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中药枳壳中环肽成分的研究

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摘 要:运用硅胶、凝胶和高效液相色谱进行分离纯化,根据理化常数和波谱数据鉴定化合物的结构。从中药枳壳中分离并鉴定了 7 个环肽成分:环-(亮氨酸[1]-异亮氨酸[2]-丙氨酸[3]-苏氨酸[4]-甘氨酸[5]-苏氨酸[6]-苯丙氨酸[7])(1)、环-(甘氨酸[1]-亮氨酸[2]-缬氨酸[3]-亮氨酸[4]-脯氨酸[5]-丝氨酸[6])(2)、环-(亮氨酸[1]-亮氨酸[2]-脯氨酸[3]-酪氨酸[4]-甘氨酸[5]-丝氨酸[6]-脯氨酸[7])(3)、环-(甘氨酸[1]-甘氨酸[2]-亮氨酸[3]-亮氨酸[4]-亮氨酸[5]-脯氨酸[6]-脯氨酸[7]-苯丙氨酸[8])(4)、环-(脯氨酸-丙氨酸)(5)、环-(丙氨酸-异亮氨酸)(6)、环-(丙氨酸-亮氨酸)(7)。除 2 和 4 外,其余环肽均为首次从中药枳壳中分离得到。

关键词:芸香科;枳壳;环肽

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Cyclopeptides from Immature Fruits of *Citrus aurantium*

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Abstract:Seven cyclopeptides were isolated and purified from the immature fruits of *Citrus aurantium* L. by silica gel, Sephadex LH-20 and HPLC. Their structures were determined on the basis of spectroscopic data as Cyclo-(Leu[1]-Ile[2]-Ala[3]-Thr[4]-Gly[5]-Thr[6]-Phe[7]) (Citrusin I) (**1**), Cyclo-(Gly[1]-Leu[2]-Val[3]-Leu[4]-Pro[5]-Ser[6]) (**2**), Cyclo-(Leu[1]-Leu[2]-Pro[3]-Tyr[4]-Gly[5]-Ser[6]-Pro[7]) (Citrusin III) (**3**), Cyclo-(Gly[1]-Gly[2]-Leu[3]-Leu[4]-Leu[5]-Pro[6]-Pro[7]-Phe[8]) (**4**), Cyclo-(Pro-Ala) (**5**), Cyclo-(Ala-Ile) (**6**), Cyclo-(Ala-Leu) (**7**). All compounds except **2** and **4** were isolated from this plant for the first time.

Key words:Rutaceae;*Citrus aurantium*;cyclopeptide

中药枳壳为芸香科植物酸橙(*Citrus aurantium* L.)及其栽培变种黄皮酸橙(*C. aurantium* 'Huangpi')、代代花(*C. aurantium* 'Daidai')、朱栾(*C. aurantium* 'Chuluan')、塘橙(*C. aurantium* 'Tangcheng')的未成熟果实[1]。枳壳的药理作用主要集中于胃肠道、心血管、气管平滑肌、抗癌、抗菌、抗炎等方面[2]。枳壳中主要含有黄酮、生物碱、香豆素、柠檬苦素及环肽等成分[3]。前期我们研究了购买于云南省昆明市菊花村药材市场的中药枳壳中的色原烷苷和四降三萜成分[4]。本文对其中的环肽成分进行了研究,从中分离并鉴定了 7 个环肽,其中 5 个为首次从该植物中分离得到。

1 仪器与材料

Bruker AM-400 型核磁共振波谱仪,以 TMS 为内标;VG Autospec-3000 质谱仪;Agilent 1100 高效液相色谱仪,Agilent Zorbax Eclipse XDB-C_{18}(9.4 mm×250 mm,粒径 5 μm,2 mL/min)色谱柱;柱色谱硅胶(100~200 目和 200~300 目)、薄层色谱硅胶板均为青岛裕民源硅胶试剂厂产品;凝胶(Sephadex LH-20)为法玛西雅公司生产;所用试剂均为化学纯或分析纯。

中药枳壳(25 kg)2009 年 8 月购于云南省昆明市菊花村药材市场绿生药业有限公司,经中国科学院昆明植物研究所陶定德研究员鉴定为芸香科柑橘属植物酸橙(*Citrus aurantium* L.)的未成熟果实。

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2 提取与分离

干燥的中药枳壳(25 kg),粉碎后用95%的工业甲醇回流提取3次,每次30 L/3 h,减压浓缩得到甲醇提取物。加水悬浮后,依次用石油醚、乙酸乙酯和正丁醇等体积各萃取三次(15 L(3次),回收溶剂得到石油醚部分、乙酸乙酯部分和正丁醇部分。将乙酸乙酯部分(1.32 kg)用氯仿-甲醇混合溶剂溶解吸附于等量硅胶上,在室温下挥干溶剂经硅胶(100~200目)色谱柱分离,以氯仿-甲醇梯度(100∶0、95∶5、9∶1、8∶2、7∶3、1∶1、0∶100)洗脱,用环肽检测方法[5]进行检测,合并含环肽部分(190 mg)。用凝胶(Sephadex LH-20)对环肽部分进行划段得到3个组分Fr.1-3。Fr.1(45 mg)经HPLC分离和纯化,以甲醇-水(65%)等度洗脱得到化合物**4**(12 mg)。Fr.2(90 mg)经HPLC分离和纯化,以甲醇-水(60%)等度洗脱得到化合物**1**(17 mg)、**2**(16 mg)、**3**(21 mg)。Fr.3(55 mg)经HPLC分离和纯化,以甲醇-水(70%)等度洗脱得到化合物**5**(7 mg)、**6**(6 mg)、**7**(10 mg)。

3 结构鉴定

化合物1 白色粉末,分子式为$C_{34}H_{53}N_7O_9$,FAB-MS $[M+H]^+$ *m/z* 704,^{1}H NMR(C_5D_5N,400 MHz)δ_H:8.42(1H,br. s,Phe^7-NH),8.01(1H,br. s,Ile^2-NH),8.01(1H,br. s,Thr^6-NH),8.00(1H,br. s,Thr^4-NH),7.92(1H,br. s,Leu^1-NH),7.40(1H,br. s,Ala^3-NH),7.39(1H,br. s,Gly^5-NH),7.26(2H,br. s,Phe^7-δH),7.25(2H,br. s,Phe^7-εH),7.24(1H,br. s,Phe^7-ζH),4.80(1H,d,*J* = 6.0 Hz,Phe^7-αH),4.54(1H,m,Leu^1-αH),4.52(1H,m,Thr^4-αH),4.48(1H,m,Thr^6-βH),4.37(1H,d,*J* = 3.0 Hz,Thr^6-αH),4.16(1H,d,*J* = 17.0 Hz,Gly^5-αHb),4.00(1H,d,*J* = 7.0 Hz,Ala^3-αH),3.98(1H,m,Thr^4-βH),3.87(1H,d,*J* = 7.5 Hz,Ile^2-αH),3.46(1H,d,*J* = 17.0 Hz,Gly^5-αHa),3.26(1H,dd,*J* = 6.0,14.0 Hz,Phe^7-βHa),3.00(1H,dd,*J* = 6.0,14.0 Hz,Phe^7-βHb),1.88(1H,m,Ile^2-βH),1.68(2H,m,Leu^1-βH),1.67(1H,m,Ile^2-γHb),1.66(1H,m,Leu^1-γH),1.53(3H,d,*J* = 7.0 Hz,Ala^3-βCH$_3$),1.28(1H,m,Ile^2-γHa),1.16(3H,d,*J* = 6.5 Hz,Thr^6-γCH$_3$),1.08(3H,d,*J* = 6.5 Hz,Thr^4-γCH$_3$),0.98(3H,d,*J* = 7.0 Hz,Leu^1-δCH$_3$),0.96(3H,d,*J* = 7.0 Hz,Leu^1-δCH$_3$),0.95(3H,t,*J* = 6.5 Hz,Ile^2-γCH$_3$),0.93(3H,m,Ile^2-δCH$_3$);^{13}C NMR(C_5D_5N,100 MHz)δ_C:175.7(s,Ala^3-CO),174.4(s,Leu^1-CO),173.6(s,Phe^7-CO),173.2(s,Thr^6-CO),173.2(s,Thr^4-CO),172.6(s,Ile^2-CO),171.6(s,Gly^5-CO),138.3(s,Phe^7-γC),130.7(d,Phe^7-εCH),129.5(d,Phe^7-δCH),127.7(d,Phe^7-ζCH),70.0(d,Thr^6-βCH),67.7(d,Thr^4-βCH),60.6(d,Thr^6-αCH),60.5(d,Thr^4-αCH),55.9(d,Ile^2-αCH),53.0(d,Phe^7-αCH),52.1(d,Leu^1-αCH),47.8(d,Ala^3-αCH),44.1(t,Gly^5-αCH$_2$),41.4(t,Leu^1-βCH$_2$),37.7(t,Phe^7-βCH$_2$),37.0(d,Ile^2-βCH),26.9(d,Ile^2-γCH),26.1(d,Leu^1-γCH),23.6(q,Leu^1-δCH$_3$),21.5(q,Leu^1-δCH$_3$),20.3(q,Thr^6-γCH$_3$),20.0(q,Thr^4-γCH$_3$),16.6(q,Ala^3-βCH$_3$),15.8(q,Ile^2-γCH$_3$),11.3(q,Ile^2-δCH$_3$)。其结构见图1。化合物**1**的波谱数据与文献[6]报道一致,故鉴定化合物**1**为Cyclo-(Leu^1-Ile^2-Ala^3-Thr^4-Gly^5-Thr^6-Phe^7)(Citrusin I)。

化合物2 白色粉末,分子式为$C_{27}H_{46}N_6O_7$,FAB-MS $[M+H]^+$ *m/z* 567,^{1}H NMR(C_5D_5N,400 MHz)δ_H:9.43(1H,br. s,Gly^1-NH),9.05(1H,br. s,Leu^4-NH),8.58(1H,br. s,Val^3-NH),7.84(1H,br. s,Leu^2-NH),7.71(1H,br. s,Ser^6-NH),4.87(1H,m,Ser^6-αH),4.70(1H,m,Ser^6-βHb),4.69(1H,br. s,Gly^1-αHb),4.57(1H,br. s,Gly^1-αHa),4.56(1H,br. s,Pro^5-αH),4.55(1H,m,Ser^6-βHa),4.47(1H,m,Leu^4-αH),4.27(1H,m,Val^3-αH),4.12(1H,d,*J* = 13.4 Hz,Leu^2-αH),3.69(1H,m,Pro^5-δHb),3.55(1H,m,Pro^5-δHa),2.28(2H,m,Pro^5-βH),2.12(1H,m,Val^3-βH),1.93(1H,m,Pro^5-γHb),1.83(1H,m,Pro^5-γHa),1.81(1H,m,Leu^2-γH),1.64(2H,m,Leu^2-βH),1.45(1H,m,Leu^4-γH),1.29(2H,m,Leu^4-βH),1.05(3H,m,Val^3-γCH$_3$),0.97(3H,br. s,Leu^2-δCH$_3$),0.92(3H,br. s,Leu^2-δCH$_3$),0.85(3H,m,Leu^4-δCH$_3$),0.84(3H,m,Val^3-γCH$_3$),0.83(3H,m,Leu^4-δCH$_3$);^{13}C NMR(C_5D_5N,100 MHz)δ_C:173.5(s,Leu^2-CO),173.4(s,Val^3-CO),172.5(s,Leu^4-CO),172.3(s,Ser^6-CO),172.2(s,Pro^5-CO),

172.2 (s, Gly^1-CO), 63.4 (t, Ser^6-βCH_2), 61.7 (d, Pro^5-αCH), 57.9 (d, Ser^6-αCH), 57.9 (d, Val^3-αCH), 55.0 (d, Leu^2-αCH), 52.6 (d, Leu^4-αCH), 47.3 (t, Pro^5-δCH_2), 44.3 (t, Gly^1-αCH_2), 41.1 (t, Leu^2-βCH_2), 39.5 (t, Leu^4-βCH_2), 32.6 (d, Val^3-βCH), 30.1 (t, Pro^5-βCH_2), 25.3 (d, Leu^2-γCH), 25.1 (d, Leu^4-γCH), 23.3 (q, Leu^2-δCH_3), 23.0 (q, Leu^4-δCH_3), 22.9 (q, Leu^2-δCH_3), 22.4 (t, Pro^5-γCH_2), 21.7 (q, Leu^4-δCH_3), 21.5 (q, Val^3-γCH_3), 19.8 (q, Val^3-γCH_3)。**其结构见图1。化合物2的波谱数据与文献[7]报道一致，故鉴定化合物2为** Cyclo-(Gly[1]-Leu[2]-Val[3]-Leu[4]-Pro[5]-Ser[6])。

化合物3　白色粉末，分子式为 $C_{36}H_{53}N_7O_9$，FAB-MS $[M+H]^+$ *m/z* 728，^{1}H NMR (C_5D_5N，400 MHz) δ_H: 9.60 (1H, d, *J* = 4.8 Hz, Leu^1-NH), 9.34 (1H, d, *J* = 7.7 Hz, Leu^2-NH), 9.06 (1H, d, *J* = 8.0 Hz, Ser^6-NH), 8.31 (1H, br. s, Gly^5-NH), 7.90 (1H, d, *J* = 8.0 Hz, Tyr^4-NH), 7.25 (2H, d, *J* = 8.3 Hz, Tyr^4-δH), 7.07 (2H, d, *J* = 8.3 Hz, Tyr^4-εH), 4.95 (1H, m, Tyr^4-αH), 4.83 (1H, m, Gly^5-αHa), 4.75 (1H, m, Ser^6-αH), 4.56 (1H, m, Pro^3-αH), 4.45 (1H, m, Pro^7-αH), 4.36 (1H, m, Ser^6-βHa), 4.05 (1H, m, Leu^1-αH), 3.84 (1H, m, Leu^2-αH), 3.53 (1H, m, Gly^5-αHb), 3.37 (1H, m, Ser^6-βHb), 3.34 (2H, m, Pro^3-δH), 3.24 (2H, m, Pro^7-δH), 2.57 (1H, m, Tyr^4-βHa), 2.54 (1H, m, Pro^7-γHb), 2.10 (1H, m, Tyr^4-βHb), 2.04 (1H, m, Pro^3-βHa), 2.01 (1H, m, Pro^7-βHa), 1.98 (1H, m, Pro^3-γHa), 1.83 (1H, m, Pro^3-βHb), 1.82 (1H, m, Pro^7-βHb), 1.74 (1H, m, Leu^1-γH), 1.70 (1H, m, Leu^2-γH), 1.67 (2H, m, Leu^1-βH), 1.66 (1H, m, Pro^3-γHb), 1.60 (2H, m, Leu^2-βH), 1.59 (1H, m, Pro^7-γHa), 0.93 (3H, d, *J* = 6.5 Hz, Leu^1-δCH_3), 0.89 (3H, d, *J* = 6.5 Hz, Leu^2-δCH_3), 0.85 (3H, d, *J* = 6.5 Hz, Leu^1-δCH_3), 0.81 (3H, d, *J* = 6.5 Hz, Leu^2-δCH_3)；^{13}C NMR (C_5D_5N，100 MHz) δ_C: 172.8 (s, Pro^3-CO), 172.7 (s, Pro^7-CO), 172.6 (s, Leu^1-CO), 171.5 (s, Leu^2-CO), 171.4 (s, Ser^6-CO), 171.1 (s, Tyr^4-CO), 170.5 (s, Gly^5-CO), 157.9 (s, Tyr^4-ζC), 130.9 (d, Tyr^4-δCH), 127.6 (s, Tyr^4-γC), 116.3 (d, Tyr^4-εCH), 62.6 (t, Ser^6-βCH_2), 61.8 (d, Pro^3-αCH), 60.0 (d, Pro^7-αCH), 58.8 (d, Leu^1-αCH), 58.6 (d, Leu^2-αCH), 54.1 (d, Ser^6-αCH), 50.0 (d, Tyr^4-αCH), 47.9 (t, Pro^3-δCH_2), 47.2 (t, Pro^7-δCH_2), 42.8 (t, Leu^1-βCH_2), 41.7 (t, Leu^2-βCH_2), 40.1 (t, Gly^5-αCH_2), 36.9 (t, Tyr^4-βCH_2), 32.1 (t, Pro^3-βCH_2), 28.8 (t, Pro^7-βCH_2), 25.3 (t, Pro^3-γCH_2), 25.0 (d, Leu^2-γCH), 24.9 (d, Leu^1-γCH), 23.5 (q, Leu^1-δCH_3), 23.2 (q, Leu^2-δCH_3), 22.8 (q, Leu^1-δCH_3), 22.4 (t, Pro^7-γCH_2), 21.2 (q, Leu^2-δCH_3)。**其结构见图1。化合物3的波谱数据与文献[8]报道一致，故鉴定化合物3为** Cyclo-(Leu[1]-Leu[2]-Pro[3]-Tyr[4]-Gly[5]-Ser[6]-Pro[7]) (Citrusin III)。

化合物4　白色粉末，分子式为 $C_{41}H_{62}N_8O_8$，FAB-MS $[M+H]^+$ *m/z* 795，^{1}H NMR (C_5D_5N，400 MHz) δ_H: 9.91 (1H, br. s, Phe^8-NH), 8.90 (1H, br. s, Leu^5-NH), 8.28 (1H, br. s, Leu^4-NH), 7.81 (1H, br. s, Leu^3-NH), 7.53 (1H, br. s, Gly^2-NH), 7.32 (2H, m, Phe^8-εH), 7.29 (2H, m, Phe^8-δH), 7.25 (1H, m, Phe^8-ζH), 6.54 (1H, br. s, Gly^1-NH), 4.76 (1H, m, Phe^8-αH), 4.63 (1H, m, Leu^5-αH), 4.43 (1H, m, Pro^6-αH), 4.40 (1H, br. s, Gly^1-αHb), 4.36 (1H, m, Pro^7-αH), 4.26 (1H, m, Leu^4-αH), 4.11 (1H, br. s, Gly^2-αHb), 3.93 (1H, m, Leu^3-αH), 3.63 (1H, br. s, Gly^1-αHa), 3.58 (2H, m, Pro^6-δH), 3.51 (1H, br. s, Gly^2-αHa), 3.48 (1H, m, Phe^8-βHb), 3.38 (2H, m, Pro^7-δH), 2.81 (1H, m, Phe^8-βHa), 2.23 (1H, m, Pro^6-βHb), 2.07 (2H, m, Pro^6-γH), 2.02 (1H, m, Pro^7-βHb), 1.79 (1H, m, Pro^6-βHa), 1.77 (1H, m, Leu^3-γH), 1.76 (1H, m, Pro^7-βHa), 1.63 (3H, m, Leu^5-δCH_3), 1.62 (2H, m, Leu^4-βH), 1.61 (1H, m, Leu^5-γH), 1.60 (1H, m, Leu^4-γH), 1.59 (2H, m, Leu^3-βH), 1.58 (3H, m, Leu^5-δCH_3), 1.54 (1H, m, Pro^7-γHb), 1.47 (2H, m, Leu^5-βH), 1.32 (3H, br. s, Leu^4-δCH_3), 1.30 (3H, br. s, Leu^4-δCH_3), 1.22 (3H, m, Leu^3-δCH_3), 0.89 (3H, br. s, Leu^3-δCH_3), 0.88 (1H, m, Pro^7-γHa)；^{13}C NMR (C_5D_5N，100 MHz) δ_C: 174.4 (s, Leu^3-CO), 172.8 (s, Leu^4-CO), 172.4 (s, Pro^7-CO), 172.2 (s, Pro^6-CO), 171.9 (s, Gly^1-CO), 171.9 (s, Phe^8-CO), 170.2 (s, Gly^2-CO), 169.5 (s, Leu^5-CO), 136.3 (s, Phe^8-γC), 129.1 (d, Phe^8-δCH), 128.6 (d, Phe^8-εCH), 127.6 (d, Phe^8-ζCH), 61.2 (d, Pro^7-αCH), 59.6 (d, Pro^6-αCH), 57.9 (d, Phe^8-αCH), 54.1 (d, Leu^3-αCH), 53.5 (d, Leu^4-αCH), 50.1 (d, Leu^5-αCH), 47.3 (t, Pro^6-δCH_2), 46.8 (t, Pro^7-δCH_2),

44.0 (t,Gly^1-αCH_2),43.1 (t,Gly^2-αCH_2),40.3 (t,Leu^3-βCH_2),40.1 (t,Leu^4-βCH_2),39.9 (t,Leu^5-βCH_2),37.1 (t,Phe^8-βCH_2),31.9 (t,Pro^7-βCH_2),28.9 (t,Pro^6-βCH_2),25.1 (t,Pro^6-γCH_2),25.0 (d,Leu^3-γCH),25.0 (d,Leu^4-γCH),24.9 (t,Pro^7-γCH_2),24.7 (d,Leu^5-γCH),23.2 (q,Leu^3-δCH_3),23.0 (q,Leu^4-δCH_3),22.9 (q,Leu^5-δCH_3),22.6 (q,Leu^5-δCH_3),22.5 (q,Leu^3-δCH_3),21.2 (q,Leu^4-δCH_3)。**其结构见图**1。**化合物4的波谱数据与文献**[7]**报道一致,故鉴定化合物4为** Cyclo-(Gly[1]-Gly[2]-Leu[3]-Leu[4]-Leu[5]-Pro[6]-Pro[7]-Phe[8])。

化合物5　白色粉末,分子式为 $C_8H_{12}N_2O_2$,FAB-MS [M+H]$^+$ *m/z* 169,^{1}H NMR ($CDCl_3$,400 MHz) δ_H:9.25 (1H,br. s,Ala-NH),4.21 (1H,m,Ala-αH),4.16 (1H,m,Pro-αH),3.52,3.45 (2H,m,Pro-δH),2.21,2.15 (2H,m,Pro-βH),1.66 (2H,m,Pro-γH),1.60 (3H,d,*J* = 6.7 Hz,Ala-βCH_3);^{13}C NMR ($CDCl_3$,100 MHz) δ_C:170.6 (s,Ala-CO),164.9 (s,Pro-CO),59.2 (d,Pro-αCH),51.1 (d,Ala-αCH),45.4 (t,Pro-δCH_2),28.1 (t,Pro-βCH_2),22.7 (t,Pro-γCH_2),15.8 (q,Ala-βCH_3);**化合物5结构见图**1。**其波谱数据与文献**[8]**报道一致,故鉴定化合物5为** Cyclo-(Pro-Ala)。

化合物6　白色粉末,分子式为 $C_9H_{16}N_2O_2$,FAB-MS [M]$^+$ *m/z* 184,^{1}H NMR (C_5D_5N,400 MHz) δ_H: 9.27 (1H,s,Ala-NH),8.97 (1H,s,Ile-NH),4.27 (1H,overlapped,Ala-αH),4.11 (1H,overlapped,Ile-αH),1.82 (1H,overlapped,Ile-βH),1.42 (2H,m,Ile-γH),1.26 (3H,d,*J* = 5.6,Ala-βCH_3),1.14 (3H,d,*J* = 7.2 Hz,Ile-γCH_3),0.87 (3H,d,*J* = 7.2 Hz,Ile-δCH_3);^{13}C NMR (C_5D_5N,100 MHz) δ_C: 169.6 (s,Ala-CO),167.8 (s,Ile-CO),60.4 (d,Ile-αCH),51.1 (d,Ala-αCH),39.1 (d,Ile-βCH),24.7 (t,Ile-γCH_2),20.9 (q,Ala-βCH_3),15.7 (q,Ile-γCH_3),12.2 (q,Ile-δCH_3);**化合物6结构见图**1。**其波谱数据与文献**[9]**报道一致,故鉴定化合物6为** Cyclo-(Ala-Ile)。

化合物7　白色粉末,分子式为 $C_9H_{16}N_2O_2$,FAB-MS [M]$^+$ *m/z* 184,^{1}H NMR (C_5D_5N,400 MHz) δ_H:8.94 (1H,s,Ala-NH),8.82 (1H,s,Leu-NH),4.31 (1H,overlapped,Ala-αH),4.25 (1H,overlapped,Leu-αH),2.11 (1H,overlapped,Leu-γH),1.85 (2H,m,Leu-βH),1.66 (3H,d,*J* = 7.2 Hz,Ala-βCH_3),0.95 (6H,m,Leu-δCH_3);^{13}C NMR (C_5D_5N,100 MHz) δ_C: 169.9 (s,Ala-CO),169.5 (s,Leu-CO),54.1 (d,Leu-αCH),51.4 (d,Ala-αCH),43.8 (t,Leu-βCH_2),24.8 (d,Leu-γCH),23.3 (q,Leu-δCH_3),21.9 (q,Leu-δCH_3),20.3 (q,Ala-βCH_3);**化合物7结构见图**1。**其波谱数据与文献**[9]**报道一致,故鉴定化合物7为** Cyclo-(Ala-Leu)。

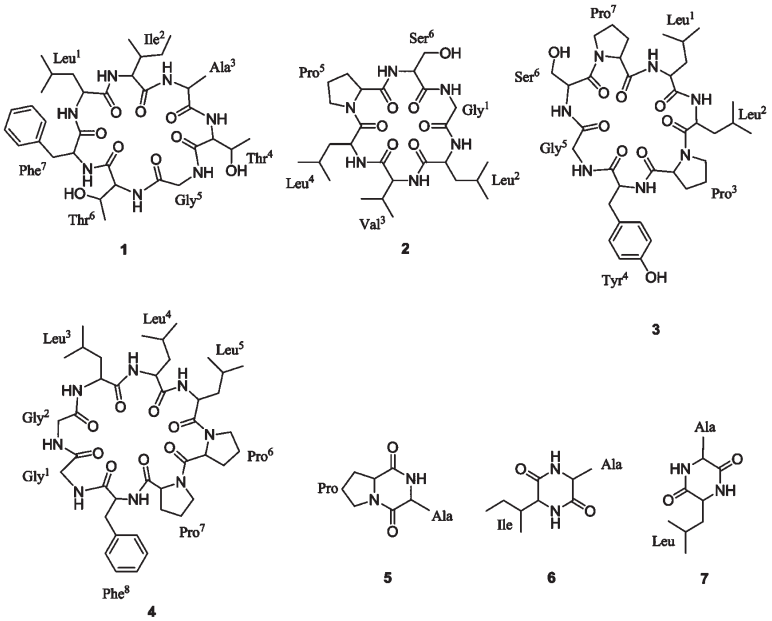

图1　化合物1~7的化学结构

Fig. 1　Chemical structures of compounds **1-7**

参考文献

1 Chinese Pharmacopoeia Commission(国家药典委员会). Pharmacopoeia of the People's Republic of China(中华人民共和国药典). Beijing: China Medical Science Press, 2010. Vol Ⅰ,229.

2 Zhuang XG(庄须国), Pan ZW(潘振伟), Liu XD(刘晓丹), *et al*. Constrictive effects of Fructus Aurantii on rattho-racic aorta and the underlying mechanisms. *Chin Pharm Bull*(中国药理学通报),2008,24:810-814.

3 Zhao SM(赵思蒙), Kuang B(邝彬), Peng WW(彭文文), *et al*. Chemical progress in cyclopeptide-containing traditional medicines cited in Chinese pharmacopoeia. *Chin J Chem*(中国化学),2012,30:1213-1225.

4 Peng WW(彭文文), Yan H(闫合), Tan NH(谭宁华). One new chroman glycoside derivative from the unmatured fruits of *Citrus aurantium* L. *China J Chin Mat Med*(中国中药杂志),2013,38:60-63.

5 Zhou J(周俊), Tan NH(谭宁华). Application of a new TLC chemical method to identification of cyclopeptides. *Chin Sci Bull*(科学通报),2000,4:1047-1051.

6 Matsubara Y, Yusa T, Sawabe A, *et al*. Structures of new cyclic peptides in young unshiu(*Citrus unshiu* Marcov.), Orange(*Citrus sinensis* Osbeck.). *Agric Biol Chem*,1991,55:2923-2929.

7 Mastumoto T, Tashiro N, Nishimura K, *et al*. New cyclicpeptides from *Citrus aurantium*. *Heterocycles*,2002,56:477-482.

8 Liu C, Yang XQ, Ding ZT, *et al*. Cyclodipeptides from the secondary metabolites of two novel actinomycetes. *Chin J Nat Med*,2011,9:78-80.

9 Xiang L(向兰), Guo DX(郭东晓), Ju R(鞠瑞), *et al*. Cyclic dipeptides from *Portulaca oleracea*. *Chin Tradit Herb Drugs*(中草药),2007,11:1622-1625.

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7 Liu TQ(刘铁秋), Sun XD(孙雪丹), He M(何苗), *et al*. Inhibitory effects of 20 species of Sichuan authentic herbal medicine on mycelial growth of *Botrytis cinerea*. *Sci Tech Food Ind*(食品工业科技),2013,34:114-119.

8 Li GZ(李广志), Chen F(陈峰), Shen LG(沈连钢), *et al*. Study on chemical constituents from roots and rhizomes of *Acorus tatarinowii*. *Chin Tradit Herb Drugs*(中草药),2013,44:808-811.

9 Liu TQ(刘铁秋), Sun XD(孙雪丹), Lu FR(卢发瑞), *et al*. Inhibitory effect on *Botrytis cinerea* and optimization of extraction procedure of antifungal substances from rhizome *Acorus tatarinowii*. *Chin J Biologicals*(中国生物制品学杂志),2014,1:94-99.

10 Tang Y(唐艳), Zhang B(张宾), Huo JC(霍健聪), *et al*. Antibacterial effect of twelve Chinese herbal medicine. *J Zhejiang Ocean Univ*, *Nat Sci*(浙江海洋学院学报,自科版),2012,31:147-152.

11 Wu ZY(吴振宇), Ai QJ(艾启俊), Wang Y(王燕), *et al*. Study on inhibitory effects of herbal extracts against *Monilinia fructicola*. *Sci Tech Food Ind*(食品工业科技),2008,29:102-105.

12 NY/T 1156.1-2006, Agricultural industry standard of the people's Republic of China Pesticides guidelines for laboratory bioactivity test Part 1: Determining fungicide inhibition of pathogen spore germination on concave slides(中华人民共和国农业行业标准 农药室内生物测定试验准则 杀菌剂 第1部分:抑制病原真菌孢子萌发试验 凹玻片法). Beijing: Ministry of Agriculture of the People's Republic of China,2006.

13 NY/T 1156.10-2008, Agricultural industry standard of the people's Republic of China Guideline for laboratory bioassay of pesticides Part 10: Potted plant test for fungicide control *Botrytis cinerea* Pers(中华人民共和国农业行业标准 农药室内生物测定试验准则 杀菌剂 第10部分:防治灰霉病试验 盆栽法), Beijing: Ministry of Agriculture of the People's Republic of China,2008.

14 Xie HQ(谢慧琴), Zhang JH(张建华), Wang PL(王佩玲), *et al*. Research survey and exploiting prospect of botanical insecticide in Xinjian. *J Shihezi Univ*, *Nat Sci*(石河子大学学报,自科版),2003,7:333-335.

15 Duan XM(段晓明), Yin W(尹卫). Research and progress of botanical pesticides. *J Qinghai Univ*, *Nat Sci*(青海大学学报,自科版),2006,24:56-59.

16 Lee HS. Fungicidal property of active component derived from *Acorus gramineus* rhizome against phytopathogenic fungi. *Bioresour Technol*,2007,98:1324-1328.