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北葶苈子黄酮苷类成分研究 Ⅱ

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摘要: 为了解北葶苈子的化学成分, 从其 50% 乙醇提取物中分离鉴定了 8 个单体成分, 经理化性质和波谱数据分析, 分别鉴定为: 槲皮素-3-*O*-β-D-吡喃葡萄糖苷 (**1**)、槲皮素-3-*O*-β-D-葡萄糖醛酸苷 (**2**)、槲皮素-3,7-二-*O*-β-D-葡萄糖苷 (**3**)、槲皮素-3-*O*-β-D-葡萄糖-(1→2)-β-D-葡萄糖苷 (**4**)、quercetin-3-*O*-[2-*O*-(6-*O*-*E*-sinapoyl)-β-D-glucopyranosyl]-β-D-glucopyranoside (**5**)、槲皮素-3-*O*-[(6-*O*-*trans*-咖啡酰基)-β-D-吡喃葡萄糖基(1→2)-β-D-吡喃葡萄糖]-7-*O*-β-D-吡喃葡萄糖苷 (**6**)、isorhamnetin-3-*O*-sophoroside (**7**) 和异鼠李素-3-*O*-β-D-[2-*O*-(6-*O*-芥子酰基)-β-D-吡喃葡萄糖基]-吡喃葡萄糖苷 (**8**)。化合物 **3** 为首次从该种中分离得到, 化合物 **2**、**4**、**6**、**7** 为首次从独行菜属中分离得到, 且化合物 **6** 的 NMR 数据为首次报道。

关键词: 北葶苈子; 化学成分; 黄酮苷
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Flavonoid Glycosides from Seeds of *Lepidium apetalum* Willd. (Ⅱ)

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Abstract: In order to understand the chemical constituents of *Lepidium apetalum* Willd., eight flavonoid glycosides were obtained from 50% EtOH extract of its seeds. On the basis of physicochemical and spectral data, they were identified as quercetin-3-*O*-β-D-glucoside (**1**), quercetin-3-*O*-β-D-glucuronide (**2**), quercetin-3,7-di-*O*-β-D-glucopyranoside (**3**), quercetin-3-*O*-β-D-glucosyl(1→2)-β-D-glucoside (**4**), quercetin-3-*O*-[2-*O*-(6-*O*-*E*-sinapoyl)-β-D-glucopyranosyl]-β-D-glucopyranoside (**5**), quercetin-3-*O*-[(6-*O*-*trans*-caffeoyl)-β-D-glucopyranosyl(1→2)-β-D-glucopyranosyl]-7-*O*-β-D-glucopyranoside (**6**), isorhamnetin-3-*O*-sophoroside (**7**) and isorhamnetin-3-*O*-[2-*O*-(6-*O*-*E*-sinapoyl)-β-D-glucopyranosyl]-β-D-glucopyranoside (**8**). Among them, compound **3** was isolated from this species for the first time, and compounds **2, 4, 6** and **7** were obtained from *Lepidium* genus for the first time. Meanwhile, the NMR data of compound **6** was reported firstly.

Key words: *Lepidium apetalum* seed; Chemical constituent; Flavonoid glycoside

葶苈子为十字花科(Cruciferae)植物独行菜(*Lepidium apetalum* Willd.)和播娘蒿[*Descurainia sophia* (Linn.) Webb. Ex Prantl] 的干燥成熟种子, 因来源不同, 有南北之分, 前者称为“北葶苈子”, 后者称为“南葶苈子”。北葶苈子主要分布于河北、辽宁、内蒙古、吉林等地, 南葶苈子主要分布于江苏、山东、安徽、浙江等地。中医理论认为: 葶苈子味苦、辛, 性大寒, 临床常用于治疗痰涎壅肺, 喘咳痰多, 胸腹水肿, 小便不利等症。现代药理研究表明, 葶苈子具有强心、利尿、抗菌、抗癌、抗衰老等作用[1–2], 但其药效物质和作用机制尚未明确。葶苈子的化学成分主要有脂肪类、黄酮、强心苷、生物碱、类萜类等[2–5], 但缺乏

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系统性研究。我们对北葶苈子 50% 乙醇提取物的化学成分进行研究，从中分离鉴定了 8 个黄酮苷类(图 1)成分。本文重点对其核磁共振波谱数据进行报道，为阐明其作用机制奠定物质基础。

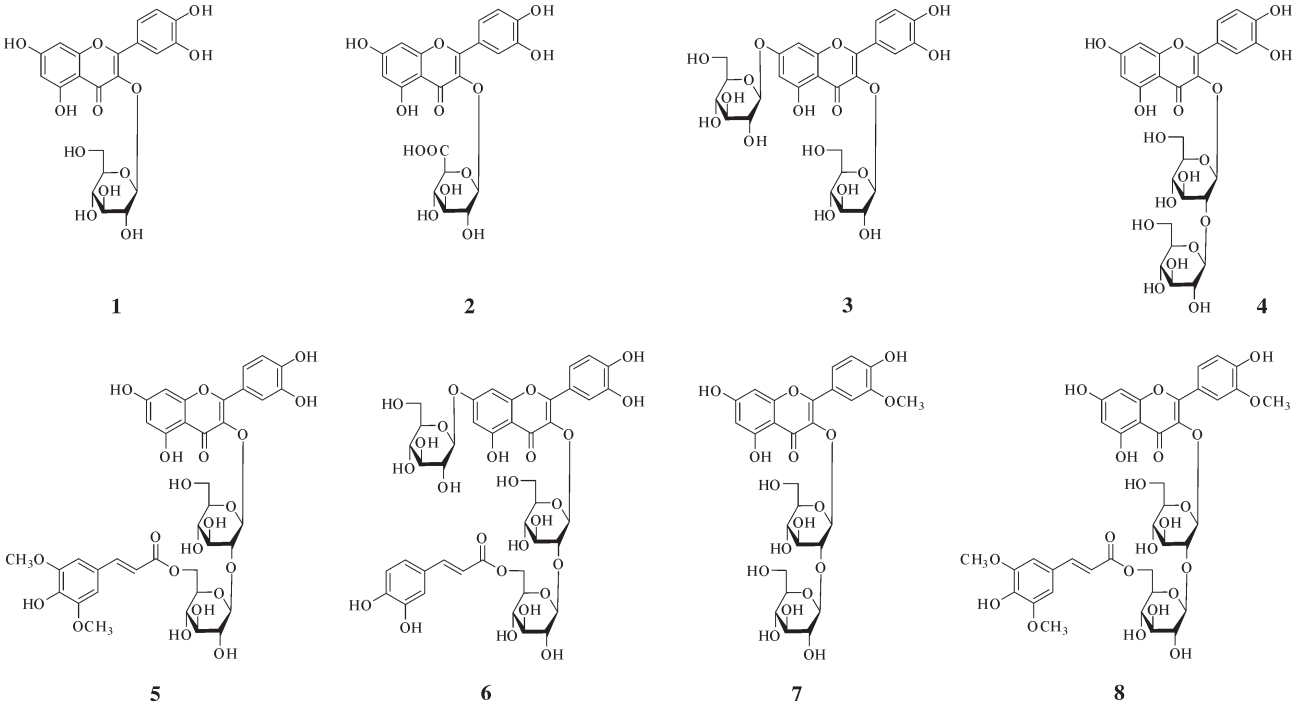

图 1 北葶苈子中化合物 **1**~**8** 的结构

Fig. 1 Structures of compounds **1**–**8** from seeds of *Lepidium apetalum*

1 材料和方法

1.1 材料

北葶苈子采购自河北省安国市，由天津中医药大学李天祥副教授鉴定为十字花科独行菜属独行菜(*Lepidium apetalum* Willd.)的干燥成熟种子。

1.2 仪器和试剂

Bruker 500 MHz NMR 超导核磁共振波谱仪[Avance Ⅲ 500MR(瑞士 Bruker 公司)]；安捷伦 6500 系列四级杆-飞行时间质谱仪[Agilent(美国 Agilent)]；分析型高效液相色谱仪[Waters e2695(美国 Waters)]；制备型高效液相色谱仪[(LC-8A)(日本岛津)]。

D101 大孔吸附树脂(净品级，天津市海光化工有限公司)；柱层析硅胶(100~200 目，青岛海洋化工厂)，Chromatorex ODS MB 100~40/75 (40~75 μm，Fuji Silisia Chemical，Ltd., Japan)；Sephadex LH-20 (Ge Healthcare Bio-Sciences AB，Sweden)；HPLC 用分析柱/制备柱(Cosmosil 5C18-MS-II 250 mm × 4.6 mm i.d./250 mm×20 mm i.d., Nacalai Tesque Inc., Japan)。

色谱纯及分析纯试剂购自天津市康科德科技有限公司。

1.3 提取和分离

干燥北葶苈子 10 kg，用 50% 乙醇(EtOH)加热回流提取 2 次，每次 2 h，减压回收溶剂，得浸膏。浸膏加水溶解，用 $CHCl_3$-H_2O 萃取，将 H_2O 层萃取物除去氯仿层，经 D101 大孔吸附树脂 (H_2O → 95% EtOH)分离。取 95% EtOH 洗脱物(80 g)经硅胶柱层析[$CHCl_3$-MeOH (100∶0 → 100∶5，V/V) → $CHCl_3$-MeOH-H_2O (10∶3∶1→6∶4∶1，下层，V/V/V)→MeOH]，得 Fr. 1~Fr. 16 共 16 个组分。Fr. 11 和 Fr. 12 组分分别经 ODS 柱色谱及制备型高效液相色谱分离，得到化合物 **1** (3.5 mg)、**4** (6.6 mg)、**5** (68.0 mg)、**7** (16.7 mg) 和 **8** (7.0 mg)。Fr. 14 和 Fr. 16 组分采用 Sephadex LH-20 柱色谱结合 PHPLC 的方法分离，

得到化合物 **2** (4.1 mg)、**3** (5.9 mg)和 **6** (18.0 mg)。

1.4 结构鉴定

化合物 1　黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m/z*: 463.0879 $[M-H]^-$ (Calcd for $C_{21}H_{19}O_{12}$, 463.0882, *diff*. 0.65), 分子式为 $C_{21}H_{20}O_{12}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.07 (1H, br. s, H-6), 6.26 (1H, br. s, H-8), 7.56 (2H, m, H-2′and 6′), 6.79 (1H, d, *J* = 8.0 Hz, H-5′), 5.41 (1H, d, *J* = 7.5 Hz, H-1″), 3.09~3.59 (6H, m, H-2″~6″)。^{13}C NMR (125 MHz, DMSO-d_6): δ 156.5 (C-2), 133.0 (C-3), 176.7 (C-4), 161.0 (C-5), 99.4 (C-6), 164.1 (C-7), 93.9 (C-8), 155.6 (C-9), 102.6 (C-10), 120.7 (C-1′), 115.8 (C-2′), 145.0 (C-3′), 149.0 (C-4′), 115.1 (C-5′), 121.4 (C-6′), 101.2 (C-1″), 74.1 (C-2″), 76.5 (C-3″), 69.9 (C-4″), 77.4 (C-5″), 60.9 (C-6″)。以上波谱数据与文献[6]报道基本一致 , 鉴定该化合物为槲皮素-3-*O*-β-D-吡喃葡萄糖苷。

化合物 2　黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m/z*: 477.0675 $[M-H]^-$ (Calcd for $C_{21}H_{17}O_{13}$, 477.0675, *diff*. –0.08), 分子式为 $C_{21}H_{18}O_{13}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.20 (1H, br. s, H-6), 6.39 (1H, br. s, H-8), 8.30 (1H, d, *J* = 1.5 Hz, H-2′), 6.83 (1H, d, *J* = 8.0 Hz, H-5′), 7.35 (1H, dd, *J* = 1.5, 8.0 Hz, H-6′), 5.24 (1H, d, *J* = 7.0 Hz, H-1″), 3.17~3.51 (4H, m, H-2″~5″)。^{13}C NMR (125 MHz, DMSO-d_6): δ 157.6 (C-2), 134.0 (C-3), 177.5 (C-4), 160.9 (C-5), 98.9 (C-6), 164.6 (C-7), 93.7 (C-8), 156.4 (C-9), 103.6 (C-10), 120.5 (C-1′), 118.0 (C-2′), 144.8 (C-3′), 148.4 (C-4′), 115.3 (C-5′), 120.4 (C-6′), 103.0 (C-1″), 74.1 (C-2″, 5″), 76.6 (C-3″), 71.7 (C-4″), 171.9 (C-6″)。以上波谱数据与文献[7]报道基本一致,鉴定该化合物为槲皮素-3-*O*-β-D-葡萄糖醛酸苷。

化合物 3　黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m/z*: 625.1418 $[M-H]^-$ (Calcd for $C_{27}H_{29}O_{17}$, 625.1410, *diff*. –1.24), 分子式为 $C_{27}H_{30}O_{17}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.44 (1H, br. s, H-6), 6.76 (1H, br. s, H-8), 7.61 (1H, d, *J* = 1.5 Hz, H-2′), 6.87 (1H, d, *J* = 8.5 Hz, H-5′), 7.58 (1H, dd, *J* = 1.5, 8.5 Hz, H-6′), 5.49 (1H, d, *J* = 7.5 Hz, H-1″), 5.09 (1H, d, *J* = 7.5 Hz, H-1‴), 3.09~3.71 (12H, m, H-2″~6″, 2‴~6‴)。^{13}C NMR (125 MHz, DMSO-d_6): δ 156.8 (C-2), 133.5 (C-3), 177.5 (C-4), 160.8 (C-5), 99.2 (C-6), 162.7 (C-7), 94.2 (C-8), 155.9 (C-9), 105.5 (C-10), 120.9 (C-1′), 116.3 (C-2′), 144.8 (C-3′), 148.6 (C-4′), 115.1 (C-5′), 121.5 (C-6′), 100.6 (C-1″), 74.0 (C-2″), 76.4 (C-3″), 69.8 (C-4″), 77.5 (C-5″), 60.9 (C-6″), 99.6 (C-1‴), 73.0 (C-2‴), 76.3 (C-3‴), 69.5 (C-4‴), 77.1 (C-5‴), 60.5 (C-6‴)。以上波谱数据与文献[8]报道基本一致,鉴定该化合物为槲皮素-3,7-二-*O*-β-D-葡萄糖苷。

化合物 4　黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m/z*: 625.1421 $[M-H]^-$ (Calcd for $C_{27}H_{29}O_{17}$, 625.1410, *diff*. –1.72), 分子式为 $C_{27}H_{30}O_{17}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.20 (1H, br. s, H-6), 6.41 (1H, br. s, H-8), 7.56 (1H, br. s, H-2′), 6.88 (1H, d, *J* = 8.5 Hz, H-5′), 7.60 (1H, br. d, ca. *J* = 9 Hz, H-6′), 5.70 (1H, d, *J* = 7.5 Hz, H-1″), 3.53 (1H, dd, *J* = 7.5, 8.0 Hz, H-2″), 3.48 (1H, dd, *J* = 8.0, 8.0 Hz, H-3″), 3.15 (1H, dd, *J* = 8.0, 9.5 Hz, H-4″), 3.13 (1H, m, H-5″), [3.29 (1H, dd, *J* = 5.0, 11.5 Hz), 3.55 (1H, m, overlapped), H_2-6″, 4.61 (1H, d, *J* = 8.0 Hz, H-1‴), 3.08 (1H, dd, *J* = 8.0, 8.0 Hz, H-2‴), 3.19 (1H, dd, *J* = 8.0, 9.0 Hz, H-3‴), 3.18 (1H, dd, *J* = 9.0, 9.0 Hz, H-4‴), 3.10 (1H, m, H-5‴), [3.50 (1H, dd, *J* = 6.0, 14.0 Hz), 3.55 (1H, m, overlapped), H_2-6‴]。^{13}C NMR (125 MHz, DMSO-d_6): δ 155.4 (C-2), 132.9 (C-3), 177.3 (C-4), 161.2 (C-5), 98.6 (C-6), 164.2 (C-7), 93.4 (C-8), 156.2 (C-9), 103.7 (C-10), 121.0 (C-1′), 116.0 (C-2′), 144.7 (C-3′), 148.4 (C-4′), 115.3 (C-5′), 121.7 (C-6′), 97.9 (C-1″), 82.6 (C-2″), 76.4 (C-3″), 69.4 (C-4″), 76.7 (C-5″), 60.5 (C-6″), 104.1 (C-1‴), 74.3 (C-2‴), 76.4 (C-3‴), 69.5 (C-4‴), 77.4(C-5‴), 60.6 (C-6‴)。以上波谱数据与文献[9]报道基本一致,鉴定该化合物为槲皮素-3-*O*-β-D-葡萄糖-(1→2)-β-D-葡萄糖苷。同时,通过 2D-NMR 谱的解析,对文献中报道的 C-2、9、10、2′、5′、1‴位碳谱数据进行了更正。

化合物 5　黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m/z*: 831.2013 $[M-H]^-$ (Calcd for $C_{38}H_{39}O_{21}$, 831.1989, *diff*. –2.85), 分子式为 $C_{38}H_{40}O_{21}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.20 (1H, br. s, H-6), 6.31 (1H, br. s, H-8), 7.58 (1H, br. s, H-2′), 6.92 (1H, d, *J* = 8.5 Hz, H-5′), 7.64 (1H, br. d, ca. *J* = 9 Hz, H-6′), 5.73 (1H, d, *J* = 7.5 Hz, H-1″),

3.55 (2H, m, overlapped, H-2″, 3″), 3.19 (1H, dd, *J* = 9.0, 9.0 Hz, H-4″), 3.15 (1H, m, H-5″), [3.34 (1H, m, overlapped), 3.55 (1H, m, overlapped), H_2-6″], 4.73 (1H, d, *J* = 7.5 Hz, H-1‴), 3.22 (1H, dd, *J* = 7.5, 8.0 Hz, H-2‴), 3.32 (1H, dd, *J* = 8.0, 8.0 Hz, H-3‴), 3.31 (1H, dd, *J* = 8.0, 8.0 Hz, H-4‴), 3.56 (1H, m, H-5‴), [4.25 (1H, br. d, ca. *J* = 12 Hz), 4.33 (1H, dd, *J* = 5.0, 12.0 Hz), H_2-6‴], 6.83 (2H, s, H-2⁗, 6⁗), 7.41 (1H, d, *J* = 16.0 Hz, H-7′′′′), 6.30 (1H, d, *J* = 16.0 Hz, H-8′′′′), 3.78 (6H, s, 3⁗, 5⁗-OCH_3)。^{13}C NMR (125 MHz, DMSO-d_6): δ 155.5 (C-2), 133.0 (C-3), 177.4 (C-4), 161.2 (C-5), 98.5 (C-6), 163.9 (C-7), 93.4 (C-8), 156.1 (C-9), 103.9 (C-10), 121.2 (C-1′), 116.1 (C-2′), 144.8 (C-3′), 148.4 (C-4′), 115.3 (C-5′), 121.9 (C-6′), 97.9 (C-1″), 83.3 (C-2″), 76.4 (C-3″), 69.5 (C-4″), 77.4 (C-5″), 60.5 (C-6″), 104.4 (C-1‴), 74.5 (C-2‴), 76.3 (C-3‴), 69.5 (C-4‴), 73.9 (C-5‴), 63.1 (C-6‴), 124.3 (C-1⁗), 105.9 (C-2⁗, 6⁗), 147.9 (C-3′′′′, 5′′′′), 138.2 (C-4′′′′), 145.2 (C-7′′′′), 114.4 (C-8′′′′), 166.5 (C-9′′′′), 55.9 (3⁗, 5⁗-OCH_3)。以上波谱数据与文献[10]报道基本一致，鉴定该化合物为 quercetin-3-*O*-[2-*O*-(6-*O*-*E*-sinapoyl)-β-D-glucopyranosyl]-β-D-glucopyranoside。同时，通过 2D-NMR 谱的解析，对文献中报道的 C-2′、5′ 位碳谱数据进行了更正。

化合物 6 黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m*/*z*: 949.2258 $[M - H]^-$ (Calcd for $C_{42}H_{45}O_{25}$, 949.2255, *diff.* −0.27), 分子式为 $C_{42}H_{46}O_{25}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.40 (1H, d, *J* = 1.5 Hz, H-6), 6.64 (1H, d, *J* = 1.5 Hz, H-8), 7.62 (1H, br. s, H-2′), 6.89 (1H, d, *J* = 9.0 Hz, H-5′), 7.61 (1H, br. d, ca. *J* = 9 Hz, H-6′), 5.73 (1H, d, *J* = 7.5 Hz, H-1″), 3.50 (2H, m, H-2″, 3″), 3.19 (1H, d, *J* = 9.0, 9.0 Hz, H-4″), 3.11 (1H, m, overlapped, H-5″), [3.27 (1H, dd, *J* = 6.0, 11.0 Hz), 3.49 (1H, m, overlapped), H_2-6″], 4.67 (1H, d, *J* = 8.0 Hz, H-1′′′′), 3.15 (1H, dd, *J* = 8.0, 8.0 Hz, H-2′′′′), 3.26 (1H, dd, *J* = 8.0, 8.0 Hz, H-3′′′′), 3.19 (1H, dd, *J* = 9.0, 9.0 Hz, H-4′′′′), 3.49 (1H, m, overlapped, H-5′′′′), [4.18 (1H, dd, *J* = 5.0, 11.5 Hz), 4.22 (1H, br. d, ca. *J* = 11 Hz), H_2-6′′′′], 6.90 (1H, d, *J* = 1.5 Hz, H-2′′′′), 6.71 (1H, d, *J* = 8.5 Hz, H-5′′′′), 6.78 (1H, dd, *J* = 1.5, 8.5 Hz, H-6′′′′), 7.30 (1H, d, *J* = 16.0 Hz, H-7′′′′), 6.00 (1H, d, *J* = 16.0 Hz, H-8′′′′), 5.05 (1H, d, *J* = 7.5 Hz, H-1′′′′′), 3.26 (1H, dd, *J* = 7.5, 8.0 Hz, H-2′′′′′), 3.33 (1H, dd, *J* = 8.5, 9.0 Hz, H-3′′′′′), 3.19 (1H, m, overlapped, H-4′′′′′), 3.47 (1H, m, H-5′′′′′), [3.49 (1H, m, overlapped), 3.71 (1H, br. d, ca. *J* = 11 Hz), H_2-6′′′′′]。^{13}C NMR (125 MHz, DMSO-d_6): δ 155.7 (C-2), 133.1 (C-3), 177.4 (C-4), 160.7 (C-5), 99.1 (C-6), 162.5 (C-7), 94.1 (C-8), 155.9 (C-9), 105.4 (C-10), 120.9 (C-1′), 116.3 (C-2′), 144.8 (C-3′), 148.7 (C-4′), 115.2 (C-5′), 121.8 (C-6′), 97.7 (C-1″), 83.7 (C-2″), 76.3 (C-3″), 69.4 (C-4″), 77.5 (C-5″), 60.4 (C-6″), 104.5 (C-1‴), 74.4 (C-2‴), 76.1 (C-3‴), 69.5 (C-4‴), 73.9 (C-5‴), 63.2 (C-6‴), 125.3 (C-1⁗), 114.9 (C-2⁗), 145.3 (C-3⁗), 148.2 (C-4⁗), 115.6 (C-5⁗), 120.9 (C-6⁗), 144.9 (C-7⁗), 113.5 (C-8⁗), 166.4 (C-9⁗), 99.6 (C-1′′′′), 73.0 (C-2′′′′), 76.3 (C-3′′′′), 69.5 (C-4′′′′), 77.0 (C-5′′′′), 60.5 (C-6′′′′)，结合 ^{1}H-^{1}H COSY、HSQC、HMBC 等 2D-NMR 谱鉴定该化合物为槲皮素-3-*O*-[(6-*O*-*trans*-咖啡酰基)-β-D-吡喃葡萄糖基(1→2)-β-D-吡喃葡萄糖]-7-*O*-β-D-吡喃葡萄糖苷，其核磁共振波谱数据为首次报道。

化合物 7 黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m*/*z*: 639.1568 $[M - H]^-$ (Calcd for $C_{28}H_{31}O_{17}$, 639.1567, *diff.* −0.20), 分子式为 $C_{28}H_{32}O_{17}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.20 (1H, br. s, H-6), 6.45 (1H, br. s, H-8), 7.81 (1H, d, *J* = 1.5 Hz, H-2′), 6.93 (1H, d, *J* = 8.5 Hz, H-5′), 7.62 (1H, dd, *J* = 1.5, 8.5 Hz, H-6′), 5.76 (1H, d, *J* = 7.0 Hz, H-1″), 3.52 (2H, m, H-21″, 31″), 3.15 (1H, dd, *J* = 9.0, 9.0 Hz, H-4″), 3.14 (1H, m, H-5″), [3.33 (1H, dd, *J* = 4.5, 11.5 Hz), 3.54 (1H, m, overlapped), H_2-6″], 4.62 (1H, d, *J* = 7.5 Hz, H-1‴), 3.08 (1H, dd, *J* = 7.5, 8.0 Hz, H-2‴), 3.18 (1H, dd, *J* = 8.0, 9.0 Hz, H-3‴), 3.13 (1H, dd, *J* = 9.0, 9.0 Hz, H-4‴), 3.07 (1H, m, H-5‴), [3.44 (1H, dd, *J* = 5.0, 11.5 Hz), 3.53 (1H, m, overlapped), H_2-6‴], 3.86 (3H, s, 3′-OCH_3)。^{13}C NMR (125 MHz, DMSO-d_6): δ 155.8 (C-2), 132.8 (C-3), 177.3 (C-4), 161.2 (C-5), 98.7 (C-6), 164.5 (C-7), 93.7 (C-8), 156.3 (C-9), 103.8 (C-10), 121.1 (C-1′), 113.1 (C-2′), 147.0 (C-3′), 149.5 (C-4′), 115.3 (C-5′), 122.7 (C-6′), 98.2 (C-1″), 82.0 (C-2″), 76.5 (C-3″), 69.5 (C-4″), 77.3 (C-5″), 60.5 (C-6″), 103.4 (C-1‴), 74.2 (C-2‴), 76.5

(C-3‴), 69.8 (C-4‴), 76.7 (C-5‴), 60.8 (C-6‴), 55.8 (3′-OCH_3)。以上波谱数据与文献[11]报道基本一致，结合 ^{1}H-^{1}H COSY、HMBC 等二维谱鉴定该化合物为 isorhamnetin-3-*O*-sophoroside。

化合物 8　黄色粉末。高分辨 Q-TOF-ESI-MS 准分子离子峰 *m*/*z*: 845.2174 [M – H]$^-$ (Calcd for $C_{39}H_{41}O_{21}$, 845.2146, *diff*. –3.33), 分子式为 $C_{39}H_{42}O_{21}$。^{1}H NMR (500 MHz, DMSO-d_6): δ 6.16 (1H, br. s, H-6), 6.34 (1H, br. s, H-8), 7.77 (1H, d, *J* = 1.5 Hz, H-2′), 6.89 (1H, d, *J* = 8.0 Hz, H-5′), 7.55 (1H, dd, *J* = 1.5, 8.0 Hz, H-6′), 5.74 (1H, d, *J* = 7.0 Hz, H-1″), 4.72 (1H, d, *J* = 7.5 Hz, H-1‴), 6.84 (2H, s, H-2⁗, 6⁗), 7.40 (1H, d, *J* = 15.5 Hz, H-7⁗), 6.32 (1H, d, *J* = 15.5 Hz, H-8⁗), 3.11~3.59 (12H, m, H-2″~6″, 2‴~6‴), 3.74 (6H, s, 3‴, 5⁗-OCH_3), 3.83 (3H, s, 3′-OCH_3)。^{13}C NMR (125 MHz, DMSO-d_6): δ 155.7 (C-2), 132.7 (C-3), 177.2 (C-4), 161.1 (C-5), 98.6 (C-6), 164.4 (C-7), 93.6 (C-8), 156.2 (C-9), 103.7 (C-10), 121.0 (C-1′), 113.0 (C-2′), 146.9 (C-3′), 149.4 (C-4′), 115.2 (C-5′), 122.6 (C-6′), 97.9 (C-1″), 82.1 (C-2″), 76.4 (C-3″), 69.4 (C-4″), 77.2 (C-5″), 60.2 (C-6″), 103.3 (C-1‴), 74.2 (C-2‴), 76.3 (C-3‴), 69.5 (C-4‴), 73.8 (C-5‴), 63.2 (C-6‴), 124.2 (C-1⁗), 105.9 (C-2⁗, 6⁗), 147.8 (C-3⁗, 5⁗), 138.1 (C-4⁗), 145.2 (C-7⁗), 114.4 (C-8⁗), 166.4 (C-9⁗), 55.9 (3⁗, 5⁗-OCH_3), 55.8 (3′-OCH_3)。以上波谱数据与文献[12]报道基本一致，鉴定该化合物为异鼠李素-3-*O*-β-D-[2-*O*-(6-*O*-芥子酰基)-β-D-吡喃葡萄糖基]-吡喃葡萄糖苷。

2 结果和讨论

我国南北葶苈资源丰富，葶苈子作为常用中草药在民间广泛使用且疗效显著。但至今，葶苈子的临床使用仍是在单一的中医理论的指导下进行。为丰富其作用机制，从而更加科学、有效、合理地应用于临床，本文从药效物质基础出发，首先对其化学成分进行了系统研究。

利用正相硅胶、反相 ODS 及 Sephadex LH-20 柱色谱和高效液相色谱制备等分离手段，从北葶苈子 50% 乙醇提取物中分离得到了 8 个黄酮苷类单体成分。通过光谱分析及文献对照，他们分别鉴定为槲皮素-3-*O*-β-D-吡喃葡萄糖苷 (**1**)、槲皮素-3-*O*-β-D-葡萄糖醛酸苷 (**2**)、槲皮素-3,7-二-*O*-β-D-葡萄糖苷 (**3**)、槲皮素-3-*O*-β-D-葡萄糖-(1→2)-β-D-葡萄糖苷 (**4**)、quercetin-3-*O*-[2-*O*-(6-*O*-*E*-sinapoyl)-β-D-glucopyranosyl]-β-D-glucopyranoside (**5**)、槲皮素-3-*O*-[(6-*O*-*trans*-咖啡酰基)-β-D-吡喃葡萄糖基(1→2)-β-D-吡喃葡萄糖]-7-*O*-β-D-吡喃葡萄糖苷 (**6**)，isorhamnetin-3-*O*-sophoroside (**7**)、异鼠李素-3-*O*-β-D-[2-*O*-(6-*O*-芥子酰基)-β-D-吡喃葡萄糖基]-吡喃葡萄糖苷 (**8**)。化合物 **3** 为首次从该种中分离得到，化合物 **2**、**4**、**6** 和 **7** 为首次从独行菜属中分离得到，并对化合物 **6** 的 NMR 数据进行了首次报道。

黄酮类化合物，结构复杂多样，具有多种生物活性，如抗氧化、抗癌、抗肿瘤、抗心血管疾病等[13]。据文献报道，化合物 **1**、**2** 和 **4** 均有较强的抗氧化活性[14–16]。本研究进一步完善了北葶苈子的物质基础，为其活性成分的研究和作用机制的阐述奠定基础。

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