 (3H, s, OCOCH₃), 1.92 (3H, s, OCOCH₃), 1.48 (3H, s, H-30), 1.34 (3H, s, H-18), 0.98 (3H, s, H-29); ¹³C NMR (CDCl₃, 100 MHz) δ : 70.1 (d, C-1), 28.1 (t, C-2), 70.7 (d, C-3), 42.2 (s, C-4), 34.9 (d, C-5), 71.7 (d, C-6), 82.9 (d, C-7), 51.9 (s, C-8), 48.1 (d, C-9), 49.8 (s, C-10), 106.6 (s, C-11), 169.0 (s, C-12), 93.5 (s, C-13), 92.8 (s, C-14), 81.9 (d, C-15), 28.8 (t, C-16), 48.1 (d, C-17), 25.8 (q, C-18), 70.5 (t, C-19), 91.7 (s, C-20), 105.8 (d, C-21), 105.4 (d, C-22), 146.7 (d, C-23), 76.0 (t, C-28), 18.1 (q, C-29), 18.0 (q, C-30), 166.6 (s, C-1'), 128.2 (s, C-2'), 138.1 (d, C-3'), 14.3 (q, C-4'), 12.0 (q, C-5'), 170.2, 171.4 (s, COCH₃), 20.9, 21.4 (q, COCH₃), 52.3 (q, C₁₁-OCH₃), 53.1 (q, C₁₂-OCH₃)。以上数据与文献^[14]报道一致,故该化合物鉴定为 3,20-diacyl-11-methoxy-1-tigloylmeliacarpinin。

化合物 6 无色针状结晶 (MeOH), mp. 145 ~ 147 °C; EI-MS: m/z 210 [M]⁺, 分子式 C₁₀H₁₀O₅; ¹H NMR (CDCl₃, 400 MHz) δ : 12.89, (1H, s, 4-OH), 12.42 (1H, s, 2-OH), 10.34 (1H, s, CHO), 6.29 (1H, s, H-5), 3.96 (3H, s, OCH₃), 2.53 (3H, s, CH₃); ¹³C NMR (CDCl₃, 100 MHz) δ : 193.9 (s, CHO), 172.0 (s, C-1'), 168.3 (s, C-4), 166.6 (s, C-2), 152.3 (s, C-6), 112.1 (d, C-5), 108.4 (s, C-3), 103.8 (s, C-1), 52.3 (q, OCH₃), 25.2 (CH₃, q)。以上数据与文

献^[15]报道一致,故该化合物鉴定为 methyl 3-formyl-2,4-dihydroxy-6-methyl benzoate。

化合物 7 浅黄色针状结晶(MeOH), mp. 203 ~ 204 °C; FAB-MS(negative): m/z 343 [M-1]⁻; 分子式为 C₁₈H₁₆O₇; ¹H NMR(CDCl₃, 500 MHz) δ: 13.3 (1H, s, 7-OH), 11.0 (1H, s, 3-OH), 5.98 (1H, s, H-4), 2.68 (3H, s, H-14), 2.66 (3H, s, H-12), 2.11 (3H, s, H-15), 1.76 (3H, s, H-10); ¹³C NMR(CDCl₃, 125 MHz) δ: 201.8 (s, C-1), 103.9 (s, C-2), 191.7 (s, C-3), 98.3 (d, C-4), 101.5 (s, C-6), 163.9 (s, C-7), 109.3 (s, C-8), 157.5 (s, C-9), 32.1 (q, C-10), 198.0 (s, C-11), 27.9 (q, C-12), 200.4 (s, C-13), 31.3 (q, C-14), 7.6 (q, C-15), 179.4 (s, C-4a), 155.2 (s, C-6a), 105.2 (s, C-9a), 59.1 (s, C-9b)。以上数据与文献^[16,17]报道一致,故该化合物鉴定为 usnic acid。

化合物 8 浅黄色针状结晶(丙酮), mp. 241 ~ 243 °C; FAB-MS(negative): m/z 289 [M-1]⁻; 分子式为 C₁₅H₁₄O₆; ¹H NMR(CD₃OD, 400 MHz) δ: 6.82, (1H, d, $J = 1.5$ Hz, H-2'), 6.75 (1H, d, $J = 8.1$ Hz, H-5'), 6.70 (1H, dd, $J = 8.1, 1.6$ Hz, H-6'), 5.91 (1H, d, $J = 2.2$ Hz, H-6), 5.84 (1H, d, $J = 2.2$ Hz, H-8), 4.55 (1H, d, $J = 7.5$ Hz, H-2), 3.96 (1H, dd, $J = 13.8, 7.7$ Hz, H-3), 2.83 (1H, dd, $J = 116.1, 5.4$ Hz, H-3), 2.48 (1H, dd, $J = 16.1, 8.1$ Hz, H-3); ¹³C NMR(CD₃OD, 100 MHz) δ: 82.8 (d, C-2), 68.8 (d, C-3), 28.5 (t, C-4), 100.8 (s, C-4a), 157.8 (s, C-5), 96.3 (d, C-6), 157.6 (s, C-7), 95.5 (d, C-8), 156.9

(s, C-8a), 132.2 (s, C-1'), 115.2 (d, C-2'), 146.2 (s, C-3' and C-4'), 116.1 (d, C-5'), 120.2 (d, C-6')。以上数据与文献^[18,19]报道一致,故该化合物鉴定为 *epi*-catechin。

3.2 化合物 2~5 抗糖尿病活性

3.2.1 GK 体外活性筛选

化合物 2~5 对人 GK 激动作用筛选实验重复 3 次,结果表明,1 μmol/L 的阳性对照 PSN-GK1 可使 GK 活性增加至溶剂对照组的 2.63 倍,而化合物 2~5 在浓度为 10 μmol/L 时,仅使其活性增加至对照组的 0.79~1.11 倍,因此,受试化合物无明显的 GK 激动活性。

3.2.2 化合物对人 SIRT1 激动剂体外活性筛选

上述化合物对人 SIRT1 的激动作用筛选试验重复 2 次,结果表明,200 μmol/L 的阳性对照 RSV 可使 SIRT1 活性增加至溶剂对照组的 10.51 倍,而上述化合物在相同浓度时,仅使其活性增加至对照组的 0.82~1.00 倍,因此,受试化合物均不具有显著的 SIRT1 激动活性。

3.2.3 化合物体外抑制 DPPIV 活性筛选

测定上述化合物对 DPPIV 的抑制作用,结果表明,0.1 μmol/L 的阳性对照 MK0431 有很强的抑制作用,其比活力值为 25.2%;受试化合物浓度为 10 μmol/L 时,其比活力值为 97.67~103.96%,表明上述化合物对 DPPIV 均无激动活性。

3.2.4 化合物体外抑制 11β-HSD 活性筛选

测定上述化合物对 11β-羟基类固醇脱氢酶(11β-HSD)的抑制活性,结果见表 1。

表 1 化合物对小鼠和人抑制 11β-HSD1 型酶抑制率

Table 1 Inhibitory activity of compounds 2-5 against 11β-HSD1

化合物及浓度 Concentration of compounds	小鼠 HSD1 Mouse HSD1	人 HSD1 Human HSD1	化合物及浓度 Concentration of compounds	小鼠 HSD1 Mouse HSD1	人 HSD1 Human HSD1
GA(1 nmol/L)	19.92%	16.36%	3(1 μmol/L)	10.70%	17.63%
GA(10 nmol/L)	48.67%	47.06%	4(1 μmol/L)	10.64%	25.95%
GA(100 nmol/L)	80.25%	84.73%	5(1 μmol/L)	10.76%	26.48%
2(1 μmol/L)	14.42%	88.90%			

注:“GA”表示阳性对照甘草酸。

Note:“GA” is the positive control glycyrrhetic acid.

由表 1 可知,化合物 2 对人 11β-HSD1 有明显的抑制作用,进一步测定该化合物对 11β-HSD1 抑制作用的 IC₅₀ 值和对人 11β-HSD2 的抑制率,结果见表 2。

经测定,化合物 2 对人 11β-HSD1 的 IC₅₀ 为 94.15 nmol/L。从表 2 可知,该化合物对人 11β-HSD1 具有显著的抑制作用,当其剂量为 1 mmol/L 时对人 11β-HSD2 的抑制率低于 50%,提示该化合

表2 化合物2对人11 β -HSD1和11 β -HSD2的抑制率($X \pm SD, n = 2$)Table 2 The inhibition activity of compounds 2 against human 11 β -HSD1 and 11 β -HSD2($X \pm SD, n = 2$)

化合物及浓度 Concentration of compounds	均值 Means	标准差 SD	化合物及浓度 Concentration of compounds	均值 Means	标准差 SD
	11 β -HSD1	2(0.3 μ mol/L)	69.02%	6.79%	
GA(1 nmol/L)	10.02%	6.53%	2(1 μ mol/L)	74.27%	1.22%
GA(10 nmol/L)	42.09%	2.18%		11 β -HSD2	
GA(100 nmol/L)	81.53%	1.45%	GA(0.01 nmol/L)	10.17%	1.04%
2(0.01 μ mol/L)	24.85%	4.58%	GA(0.1 nmol/L)	31.79%	4.76%
2(0.03 μ mol/L)	34.98%	3.49%	GA(1 nmol/L)	56.83%	3.98%
2(0.1 μ mol/L)	45.43%	4.10%	2(1 mmol/L)	9.42%	10.85%

注:“GA”表示阳性对照甘草酸。

Note:“GA” is the positive control glycyrrhetic acid.

物对人11 β -HSD2有良好的选择性。

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