研究简报

# 风车草的化学成分

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**摘要**: 以体积分数为85%的乙醇回流提取风车草(*Clinopodium chinensis O. Kuntze var. grandiflorum* (Maxim.) Hara.)茎叶, 得提取物, 再经大孔吸附树脂吸附、硅胶和ODS柱色谱法分离各化学成分, 并经理化性质和波谱数据分析鉴定它们的化学结构. 共分离得到10个化合物, 分别鉴定为醉鱼草苷Ⅳb(**1**), 醉鱼草苷Ⅳ(**2**), 风轮菜皂苷(Ⅺ)(**3**), 香峰草苷(**4**), 3$\beta$,16$\beta$,23,28-四羟基齐墩果烷-11,13(18)-二烯-3-[$\beta$-*D*-吡喃葡萄糖-(1→2)]-[$\beta$-*D*-吡喃葡萄糖-(1→3)]基-$\beta$-*D*-吡喃夫糖苷(**5**), 槲皮素-3-O-$\beta$-*D*-葡萄糖-(1→6)-O-$\beta$-*D*-葡萄糖苷(**6**), 风轮菜皂苷Ⅴ(**7**), 风轮菜皂苷Ⅲ(**8**), 风轮菜皂苷Ⅴb(**9**), 风轮菜皂苷Ⅲb(**10**). 除化合物**1**,**2**,**4**,**5**外, 其余化合物均为首次从该植物中分离得到.

**关键词**: 风车草; 化学成分; 分离; 鉴定
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# Chemical Constituents of *Clinopodium chinensis O. Kuntze var. grandiflorum* (Maxim.) Hara.

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**Abstract**: The leaves of *Clinopodium chinensis O. Kuntze var. grandiflorum* (Maxim.) Hara. were extracted with 85% volume fraction ethanol under refluxing conditions, the extracts were separated by column chromatography with adsorption resin, silica gel and ODS respectively to obtain the chemical constituents, whose structures were elucidated by spectral analysis, physical and chemical evidence. Ten compounds were isolated and identified as buddlejasaponin Ⅳb(**1**), buddlejasaponin Ⅳ(**2**), Clinoposaponin Ⅺ(**3**), didymin(**4**), 3$\beta$,16$\beta$,23,28-trihydroxyoleana-11,13(18)-dien-3-yl-[$\beta$-*D*-glucopyranosyl-(1→2)]-[$\beta$-*D*-glucopyranosyl-(1→3)]-$\beta$-*D*-fucopyranoside(**5**), quercetin-3-O-$\beta$-*D*-glucopyranosyl-(1→6)-O-$\beta$-*D*-glucopyanoside(**6**), Clinoposaponin Ⅴ(**7**), Clinoposaponin Ⅲ(**8**), Clinoposaponin Ⅴb(**9**) and Clinoposaponin Ⅲb(**10**). Except compounds **1**, **2**, **4** and **5**, all the other compounds were isolated from *Clinopodium chinensis O. Kuntze var. grandiflorum* (Maxim.) Hara. for the first time.

**Key words**: *Clinopodium chinensis O. Kuntze var. grandiflorum* (Maxim.) Hara.; chemical constituents; isolation; identification

风车草(*Clinopodium chinensis O. Kuntze var. grandiflorum* (Maxim.) Hara.)为唇形科风轮菜属植物, 是该属植物风轮菜(*Clinopodium chinensis* (Benth.) *O. Kuntze*)的变种, 主产于长白山区各县, 分布于中

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国的东北、华北、中南等地区, 具有止血的功效[1-2]. 本文对风车草的化学成分进行了提取、分离和结构鉴定.

## 1　仪器与材料

德国 BRUKER 公司生产的 AV600 型核磁共振仪(600 MHz); 美国应用生物系统公司生产的 Q-trap 型质谱仪; 北京泰克仪器有限公司生产的 XT-4 型显微熔点测定仪(未校正); 德国 Startorius 公司生产的 YDO-OIR 型电子天平; 德国 Merk 公司生产的 Silica 60 F254 型高效薄层层析板和 ODS RP-18 F254s 型薄层层析板; 青岛海洋化工厂生产的柱层析用硅胶(200 ~ 300 目); 北京金欧亚科技发展公司生产的 ODS 柱(40 ~ 60 μm). 其他试剂均为国产分析纯(北京化工厂).

本实验所用药材经长春中医药大学邓明鲁教授鉴定确认为风车草.

## 2　提取分离

取干燥的风车草 5 kg, 粉碎后过 40 目筛, 用体积分数为 85% 的乙醇回流提取 3 次, 乙醇用量分别为 35,25,20 L, 时间分别为 2,1.5,1 h, 合并提取液, 过滤后浓缩, 加 5 倍体积的水稀释, 过大孔树脂吸附, 用无水乙醇洗脱, 回收乙醇, 得到粗提物 273 g.

将粗提物进行硅胶柱层析分离, 以 $V$(乙酸乙酯) : $V$(乙醇) : $V$(水) =4 : 1 : 0.4 为洗脱剂洗脱, 合并相同组分, 得到 A,B,C,D,E 五部分. 再反复经过硅胶(洗脱剂: 乙酸乙酯-乙醇-水)、ODS 柱层析(洗脱剂: 甲醇-水), 由 D 部分得到化合物 **1**(568 mg), **2**(763 mg), **3**(95 mg)和 **5**(11 mg), 由B 部分得到化合物 **4**(23 mg), 由 C 部分得到化合物 **6**(8.0 mg), 由 E 部分得到化合物 **7**(1.76 g), **8**(210 mg), **9**(370 mg), **10**(60 mg).

## 3　结构鉴定

3.1　化合物 **1**　白色粉末, m.p. 252 ~ 253 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS($m/z$): 965.6 $[M+Na]^+$, 分子式为 $C_{48}H_{78}O_{18}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 0.938, 0.846, 0.823, 0.790, 0.763, 0.742, 0.721(均为 3H, s, —$CH_3$), 5.570(1H, d, $J$ = 10.8 Hz, H-12), 6.384(1H, d, $J$ = 10.8 Hz, H-11), 5.489(1H, d, $J$ =7.8 Hz, H-1″), 5.218(1H, d, $J$ =7.8 Hz, H-1‴), 4.825(1H, d, $J$ =7.8 Hz, H-1′). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.52(C-1), 26.16(C-2), 82.64(C-3), 43.91(C-4), 47.86(C-5), 18.40(C-6), 32.52(C-7), 40.58(C-8), 54.62(C-9), 36.58(C-10), 127.21(C-11), 125.78(C-12), 136.54(C-13), 44.37(C-14), 35.03(C-15), 76.68(C-16), 44.51(C-17), 133.40(C-18), 38.40(C-19), 32.76(C-20), 35.25(C-21), 30.06(C-22), 64.56(C-23), 12.91(C-24), 18.84(C-25), 17.13(C-26), 22.05(C-27), 64.10(C-28), 24.92(C-29), 32.37(C-30), 104.18(C-1′), 77.36(C-2′), 84.83(C-3′), 72.37(C-4′), 70.62(C-5′), 17.35(C-6′), 104.29(C-1″), 76.41(C-2″), 78.96(C-3″), 72.13(C-4″), 77.55(C-5″), 63.28(C-6″), 105.29(C-1‴), 75.50(C-2‴), 78.56(C-3‴), 71.71(C-4‴), 78.65(C-5‴), 62.68(C-6‴). 与文献[3]对照, 确定其为醉鱼草苷Ⅳb.

3.2　化合物 **2**　白色粉末, m.p. 262 ~ 263 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS($m/z$): 965.5 $[M+Na]^+$, 分子式为 $C_{48}H_{78}O_{18}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 5.533(1H, d, $J$ =7.2 Hz, H-12), 5.866(1H, d, $J$ = 10.8 Hz, H-11), 5.481(1H, d, $J$ = 7.8 Hz, H-1″), 5.203(1H, d, $J$ = 7.8 Hz, H-1‴), 4.809(1H, d, $J$ = 7.8 Hz, H-1′). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.74(C-1), 26.15(C-2), 82.64(C-3), 43.95(C-4), 47.94(C-5), 17.78(C-6), 31.72(C-7), 42.32(C-8), 53.19(C-9), 36.37(C-10), 132.32(C-11), 131.25(C-12), 84.10(C-13), 45.77(C-14), 36.28(C-15), 64.17(C-16), 47.11(C-17), 52.27(C-18), 37.86(C-19), 31.72(C-20), 34.84(C-21), 25.87(C-22), 64.71(C-23), 12.81(C-24), 18.78(C-25), 20.15(C-26), 20.95(C-27), 73.13(C-28), 33.75(C-29), 23.94(C-30), 104.18(C-1′), 77.34(C-2′), 84.98(C-3′), 72.12(C-4′), 70.61(C-5′), 17.34(C-6′), 104.21(C-1″), 76.39(C-2″), 78.96(C-3″), 72.33(C-4″), 77.58(C-5″), 63.25(C-6″), 105.28(C-1‴), 75.50(C-2‴), 78.55(C-3‴), 71.70(C-4‴), 78.64(C-5‴), 62.67(C-6‴). 与文献[4]对照, 确定其为醉鱼草苷Ⅳ.

3.3 化合物 **3** 白色无定型粉末, m. p. 255 ~ 256 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS ($m/z$): 949.7[M + Na]$^+$, 分子式为 $C_{48}H_{78}O_{17}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 5.541(1H , d, $J$ = 7.8 Hz, H-12), 5.839(1H, d, $J$ = 10.2 Hz, H-11), 5.464(1H, d, $J$ = 7.8 Hz, H-1″), 5.267(1H, d, $J$ = 7.8 Hz, H-1‴), 4.286(1H, d, $J$ = 7.8 Hz, H-1′). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.69(C-1), 26.69(C-2), 89.13(C-3), 39.98(C-4), 55.50(C-5), 18.02(C-6), 32.00(C-7), 42.32(C-8), 53.02(C-9), 36.45(C-10), 132.23(C-11), 131.32(C-12), 84.10(C-13), 45.78(C-14), 36.28(C-15), 64.18(C-16), 47.14(C-17), 52.27(C-18), 37.91(C-19), 31.75(C-20), 34.84(C-21), 25.88(C-22), 27.84(C-23), 16.22(C-24), 18.30(C-25), 20.11(C-26), 21.02(C-27), 73.15(C-28), 33.80(C-29), 23.94(C-30), 105.32(C-1′), 77.46(C-2′), 84.56(C-3′), 72.18(C-4′), 70.68(C-5′), 17.36(C-6′), 104.22(C-1″), 76.49(C-2″), 78.83(C-3″), 72.72(C-4″), 77.23(C-5″), 63.50(C-6″), 105.32(C-1‴), 75.52(C-2‴), 78.63(C-3‴), 71.70(C-4‴), 78.77(C-5‴), 62.68(C-6‴). 与文献[5]对照, 确定其为风轮菜皂苷Ⅺ.

3.4 化合物 **4** 白色粉末, m. p. 210 ~ 212 ℃. HCl-Mg 反应呈阳性, 淡紫红色. Molish 反应呈阳性. ESI-MS($m/z$): 617.2[M + Na]$^+$. 分子式为 $C_{28}H_{34}O_{14}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 6.507(1H, d, $J$ = 1.8 Hz, H-6), 6.399(1H, d, $J$ = 1.8 Hz, H-8), 7.462(2H, d, $J$ = 8.4 Hz, H-2′, H-6′), 6.929(2H, d, $J$ = 8.4 Hz, H-3′, H-5′), 3.549(s, 3H, —$OCH_3$-4′), 5.522(1H, d, $J$ = 7.2 Hz, H-1″), 4.526(1H, brs, H-1‴). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 79.40(C-2), 43.18(C-3), 197.10(C-4), 164.62(C-5), 97.94(C-6), 166.61(C-7), 96.55(C-8), 163.57(C-9), 104.44(C-10), 131.30(C-1′), 128.80(C-2′), 114.66(C-3′), 160.57(C-4′), 114.66(C-5′), 128.80(C-6′), 102.59(C-1″), 74.71(C-2″), 77.71(C-3″), 71.42(C-4″), 78.57(C-5″), 67.47(C-6″), 101.63(C-1‴), 72.87(C-2‴), 72.23(C-3‴), 74.24(C-4‴), 69.92(C-5‴), 18.70(C-6‴), 55.38 (—$OCH_3$-4′). 与文献[6]对照, 确定其为香蜂草苷.

3.5 化合物 **5** 白色无定型粉末. m. p. 248 ~ 250 ℃. Liebermann-Burchard 反应呈阳性. 分子式为 $C_{48}H_{18}O_{17}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 5.544(1H, d, $J$ = 10.2 Hz, H-12), 6.394(1H, d, $J$ = 10.8 Hz, H-11), 5.473(1H, d, $J$ = 7.8 Hz, H-1″), 5.277(1H, d, $J$ = 7.8 Hz, H-1‴), 4.618(1H, d, $J$ = 7.8 Hz, H-1′). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.55(C-1), 26.71(C-2), 89.27(C-3), 39.95(C-4), 55.53(C-5), 18.66(C-6), 32.79(C-7), 40.58(C-8), 54.45(C-9), 36.69(C-10), 127.12(C-11), 125.84(C-12), 136.53(C-13), 44.41(C-14), 35.01(C-15), 76.71(C-16), 44.55(C-17), 133.40(C-18), 38.38(C-19), 32.38(C-20), 35.26(C-21), 30.08(C-22), 27.89(C-23), 16.31(C-24), 18.38(C-25), 17.09(C-26), 22.10(C-27), 63.53(C-28), 24.94(C-29), 32.38(C-30), 105.34(C-1′), 77.20(C-2′), 84.61(C-3′), 72.19(C-4′), 70.71(C-5′), 17.37(C-6′), 104.22(C-1″), 76.50(C-2″), 78.84(C-3″), 72.76(C-4″), 77.53(C-5″), 63.53(C-6″), 105.39(C-1‴), 75.53(C-2‴), 78.56(C-3‴), 71.74(C-4‴), 78.63(C-5‴), 62.70(C-6‴). 与文献[5]对照, 确定其为3$\beta$,16$\beta$,23,28-四羟基齐墩果烷-11,13(18)-二烯-3-[$\beta$-$D$-吡喃葡萄糖-(1→2)]-[$\beta$-$D$-吡喃葡萄糖-(1→3)]基-$\beta$-$D$-吡喃夫糖苷.

3.6 化合物 **6** 黄色粉末, m. p. 210 ~ 212 ℃. HCl-Mg 反应呈阳性, 淡紫红色. Molish 反应呈阳性. 分子式为 $C_{27}H_{30}O_{17}$. $^1$H-NMR(DMSO-$d_6$, 600 MHz) $\delta$: 12.623, 10.818, 9.691, 9.203(均为 1H, s, —OH), 6.187(1H, s, H-6), 6.383(1H, s, H-8), 7.575(1H, s, H-2′), 6.851(1H, d, $J$ = 9.0 Hz, H-5′), 5.405(1H, d, $J$ = 7.2 Hz, H-1″), 4.059(1H, d, $J$ = 7.8 Hz, H-1‴). $^{13}$C-NMR(DMSO-$d_6$, 150 MHz) $\delta$: 156.33(C-2), 133.31(C-3), 177.34(C-4), 161.19(C-5), 98.63(C-6), 164.03(C-7), 93.55(C-8), 156.33(C-9), 104.02(C-10), 121.12(C-1′), 115.20(C-2′), 144.72(C-3′), 148.42(C-4′), 116.23(C-5′), 121.63(C-6′), 100.88(C-1″), 73.96(C-2″), 76.38(C-3″), 69.74(C-4″), 76.49(C-5″), 68.07(C-6″), 103.09(C-1‴), 73.37(C-2‴), 76.33(C-3‴), 69.67(C-4‴), 76.49(C-5‴), 60.70(C-6‴). 与文献[7]对照, 确定其为槲皮素-3-O-$\beta$-$D$-葡萄糖-(1→6)-O-$\beta$-$D$-葡萄糖苷.

3.7　化合物 **7**　白色粉末. m. p. 251 ~ 252 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS(*m/z*): 1 290.5[M + Na]$^+$, 分子式为 $C_{60}H_{98}O_{28}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 4.051(1H, d, *J* = 9.0 Hz, H-3), 5.875(1H, d, *J* = 10.2 Hz, H-11), 5.538(1H, d, *J* = 10.2 Hz, H-12), 4.398(1H, m, H-16), 0.948(3H, s, H-24), 0.844(3H, s, H-25), 1.264(3H, s, H-26), 0.980(3H, s, H-27), 0.811(3H, s, H-29), 0.777(3H, s, H-30), 4.793(1H, d, *J* = 7.8 Hz, H-1′), 5.424(1H, d, *J* = 7.8 Hz, H-1″), 5.063(1H, d, *J* = 7.8 Hz, H-1‴), 4.825(1H, d, *J* = 7.2 Hz, H-1⁗), 5.050(1H, d, *J* = 7.8 Hz, H-1⁗′). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.74(C-1), 26.08(C-2), 82.82(C-3), 43.91(C-4), 48.10(C-5), 17.80(C-6), 31.73(C-7), 42.32(C-8), 53.21(C-9), 36.38(C-10), 132.34(C-11), 131.27(C-12), 84.11(C-13), 45.77(C-14), 36.28(C-15), 64.17(C-16), 47.12(C-17), 52.27(C-18), 37.87(C-19), 31.73(C-20), 34.82(C-21), 25.88(C-22), 64.92(C-23), 12.79(C-24), 18.78(C-25), 20.17(C-26), 20.95(C-27), 73.14(C-28), 33.77(C-29), 23.94(C-30), 104.11(C-1′), 77.36(C-2′), 85.31(C-3′), 72.01(C-4′), 70.68(C-5′), 17.45(C-6′), 104.20(C-1″), 76.29(C-2″), 78.95(C-3″), 72.25(C-4″), 77.56(C-5″), 63.21(C-6″), 105.03(C-1‴), 75.29(C-2‴), 78.40(C-3‴), 72.01(C-4‴), 77.21(C-5‴), 70.36(C-6‴), 105.09(C-1⁗), 75.01(C-2⁗), 76.64(C-3⁗), 80.95(C-4⁗), 76.54(C-5⁗), 61.99(C-6⁗), 105.03(C-1⁗′), 74.81(C-2⁗′), 78.31(C-3⁗′), 71.58(C-4⁗′), 78.55(C-5⁗′), 62.51(C-6⁗′). 与文献[8]对照, 确定其为风轮菜皂苷Ⅴ.

3.8　化合物 **8**　白色粉末, m. p. 257 ~ 258 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS(*m/z*): 1 127.5[M + Na]$^+$, 分子式为 $C_{54}H_{88}O_{23}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 4.038(1H, d, *J* = 9.0 Hz, H-3), 5.860(1H, d, *J* = 10.2 Hz, H-11), 5.538(1H, d, *J* = 10.2 Hz, H-12), 4.375(1H, m, H-16), 0.981(3H, s, H-24), 0.948(3H, s, H-25), 1.173(3H, s, H-26), 1.084(3H, s, H-27), 0.844(3H, s, H-29), 0.810(3H, s, H-30), 4.791(1H, d, *J* = 7.8 Hz, H-1′), 5.427(1H, d, *J* = 7.8 Hz, H-1″), 5.071(1H, d, *J* = 7.8 Hz, H-1‴), 4.861(1H, d, *J* = 7.8 Hz, H-1⁗). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.74(C-1), 26.06(C-2), 82.81(C-3), 43.90(C-4), 48.12(C-5), 17.80(C-6), 31.73(C-7), 42.32(C-8), 53.22(C-9), 36.38(C-10), 132.31(C-11), 131.28(C-12), 84.09(C-13), 45.76(C-14), 36.28(C-15), 64.16(C-16), 47.11(C-17), 52.26(C-18), 37.87(C-19), 31.73(C-20), 34.81(C-21), 25.87(C-22), 64.92(C-23), 12.78(C-24), 18.78(C-25), 20.16(C-26), 20.95(C-27), 73.13(C-28), 33.76(C-29), 23.94(C-30), 104.11(C-1′), 77.42(C-2′), 85.04(C-3′), 72.04(C-4′), 70.65(C-5′), 17.39(C-6′), 104.24(C-1″), 76.30(C-2″), 78.95(C-3″), 72.23(C-4″), 77.57(C-5″), 63.20(C-6″), 104.98(C-1‴), 75.28(C-2‴), 78.41(C-3‴), 72.04(C-4‴), 77.22(C-5‴), 70.41(C-6‴), 105.52(C-1⁗), 75.50(C-2⁗), 78.50(C-3⁗), 71.66(C-4⁗), 78.43(C-5⁗), 62.75(C-6⁗). 与文献[8]对照, 确定其为风轮菜皂苷Ⅲ.

3.9　化合物 **9**　白色粉末. m. p. 240 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS(*m/z*): 1 289.6[M + Na]$^+$, 分子式为 $C_{60}H_{98}O_{28}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 6.386(1H, d, *J* = 10.2 Hz, H-11), 5.577(1H, d, *J* = 10.2 Hz, H-12), 0.940(3H, s, H-24), 0.819(3H, s, H-25), 0.713(3H, s, H-26), 0.951(3H, s, H-27), 0.742(3H, s, H-29), 0.846(3H, s, H-30), 4.832(1H, d, *J* = 7.8 Hz, H-1′), 5.434(1H, d, *J* = 7.2 Hz, H-1″), 5.069(1H, d, *J* = 7.8 Hz, H-1‴), 4.819(1H, d, *J* = 7.8 Hz, H-1⁗), 5.069(1H, d, *J* = 7.8 Hz, H-1⁗′). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.54(C-1), 26.11(C-2), 82.85(C-3), 43.88(C-4), 48.03(C-5), 18.43(C-6), 32.54(C-7), 40.59(C-8), 54.65(C-9), 36.61(C-10), 127.26(C-11), 125.80(C-12), 136.58(C-13), 44.39(C-14), 35.02(C-15), 76.67(C-16), 44.51(C-17), 133.40(C-18), 38.42(C-19), 32.78(C-20), 35.26(C-21), 30.06(C-22), 64.87(C-23), 12.90(C-24), 18.86(C-25), 17.15(C-26), 22.05(C-27), 64.09(C-28), 24.94(C-29), 32.39(C-30), 104.22(C-1′), 77.36(C-2′), 85.14(C-3′), 72.04(C-4′), 70.71(C-5′), 17.48(C-6′), 104.22(C-1″), 76.36(C-2″), 78.98(C-3″), 72.31(C-4″), 77.57(C-5″), 63.25(C-6″), 105.05(C-1‴), 75.31(C-2‴), 78.43(C-3‴), 72.04(C-4‴), 77.23(C-5‴), 70.40(C-6‴), 105.12

(C-1‴), 75.02(C-2‴), 76.71(C-3‴), 80.98(C-4‴), 76.67(C-5‴), 62.01(C-6‴), 105.05(C-1⁗), 74.82(C-2⁗), 78.32(C-3⁗), 71.60(C-4⁗), 78.58(C-5⁗), 62.53(C-6⁗). 与文献[8]对照, 确定其为风轮菜皂苷Ⅴb.

3.10 化合物 **10** 白色粉末, m. p. 249 ~ 250 ℃. Liebermann-Burchard 反应呈阳性. ESI-MS(*m/z*): 1 127.5[M + Na]$^+$, 分子式为 $C_{54}H_{88}O_{23}$. $^1$H-NMR(Pyridin-$d_5$, 600 MHz) $\delta$: 6.388(1H, d, $J$ = 10.2 Hz, H-11), 5.579(1H, d, $J$ = 10.2 Hz, H-12), 4.115(1H, m, H-16), 0.941(3H, s, H-24), 0.821(3H, s, H-25), 0.715(3H, s, H-26), 0.952(3H, s, H-27), 0.778(3H, s, H-29), 0.847(3H, s, H-30), 4.812(1H, d, $J$ = 7.8 Hz, H-1′), 5.437(1H, d, $J$ = 7.8 Hz, H-1″), 5.081(1H, d, $J$ = 7.8 Hz, H-1‴), 4.868(1H, d, $J$ = 7.8 Hz, H-1⁗). $^{13}$C-NMR(Pyridin-$d_5$, 150 MHz) $\delta$: 38.54(C-1), 26.08(C-2), 82.83(C-3), 43.86(C-4), 48.04(C-5), 18.42(C-6), 32.53(C-7), 40.57(C-8), 54.65(C-9), 36.59(C-10), 127.22(C-11), 125.79(C-12), 136.55(C-13), 44.37(C-14), 35.01(C-15), 76.68(C-16), 44.50(C-17), 133.41(C-18), 38.42(C-19), 32.77(C-20), 35.24(C-21), 30.04(C-22), 64.85(C-23), 12.88(C-24), 18.83(C-25), 17.13(C-26), 22.03(C-27), 64.06(C-28), 24.92(C-29), 32.37(C-30), 104.20(C-1′), 77.41(C-2′), 85.03(C-3′), 72.05(C-4′), 70.66(C-5′), 17.40(C-6′), 104.23(C-1″), 76.31(C-2″), 78.94(C-3″), 72.29(C-4″), 77.56(C-5″), 63.24(C-6″), 105.00(C-1‴), 75.28(C-2‴), 78.51(C-3‴), 72.05(C-4‴), 77.23(C-5‴), 70.42(C-6‴), 105.52(C-1⁗), 75.50(C-2⁗), 78.42(C-3⁗), 71.67(C-4⁗), 78.41(C-5⁗), 62.76(C-6⁗). 与文献[8]对照, 确定其为风轮菜皂苷Ⅲb.

综上所述, 本文经柱层析分离, 共从风车草体积分数为85%的乙醇提取物中分离得到10个化合物, 经波谱数据分析, 确定了它们的结构. 其中化合物**4**为二氢黄酮苷类化合物, 化合物**6**为黄酮苷类化合物, 其余化合物均为五环三萜类化合物. 在分离得到的化合物中, 化合物**3**,**6**,**7**,**8**,**9**,**10**均为首次从该植物中分离得到.

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