藏药香芸火绒草化学成分及抗菌活性研究

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摘 要:为对香芸火绒草(*Leontopodium haplophylloides*)的化学成分进行分离纯化及抗炎活性研究,本实验通过正、反相硅胶柱色谱、Sephadex LH-20 凝胶柱色谱,从香芸火绒草的中分离得到 17 个化合物,并运用现代波谱技术(^{1}H NMR、^{13}C NMR)分别鉴定为:咖啡酸(**1**)、咖啡酸-β-苯乙醇酯(**2**)、原儿茶酸(**3**)、tyrosol(**4**)、对羟基苯甲酸(**5**)、邻苯二甲酸二丁酯(**6**)、异莨菪亭(**7**)、7-(2,3-epoxy-3-methyl-3-butyloxy)-6-methoxycoumarin(**8**)、洋芹素(**9**)、牡荆素(**10**)、5-羟基-4′,7-二甲氧基-6,8-二甲基黄酮(**11**)、5,7-二羟基-8-甲氧基黄酮(**12**)、百蕊草素Ⅲ(**13**)、methyl flavogallonate(**14**)、3,5,7,3′,4′-pentahydroxyflavone (**15**)、木犀草素(**16**)、高良姜素(**17**),其中化合物 **1** ~ **16** 为首次从该植物中分离得到;经抗菌筛选发现发化合 **1**、**2**、**4** ~ **6**、**9**、**10**、**13** ~ **17** 对大肠杆菌、金黄色葡萄球菌及蜡状芽孢菌有抑制作用。

关键词:香芸火绒草;咖啡酸-β-苯乙醇酯;邻苯二甲酸二丁酯;抗菌

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Chemical constituents of *Leontopodium haplophylloides* and their anti-bacterial activities

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Abstract: This paper reported the chemical constituents and anti-bacterial activties of *Leontopodium haplophylloides* Hand.-Mazz. Seventeen compounds were isolated from *Leontopodium haplophylloides* by column chromatography on silica gel, ODS, Sephadex LH20 and identified by chemical and special analysis. Their structures were elucidated as caffeic acid (**1**), phenethyl caffeate (**2**), protocatechuic acid (**3**), tyrosol (**4**), p-hydroxybenzoic acid(**5**), dibutyl phthalate(**6**), isoscopoletin(**7**), 7-(2,3-epoxy-3-methyl-3-butyloxy)-6-methoxycoumarin (**8**), apigenin (**9**), vitexin (**10**), 5-hydroxy-4′,7-dimethoxy-6,8-dimethyl flavones (**11**), 5,7-dihydroxy-8-methoxyflavone (**12**), kaempferol 3-glucorhamnoside (**13**), methyl flavogallonate (**14**), 3,5,7,3′,4′-pentahydroxyflavone (**15**), luteolin (**16**), galangin (**17**), among which compounds **1-16** were obtained from this plant for the first time. After antibacterial test, **1**, **2**, **4-6**, **9**, **10** and **13-17** have strong inhibitory effects on *E. coli*, *Staphylococcus aureus*, and *Bacillus subtilis*.

Key words: *Leontopodium haplophylloides*; phenethyl caffeate; dibutyl phthalate; anti-bacterial activities

香芸火绒草(*Leontopodium haplophylloides* Hand.-Mazz.)系菊科火绒草属多年生草本植物,在我国主要分布于青海东部地区、四川西部和北部、甘肃西南部[1],为当地藏族常用药,具有清热、凉血、消炎、利尿等功效。其化学成分主要包括苯丙素类、黄酮及挥发油类[2]。有文献记载香芸火绒草挥发性成分对病原真菌具有明显的抑制作用[2-3]。为更好地开发利用该药用资源,本实验对该植物地上部分进行了系统的化学成分研究和抑菌效应评价实验,从药理活性较高的二氯甲烷和乙酸乙酯部位进行化学成分研究,从中分离得到 17 个化合物,经理化性质及波谱分析分别鉴定为咖啡酸(caffeic acid, **1**)、咖啡酸-β-苯乙醇酯(phenethyl caffeate, **2**)、原儿茶酸(protocatechuic acid, **3**)、tyrosol(**4**)、对羟基苯甲酸(p-hydroxybenzoic acid, **5**)、邻苯二甲酸二丁酯(dibutyl phthalate, **6**)、异莨菪亭(isoscopoletin, **7**)、7-(2, 3-epoxy-3-methyl-3-butyloxy)-6-methoxycoumarin (**8**)、洋芹素(apigenin, **9**)、牡荆素(vitexin, **10**)、5-羟基-4′,7-二甲氧基-6,8-二甲基黄酮(5-hydroxy-4′,7-

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dimethoxy-6,8-dimethyl flavones,**11**)、5,7-二羟基-8-甲氧基黄酮(5,7-dihydroxy-8-methoxyflavone,**12**)、百蕊草素Ⅲ(kaempferol 3-glucorhamnoside,**13**)、methyl flavogallonate(**14**)、3,5,7,3′,4′-pentahydroxyflavone(**15**)、木犀草素(luteolin,**16**)、高良姜素(galangin,**17**)。化合**1**~**16**为首次从该植物中分离得到。

1 仪器与材料

Varian UNITYINOVA-600 型超导核磁共振仪(美国瓦里安公司);Agilent 1260 型高效液相色谱仪、Agilent Eclipse XDB-C_{18}分析色谱柱(250 mm × 4.6 mm,5 μm)(美国 Agilent 公司);EYELA SB-1000 型旋转蒸发仪(日本 EYALA 公司);JP-020 型台式实验室用超声波清洗器(深圳市洁盟清洗设备有限公司);ODS RP-18 (40~60 μm)柱色谱填料和 RP-18 F_{254}薄层预制板(美国 Merck 公司);柱色谱硅胶(200~300 目)及薄层色谱硅胶 G(青岛海洋化工厂);硅胶 GF_{254}薄层预制板(烟台化学工业研究所);Sephadex LH-20 柱色谱凝胶(瑞典 Amersham Biosciences 公司);液相色谱试剂甲醇、乙腈为市售色谱纯,其它所用试剂均为市售分析纯。大肠杆菌、金黄色葡萄球菌及枯草芽孢菌均购于北京鼎国昌盛生物技术有限责任公司。

本实验中所用香芸火绒草药材采于四川甘孜州道孚境内,由陈敬炳(研究员,湖北省中医院)主任药师鉴定为菊科火绒草属植物香芸火绒草 *Leontopodium haplophylloides* Hand.-Mazz。

2 提取与分离

取香芸火绒草地上部分 12 kg,粉碎,用 75% 乙醇浸泡,加热回流提取 3 次,每次 2 h,合并提取液,减压浓缩,得棕黑色浸膏。浸膏用水分散后依次用等体积二氯甲烷、乙酸乙酯、正丁醇反复多次萃取。萃取液减压浓缩得氯仿部位 140 g、乙酸乙酯部位 87 g、正丁醇部位 68 g。其中乙酸乙酯部位和正丁醇部位分别经反复硅胶柱色谱、Sephadex LH-20 纯化,分离得到化合物**7**(6.3 mg)、**8**(7.8 mg)、**9**(9.7 mg)、**10**(8.3 mg)、**11**(6.9 mg)、**12**(7.1 mg)、**13**(22.6 mg)、**14**(5.8 mg)、**15**(7.9 mg)、**16**(16.8 mg)、**17**(32.5 mg)。运用制备薄层色谱、重结晶等方法从二氯甲烷部位分离得到化合物**1**(14.5 mg)、**2**(6.2 mg)、**3**(15.0 mg)、**4**(13.4 mg)、**5**(8.5 mg)、**6**(17.5 mg)。

3 结构鉴定

化合物 1 橘黄色颗粒状固体(丙酮);^{1}H NMR (600 MHz, DMSO-d_6) δ: 12.11 (1H, brs, 1-COOH), 9.51 (1H, brs, OH), 9.17 (1H, brs, OH), 7.61 (1H, d, J = 3.6 Hz, H-3), 7.11 (1H, d, J = 3.0 Hz, H-5), 7.01 (1H, dd, J = 9.6, 2.4 Hz, H-9), 6.79 (1H, d, J = 8.4 Hz, H-8), 6.19 (1H, d, J = 13.2 Hz, H-2); ^{13}C NMR (150 MHz, DMSO-d_6) δ: 167.9 (C-1), 148.2 (C-6), 145.4 (C-7), 144.3 (C-3), 125.2 (C-4), 119.9 (C-9), 115.8 (C-8), 114.9 (C-2), 114.5 (C-5)。以上数据与文献[4]对照基本一致,故确定化合物**1**为咖啡酸。

化合物 2 白色晶体(二氯甲烷);^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.73 (1H, d, J = 15.6 Hz, H-8), 7.51 (1H, d, J = 16.0 Hz, H-7), 7.41 (2H, d, J = 6.6 Hz, H-4′, 8′), 7.29 ~ 7.32 (1H, m, H-6′), 7.24-7.27 (2H, m, H-5′, 7′), 7.17 (1H, d, J = 3.0 Hz, H-2), 7.13 (1H, dd, J = 3.6, 9.0 Hz, H-6), 6.98 (1H, d, J = 9.6 Hz, H-5), 3.12 (2H, t, J = 7.2 Hz, H-1′), 4.41 (2H, t, J = 10.8 Hz, H-2′); ^{13}C NMR (150 MHz, $CDCl_3$) δ: 166.9 (C-9), 143.9 (C-4), 143.1 (C-3), 141.6 (C-7), 131.9 (C-3′), 128.8 (C-1), 128.6 (C-5′, 7′), 125.9 (C-6′), 125.7 (C-4′, 8′), 122.0 (C-6), 116.5 (C-2), 116.5 (C-5, 8), 69.3 (C-1′), 28.5 (C-2′)。以上数据与文献[5]对照基本一致,故确定化合物**2**为咖啡酸-β-苯乙醇酯。

化合物 3 白色粉末(甲醇);^{1}H NMR (600 MHz, CD_3OD) δ: 7.63 (1H, s, H-2), 7.50 (1H, H-8), 6.82 (1H, J = 8.1 Hz, H-5); ^{13}C NMR (150 MHz, CD_3OD) δ: 123.7 (C-1), 117.7 (C-2), 148.1 (C-3), 152.9 (C-4), 114.0 (C-5), 123.8 (C-6), 170.3 (C-7)。以上数据与文献[6]对照基本一致,故确定化合物**3**为原儿茶酸。

化合物 4 无色针晶(丙酮);^{1}H NMR (600 MHz, CD_3OD) δ: 7.12 (2H, d, J = 8.4 Hz, H-2, 6), 6.70 (2H, d, J = 8.4 Hz, H-3, 5), 3.78 (2H, t, J = 7.2, 7.2 Hz, H-8), 2.80 (2H, d, J = 7.2 Hz, H-7); ^{13}C NMR (150 MHz, CD_3OD) δ: 131.3 (C-1), 131.2 (C-2, 6), 116.4 (C-3, 5), 157.1 (C-4), 39.7 (C-7), 64.8 (C-8)。以上数据与文献[7]对照基本一致,故确定化合物**4**为 tyrosol。

化合物 5 无色针晶(甲醇);^{1}H NMR (600 MHz, CD_3OD) δ: 7.98 (2H, d, J = 8.4 Hz, H-2, 6), 6.92 (2H, d, J = 9.0 Hz, H-3, 5); ^{13}C NMR (150 MHz, CD_3OD) δ: 170.4 (C-7), 163.7 (C-4), 133.3 (C-2, 6), 123.0 (C-1), 116.3 (C-3, 5)。以上数据与

文献[8]对照基本一致,故确定化合物 **5** 为对羟基苯甲酸。

化合物 6　无色针晶(二氯甲烷);^{1}H NMR(600 MHz ,Pyr-d_5)δ:7.75(2H,dd,J = 3.6,2.0 Hz,H-3,6),7.40(2H,dd,J = 2.0,3.6 Hz,H-4,5),4.25(4H,m,H-7,7′),1.53(4H,m,H-8,8′),1.23(4H,m,H-9,9′),0.74(6H,t,J = 7.2 Hz,H-10,10′);^{13}C NMR(600 MHz ,Pyr-d_5)δ:167.9(C-7,7′),133.2(C-1,2),131.5(C-4,5),129.4(C-3,6),65.7(C-8,8′),30.9(C-9,9′),19.5(C-10,10′),13.9(C-11,11′)。以上数据与文献[9]对照基本一致,故确定化合物 **6** 为的邻苯二甲酸二丁酯。

化合物 7　白色针晶(丙酮);^{1}H NMR(600 MHz,CD_3OD)δ:7.95(1H,d,J = 9.6Hz,H-4),7.19(1H,*s*,H-5),6.85(1H,s,H-8),6.30(1H,dd,J = 9.6 Hz,H-3),4.00(3H,s,3-OCH_3);^{13}C NMR(150 MHz,CD_3OD)δ:164.4(C-2),153.1(C-7),151.7(C-9),147.3(C-6),146.4(C-4),112.8(C-3),112.8(C-10),110.2(C-5),104.2(C-8),57.2(C-OCH_3)。以上数据与文献[10]对照基本一致,与异莨菪亭对照品薄层比较,二者的薄层层析行为一致,确定化合物 **7** 为异莨菪亭。

化合物 8　黄色粉末(甲醇),浓硫酸乙醇试剂反应显棕褐色;^{1}H NMR(600 MHz,CD_3OD)δ:9.89(1H,s,6-OH),6.26(1H,d,J = 9.6 Hz,H-3),7.59(1H,d,J = 9.0 Hz,H-4),6.89(2H,s,H-5),6.82(2H,s,H-8),3.65(3H,s,6-OCH_3),4.54 ~ 4.70(2H,m,H-1′),3.62(1H,m,H-2′),1.43(3H,s,H-4′),1.42(3H,s,H-5′);^{13}C NMR(150 MHz,CD_3OD)δ:161.4(C-2),113.5(C-3),144.0(C-4),109.4(C-5),147.0(C-6),153.7(C-7),100.6(C-8),150.6(C-9),112.0(C-10),56.4(6-OCH_3),68.8(C-1′),60.8(C-2′),56.4(C-3′),25.0(C-4′),18.3(C-5′)。以上数据与文献[11]对照基本一致,故确定化合物 **8** 为 7-(2,3-epoxy-3-methyl-3-butyloxy)-6-methoxycoumarin。

化合物 9　淡黄色粉末状结晶(丙酮),盐酸-镁粉反应呈阳性,Molish 反应呈阴性;^{1}H NMR(600 MHz,DMSO-d_6)δ:13.03(1H,s,5-OH),8.07(2H,s,H-2′,6′),7.16(2H,d,J = 9.0 Hz,H-3′,5′),6.97(1H,s,H-3),6.46(1H,d,J = 1.8 Hz,H-8),6.09(1H,d,J = 1.8 Hz,H-6);^{13}C NMR(150 MHz,DMSO-d_6)δ:177.9(C-4),166.1(C-7),162.9(C-2),161.0(C-5),158.7(C-9),131.1(C-2′,6′),124.0(C-1′),116.7(C-3′,5′),104.9(C-3),99.8(C-6),95.0(C-8)。以上数据与文献[12]对照基本一致,故确定化合物 **9** 为洋芹素。

化合物 10　黄色粉末(甲醇)。盐酸-镁粉反应呈阳性,Molish 反应阳性;^{1}H NMR(600 MHz,Pyr-d_5)δ:13.83(lH,s,5-OH),8.32(2H,d,J = 9.0 Hz,H-2′,6′),8.29(2H,d,J = 9.6 Hz,H-3′,5′),6.81(lH,s,H-3),6.69(1H,s,H-6),4.83(lH,d,J = 12.0 Hz,H-1′′),3.92(lH,dd,J = 12.6,3.0 Hz,H-6′′a),3.81(lH,dd,J = 12.6,7.2 Hz,H-6"b),3.51(lH,m,H-4′′),3.49(lH,m,H-5′′),3.43(lH,m,H-2"),3.29(lH,m,H-3′′);^{13}C NMR(150 MHz,Pyr-d_5)δ:182.8(C-4),164.9(C-2),162.8(C-5),162.7(C-4′),162.5(C-7),158.0(C-9),129.8(C-2′,6′),122.2(C-1′),116.5(C-3′,5′),106.0(C-8),105.8(C-10),103.0(C-3),99.5(C-6),83.3(C-5′′),81.1(C-3′′),75.6(C-1′′),72.9(C-2′′),72.6(C-4′′),62.6(C-6′′)。以上数据与文献[13]对照基本一致,故确定化合物 **10** 为牡荆素。

化合物 11　黄色针状结晶(丙酮),盐酸-镁粉反应呈阳性;^{1}H NMR(600 MHz,DMSO-d_6)δ:13.02(1H,s,5-OH),8.06(2H,s,H-2′,6′),7.14(2H,s,H-3′,5′),6.98(1H,s,H-3),3.86、3.76(3H,each,-OCH_3),2.10、2.35(3H,each,-CH_3);^{13}C NMR(150 MHz,DMSO-d_6)δ:182.6(C-4),163.68(C-7),162.4(C-4′),162.1(C-2),156.3(C-5),152.37(C-9),128.3(C-2′,6′),122.9(C-1′),114.7(C-3′,5′),113.1(C-6),108.7(C-8),106.5(C-10),103.5(C-3),60.3、55.5(4′,7-OCH_3)。以上数据与文献[14]对照基本一致,故确定化合物 **11** 为 5-羟基-4′,7-二甲氧基-6,8-二甲基黄酮。

化合物 12　黄色针状结晶(丙酮),TLC 薄层板上喷 1% $AlCl_3$-乙醇溶液后置紫外灯下显鲜黄色荧光;^{1}H NMR(600 MHz,CD_3OD)δ:12.51(1H,s,5-OH),10.82(1H,s,7-OH),6.99(1H,t,J = 8.4 Hz,H-4′),6.31(2H,d,J = 8.4 Hz,H-3′,5′);^{13}C NMR(150 MHz,CD_3OD)δ:182.0(C-4),163.0(C-2),157.4(C-7),156.2(C-5),149.6(C-9),132.0(C-4′),130.8(C-1′),129.2(C-3′,5′),127.8(C-8),126.2(C-2′,6′),105.0(C-3),103.7(C-10),99.1(C-6),61.0(8-OCH_3)。以上数据与文献[15]对照基本一致,故确定化合物 **12** 为 5,7-二羟基-8-甲氧基黄酮。

化合物 13　黄色针晶(甲醇),TLC 薄层板上喷

5% 香草醛-浓硫酸喷雾后加热显黄色;^{1}H NMR (600 MHz, CD_3OD) δ: 12.41 (1H, s, 5-OH), 8.13 (2H, d, J = 8.4 Hz, H-2′, 6′), 6.99 (2H, d, J = 7.2 Hz, H-3′, 5′), 6.48 (1H, s, H-8), 6.27 (1H, s, H-6); ^{13}C NMR (150 MHz, CD_3OD) δ: 176.9 (C-4), 165.3 (C-7), 161.7 (C-5), 159.3 (C-4′), 157.2 (C-9), 147.6 (C-2), 137.5 (C-3), 129.2 (C-2′, 6′), 123.7 (C-1′), 116.4 (C-3′, 5′), 103.9 (C-1′), 99.3 (C-6), 94.5 (C-8). 以上数据与文献[16]对照基本一致,故确定化合物 **13** 为百蕊草素Ⅲ。

化合物 14 淡黄色无定形粉末(甲醇),盐酸-镁粉反应呈阳性;^{1}H NMR (600 MHz, DMSO-d_6) δ: 7.47 (1H, s, H-5′), 7.07 (1H, s, H-6″), 3.43 (3H, s, OCH_3); ^{13}C NMR (150 MHz, DMSO-d_6) δ: 166.2 (C-7″), 159.0 (C-7′), 157.3 (C-7), 147.6 (C-4′), 146.0 (C-4), 144.0 (C-5″), 143.7 (C-3″), 139.2 (C-3′), 138.2 (C-3), 137.3 (C-2′), 136.3 (C-2), 135.5 (C-4″), 125.4 (C-1″), 118.8 (C-6), 118.2 (C-2″), 112.8 (C-1′), 111.5 (C-1), 119.9 (C-6), 109.1 (C-5), 107.5 (C-5′), 107.4 (C-6″), 51.3 (C-OCH_3)。以上数据与文献[17]对照基本一致,故确定化合物 **14** 为 methylflavogallonate。

化合物 15 黄色粉末(甲醇),盐酸-镁粉反应呈阳性,Molish 反应为阳性,$AlCl_3$ 显色呈黄绿色;^{1}H NMR (600 MHz, Pyr-d_5) δ: 13.21 (1H, s, 5-OH), 11.79 (2H, s, 4′, 7-OH), 8.50 (1H, d, J = 1.8 Hz, 3′-OH), 8.00 (1H, dd, J = 1.8, 1.8 Hz, H-2′), 7.28 (1H, d, J = 8.4 Hz, H-6′), 6.65 (1H, d, J = 1.8 Hz, H-5′), 6.61 (1H, d, J = 1.8 Hz, H-8); ^{13}C NMR (150 MHz, Pyr-d_5) δ: 177.4 (C-4), 165.6 (C-7), 162.6 (C-9), 157.6 (C-5), 147.9 (C-2), 147.2 (C-3′, 4′), 138.0 (C-3), 121.2 (C-1′, 6′), 116.8 (C-2′, 5′), 104.6 (C-10), 99.33 (C-6), 94.40 (C-8)。以上数据与文献[18]对照基本一致,故确定化合物 **15** 为 3,5,7,3′,4′-pentahydroxyflavone。

化合物 16 黄色粉末(甲醇),TLC 薄层板上喷 1% $AlCl_3$-乙醇溶液后置紫外灯下显鲜黄色荧光;^{1}H NMR (600 MHz, Pyr-d_5) δ: 13.21 (1H, s, 5-OH), 11.26 (2H, m, 7-OH), 11.03 (1H, m, 3′, 4′-OH), 7.29 (2H, d, J = 8.4 Hz, H-2′, 6′), 6.69 (1H, d, J = 1.8 Hz, H-5′), 6.61 (1H, s, H-3), 6.49 (1H, d, J = 1.8 Hz, H-8), 6.22 (1H, m, H-6); ^{13}C NMR (150 MHz, Pyr-d_5) δ: 179.9 (C-4), 165.6 (C-7), 165.0 (C-2), 162.5 (C-9), 157.6 (C-5), 150.4 (C-4′), 147.2 (C-3′), 121.5 (C-1′), 121.1 (C-6′), 116.8 (C-5′), 114.0 (C-2′), 104.6 (C-10), 103.5 (C-3), 99.3 (C-6), 94.4 (C-8)。以上数据与文献[19]对照基本一致,故确定化合物 **16** 为木犀草素。

化合物 17 黄色针晶(丙酮),盐酸-镁粉反应呈阳性;^{1}H NMR (600 MHz, $CDCl_3$) δ: 12.25 (1H, brs, 7-OH), 8.20 (2H, d, J = 7.8 Hz, H-2′, 6′), 7.46 ~ 7.55 (3H, m, H-3′ ~ 5′), 6.53 (1H, s, H-6), 6.22 (1H, s, H-8), 2.54 (2H, s, 5, 3-OH); ^{13}C NMR (150 MHz, $CDCl_3$) δ: 176.6 (C-4), 164.3 (C-7), 161.2 (C-5), 157.1 (C-9), 145.6 (C-2), 137.1 (C-3), 131.1 (C-10), 130.0 (C-4′), 128.5 (C-2′, 6′), 127.6 (C-3′, 5′), 103.3 (C-1′), 98.3 (C-6), 93.7 (C-8)。以上数据与文献[20]对照基本一致,故确定化合物 **17** 为高良姜素。

4 结论

本研究从香芸火绒草中分离鉴定得到 17 个化合物,包括苯丙素类、黄酮类、香豆素类等成分。针对分离得到的化合物进行抗菌活性筛选。采用培养基打孔法,测定化合物对大肠杆菌、金黄色葡萄球菌及蜡状芽孢菌的抗菌作用,使用处于对数生长期的菌种,所有样品均使用丙酮溶解配制成 5 mg/mL 的药液。抑菌圈的直径大小可以用来说明不同化合物的抗菌作用的强弱,以纯丙酮为对照。通过测量各抑菌圈直径,计算抑菌率[抑菌率 = 对照组菌落直径 - 处理组菌落直径)/对照组菌落直径 × 100%)],结果表明化合物 **1**、**2**、**4 ~ 6**、**9**、**10**、**13 ~ 17** 对大肠杆菌、金黄色葡萄球菌及蜡状芽孢杆菌均有抑制作用,其抑制率达到 60% 以上。该植物中化合物 **13**、**16** 和 **17** 含量较大,今后有望利用其植物细胞组织培养或结构修饰,以获得更多化合物,拓宽该植物的生物活性研究的内容。

参考文献

1 Institute of botany, the Chinese academy of sciences. Higher plants of China in color: vol 4 (中国高等植物图鉴:第 4 卷)[M]. Beijing: Science China Pres, 1987: 462-463.

2 Zhou JS, Mei Q. A study on chemical constituent of essential oil from *Leontopodium haplophylloides*[J]. Acta Bot Boreali-Occident Sin (西北植物学报), 2002, 22: 1482-1484.

3 Gao F. The study on extraction, chemical constituent and bioactivity of *L. haplophylloides* Hand-Mazz Volatile oil [D]. Chengdu: Sichuan University (四川大学), 2007.

4 Cai F, Tan DP, Yan QX. Chemical constituents in herbs of *Prunella vulgaris*[J]. Nat Prod Res Dev (天然产物研究与

开发),2016,28:18-20.
5 Xiang CY. Synthesis of caffeic acid β-phenethyl ester analogues and study on their anti-tumor activity [D]. Chongqing:Southwest University(西南大学),2012.
6 Yun XJ,Shu HM,Chen GY,et al. Chemical constituents from barks of *Lannea coromaruielica*[J]. Chin Herb Med,2014,6(1):65-69.
7 Li NX,Fan QF,Song QS. Chemical constituents from bark of *Gmelina arborea* and *Sambucus chinensis*[J]. Nat Prod Res Dev(天然产物研究与开发),2017,29:11-17.
8 Olaleye O,Li SS,Liu HT,et al. Study on chemical constituents and DPPH free radical scavenging activity of *Carthamus tinctorius* L.[J]. Nat Prod Res Dev(天然产物研究与开发),2014,26:60-63.
9 Huang Y,Zheng JY,Yang GJ,et al. Chemical constituents in roots of *Ilex kudingcha*[J]. Chin Tradit Herb Drugs(中草药),2015,46:2371-2376.
10 Wang QJ,Wang YS,He L,et al. Study on chemical constituents from *Ipomoea Pes-caprae*(L.)Sweet(Ⅰ)[J]. Chin J Mar Drugs(中国海洋药物),2006,25(3):15-17.
11 Stein AC,Fritz D,Lima L FP,et al. Distribution of coumarins in the tribe plucheeae, genus *Pterocaulon*[J]. Chem Nat Compd,2007,43:691-693.
12 Liu Y,Li XF,Liu AL,et al. Chemical constituents from leaves of *Elsholtzia rugulosa*[J]. Chin Tradit Herb Drugs(中草药),2009,40:1356-1359.
13 Fang ZF,Ling ZQ,Shi L,et al. Studies on chemical constituents from twigs and leaves of *Illicium majus*[J]. Chin Tradit Herb Drugs(中草药),2018,3:1019-1024.
14 Sui XL. Studies on chemical constituents of Fruits of *Eucalyptus globulus Labill.*[D]. Ji'nan:Shandong University(山东大学),2011.
15 Li WJ,Cheng XL,Liu J,et al. Phenolic compounds and antioxidant activities of *Liriope muscari*[J]. Molecules,2012,17:1797-1808.
16 Hu XL,Zhu H,Liu CR,et al. Study on the chemical constituents of the flowers of *Impatiens balsamina* L.[J]. Chin Tradit Patent Med 25:833-834.
17 Marzouk MS, El-Toumy SA, Moharram FA, et al. Pharmacologically active ellagitannins from *Terminalia myriocarpa*[J]. Planta Medica,2002,68:523-527.
18 Dong JY,Jia ZJ. Study on chemical constituents of flavonids in *Hypericum attenuatum*[J]. Chin Pharm J(中国药学杂志),2005,39:897-899.
19 Lv XH,Li ZL,Liu SX,et al. Chemical constituents from leaves of *Adinandra nitida*(Ⅱ)[J]. Chin Tradit Herb Drugs(中草药),2018,3:1272-1276.
20 Rajibul AL,Ismail S,Nayan R,et al. Antioxidant activity of *Indian propolis* and its chemical constituents[J]. Food Chem,2010,122:233-237.

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8 Yang XF, He CE, Tang RH, et al. Comparison of Hoechst33342/PI double staining and TUNEL staining in detecting neuronal apoptosisMutations in cancerous aberrations[J]. Carcinog Teratogenesks Mutagen(癌变·畸变·突变),2014.26:180-184.
9 Shan YT,Gao LF,Sun LK,et al. Effect of ATRA combined with IFN α on growth of PC3 prostatic cancer cells and expressions of GRIM 19 and STAT 3[J]. Tumor(肿瘤),2006,26:228-231.
10 Zhang CF,Jia SQ,Su XL. Effects of anticancer bioactive peptides on the gene expression of BGC-823 cells[J]. Chin J Clin Oncol(中国肿瘤临床),2010,37:1021-1023.
11 Su GY,Liu HG,Huang HX,et al. Anti-cancer activity and mechanism of dianhydrogalactitol on human lung cancer cell lines *in vitro*[J]. Chin J Exp Tradit Med Form(中国实验方剂学杂),2016,17:122-127.
12 Tang PP,Miao MS. Screening method of treatment of prostatic hyperplasia drug[J]. J Chin Med(中医学报),2012,27:594-598.
13 Xie L,Chen JL,et al. Protective Effects of resveratrol on cadmium-induced rat prostatic injury[J]. Chin Med Mat(中药材),2017,40:1695-1698.
14 Liu PA,Liu M,Pan WW,et al. *Carpesium abrotanoides* L. Chemical constituents[J]. Chin Med Mat(中药材),2014,37:2213-2215.
15 Yang YX. Study on chemical constituents of *Carpesium abrotanoides* L. in Guizhou medicine[J]. Chin J Chin Mater Med(中国中药杂志),2016,41:2105-2111.
16 Shi ZH. *Carpesium abrotanoides* L. root clinical application[J]. Mod Chin Med Res Prac(现代中医药研究),2002,16(2):61-62.
17 Wan MX,He SZ,Wang YY,et al. Study on the status of medicinal plants of the genus Tianmu[J]. J Guiyang Coll Trad Chin Med(贵阳中医学院学报),2009,31(6):76-78.
18 Feng JT,Zhang YM,Wang JR,et al. *Carpesium abrotanoides* L. Synthesis and antibacterial activity of lactone derivatives[J]. Chin J Pest Sci(农药学学报),2007,9:185-188.
19 Liu XY,Guo GW,Wang H. The effects of the drug on the Asian tapeworm cysticercosi[J]. Chin J Parasitol Paras Dis(中国寄生虫学与寄生虫病杂志),2015,33:237-238.