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望谟崖摩枝叶的化学成分及其抗炎活性研究

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摘　要:为寻找传统药用植物望谟崖摩 *Amoora ouangliensis* 中的活性成分,采用色谱分离方法进行化合物分离,并通过波谱数据分析方法鉴定化合物的结构。从望谟崖摩枝叶中分得 9 个化合物,分别鉴定为 cabralealactone (**1**)、cabraleahydroxylactone (**2**)、eichlerialactone (**3**)、金色酰胺醇酯 (aurantiamide acetate) (**4**)、金色酰胺醇 (benzenepropanamide) (**5**)、xylogranatinin (**6**)、丁香醛(**7**)、cycloartane-3β,24,25-triol (**8**)和 24(*R*)-19-cyclolanost-3-one-24,25-diol(**9**)。在脂多糖诱导的 RAW264.7 细胞炎症模型中,化合物 **2**~**4** 和 **9** 显示出一定的活性。上述化合物均为首次从该植物中分得,化合物 **2**~**8** 为首次从该属植物中分得。

关键词:楝科;望谟崖摩;抗炎活性

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Constituents from the Leaves and Twigs of *Amoora ouangliensis* and Their Anti-inflammatory Activities

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Abstract: To investigate the chemical constituents and anti-inflammation from the leaves and twigs of *Amoora ouangliensis*, we isolated and purified the constituents from *A. ouangliensis* by the chromatographic technique and Semi preparation HPLC. Nine compounds were isolated, their structures were identified as cabralealactone (**1**), cabraleahydroxylactone (**2**), eichlerialactone (**3**), aurantiamide acetate (**4**), benzenepropanamide (**5**), xylogranatinin (**6**), 3,5-Dimethoxy-4-hydroxybenzaldehyde (**7**), cycloartane-3β,24,25-triol (**8**) and 24(R)-19-cyclolanost-3-one-24,25-diol (**9**). All of the isolates were then assessed for their anti-inflammatory activities on lipopolysaccharide (LPS)-induced nitric oxide (NO) production in RAW264.7. Compounds **2-4** and **9** showed protent anti-inflammatory activities. Compounds **1-9** were obtained from this plant for the first time and except compound **1**, others are reported from the *Amoora* genus for the first time.

Key words: meliaceae; *Amoora ouangliensis*; anti-inflammation

望谟崖摩 (*Amoora ouangliensis*) 为楝科 (Meliaceae) 崖摩属植物,系高大乔木,主要分布于我国广州、贵州和云南省[1]。楝科植物用途广泛:川楝子、香椿根皮和果入药;香椿幼芽嫩叶芳香可口,食用;山楝种子含植物油,工业油料[2]。课题组对楝科的割舌树 (*Walsura robusta*)[3]、茎花葱臭木 (*Dysoxylum cauliflorum*)[4]、美洲椿 (*Trichilia americana*)[5]、鹧鸪花 (*T. connaroides*)[6]、茸果鹧鸪花 (*T. sinensis*)[7]、非洲桃花心木(*Khaya ivorensis*)[8]和米仔兰 (*Aglaia odorata*)[9]进行了系统化学成分研究研究,发现该科植物天然产物种类丰富,含有三萜、甾体、楝酰胺、柠檬苦素和多酚等类型化合物。国内外对楝科植物望谟崖摩研究不多,可供查阅的文献也较少,中国科学院昆明植物研究所杨淑敏等曾对采集于云南省西双版纳的望谟崖摩的化学成分进行了研究,从中发现了一系列具有抗癌活性的半日花烷型二萜[10,11]。除此之外并未见文献报道对望谟崖摩的化学成分及其活性研究。为了进一步研究楝

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科植物望谟崖摩中的化学成分,我们对采自中国科学院西双版纳热带植物园的传统药用植物望谟崖摩枝叶进行了化学成分研究,从中分离到了 9 个化合物,分别鉴定为 cabralealactone (**1**)、cabraleahydroxylactone (**2**)、eichlerialactone(**3**)、金色酰胺醇酯 (aurantiamide acetate) (**4**)、金色酰胺醇 (benzenepropanamide)(**5**)、xylogranatinin (**6**)、丁香醛(**7**)、cycloartane-3β,24,25-triol (**8**) 和 24(*R*)-19-cyclolanost-3-one-24,25-diol(**9**)。化合物 **1**~**3** 和 **8**~**9** 为三萜类,**4**~**5** 为二酰胺类,**6** 为生物碱类。化合物 **2**~**4** 和 **9** 具有一定的抗炎活性,其他化合物的抗炎活性不明显。

1 仪器与材料

Waters Xevo™ Triple-quadrupole 型质谱仪(Waters 公司)测定 ESI-MS;核磁谱图由 Bruker AM 500 兆超导核磁共振波谱仪测定,TMS 为内标,δ 表示化学位移(ppm),J 表示耦合常数(Hz);柱层析硅胶及薄层层析硅胶板均为青岛海洋化工厂生产;MCI 树脂(Mitsubishi Chemical 公司);凝胶 Sephadex HL-20 为日本公司生产;Water 600 型高效液相色谱仪,色谱柱:kromasil RP-C_{18}(10×250 mm,ID×L,5 μm),流速:3 mL/min,二极管阵列检测器;显色剂为 10% 硫酸乙醇溶剂(v/v),硅胶薄层板喷显色剂后适当加热显色;所有试剂均为分析纯。

2 提取与分离

望谟崖摩枝叶部分 5 kg 干燥样品,粉碎后用 80% 乙醇室温下浸提 3 次,每次 1 周,过滤并浓缩提取液得到总浸膏 300 g。把总浸膏悬浮在水里面,然后用乙酸乙酯溶剂萃取,总共萃取 3 次,得到乙酸乙酯相约 50 g。MCI 柱除去色素后,减压浓缩得浸膏 23 g。用正相硅胶柱对乙酸乙酯相划段,以氯仿:甲醇(1∶0→1∶1 v/v)洗脱,TLC 指引合并得到 5 个组分(Fr. A-E)。Fr. B(4 g)馏份继续硅胶柱分离,以氯仿∶甲醇(30∶1→1∶1,v/v)洗脱,然后采用 HPLC 制备液相,以甲醇∶水(50∶50,3 mL/min)为流动相,分离得化合物 **1**(7.2 mg,9 min)、**2**(8.5 mg,17 min)和 **3**(7.9 mg,21m in)。Fr. C(9 g)馏份反复经硅胶柱,以氯仿∶甲醇(20∶1→1∶1, v/v)洗脱,然后经过反复过凝胶 Sephadex HL-20 柱,得到化合物 **4**(13.1 mg)、**5**(8.1 mg)、**6**(8.2 mg)和 **7**(7.4 mg)。Fr. D(5 g)组分反复 RP-18 柱层析,用甲醇∶水(5∶5→9∶1,v/v)洗脱得到化合物 **8**(12.2 mg)和 **9**(8.5 mg)。

3 结构鉴定

化合物 1 白色不定型粉末(CHCl$_3$-MeOH);分子式为 $C_{27}H_{42}O_3$,ESI-MS *m/z*:415[M + H]$^+$。^{1}H NMR (500 MHz,CDCl$_3$) δ:2.66 (1H,m,H-23a),2.56 (1H,m,H-2b),2.48 (1H,m,H-23b),2.35 (1H,m,H-2a),2.14 (1H,m,H-22a),2.02 (1H,m,H-17),1.92 (1H,m,H-12a),1.86 (1H,m,H-22b),1.78 (1H,m,H-16a),1.63 (1H,m,H-1b),1.61 (1H,m,H-6b),1.60 (1H,m,H-13),1.56 (1H,m,H-7b),1.49 (1H,m,H-6a),1.48 (1H,m,H-15a),1.45 (1H,m,H-9),1.43 (1H,m,H-1a),1.42 (1H,m,11a),1.39 (3H,s,H-21),1.36 (1H,m,H-5),1.34 (1H,m,H-7a),1.27 (1H,m,H-12b),1.18 (1H,m,H-16b),1.15 (1H,m,H-11b),1.12 (1H,m,H-15b),1.10 (3H,m,H-28),1.04 (3H,m,H-29),1.01 (3H,s,H-19),0.96 (3H,s,H-18),0.91 (3H,s,H-30);^{13}C NMR (125 MHz,CDCl$_3$) δ:218.0 (C-3),176.8 (C-24),90.1 (C-20),55.3 (C-5),50.1 (C-14),49.9 (C-9),49.2 (C-19),47.4 (C-4),43.3 (C-13),40.2 (C-8),39.8 (C-1),36.9 (C-10),34.5 (C-7),34.0 (C-2),31.2 (C-15),31.0 (C-12),29.2 (C-23),26.8 (C-16),26.7 (C-28),25.5 (C-21),25.0 (C-22),21.9 (C-11),21.0 (C-29),19.6 (C-6),16.1 (C-30),16.0 (C-18),15.2 (C-19)。以上数据与文献[12]报道一致,故鉴定为 Cabralealactone(**1**)。

化合物 2 白色不定型粉末;分子式为 $C_{27}H_{44}O_3$,ESI-MS *m/z*:417[M + H]$^+$;^{1}H NMR (500 MHz,CDCl$_3$) δ:3.38 (1H,t,*J* = 2.7 Hz,H-3),2.61 (1H,ddd,*J* = 18.0,10.2,9.0 Hz,H-23b),2.51 (1H,ddd,*J* = 18.0,10.2,4.6 Hz,H-23a),2.10 (1H,ddd,*J* = 12.8,10.1,9.2 Hz,H-22b),1.96 (1H,td,*J* = 10.7,6.1 Hz,H-17),1.93 (1H,m,H-22a),1.92 (1H,m,H-2b),1.80 (1H,m,H-16b),1.72 (1H,m,H-11b),1.60 (1H,m,H-13),1.57 (1H,m,H-7b),1.56 (1H,m,H-12b),1.55 (1H,m,H-2a),1.48 (1H,m,H-16b),1.44 (1H,m,H-9),1.40 (2H,m,H-6),1.38 (1H,m,H-1b),1.34 (3H,s,H-21),1.29 (1H,m,H-1a),1.28 (H,m,H-16a),1.27 (1H,m,H-5),1.24 (1H,m,H-7a),1.21 (1H,m,H-12a),1.20 (1H,m,H-11a),1.10 (1H,ddd,*J*

=11.9,8.6,1.5 Hz,H-15a),0.94 (3H,s,H-18),0.92 (3H,s,H-28),0.88 (3H,s,H-30),0.83 (3H,s,H-19),0.82 (3H,s,H-29);^{13}C NMR (125 MHz,$CDCl_3$) δ:176.9 (C-24),90.3 (C-20),76.2 (C-3),50.3 (C-9),50.2 (C-8),49.5 (C-17),49.4 (C-5),43.1 (C-13),40.7 (C-14),37.6 (C-4),37.3 (C-10),35.1 (C-7),33.6 (C-1),31.2 (C-22),31.1 (C-15),29.2 (C-23),28.3 (C-28),26.8 (C-11),25.4 (C-2),25.3 (C-21),25.0 (C-16),22.1 (C-29),21.2 (C-12),18.2 (C-6),16.3 (C-30),15.9 (C-19),15.5 (C-18)。以上数据与文献[12]报道一致,故鉴定为 Cabraleahydroxylactone (**2**)。

化合物 3 白色不定型粉末;分子式为 $C_{27}H_{42}O_4$,ESI-MS *m/z*: 431 [M + H]$^+$;^{1}H NMR (500 MHz,$CDCl_3$) δ:4.86 (1H,br s,H-28a),4.67 (1H,br s,H-28b),2.66 (1H,dt,*J* = 18.1,9.5 Hz,H-22a),2.56 (1H,ddd,*J* = 18.1,10.1,4.2 Hz,H-22b),2.40 (1H,ddd,*J* = 15.3,10.9,5.7 Hz,H-22b),2.19 (1H,ddd,*J* = 10.9,9.7,2.2 Hz,H-2a),2.12 (1H,dt,*J* = 12.7,9.7 Hz,H-6b),2.04 (1H,m,H-9),1.98 (1H,m,H-17),1.97 (1H,m,H-1a),1.93 (1H,m,H-6a),1.84 (1H,m,H-12a),1.81 (1H,m,H-1b),1.77 (1H,m,H-16a),1.74 (3H,s,H-29),1.63 (1H,m,H-13),1.62 (2H,m,H-23),1.55 (1H,m,H-7a),1.51 (1H,m,H-5),1.47 (1H,m,H-15a),1.42 (1H,m,H-11a),1.37 (3H,s,H-21),1.30 (1H,m,H-16b),1.28 (1H,m,H-11b),1.26 (1H,m,H-7b),1.25 (1H,m,H-12b),1.16 (1H,dd,*J* = 11.5,8.3 Hz,H-15b),1.03 (3H,s,H-18),0.91 (3H,s,H-30),0.86 (3H,s,H-19);^{13}C NMR (125 MHz,$CDCl_3$) δ:178.9 (C-3),176.9 (C-24),147.4 (C-4),113.6 (C-28),90.1 (C-20),50.7 (C-17),50.5 (C-14),49.3 (C-9),43.2 (C-13),40.9 (C-5),40.0 (C-8),39.0 (C-10),34.1 (C-23),33.8 (C-7),31.4 (C-15),31.2 (C-6),29.2 (C-22),28.2 (C-2),26.7 (C-16),25.2 (C-21),25.0 (C-12),24.5 (C-1),23.2 (C-29),21.9 (C-11),20.0 (C-19),16.1 (C-30),15.3 (C-18)。以上数据与文献[12]报道一致,故鉴定为 Eichlerialactone (**3**)。

化合物 4 白色不定型粉末;分子式为 $C_{27}H_{28}N_2O_4$,ESI-MS *m/z*:467 [M + Na]$^+$;^{1}H NMR (500 MHz,CD3DO) δ:8.47 (1H,d,*J* = 7.0 Hz,N-Hb),8.12 (1H,d,*J* = 7.5 Hz,N-Ha),7.79 (2H,d,*J* = 7.5 Hz,H-16,20),7.51 (1H,t,*J* = 7.5 Hz,H-18),7.44 (2H,t,*J* = 7.5 Hz,H-17,19),7.31 (2H,d,*J* = 7.5 Hz,H-23,27),7.28 (2H,d,*J* = 7 Hz,H-24,26),7.25 (1H,t,*J* = 7.5 Hz,H-25),7.23 (2H,d,*J* = 7.3 Hz,H-5,9),7.20 (1H,t,*J* = 7.3 Hz,H-7),7.12 (2H,d,*J* = 7.3 Hz H-6,8),4.69 (1H,m,H-13),4.16 (1H,m,H-2),4.00 (1H,dd,*J* = 12.0,5.0 Hz,H-10b),3.85 (1H,dd,*J* = 12.0,5.0 Hz,H-10a),3.23 (1H,dd,*J* = 12.0,6.0 Hz,H-21b),3.11 (1H,dd,*J* = 12.0,6.0 Hz,H-21a),2.82 (1H,dd,*J* = 13.0,7.5 Hz,H-3b),2.75 (1H,dd,*J* = 13.0,7.5 Hz,H-3a),2.01 (3 Hz,H-12);^{13}C NMR (125 MHz,CD3OD) δ:171.1 (C-11,ester),170.2 (C-1,amide),166.0 (C-14,amide),138.3 (C-22),138.0 (C-4),134.0 (C-15),131.2 (C-18),130.3 (C-24,26),130.1 (C-23,27),129.1 (C-6,8),128.2 (C-5,9),128.1 (C-17,19),128.0 (C-25),127.4 (C-16,20),126.2 (C-7),64.6 (C-10),54.8 (C-13),49.1 (C-2),37.1 (C-21),36.5 (C-3),20.6 (C-12)。以上数据与文献[13]报道一致,故鉴定为金色酰胺醇酯 (Aurantiamide acetate) (**4**)。

化合物 5 白色不定型粉末;分子式为 $C_{27}H_{28}N_2O_4$,ESI-MS *m/z*: 445 [M + H]$^+$;^{1}H NMR (500 MHz,CD_3OD) δ:12.81(1H,br,COOH),8.53 (1H,d,*J* = 8.4 Hz,NHCO),8.31 (1H,d,*J* = 8.0 Hz,NHCO),7.74 (2H,d,*J* = 7.6,Hz,H-3b,7b),7.46 (1H,t,*J* = 7.3,Hz,H-5b),7.40 (2H,t,*J* = 7.3,Hz,H-4b,6b),7.33-7.12 (10H,m,H-5a-9a,5b-9b),4.72 (1H,m,H-2a),4.46 (1H,m,H-2b),3.10-2.90 (2H,m,H-3a,3b);^{13}C NMR (125 MHz,CD_3OD) δ:172.8 (C-1′),171.5 (C-1),166.2 (C-1″),138.4 (C-4),137.4 (C-4′),134.0 (C-2″),131.3 (C-5″),129.2 (4,C-6,8,C-6′,8′),128.2 (4,C-4″,6″,C-5′,9′),128.1 (C-5,9),127.4 (C-3″,7″),126.5 (C-7′),126.2 (C-7),54.6 (C-2),53.6 (C-2′),36.9 (C-3),36.7 (C-3′)。以上数据与文献[14]报道一致,故鉴定为金色酰胺醇(Benzenepropanamide) (**5**)。

化合物 6 白色不定型粉末;分子式为 $C_9H_8N_2O_3$,ESI-MS *m/z*: 215 [M + Na]$^+$;^{1}H NMR (500 MHz,$CDCl_3$) δ:7.84 (1H,d,*J* = 9.5 Hz,H-8),7.09 (1H,s,H-5),6.75 (1H,s,H-2),6.17

(1H,d,J=9.5 Hz,H-7),3.90 (3H,s,H-OCH_3);^{13}C NMR (125 MHz,$CDCl_3$) δ:164.2 (C-6),153.7 (C-10),151.7 (C-9),147.4 (C-3),146.2 (C-8),109.9 (C-5),104.1 (C-2),56.8 (C-OCH_3)。以上数据与文献[15]报道一致,故鉴定为 Xylogranatinin (**6**)。

化合物 7 白色不定型粉末;分子式为 $C_9H_{10}O_4$,ESI-MS m/z:183$[M+H]^+$;^{1}H NMR (500 MHz,$CDCl_3$) δ:9.74 (1H,s,H-CHO),7.22 (2H,s,H-2,6),3.91 (6H,s,H-2OCH_3);^{13}C NMR (125 MHz,$CDCl_3$) δ:192.2 (C-CHO),149.6 (C-3,5),143.7 (C-4),129.2 (C-1),108.3 (C-2,6),56.6 (C-2OCH_3)。以上数据与文献[16]报道一致,故鉴定为丁香醛 (**7**)。

化合物 8 白色不定型粉末;分子式为 $C_{30}H_{52}O_3$,ESI-MS m/z:461$[M+H]^+$;^{1}H NMR (500 MHz,$CDCl_3$) δ:3.37 (1H,dd, J=7.0,5.3 Hz,H-24),3.31 (1H,dd, J=11.2,4.4 Hz,H-3),2.27 (1H,m,H-2a),2.17 (1H,m,H-2b),1.85 (1H,m,H-1a),1.64 (1H,m,H-20),1.62 (1H,m,H-5),1.60 (2H,m,H-1,16a),1.56 (2H,m,H-11a,12a),1.55 (1H, m, H-15a),1.54 (1H, m, H-6a.7a),1.47 (1H,m,H-17),1.45 (2H,m,H-23),1.37 (1H,m,H-8),1.34 (1H,m,H-16b),1.31 (2H,m,H-11b,12b),1.29 (1H,m,H-15b),1.27 (1H,m,H-6b),1.25 (1H,m,H-7b),1.24 (6H,s,27),1.19 (3H,s,H-26),0.99 (3H,s,H-18),0.98 (3H,s,H-29),0.92 (3H,s,H-28),0.90 (3H,d,J=6.4 Hz,H-21),0.57 (1H,d,J=4.1 Hz,H-19b),0.36 (1H,d,J=4.1 Hz,H-19a);^{13}C NMR (125 MHz,$CDCl_3$) δ:78.8 (C-24),78.7 (C-3),73.2 (C-25),52.4 (C-17),48.8 (C-14),48.0 (C-8),47.1 (C-5),45.3 (C-13),40.4 (C-4),35.9 (C-20),35.5 (C-12),33.1 (C-22),32.9 (C-15),31.9 (C-1),30.3 (C-2),29.9 (C-19),28.4 (C-23),28.2 (C-7),26.6 (C-27),26.4 (C-16),26.0 (C-10),26.0 (C-11),25.4 (C-30),23.2 (C-26),21.1 (C-6),19.9 (C-9),19.3 (C-28),18.1 (C-21),18.0 (C-18),14.0 (C-29)。以上数据与文献[17]报道一致,故鉴定为 Cycloartane-3β,24,25-triol (**8**)。

化合物 9 白色不定型粉末;分子式为 $C_{30}H_{50}O_3$,ESI-MS m/z:459$[M+H]^+$;^{1}H NMR (500 MHz,CD_3OD) δ:3.29 (1H,dd, J=6.8,5.0 Hz,H-24),2.27 (1H, m, H-2a),2.17 (1H, m, H-2b),1.85 (1H,m,H-1a),1.64 (1H,m,H-20),1.62 (1H,m,H-5),1.60 (2H,m,H-1,16a),1.56 (2H,m,H-11a,12a),1.55 (1H, m, H-15a),1.53 (1H, m, H-6a.7a),1.47 (1H,m,H-17),1.47 (2H,m,H-23),1.39 (1H, m, H-8),1.35 (1H, m, H-16b),1.31 (2H,m,H-11b,12b),1.30 (1H,m,H-15b),1.27 (1H,m,H-6b),1.26 (1H,m,H-7b),1.26 (6H,s,H-29,30),1.24 (6H,s,H-26,27),1.04 (3H,s,H-14),0.99 (3H,s,H-18),0.90 (3H,d,J=6.4 Hz,H-21),0.78 (1H,d,J=4.4 Hz,H-19b),0.64 (1H,d,J=4.4 Hz,H-19a);^{13}C NMR (125 MHz,CD_3OD) δ:216.7 (C-3),79.6 (C-26),73.3 (C-25),52.3 (C-17),50.3 (C-4),48.7 (C-14),45.3 (C-13),37.5 (C-2),36.4 (C-20),35.6 (C-12),33.5 (C-1),33.4 (C-22),32.8 (C-15),29.6 (C-19),28.7 (C-23),28.1 (C-7),26.7 (C-16),25.9 (C-11),26.0 (C-10),23.2 (C-26),22.2 (C-29),21.5 (C-6),21.1 (C-9),20.8 (C-30),19.3 (C-28),18.4 (C-21),18.1 (C-18)。以上数据与文献[18]报道一致,故鉴定为 24(R)-19-cyclolanost-3-one-24,25-diol (**9**)。

4 抗炎活性

用 DMEM 高糖培养基[含 10% 胎牛血清(FBS),含青霉素链霉素双抗、谷丙酰胺各 1%]培养 RAW264.7 细胞。将细胞置于 37 ℃ 5% CO_2 细胞培养箱中进行传代培养,取对数生长期细胞用于实验。通过预实验发现用 DMSO 溶解化合物至不同浓度处理细胞 24 h 后,80 μM 及以上浓度的化合物对细胞有毒性。所以后续实验选择的化合物浓度为 80 μM 及以下。

将处于对数生长期的 RAW264.7 细胞按 5 × 10^5 个/mL 接种于 96 孔板,每孔 100 μL,设置空白对照,Dex 阳性对照组,LPS 组,LPS + 样品处理组,每组三个平行,培养过夜。过夜后,将上清液吸出,每孔加 100 μL 样品(化合物溶解于 DMSO 再用培养基稀释为 80、40、20 μM)孵育 0.5 h,后加 LPS (1 μg/mL)刺激 24 h。按照 Griess 试剂盒操作说明检测上清液中 NO 含量。

实验数据采用 Graph Prism 5.0 软件进行分析并进行图像处理。应用 One-way ANOVA 进行统计

处理,两组之间采用 Dunnett's t-test 分析,实验结果采用 Mean ± SD 表示,$P<0.05$ 有统计学意义。

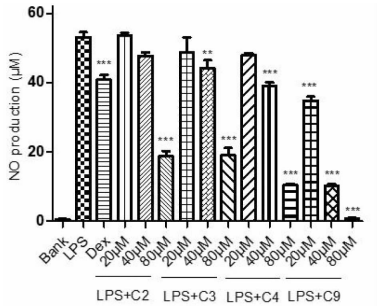

图 1　化合物 2 ~ 4 和 9 对 LPS 诱导 RAW264.7 细胞产生 NO 的影响

Fig. 1　Effect of compounds **2-4** and **9** on NO production in RAW264.7 cells stimulated by LPS

注:与 LPS 组相比,** $P<0.01$;*** $P<0.001$。

Note: Compared with LPS group, ** $P<0.01$; *** $P<0.001$.

化合物 **2 ~ 4** 和 **9** 在三种浓度下对 1 μg/mL LPS 诱导的 RAW246.7 炎症细胞 NO 产生的影响结果见图 1,且呈浓度依赖性。化合物 **2** 的浓度为 20 μM 和 40 μM 时对 NO 产生的抑制作用不明显,在 80 μM 时则显示出显著的抑制作用,且优于阳性对照 Dex 组(20 μM);化合物 **3** 和 **4** 的浓度为 40 μM 和 80 μM 时能显着抑制 NO 产生,在 80 μM 浓度是抑制效果;化合物 **4** 在三种浓度下均能显著抑制 NO 产生,且抑制效果均优于 Dex 组。其他化合物对 NO 产生无显著抑制活性。

5　结论

为了寻找传统药用植物化合成分及其抗炎活性,通过色谱分离法从楝科植物望谟崖摩中分离到一系列种类丰富的化合物,根据波谱数据和对照文献解析了化合物的结构。化合物 **1 ~ 9** 均是首次从该植物中分到,化合物 **2 ~ 8** 均是首次从该属植物中分到。对分离到的所有的化合物进行抗炎活性研究,其中化合物 **2 ~ 4** 和 **9** 有一定的抗炎活性,但其构效关系与作用机制尚不明确,有待进一步研究。其余化合物均没有明显的抗炎活性。本研究可为对于开发利用望谟崖摩提供了科学依据。据文献报道,化合物 **1** 对 NCI-H187 肺癌细胞株具有中等活性[12];化合物 **2** 对 1 型单纯疱疹病毒具有抗病毒活性[12];化合物 **3** 对革兰氏阳性病菌有良好的抗菌活性[19];化合物 **4** 具有抗炎、抗病毒[20]、镇痛、免疫调节[13]、抗神经炎症[21]等活性;其他化合物未见活性文献报道。由此可见,植物望谟崖摩中应该还有更多的有效的活性成分值得我们去探索与发现。

参考文献

1　Wu ZY(吴征镒). Flora of Yunnan(云南植物志):43[M]. Beijing:Science Press,1983:82-83.

2　China Flora Editorial Board of CAS(中国科学院中国植物编委会). Flora of China(中国植物志):43[M]. Beijing: Science Press,1997:43-44.

3　Ji KL, Li XN, Liao SG, *et al.* Cytotoxic limonoids from the leaves of *Walsura robusta*[J]. *Phytochem Lett*,2016,15:53-56.

4　Tang T(唐霆), Na Z(纳智), Xu YK(许又凯). Chemical constituents from *Dysoxylum cauliflorum* (Meliaceae)[J]. *Nat Prod Res Dev*(天然产物研究与开发),2012,24:777-779.

5　Ji KL, Zhang P, Li XN, *et al.* Cytotoxic limonoids from *Trichilia americana* leaves[J]. *Phytochemistry*, 2015, 118: 61-67.

6　Ji KL, Cao DH, Li XF, *et al.* Two new limonoids from the roots of *Trichilia connaroides* with inhibitory activityagainst nitric oxide production in lipopolysaccharide-stimulated RAW 264.7 cells[J]. *Phytochem Lett*,2015,14:234-238.

7　Cao DH, Liao SG, Lin Y, *et al.* Trichiliasinenoids A-C, Three 6,7-Secomexicanolide Limonoids with a 7,29 Linkage from *Trichilia sinensis*[J]. *Tetrahedron Lett*,2017,58:3283-3286.

8　Ji KL, Liao SG, Zheng XN, *et al.* Limonoids from the fruits of *Khaya ivorensis*[J]. *Molecules*,2014,19:3004-3011.

9　Liu B, Xu YK. Cytotoxicity and synergistic effect of the constituents from roots of *Aglaia odorata* (Meliaceae)[J]. *Nat Prod Res*,2016. 30:433-437.

10　Yang SM(杨淑敏), Liu XK(刘锡奎), Wu DG(吴大刚), *et al.* Chemical constituents from *Amoora ouangtliensis* and *A. stellato-squamosa*[J]. *Nat Prod Res Dev*(天然产物研究与开发),2008,20:1000-1004.

11　Yang SM, Wu DG, Liu XK. Anticancer activity of diterpenoids from *Amoora ouangliensis* and *Amoora stellato-squamosa*[J]. *Z Naturforsch C*,2010,65:39-41.

12　Jarinporn P, Takuya K, Tsutomu I, *et al.* Biologically active constituents of *Aglaia erythrosperma*[J]. *Nat Prod Res*, 2011,25:1621-1628.

13　Liu XB, Yang BX, Zhang L, *et al.* An in vivo and in vitro assessment of the anti-inflammatory, antinociceptive, and immunomodulatory activities of *Clematis terniflora DC.* extract, participation of aurantiamide acetate[J]. *J Ethnopharmac*, 2015,169:287-294.

14　Bandyopadhyay D, Nayak A, Basak B, *et al.* N-(4-methylphe-

nyl) benzenepropanamide-the first isolated amide from the genus *Paederia*[J]. *Nat Prod Commun*,2007,2:753-754.

15 Zhou Y,Jun W,and Kun Z. Xylogranatinin,a new pyrido[1,2-a] pyrazine alkaloid from the fruit of a Chinese mangrove *Xylocarpus granatum*[J]. *Chem Nat Compd*,2007,43:426-428.

16 He L(何蕾),Shi Q R(史琪荣),Liu R H(柳润辉),*et al*. Anti-inflammatory constituents from the stems of *Daphne genkwa*[J]. *Acad J Second Military Med Univ*(第二军医大学学报),2008,29:1221-1226.

17 Shamasabadipour S,Zarei S M,Ghanadian M,*et al*. A New taraxastane triterpene from *Euphorbia denticulata* with cytotoxic activity against prostate cancer cells[J]. *Iran J Pharm Res*,2018,17:336-342.

18 Barik BR,Bhaumik T,Dey AK,*et al*. Triterpenoids from *Artocarpus heterophyllus*[J]. *Phytochemistry*, 1994, 35: 1001-1004.

19 Joycharat N,Thammavong S,Voravuthikunchai S P,*et al*. Chemical constituents and antimicrobial properties of the essential oil and ethanol extract from the stem of *Aglaia odorata* Lour[J]. *Nat Prod Res*,2014,28:2169-2172.

20 Zhou B,Yang Z,Feng Q,*et al*. Aurantiamide acetate from *Baphicacanthus cusia* root exhibits anti-inflammatory and anti-viral effects via inhibition of the NF-κB signaling pathway in Influenza a virus-infected cells[J]. *J Ethnopharmac*, 2017,199:60-67.

21 Yoon CS,Kim DC,Lee DS,*et al*. Anti-neuroinflammatory effect of aurantiamide acetate from the marine fungus *Aspergillus* sp. SF-5921:inhibition of NF-κB and MAPK pathways in lipopolysaccharide-induced mouse BV2 microglial cells[J]. *Int Immunopharmacol*,2014,23:568-574.

(上接第 1324 页)

8 Li QY(李庆云),Zhang YJ(张艳军). Study on the anti-tumor mechanism of tuckahoe polysaccharide[J]. *Jilin J Tradit Chin Med*(吉林中医药),2010,4:345-347.

9 Xu LL(徐玲玲),Zhang YB(张耀斌). Research Progress on the anti-tumor effect of volatile oil of *Atractylodes macrocephala*[J]. *J Xi'an Univer of Arts & Science*(西安文理学院学报:自科版),2010,1:59-61.

10 Wei Q(魏强),Sun T(孙涛). Review on antitumor components from taxus and their derivatives[J]. *Nat Prod Res Dev*(天然产物研究与开发),2016,28:1664-1675.

11 Yu T,Zhang QS,Qi YJ. Improvement of Kanglaite on the symptoms and quality of life in advanced lung cancer patients[J]. *Chin Pharm*(中国药业),2015,24(23):29-31.

12 Wang YF(王亚飞). Study on anti-lung cancer pharmacodynamics of volatile oil from Houttuyniae Herba and preparation of its hydroxypropyl-β-cyclodextrin inclusion compound[D]. Zhengzhou University(郑州大学),2016.

13 Zhao SQ(赵尚清),Xu CQ(许长青),Chen XH(陈晓辉). Effect of Wei Maine Capsule on non-small cell lung cancer and its effect on serum epidermal growth factor receptor[J]. *Chin J of Geriatrics*(中国老年学杂志),2014,18:5070-5071.

14 Yan X(闫雪). The combination of CZBG reversal of multidrug resistance of leukemia research[D]. Beijing Univer of Chine Med(北京中医药大学),2012.

15 Cai X(蔡翔),Chen PH(陈培红),Rao YF(饶玉凤). A new clinical application of Hairyvein Agrimony[J]. *J Bas Chi Med*(中国中医基础医学杂志),2016,22:1109-1110.