

金银花三萜皂苷类成分及其抗肿瘤、抗炎活性研究

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摘要: **目的** 研究金银花中三萜皂苷类成分及其抗肿瘤、抗炎活性。**方法** 采用 MAR、Sephadex LH-20、ODS、D101 大孔树脂及半制备 HPLC 进行分离纯化, 依据理化性质及波谱数据鉴定所得化合物的结构。采用 MTT 法评价化合物对 MCF-7、HepG-2 肿瘤细胞增殖的抑制活性, LPS 诱导 RAW 264.7 细胞炎症模型评价其抗炎活性。**结果** 从中分离得到 12 个三萜皂苷, 分别鉴定为 colchiside A (1)、3-*O*- α -*L*-rhamnopyranosyl- (1 $\rightarrow$ 2) - β -*D*-xylopyranosyl-hedragenin (2)、 α -hederin (3)、pictoside A (4)、3-*O*- α -*L*-arabinopyranosyl-gypsogenic acid (5)、 β -hederin (6)、3-*O*- β -*D*-glucopyranosyl- (1 $\rightarrow$ 2) - α -*L*-arabinopyranosyl-oleanolic acid (7)、leontoside B (8)、pulsatilla saponin D (9)、macranthoside A (10)、lecanioside A (11)、3-*O*- β -*D*-glucopyranosyl- (1 $\rightarrow$ 4) - β -*D*-glucopyranosyl- (1 $\rightarrow$ 3) - α -*L*-rhamnopyranosyl- (1 $\rightarrow$ 2) - α -*L*-arabinopyranosyl-oleanolic acid (12)。化合物 2、3、6、10、12 对 MCF-7 细胞的 IC₅₀ 值为 (9.47 $\pm$ 0.11) ~ (18.64 $\pm$ 0.20) μ mol/L, 3、6、12 对 HepG-2 细胞的 IC₅₀ 值分别为 (17.21 $\pm$ 0.10)、(7.47 $\pm$ 0.09)、(6.04 $\pm$ 0.07) μ mol/L。化合物 2、6、9~12 对 RAW264.7 细胞 NO 生成量的 IC₅₀ 值为 (3.59 $\pm$ 0.09) ~ (9.06 $\pm$ 0.17) μ mol/L。**结论** 化合物 4、5、9 为首次从忍冬科植物中分离得到, 8、12 为首次从忍冬属植物中分离得到。化合物 2、3、6、10、12 具有抗肿瘤活性, 2、6、9~12 具有抗炎活性。
关键词: 金银花; 三萜皂苷; 分离鉴定; 抗肿瘤活性; 抗炎活性
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Triterpenoid saponins from *Lonicerae Japonicae Flos* and their anti-tumor, anti-inflammatory activities

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ABSTRACT: **AIM** To study the triterpenoid saponins from *Lonicerae Japonicae Flos* and their anti-tumor, anti-inflammatory activities. **METHODS** Separation and purification were performed using MAR, Sephadex LH-20, ODS, D101 macroporous resin and semi-preparative HPLC, then the structures of obtained compounds were identified by physicochemical properties and spectral data. The antiproliferative activity of the compounds against MCF-7 and HepG-2 cancer cells was evaluated by MTT assay, and the anti-inflammatory activity was assessed using LPS-induced RAW264.7 macrophage inflammatory model. **RESULTS** A total of twelve triterpenoid saponins were isolated and identified as colchiside A (1), 3-*O*- α -*L*-rhamnopyranosyl- (1 $\rightarrow$ 2) - β -*D*-xylopyranosyl-hedragenin (2), α -hederin (3), pictoside A (4), 3-*O*- α -*L*-arabinopyranosyl-gypsogenic acid (5), β -hederin (6), 3-*O*- β -*D*-glucopyranosyl- (1 $\rightarrow$ 2) - α -*L*-arabinopyranosyl-oleanolic acid (7), leontoside B (8), pulsatilla

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saponin D (9), macranthoside A (10), lecanioside A (11), 3-*O*- β -*D*-glucopyranosyl- (1 $\rightarrow$ 4) - β -*D*-glucopyranosyl- (1 $\rightarrow$ 3) - α -*L*-rhamnopyranosyl- (1 $\rightarrow$ 2) - α -*L*- arabinopyranosyl-oleanolic acid (12). The IC₅₀ values of compounds 2, 3, 6, 10 and 12 against MCF-7 cells ranged from (9.47 $\pm$ 0.11) to (18.64 $\pm$ 0.20) μ mol/L, while the IC₅₀ values of 3, 6 and 12 against HepG-2 cells were (17.21 $\pm$ 0.10), (7.47 $\pm$ 0.09), and (6.04 $\pm$ 0.07) μ mol/L, respectively. The IC₅₀ values of compounds 2, 6 and 9–12 against NO production in RAW264.7 cells ranged from (3.59 $\pm$ 0.09) to (9.06 $\pm$ 0.17) μ mol/L. **CONCLUSION** Compounds 4, 5 and 9 are isolated from Caprifoliaceae family for the first time, while 8 and 12 are first isolated from *Lonicera* genus. Compounds 2, 3, 6, 10 and 12 exhibit anti-tumor activity, while 2, 6, 9–12 demonstrates significant anti-inflammatory activity.

KEY WORDS: *Lonicerae Japonicae Flos*; triterpenoid saponins; isolation and identification; anti-tumor activity; anti-inflammatory activity

金银花为忍冬科忍冬属植物忍冬 *Lonicera japonica* Thunb. 的干燥花蕾或带初开花^[1], 首次记载于《名医别录》, 被列为上品^[2], 广泛分布于我国各地, 以河南、山东资源最丰富^[3], 其性寒, 味甘, 归肺、心、胃经, 临床药用历史悠久, 具有清热解毒、疏散风热功效^[4], 常用于治疗痈肿疔疮、热毒血痢、温病发热等^[5]。作为清热解毒良药, 金银花具有“中药中的抗生素”之称, 既可入药, 也可食用, 即为药食两用品种^[6]。

金银花含有丰富的化学成分, 包括黄酮、酚酸、皂苷、环烯醚萜等, 具有抗炎、抗肿瘤、抗病毒、抗氧化等生物活性^[7-11], 其中三萜皂苷类有着较强的抗炎、抗肿瘤作用, 可能为功效物质^[12]。为了更好地挖掘金银花药效物质基础, 本研究以三萜皂苷为目标成分对该药材进行分离纯化, 并对其进行抗肿瘤、抗炎活性评价, 以期为其进一步合理开发利用奠定实验基础。

1 材料

Avance III HD 600 MHz 核磁共振波谱仪 (德国 Bruker 公司); 旋转蒸发仪 (瑞士 Buchi 公司); 安捷伦 1260 HPLC-1290 UPLC/6230 TOF 液相色谱质谱联用仪、安捷伦 1260 半制备高效液相色谱仪、C₁₈ 分析色谱柱 (4.6 mm $\times$ 100 mm, 5 μ m) (美国 Agilent 公司); YMC 反相制备柱 (250 mm $\times$ 20 mm, 5 μ m) (日本 YMC 公司); Sephadex LH-20 (美国 GE 公司); 硅胶填料 (青岛海洋化工有限公司); D101 大孔吸附树脂柱 (国药集团化学试剂公司)。人乳腺癌 MCF-7 细胞、人肝癌 HepG2 细胞、RAW 264.7 小鼠巨噬细胞 (中国科学院上海细胞保存库)。胰蛋白酶 (批号 2502005, 上海逍鹏生物科技有限公司); 胎牛血清 (批号 24070703, 杭州四季青生物工程材料有限公司); DMEM 高糖培养基

(批号 WHB825X141, 武汉普诺赛生命科技有限公司); 脂多糖 (批号 33124001AZ, 北京兰杰柯科技有限公司); 地塞米松 (批号 JS252834, 上海源叶生物科技有限公司); CCK-8、NO 检测试剂盒 (上海碧云天生物技术股份有限公司)。甲醇 (色谱纯, 美国 Thermo Fisher Scientific 公司); 其余试剂均为分析纯 (天津富宇精细化工有限公司); 水为纯净水。

金银花购自山东省临沂市平邑县, 经山东中医药大学张芳教授鉴定为忍冬科植物忍冬 *Lonicera japonica* Thunb. 的干燥花蕾, 凭证标本 (编号 20230725) 保存于山东中医药大学天然药物化学实验室。

2 提取与分离

取干燥金银花 10 kg, 粉碎, 75% 乙醇室温浸漉提取 3 次, 时间分别为 8、7、6 d, 减压浓缩得到浸膏, 用水混悬, 以乙酸乙酯和正丁醇萃取, 分别得到乙酸乙酯部位 (260 g) 和正丁醇部位 (400 g)。正丁醇部位经大孔吸附树脂柱分离, 以乙醇-水 (0 : 1、30 : 1、50 : 1、70 : 1、90 : 1) 梯度洗脱, 得到组分 Fr. 1~Fr. 5。

Fr. 3 (120 g) 经硅胶柱分离, 以二氯甲烷-甲醇 (200 : 1~5 : 1) 梯度洗脱, 得到 16 个流分 (Fr. 3-1~Fr. 3-16)。Fr. 3-2 (10 g) 经 Sephadex LH-20 凝胶柱分离, 以二氯甲烷-甲醇 (1 : 1) 洗脱, 得到化合物 1 (3.52 mg); Fr. 3-5 (23 g) 经 Sephadex LH-20 凝胶柱分离, 以甲醇洗脱, 得到 4 个组分 (Fr. 3-5-1~Fr. 3-5-4), Fr. 3-5-2 经半制备 HPLC (流动相 80% 甲醇) 分离, 得到化合物 2 (3.00 mg, t_R = 15.8 min)、3 (2.83 mg, t_R = 21.5 min); Fr. 3-5-3 经半制备 HPLC (流动相 70% 甲醇) 纯化, 得到化合物 4 (2.13 mg, t_R = 9.5 min)、5 (1.89 mg, t_R = 13.2 min)。Fr. 3-8 (17.8 g) 经

Sephadex LH-20 凝胶柱分离,以二氯甲烷-甲醇(1:1)洗脱,得到5个组分(Fr. 3-8-1~Fr. 3-8-5),Fr. 3-8-3经Sephadex LH-20凝胶柱分离,以甲醇洗脱,得到化合物**6**(8.72 mg)、**7**(7.20 mg);Fr. 3-8-5经硅胶柱分离,以二氯甲烷-甲醇(100:1~10:1)梯度洗脱,得到8个组分(Fr. 3-8-5-1~Fr. 3-8-5-8),Fr. 3-8-5-4经半制备HPLC(流动相75%甲醇)分离,得到化合物**8**(4.52 mg, t_R = 16.1 min)、**9**(3.45 mg, t_R = 25.2 min);Fr. 3-8-5-7经半制备HPLC(流动相65%甲醇)分离,得到化合物**10**(3.91 mg, t_R = 13.4 min)。Fr. 3-14(9.8 g)经硅胶柱分离,以石油醚-乙酸乙酯(10:1~1:1)梯度洗脱,得到5个组分(Fr. 3-14-1~Fr. 3-14-5),Fr. 3-14-3经半制备HPLC(流动相70%甲醇)分离,得到化合物**11**(4.6 mg, t_R = 11.2 min)、**12**(5.1 mg, t_R = 17.6 min)。另外,半制备HPLC体积流量均为2 mL/min,检测波长均为230 nm。

3 结构鉴定

化合物**1**:白色粉末,ESI-MS m/z : 627.404 1 $[M+Na]^+$ 。¹H-NMR (600 MHz, CD₃OD) δ : 1.54, 1.28 (2H, m, H-1), 1.77, 1.40 (2H, m, H-2), 3.61 (1H, m, H-3), 0.96 (1H, m, H-5), 1.60, 1.36 (2H, m, H-6), 1.63, 1.25 (2H, m, H-7), 1.12 (1H, m, H-9), 2.00, 1.90 (2H, m, H-11), 5.24 (1H, s, H-12), 1.40, 1.17 (2H, m, H-15), 1.86, 1.40 (2H, m, H-16), 3.28 (1H, m, H-18), 1.60, 1.22 (2H, m, H-19), 1.66, 1.63 (2H, m, H-21), 1.90, 1.63 (2H, m, H-22), 3.83, 3.61 (2H, m, H-23), 0.81 (3H, s, H-24), 0.69 (3H, s, H-25), 0.92 (3H, s, H-26), 1.15 (3H, s, H-27), 0.97 (3H, s, H-29), 0.93 (3H, s, H-30), 5.08 (1H, m, H-1'), 3.81 (1H, m, H-2'), 4.29 (1H, m, H-3'), 3.80 (1H, m, H-4'), 3.59, 3.46 (2H, m, H-5');¹³C-NMR (150 MHz, CD₃OD) δ : 39.5 (C-1), 26.4 (C-2), 83.3 (C-3), 42.9 (C-4), 48.2 (C-5), 18.9 (C-6), 33.6 (C-7), 39.5 (C-8), 48.2 (C-9), 37.7 (C-10), 24.1 (C-11), 123.5 (C-12), 145.3 (C-13), 43.0 (C-14), 28.9 (C-15), 24.6 (C-16), 49.1 (C-17), 43.0 (C-18), 47.3 (C-19), 31.6 (C-20), 33.5 (C-21), 33.8 (C-22), 64.8 (C-23), 13.4 (C-24), 16.5 (C-25), 17.8 (C-26), 18.9 (C-27),

182.0 (C-28), 26.5 (C-29), 24.0 (C-30), 106.4 (C-1'), 73.0 (C-2'), 74.6 (C-3'), 69.8 (C-4'), 66.8 (C-5')。以上数据与文献[13]报道基本一致,故鉴定该化合物为 colchiside A。

化合物**2**:白色粉末,ESI-MS m/z : 773.545 3 $[M+Na]^+$ 。¹H-NMR (600 MHz, CD₃OD) δ : 1.53, 1.28 (2H, m, H-1), 1.77, 1.39 (2H, m, H-2), 3.62 (1H, m, H-3), 0.99 (1H, m, H-5), 1.62, 1.39 (2H, m, H-6), 1.61, 1.28 (2H, m, H-7), 1.10 (1H, m, H-9), 2.03, 1.91 (2H, m, H-11), 5.24 (1H, m, H-12), 1.41, 1.10 (2H, m, H-15), 1.90, 1.42 (2H, m, H-16), 3.36 (1H, m, H-18), 1.51, 1.21 (2H, m, H-19), 1.62, 1.39 (2H, m, H-21), 1.87, 1.63 (2H, m, H-22), 3.90, 3.65 (2H, m, H-23), 0.84 (3H, s, H-24), 0.72 (3H, s, H-25), 0.90 (3H, s, H-26), 1.16 (3H, s, H-27), 0.96 (3H, s, H-29), 0.95 (3H, s, H-30), 5.14 (1H, d, J = 6.8 Hz, H-1'), 3.85 (1H, m, H-2'), 3.49 (1H, m, H-3'), 3.51 (1H, m, H-4'), 3.49, 3.39 (2H, m, H-5'), 5.24 (1H, m, H-1''), 3.83 (1H, m, H-2''), 3.77 (1H, m, H-3''), 3.71 (1H, m, H-4''), 4.56 (1H, m, H-5''), 1.24 (3H, d, J = 6.2 Hz, H-6'');¹³C-NMR (150 MHz, CD₃OD) δ : 37.6 (C-1), 26.5 (C-2), 82.2 (C-3), 42.7 (C-4), 49.0 (C-5), 18.8 (C-6), 33.5 (C-7), 39.7 (C-8), 47.8 (C-9), 37.4 (C-10), 24.2 (C-11), 123.5 (C-12), 145.2 (C-13), 43.1 (C-14), 28.7 (C-15), 24.5 (C-16), 49.8 (C-17), 48.1 (C-18), 47.3 (C-19), 33.8 (C-20), 31.6 (C-21), 33.6 (C-22), 64.8 (C-23), 13.7 (C-24), 16.4 (C-25), 17.8 (C-26), 24.0 (C-27), 181.6 (C-28), 33.6 (C-29), 26.5 (C-30), 104.4 (C-1'), 73.7 (C-2'), 76.7 (C-3'), 70.2 (C-4'), 64.6 (C-5'), 101.9 (C-1''), 72.0 (C-2''), 73.9 (C-3''), 72.2 (C-4''), 69.2 (C-5''), 18.0 (C-6'')。以上数据与文献[14]报道基本一致,故鉴定该化合物为 3-*O*- α -*L*-rhamnopyranosyl-(1 $\rightarrow$ 2)- β -*D*-xylopyranosyl-hedragenin。

化合物**3**:白色粉末,ESI-MS m/z : 773.525 1 $[M+Na]^+$ 。¹H-NMR (600 MHz, CD₃OD) δ : 1.53, 1.27 (2H, m, H-1), 1.73, 1.38 (2H, m, H-2), 3.61 (1H, m, H-3), 1.07 (1H, m, H-5),

1.64, 1.38 (2H, m, H-6), 1.59, 1.30 (2H, m, H-7), 1.13 (1H, m, H-9), 2.00, 1.90 (2H, m, H-11), 5.24 (1H, m, H-12), 1.38, 1.13 (2H, m, H-15), 1.94, 1.38 (2H, m, H-16), 3.38 (1H, m, H-18), 1.59, 1.27 (2H, m, H-19), 1.64, 1.48 (2H, m, H-21), 1.94, 1.64 (2H, m, H-22), 3.92, 3.61 (2H, m, H-23), 0.82 (3H, s, H-24), 0.70 (3H, s, H-25), 0.91 (3H, s, H-26), 1.17 (3H, s, H-27), 0.94 (3H, s, H-29), 0.97 (3H, s, H-30), 4.46 (1H, d, $J = 7.3$ Hz, H-1'), 3.83 (1H, m, H-2'), 3.46 (1H, m, H-3'), 3.57 (1H, m, H-4'), 3.41, 3.33 (2H, m, H-5'), 5.32 (1H, m, H-1''), 3.95 (1H, m, H-2''), 3.83 (1H, m, H-3''), 3.74 (1H, m, H-4''), 4.59 (1H, m, H-5''), 1.22 (3H, d, $J = 6.2$ Hz, H-6''); $^{13}\text{C-NMR}$ (150 MHz, CD_3OD) δ : 39.7 (C-1), 26.8 (C-2), 81.9 (C-3), 42.8 (C-4), 48.2 (C-5), 18.8 (C-6), 33.4 (C-7), 40.5 (C-8), 49.5 (C-9), 37.6 (C-10), 24.1 (C-11), 123.5 (C-12), 145.4 (C-13), 44.0 (C-14), 28.9 (C-15), 24.5 (C-16), 47.8 (C-17), 48.9 (C-18), 47.3 (C-19), 31.6 (C-20), 33.8 (C-21), 35.0 (C-22), 64.4 (C-23), 13.8 (C-24), 16.4 (C-25), 17.7 (C-26), 24.0 (C-27), 181.0 (C-28), 33.6 (C-29), 26.4 (C-30), 105.4 (C-1'), 73.9 (C-2'), 78.7 (C-3'), 71.7 (C-4'), 66.6 (C-5'), 101.9 (C-1''), 72.1 (C-2''), 78.8 (C-3''), 71.9 (C-4''), 70.1 (C-5''), 18.0 (C-6''). 以上数据与文献 [15] 报道基本一致, 故鉴定该化合物为 α -hederin。

化合物 4: 白色粉末, ESI-MS m/z : 789.244 7 $[\text{M}+\text{Na}]^+$ 。 $^1\text{H-NMR}$ (600 MHz, CD_3OD) δ : 1.50, 1.29 (2H, m, H-1), 1.74, 1.39 (2H, m, H-2), 3.86 (1H, m, H-3), 1.09 (1H, m, H-5), 1.63, 1.38 (2H, m, H-6), 1.63, 1.29 (2H, m, H-7), 1.12 (1H, m, H-9), 1.95, 1.90 (2H, m, H-11), 5.49 (1H, m, H-12), 1.50, 1.24 (2H, m, H-15), 5.24 (1H, m, H-16), 3.62 (1H, m, H-18), 1.63, 1.29 (2H, m, H-19), 1.74, 1.50 (2H, m, H-21), 1.95, 1.74 (2H, m, H-22), 3.62, 3.37 (2H, m, H-23), 0.83 (3H, s, H-24), 0.70 (3H, s, H-25), 0.94 (3H, s, H-26), 1.19 (3H, s, H-27),

0.97 (3H, s, H-29), 0.99 (3H, s, H-30), 4.57 (1H, d, $J = 7.3$ Hz, H-1'), 3.86 (1H, m, H-2'), 3.49 (1H, m, H-3'), 3.62 (1H, m, H-4'), 3.49, 3.34 (2H, m, H-5'), 5.49 (1H, m, H-1''), 3.90 (1H, m, H-2''), 3.82 (1H, m, H-3''), 3.71 (1H, m, H-4''), 3.71 (1H, m, H-5''), 1.24 (3H, d, $J = 6.3$ Hz, H-6''); $^{13}\text{C-NMR}$ (150 MHz, CD_3OD) δ : 39.7 (C-1), 26.9 (C-2), 82.2 (C-3), 43.1 (C-4), 48.1 (C-5), 18.8 (C-6), 33.3 (C-7), 40.7 (C-8), 49.2 (C-9), 37.6 (C-10), 24.6 (C-11), 123.8 (C-12), 144.5 (C-13), 44.1 (C-14), 28.4 (C-15), 74.0 (C-16), 48.8 (C-17), 48.1 (C-18), 46.8 (C-19), 32.1 (C-20), 33.3 (C-21), 35.0 (C-22), 64.5 (C-23), 13.7 (C-24), 16.3 (C-25), 17.8 (C-26), 25.2 (C-27), 185.7 (C-28), 33.6 (C-29), 26.9 (C-30), 104.3 (C-1'), 73.9 (C-2'), 76.7 (C-3'), 70.2 (C-4'), 64.8 (C-5'), 101.9 (C-1''), 72.2 (C-2''), 73.7 (C-3''), 72.0 (C-4''), 69.2 (C-5''), 18.0 (C-6'')。以上数据与文献 [16] 报道基本一致, 故鉴定该化合物为 pictoside A。

化合物 5: 白色粉末, ESI-MS m/z : 641.787 6 $[\text{M}+\text{Na}]^+$ 。 $^1\text{H-NMR}$ (600 MHz, CD_3OD) δ : 1.53, 1.12 (2H, m, H-1), 1.93, 1.20 (2H, m, H-2), 4.26 (1H, m, H-3), 1.93 (1H, m, H-5), 1.39, 1.17 (2H, m, H-6), 1.77, 1.25 (2H, m, H-7), 1.87 (1H, m, H-9), 2.00, 1.90 (2H, m, H-11), 5.24 (1H, s, H-12), 1.50, 1.30 (2H, m, H-15), 1.87, 1.57 (2H, m, H-16), 3.51 (1H, m, H-18), 1.59, 1.21 (2H, m, H-19), 1.74, 1.67 (2H, m, H-21), 1.77, 1.69 (2H, m, H-22), 1.17 (3H, s, H-24), 0.80 (3H, s, H-25), 0.91 (3H, s, H-26), 1.14 (3H, s, H-27), 0.97 (3H, s, H-29), 0.94 (3H, s, H-30), 4.69 (1H, m, H-1'), 3.78 (1H, m, H-2'), 4.00 (1H, m, H-3'), 3.82 (1H, m, H-4'), 3.51, 3.49 (2H, m, H-5'); $^{13}\text{C-NMR}$ (150 MHz, CD_3OD) δ : 39.6 (C-1), 26.5 (C-2), 86.3 (C-3), 52.8 (C-4), 49.2 (C-5), 21.9 (C-6), 33.8 (C-7), 40.8 (C-8), 49.6 (C-9), 37.4 (C-10), 24.1 (C-11), 123.4 (C-12), 145.2 (C-13), 42.9 (C-14), 28.8 (C-15), 24.5 (C-16), 47.6 (C-17), 42.7 (C-18), 47.3 (C-19), 31.6 (C-20), 33.6 (C-21), 34.9 (C-

22), 181.9 (C-23), 12.4 (C-24), 16.2 (C-25), 17.6 (C-26), 26.4 (C-27), 180.2 (C-28), 33.6 (C-29), 24.0 (C-30), 105.7 (C-1'), 72.6 (C-2'), 74.1 (C-3'), 69.3 (C-4'), 66.3 (C-5')。以上数据与文献 [17] 报道基本一致, 故鉴定该化合物为 3-*O*- α -*L*-arabinopyranosyl-gypsogenic acid。

化合物 6: 白色粉末, ESI-MS m/z : 757.545 9 $[M+Na]^+$ 。¹H-NMR (600 MHz, CD₃OD) δ : 1.54, 1.30 (2H, m, H-1), 1.77, 1.40 (2H, m, H-2), 3.48 (1H, m, H-3), 1.07 (1H, m, H-5), 1.63, 1.40 (2H, m, H-6), 1.59, 1.30 (2H, m, H-7), 1.13 (1H, m, H-9), 2.00, 1.90 (2H, m, H-11), 5.24 (1H, m, H-12), 1.49, 1.12 (2H, m, H-15), 1.90, 1.54 (2H, m, H-16), 3.48 (1H, m, H-18), 1.63, 1.17 (2H, m, H-19), 1.69, 1.49 (2H, m, H-21), 1.82, 1.63 (2H, m, H-22), 3.81, 3.69 (2H, m, H-23), 0.82 (3H, s, H-24), 0.85 (3H, s, H-25), 0.91 (3H, s, H-26), 1.16 (3H, s, H-27), 0.94 (3H, s, H-29), 0.95 (3H, s, H-30), 5.10 (1H, d, $J = 6.8$ Hz, H-1'), 3.84 (1H, m, H-2'), 3.48 (1H, m, H-3'), 3.69 (1H, m, H-4'), 3.38, 3.35 (2H, m, H-5'), 5.49 (1H, m, H-1''), 3.84 (1H, m, H-2''), 3.79 (1H, m, H-3''), 3.73 (1H, m, H-4''), 4.55 (1H, m, H-5''), 1.22 (3H, d, $J = 6.3$ Hz, H-6''); ¹³C-NMR (150 MHz, CD₃OD) δ : 39.8 (C-1), 27.0 (C-2), 90.6 (C-3), 42.8 (C-4), 49.5 (C-5), 19.4 (C-6), 33.8 (C-7), 40.2 (C-8), 49.8 (C-9), 37.9 (C-10), 24.1 (C-11), 123.5 (C-12), 145.3 (C-13), 42.9 (C-14), 28.9 (C-15), 24.6 (C-16), 47.8 (C-17), 49.1 (C-18), 47.3 (C-19), 31.6 (C-20), 34.0 (C-21), 34.9 (C-22), 28.6 (C-23), 17.1 (C-24), 16.0 (C-25), 17.8 (C-26), 24.0 (C-27), 182.2 (C-28), 33.6 (C-29), 26.4 (C-30), 104.8 (C-1'), 73.1 (C-2'), 76.8 (C-3'), 70.2 (C-4'), 63.8 (C-5'), 102.1 (C-1''), 72.2 (C-2''), 70.2 (C-3''), 72.2 (C-4''), 68.4 (C-5''), 17.9 (C-6'')。以上数据与文献 [18] 报道基本一致, 故鉴定该化合物为 β -hederin。

化合物 7: 白色粉末, ESI-MS m/z : 773.945 3 $[M+Na]^+$ 。¹H-NMR (600 MHz, CD₃OD) δ : 1.52, 1.29 (2H, m, H-1), 1.73, 1.39 (2H, m, H-

2), 3.64 (1H, m, H-3), 1.00 (1H, m, H-5), 1.66, 1.39 (2H, m, H-6), 1.60, 1.29 (2H, m, H-7), 1.11 (1H, m, H-9), 1.99, 1.90 (2H, m, H-11), 5.24 (1H, m, H-12), 1.39, 1.19 (2H, m, H-15), 1.93, 1.39 (2H, m, H-16), 3.35 (1H, m, H-18), 1.60, 1.52 (2H, m, H-19), 1.66, 1.52 (2H, m, H-21), 1.85, 1.77 (2H, m, H-22), 0.83 (3H, s, H-23), 0.85 (3H, s, H-24), 0.90 (3H, s, H-25), 0.94 (3H, s, H-26), 1.16 (3H, s, H-27), 0.95 (3H, s, H-29), 1.06 (3H, s, H-30), 4.51 (1H, d, $J = 6.1$ Hz, H-1'), 3.84 (1H, m, H-2'), 3.51 (1H, m, H-3'), 3.64 (1H, m, H-4'), 3.83, 3.76 (2H, m, H-5'), 4.59 (1H, m, H-1''), 3.89 (1H, m, H-2''), 3.84 (1H, m, H-3''), 3.81 (1H, m, H-4''), 3.83 (1H, m, H-5''), 3.35, 3.25 (2H, m, H-6''); ¹³C-NMR (150 MHz, CD₃OD) δ : 39.2 (C-1), 26.5 (C-2), 90.7 (C-3), 42.3 (C-4), 42.4 (C-5), 18.8 (C-6), 33.4 (C-7), 40.0 (C-8), 49.0 (C-9), 37.4 (C-10), 24.0 (C-11), 122.9 (C-12), 145.4 (C-13), 39.8 (C-14), 28.3 (C-15), 24.0 (C-16), 48.3 (C-17), 49.0 (C-18), 46.8 (C-19), 31.1 (C-20), 33.5 (C-21), 34.4 (C-22), 15.3 (C-23), 16.3 (C-24), 17.3 (C-25), 23.5 (C-26), 25.8 (C-27), 180.3 (C-28), 27.9 (C-29), 33.0 (C-30), 104.2 (C-1'), 73.2 (C-2'), 77.4 (C-3'), 71.2 (C-4'), 64.7 (C-5'), 104.8 (C-1''), 71.2 (C-2''), 78.4 (C-3''), 77.6 (C-4''), 75.2 (C-5''), 62.3 (C-6'')。以上数据与文献 [19] 报道基本一致, 故鉴定该化合物为 3-*O*- β -*D*-glucopyranosyl- (1 $\rightarrow$ 2) - α -*L*-arabinopyranosyl-oleanolic acid。

化合物 8: 白色粉末, ESI-MS m/z : 789.454 7 $[M+Na]^+$ 。¹H-NMR (600 MHz, CD₃OD) δ : 1.58, 1.30 (2H, m, H-1), 1.68, 1.41 (2H, m, H-2), 3.64 (1H, m, H-3), 0.96 (1H, m, H-5), 1.68, 1.41 (2H, m, H-6), 1.59, 1.30 (2H, m, H-7), 1.16 (1H, m, H-9), 1.88, 1.80 (2H, m, H-11), 5.14 (1H, m, H-12), 1.49, 1.03 (2H, m, H-15), 1.80, 1.49 (2H, m, H-16), 2.74 (1H, m, H-18), 1.59, 1.29 (2H, m, H-19), 1.68, 1.49 (2H, m, H-21), 1.80, 1.68 (2H, m, H-22), 3.57, 3.46 (2H, m, H-23), 0.71 (3H, s, H-24), 0.58 (3H, s, H-

25), 0.87 (3H, s, H-26), 1.09 (3H, s, H-27), 0.87 (3H, s, H-29), 0.88 (3H, s, H-30), 4.33 (1H, d, $J = 7.7$ Hz, H-1'), 3.57 (1H, m, H-2'), 3.61 (1H, m, H-3'), 3.64 (1H, m, H-4'), 3.41, 3.33 (2H, m, H-5'), 4.43 (1H, d, $J = 6.7$ Hz, H-1''), 3.46 (1H, m, H-2''), 3.13 (1H, m, H-3''), 3.16 (1H, m, H-4''), 3.64 (1H, m, H-5''), 3.46, 3.11 (2H, m, H-6''); $^{13}\text{C-NMR}$ (150 MHz, CD_3OD) δ : 39.9 (C-1), 26.7 (C-2), 81.3 (C-3), 42.8 (C-4), 48.3 (C-5), 18.6 (C-6), 33.9 (C-7), 40.7 (C-8), 49.3 (C-9), 37.9 (C-10), 24.0 (C-11), 123.8 (C-12), 145.5 (C-13), 44.5 (C-14), 28.6 (C-15), 24.0 (C-16), 46.8 (C-17), 47.9 (C-18), 46.3 (C-19), 30.9 (C-20), 33.9 (C-21), 34.0 (C-22), 64.8 (C-23), 13.2 (C-24), 16.7 (C-25), 17.9 (C-26), 24.3 (C-27), 181.3 (C-28), 33.8 (C-29), 26.7 (C-30), 105.7 (C-1'), 73.8 (C-2'), 76.7 (C-3'), 75.7 (C-4'), 66.3 (C-5'), 105.9 (C-1''), 73.1 (C-2''), 77.8 (C-3''), 71.6 (C-4''), 74.1 (C-5''), 62.0 (C-6''). 以上数据与文献 [20] 报道基本一致, 故鉴定该化合物为 leontoside B。

化合物 9: 白色粉末, ESI-MS m/z : 935.485 9 $[\text{M}+\text{Na}]^+$ 。 $^1\text{H-NMR}$ (600 MHz, CD_3OD) δ : 1.51, 1.27 (2H, m, H-1), 1.76, 1.37 (2H, m, H-2), 4.47 (1H, m, H-3), 1.08 (1H, m, H-5), 1.63, 1.37 (2H, m, H-6), 1.60, 1.27 (2H, m, H-7), 1.10 (1H, m, H-9), 2.00, 1.88 (2H, m, H-11), 5.17 (1H, m, H-12), 1.37, 1.25 (2H, m, H-15), 1.88, 1.48 (2H, m, H-16), 2.84 (1H, m, H-18), 1.60, 1.27 (2H, m, H-19), 1.63, 1.48 (2H, m, H-21), 1.88, 1.69 (2H, m, H-22), 3.91, 3.62 (2H, m, H-23), 0.81 (3H, s, H-24), 0.69 (3H, s, H-25), 0.90 (3H, s, H-26), 1.17 (3H, s, H-27), 0.93 (3H, s, H-29), 0.95 (3H, s, H-30), 4.50 (1H, d, $J = 7.7$ Hz, H-1'), 3.83 (1H, m, H-2'), 3.50 (1H, m, H-3'), 3.56 (1H, m, H-4'), 3.37, 3.34 (2H, m, H-5'), 5.23 (1H, m, H-1''), 3.91 (1H, m, H-2''), 3.87 (1H, m, H-3''), 3.75 (1H, m, H-4''), 4.59 (1H, m, H-5''), 1.25 (3H, d, $J = 6.2$ Hz, H-6''), 4.47 (1H, d, $J = 6.8$ Hz, H-1'''), 3.50

(1H, m, H-2'''), 3.87 (1H, m, H-3'''), 3.62 (1H, m, H-4'''), 3.37 (1H, m, H-5'''), 3.35, 3.34 (2H, m, H-6'''); $^{13}\text{C-NMR}$ (150 MHz, CD_3OD) δ : 39.7 (C-1), 26.7 (C-2), 82.9 (C-3), 43.0 (C-4), 48.1 (C-5), 18.8 (C-6), 33.4 (C-7), 40.5 (C-8), 49.5 (C-9), 37.6 (C-10), 24.0 (C-11), 123.6 (C-12), 145.3 (C-13), 44.0 (C-14), 28.8 (C-15), 24.5 (C-16), 47.8 (C-17), 48.1 (C-18), 47.3 (C-19), 31.6 (C-20), 33.9 (C-21), 35.0 (C-22), 64.5 (C-23), 13.7 (C-24), 16.4 (C-25), 17.8 (C-26), 24.0 (C-27), 182.0 (C-28), 33.6 (C-29), 26.5 (C-30), 105.1 (C-1'), 74.0 (C-2'), 77.8 (C-3'), 71.3 (C-4'), 65.8 (C-5'), 101.8 (C-1''), 72.6 (C-2''), 74.1 (C-3''), 71.1 (C-4''), 70.1 (C-5''), 18.1 (C-6''), 105.1 (C-1'''), 75.4 (C-2'''), 77.8 (C-3'''), 76.9 (C-4'''), 70.0 (C-5'''), 62.4 (C-6'''). 以上数据与文献 [21] 报道基本一致, 故鉴定该化合物为 pulsatilla saponin D。

化合物 10: 白色粉末, ESI-MS m/z : 935.502 6 $[\text{M}+\text{Na}]^+$ 。 $^1\text{H-NMR}$ (600 MHz, CD_3OD) δ : 1.52, 1.28 (2H, m, H-1), 1.77, 1.37 (2H, m, H-2), 4.48 (1H, m, H-3), 1.10 (1H, m, H-5), 1.65, 1.37 (2H, m, H-6), 1.59, 1.25 (2H, m, H-7), 1.10 (1H, m, H-9), 2.01, 1.88 (2H, m, H-11), 5.17 (1H, m, H-12), 1.37, 1.25 (2H, m, H-15), 1.88, 1.52 (2H, m, H-16), 2.84 (1H, m, H-18), 1.65, 1.28 (2H, m, H-19), 1.70, 1.52 (2H, m, H-21), 1.88, 1.77 (2H, m, H-22), 3.91, 3.64 (2H, m, H-23), 0.81 (3H, s, H-24), 0.70 (3H, s, H-25), 0.90 (3H, s, H-26), 1.17 (3H, s, H-27), 0.94 (3H, s, H-29), 0.97 (3H, s, H-30), 4.50 (1H, d, $J = 7.6$ Hz, H-1'), 3.83 (1H, m, H-2'), 3.57 (1H, m, H-3'), 3.61 (1H, m, H-4'), 3.37, 3.33 (2H, m, H-5'), 5.17 (1H, m, H-1''), 3.91 (1H, m, H-2''), 3.87 (1H, m, H-3''), 3.75 (1H, m, H-4''), 4.59 (1H, m, H-5''), 1.25 (3H, d, $J = 6.1$ Hz, H-6''), 4.48 (1H, d, $J = 6.7$ Hz, H-1'''), 3.57 (1H, m, H-2'''), 3.91 (1H, m, H-3'''), 3.61 (1H, m, H-4'''), 3.37 (1H, m, H-5'''), 3.35, 3.33 (2H, m, H-6'''); $^{13}\text{C-NMR}$ (150 MHz, CD_3OD) δ : 40.0 (C-1), 27.0 (C-2), 83.3 (C-3), 43.4

(C-4), 48.5 (C-5), 19.2 (C-6), 33.8 (C-7), 40.9 (C-8), 48.5 (C-9), 38.0 (C-10), 24.5 (C-11), 124.1 (C-12), 145.7 (C-13), 44.4 (C-14), 29.3 (C-15), 24.9 (C-16), 48.0 (C-17), 49.1 (C-18), 47.7 (C-19), 32.0 (C-20), 34.3 (C-21), 35.3 (C-22), 64.9 (C-23), 14.1 (C-24), 16.8 (C-25), 18.2 (C-26), 24.4 (C-27), 182.4 (C-28), 34.0 (C-29), 26.9 (C-30), 106.2 (C-1'), 74.5 (C-2'), 77.3 (C-3'), 71.5 (C-4'), 66.2 (C-5'), 102.6 (C-1''), 71.7 (C-2''), 78.1 (C-3''), 71.5 (C-4''), 70.6 (C-5''), 18.6 (C-6''), 105.5 (C-1'''), 75.8 (C-2'''), 78.3 (C-3'''), 73.0 (C-4'''), 70.3 (C-5'''), 62.9 (C-6''').以上数据与文献[22]报道基本一致,故鉴定该化合物为 macranthoside A。

化合物 11: 白色粉末, ESI-MS m/z : 935.492 5 $[M+Na]^+$ 。 ^1H -NMR (600 MHz, CD_3OD) δ : 1.52, 1.27 (2H, m, H-1), 1.79, 1.38 (2H, m, H-2), 4.49 (1H, m, H-3), 0.99 (1H, m, H-5), 1.62, 1.38 (2H, m, H-6), 1.69, 1.27 (2H, m, H-7), 1.12 (1H, m, H-9), 1.95, 1.79 (2H, m, H-11), 5.15 (1H, m, H-12), 1.38, 1.25 (2H, m, H-15), 1.80, 1.52 (2H, m, H-16), 2.75 (1H, m, H-18), 1.69, 1.27 (2H, m, H-19), 1.69, 1.52 (2H, m, H-21), 1.79, 1.62 (2H, m, H-22), 3.80, 3.60 (2H, m, H-23), 0.70 (3H, s, H-24), 0.60 (3H, s, H-25), 0.81 (3H, s, H-26), 1.07 (3H, s, H-27), 0.83 (3H, s, H-29), 0.88 (3H, s, H-30), 4.46 (1H, d, $J = 6.6$ Hz, H-1'), 3.80 (1H, m, H-2'), 3.60 (1H, m, H-3'), 3.67 (1H, m, H-4'), 3.39, 3.29 (2H, m, H-5'), 5.15 (1H, m, H-1''), 3.73 (1H, m, H-2''), 3.80 (1H, m, H-3''), 3.73 (1H, m, H-4''), 4.49 (1H, m, H-5''), 1.18 (3H, d, $J = 6.2$ Hz, H-6''), 5.28 (1H, d, $J = 8.2$ Hz, H-1'''), 3.52 (1H, m, H-2'''), 3.67 (1H, m, H-3'''), 3.60 (1H, m, H-4'''), 3.39 (1H, m, H-5'''), 3.29, 3.25 (2H, m, H-6'''); ^{13}C -NMR (150 MHz, CD_3OD) δ : 39.7 (C-1), 26.5 (C-2), 82.3 (C-3), 43.0 (C-4), 48.2 (C-5), 18.8 (C-6), 33.2 (C-7), 40.7 (C-8), 48.0 (C-9), 40.7 (C-10), 24.0 (C-11), 123.8 (C-12), 144.9 (C-13), 44.4 (C-14), 28.9 (C-15), 24.6 (C-16), 48.2

(C-17), 48.1 (C-18), 47.3 (C-19), 31.5 (C-20), 33.5 (C-21), 34.3 (C-22), 64.8 (C-23), 13.7 (C-24), 16.5 (C-25), 17.8 (C-26), 24.0 (C-27), 178.1 (C-28), 33.4 (C-29), 26.4 (C-30), 104.3 (C-1'), 74.0 (C-2'), 76.7 (C-3'), 71.1 (C-4'), 64.6 (C-5'), 101.9 (C-1''), 70.7 (C-2''), 78.3 (C-3''), 72.0 (C-4''), 69.5 (C-5''), 18.8 (C-6''), 95.7 (C-1'''), 74.0 (C-2'''), 78.7 (C-3'''), 73.7 (C-4'''), 72.2 (C-5'''), 62.4 (C-6''')。以上数据与文献[23]报道基本一致,故鉴定该化合物为 lecanioside A。

化合物 12: 白色粉末, ESI-MS m/z : 1057.337 1 $[M-H]^-$ 。 ^1H -NMR (600 MHz, CD_3OD) δ : 1.51, 1.29 (2H, m, H-1), 1.74, 1.44 (2H, m, H-2), 4.38 (1H, m, H-3), 1.01 (1H, m, H-5), 1.67, 1.29 (2H, m, H-6), 1.58, 1.21 (2H, m, H-7), 1.10 (1H, m, H-9), 1.91, 1.80 (2H, m, H-11), 5.14 (1H, m, H-12), 1.44, 1.27 (2H, m, H-15), 1.86, 1.58 (2H, m, H-16), 2.75 (1H, m, H-18), 1.67, 1.21 (2H, m, H-19), 1.74, 1.51 (2H, m, H-21), 1.86, 1.80 (2H, m, H-22), 0.72 (3H, s, H-23), 0.75 (3H, s, H-24), 0.81 (3H, s, H-25), 0.84 (3H, s, H-26), 1.06 (3H, s, H-27), 0.85 (3H, s, H-29), 0.93 (3H, s, H-30), 4.32 (1H, d, $J = 7.8$ Hz, H-1'), 3.81 (1H, m, H-2'), 3.56 (1H, m, H-3'), 3.62 (1H, m, H-4'), 3.32, 3.28 (2H, m, H-5'), 5.05 (1H, m, H-1''), 3.81 (1H, m, H-2''), 3.77 (1H, m, H-3''), 3.67 (1H, m, H-4''), 3.79 (1H, m, H-5''), 1.14 (3H, d, $J = 6.2$ Hz, H-6''), 4.43 (1H, d, $J = 7.8$ Hz, H-1'''), 3.56 (1H, m, H-2'''), 3.81 (1H, m, H-3'''), 3.67 (1H, m, H-4'''), 3.39 (1H, m, H-5'''), 3.43, 3.26 (2H, m, H-6'''), 4.38 (1H, d, $J = 6.4$ Hz, H-1'''), 3.62 (1H, m, H-2'''), 3.67 (1H, m, H-3'''), 3.73 (1H, m, H-4'''), 3.59 (1H, m, H-5'''), 3.39, 3.26 (2H, m, H-6'''); ^{13}C -NMR (150 MHz, CD_3OD) δ : 39.6 (C-1), 26.8 (C-2), 82.6 (C-3), 42.5 (C-4), 48.3 (C-5), 19.1 (C-6), 33.6 (C-7), 40.3 (C-8), 48.5 (C-9), 37.4 (C-10), 23.8 (C-11), 123.3 (C-12), 145.0 (C-13), 42.6 (C-14), 28.6 (C-15), 24.3 (C-16), 47.0 (C-17), 42.5 (C-18), 47.0 (C-19), 31.3 (C-

20), 33.8 (C-21), 34.5 (C-22), 28.2 (C-23), 15.8 (C-24), 16.7 (C-25), 17.4 (C-26), 23.8 (C-27), 181.6 (C-28), 33.7 (C-29), 26.8 (C-30), 105.2 (C-1'), 75.8 (C-2'), 74.6 (C-3'), 69.7 (C-4'), 65.2 (C-5'), 101.5 (C-1''), 71.0 (C-2''), 79.3 (C-3''), 73.2 (C-4''), 68.8 (C-5''), 17.8 (C-6''), 105.3 (C-1'''), 76.1 (C-2'''), 77.6 (C-3'''), 77.8 (C-4'''), 72.3 (C-5'''), 62.2 (C-6'''), 104.3 (C-1'''), 76.6 (C-2'''), 73.3 (C-3'''), 71.1 (C-4'''), 71.0 (C-5'''), 61.2 (C-6'''). 以上数据与文献 [24] 报道基本一致, 故鉴定该化合物为 3-*O*-β-*D*-glucopyranosyl-(1→4)-β-*D*-glucopyranosyl-(1→3)-α-*L*-rhamnopyranosyl-(1→2)-α-*L*-arabinopyranosyl-oleanolic acid。

4 抗肿瘤活性评价

采用 MTT 法, 将 MCF-7、HepG-2 细胞按 1×10⁵/孔密度接种于 96 孔板中, 用含 10% 胎牛血清的 DMEM 培养基培养, 再加入不同浓度(5.0、10.0、20.0、40.0、80.0 μmol/L) 三萜皂苷, 孵育 24 h, 根据试剂盒说明书在 490 nm 波长处测定其吸光度, 以多柔比星为阳性对照。结果, 化合物 2、3、6、10、12 对 MCF-7 细胞具有抑制活性, 3、6、12 对 HepG-2 细胞具有抑制活性, 见表 1。

表 1 各化合物对 MCF-7、HepG-2 细胞的 IC₅₀ 值(μmol/L, $\bar{x}\pm s$, $n=3$)

Tab.1 IC₅₀ values of various compounds on MCF-7 and HepG-2 cells (μmol/L, $\bar{x}\pm s$, $n=3$)

化合物	MCF-7	HepG-2
1	30.24±0.22 **	28.92±0.26 **
2	18.64±0.20 **	29.66±0.11 **
3	14.12±0.13 **	17.21±0.10 **
4	27.57±0.16 **	36.62±0.27 **
5	36.18±0.12 **	30.21±0.24 **
6	13.65±0.17 **	7.47±0.09 **
7	36.37±0.27 **	33.74±0.31 **
8	32.47±0.25 **	30.00±0.23 **
9	22.88±0.21 **	30.96±0.21 **
10	13.74±0.13 **	33.61±0.19 **
11	34.02±0.27 **	36.15±0.26 **
12	9.47±0.11 **	6.04±0.07 **
多柔比星	0.48±0.09	0.63±0.05

注: 与多柔比星比较, ** $P<0.01$ 。

5 抗炎活性评价

采用脂多糖 (LPS) 诱导 RAW264.7 巨噬细胞建立体外炎症模型, 以 1×10⁵/孔密度接种于 96 孔板中, 含 10% 胎牛血清的 DMEM 培养基培养 24 h,

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用含不同浓度(5.0、10.0、20.0、40.0、80.0 μmol/L) 三萜皂苷的培养基替换原培养基, 空白对照组和模型组给予等量基础培养基, 预处理 2 h 后加入 LPS (1 μg/mL), 空白对照组给予等量 PBS, 培养 24 h 后收集上清, 按照试剂盒说明书测定 NO 含量, 以地塞米松为阳性对照。由表 2 可知, 化合物 2、6、9~12 具有抗炎活性。

表 2 各化合物对 LPS 诱导 RAW264.7 细胞中的 NO 生成量的 IC₅₀ 值(μmol/L, $\bar{x}\pm s$, $n=3$)

Tab.2 IC₅₀ values of various compounds on NO production in LPS-induced RAW264.7 cells (μmol/L, $\bar{x}\pm s$, $n=3$)

化合物	IC ₅₀	化合物	IC ₅₀
1	10.71±0.25 **	8	26.92±0.32 **
2	7.85±0.12 **	9	6.73±0.13 **
3	15.32±0.19 **	10	4.06±0.11 *
4	36.21±0.23 **	11	9.06±0.17 **
5	30.47±0.24 **	12	3.59±0.09 *
6	3.60±0.07 *	地塞米松	4.19±0.11
7	17.19±0.18 **		

注: 与地塞米松比较, * $P<0.05$, ** $P<0.01$ 。

6 讨论与结论

本研究采用多种分离手段和波谱技术对金银花乙醇提取物化学成分进行研究, 共鉴定出 12 种三萜皂苷类, 其中化合物 4、5、9 为首次从忍冬科植物中分离得到, 8、12 为首次从忍冬属植物中分离得到。生物活性研究结果表明, 化合物 2、3、6、10、12 对 MCF-7 细胞增殖表现出较强的抑制活性; 化合物 3、6、12 对 HepG-2 细胞增殖表现出较强的抑制活性, 2、6、9~12 具有显著抗炎活性。目前, 金银花化学成分研究主要聚焦于黄酮及酚酸, 三萜皂苷涉及较少, 而该类成分具有明显生物活性, 也可能是该药材有效物质。综上所述, 本研究以金银花三萜皂苷类成分为考察对象, 进一步丰富了该药材化合物库, 也为该属植物后续开发利用提供了理论基础。

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