# Compounds from the ethyl acetate extract of *Pteris multifida* Poir. collected in Nam Dinh province, Vietnam

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Received 14 September 2022; revised 14 October 2022; accepted 20 October 2022

***Abstract:***

***Pteris multifida* Poir. is an evergreen herbaceous fern that is distributed in temperate and tropical regions of East Asia and cultivated in many other countries. It is an ethnomedicinal plant used for detoxicating, cooling, reducing pain, and as a treatment for many diseases like dysentery, typhoid, cholecystitis, diarrhoea, enteritis, jaundice, and eczema among others. Several compounds including flavonoids, sesquiterpenoids, diterpenoids, coumarins, lignans, and sterols with anti-spasmodic, anti-bacterial, anti-hyperlipidemic, anti-oxidative, and cytotoxic activities have been isolated from this plant. In the present study, three sesquiterpenoids, (2*S*,3*S*)-pretosin Q (1), (2*R*,3*S*)-pterosin C (2), (2*S*,3*S*)-pterosin C (3); two lignans, pinoresinol (4); lariciresinol 9-O-β-glucopyranoside (5), three flavonoids, naringenin (6), apigenin (7), and luteolin (8) were obtained from the ethyl acetate extract of the whole of *P. multifida* collected in Nam Dinh province, Vietnam. The chemical structures were elucidated by various spectroscopic means including one- and two-dimensional (1D, 2D)-NMR, mass spectrometry, and comparison with published data. Compounds 4-6 were isolated from *P. multifida* for the first time.**

***Keywords:*** **flavonoid, lignan, *Pteris multifida* Poir., sesquiterpenoid.**

***Classification numbers:*** **2.2, 3.4**

## 1. Introduction

The genus *Pteris* is a large member of the family *Pteridaceae*. It contains about 250 species that mostly occur in the tropical and subtropical regions of the world, with about 28 species found in Vietnam [1]. Some *Pteris* species have been utilised in folk medicines, as food sources, and as phytoremediations [2]. *P. multifida*, an evergreen herbaceous fern, is native to temperate and tropical regions of East Asia and cultivated in many other countries. This plant grows extensively throughout the north and middle regions of Vietnam and is most commonly found in damp and shady locations. *P. multifida* is traditionally used for detoxicating, cooling, reducing pain, and as a treatment for many diseases like dysentery, typhoid, cholecystitis, diarrhoea, enteritis, jaundice, and eczema among others [3]. Pharmacological properties of *P. multifida* include anti-tumour, anti-inflammatory, anti-hyperlipidaemic, antimutagenic, and free radical-scavenging activities [4-7]. Previously, the presence of flavonoids, sesquiterpenoids, diterpenoids, coumarins, lignans, and sterols has been reported in this plant [8-14]. We report herein the isolation and structural elucidation of eight compounds from the ethyl acetate extract of the entire the whole of *P. multifida* fern collected in the Nam Dinh province, Vietnam. Their structures were identified as (2*S*,3*S*)-pretosin Q (**1**), (2*R*,3*S*)-pterosin C (**2**), (2*S*,3*S*)-pterosin C (**3**), pinoresinol (**4**), lariciresinol 9-O-β-glucopyranoside (**5**), naringenin (**6**), apigenin (**7**), and luteolin (**8**) by spectral analysis and comparison with spectroscopic data reported in previous literature.

## 2. Materials and methods

### *2.1. General experimental procedures*

NMR spectra were recorded with a Bruker Avance II spectrometer at 600 MHz ($^1$H-NMR) and 150 MHz ($^{13}$C-NMR) using TMS as an internal reference. Mass spectra were carried out on an Agilent LC-MSD-Trap SL system mass spectrometer. Thin layer chromatography was performed on silica gel 60F254 and Rp-18 F254s, and spots were detected with UV light (254 and 365 nm) and then sprayed with a solution of vanillin/sulfuric acid followed by heating to 110°C. Silica gel 60 (0.063-0.2 mm), Sephadex LH-20 (25-100 μm), and silica gel Rp-18 (40-63 μm) were used for normal pressure column chromatography.

### *2.2. Plant material*

The whole *P. multifida* plant was collected in the Nam Truc district, Nam Dinh province, Vietnam, in May 2021 and identified

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by Prof. Do Huu Thu, Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology (VAST). The specimens were kept at the Laboratory of Natural Products Research, Institute of Chemistry, VAST, Hanoi, Vietnam.

### *2.3. Extraction and isolation*

The dried whole plant (1600 g) of *P. multifida* was ground and extracted with methanol-water (95:5, v/v) three times at room temperature. After removing the solvent under vacuum, the concentrated extract was successively partitioned with n-hexane, ethyl acetate, and n-butanol, respectively. The EtOAc-soluble fraction (22 g) was subjected to silica gel chromatography eluted with gradient mixtures of $CH_2Cl_2$-MeOH (from 10:0 to 4:1, v/v) to give ten fractions (PE1-PE10). Fraction PE3 was re-chromatographed on a silica gel column (n-hexane-acetone, 3.5:2) to afford compound **6** (7 mg). Fraction PE4 was further purified on a silica gel column (n-hexane-acetone, 3:2, v/v) and then on a Sephadex LH-20 column ($CH_2Cl_2$-MeOH, 1:9, v/v) to give compounds **4** (10 mg) and **7** (3 mg). Fraction PE6 was re-chromatographed on a silica gel column ($CH_2Cl_2$-MeOH, 10:1, v/v) to give four sub-fractions (PE6.1-PE6.4). Sub-fraction PE6.2 was purified on a silica gel column (n-hexane-acetone, 2.5:2, v/v) to yield mixture compounds **2** and **3** (12 mg). Sub-fraction PE6.3 was purified on a silica gel column (n-hexane-acetone, 2.5:2, v/v) to afford compound **1** (10 mg). Fraction PE7 was purified on a silica gel column ($CH_2Cl_2$-MeOH, 15:1, v/v) to give compound **8** (6 mg). Compound **5** (6 mg) was obtained from fraction PE8 through column chromatography on silica gel ($CH_2Cl_2$-MeOH-$H_2O$, 9:1:0.1, v/v), then silica gel Rp-18 (MeOH-$H_2O$, 1:1).

*(2S,3S)-Pretosin Q* ***(1)****:* White powder. ESI-MS *m/z* 251.2 $[M+H]^+$. $^1$H-NMR (600 MHz, $CD_3OD$): $\delta_H$ 7.36 (1H, s, H-4), 5.34 (1H, dd, *J*=8.4, 5.4 Hz, H-12), 4.70 (1H, d, *J*=4.2 Hz H-3), 3.94 (1H, dd, *J*=11.4, 8.4 Hz, H-13a), 3.65 (1H, dd, *J*=11.4, 5.4 Hz, H-13b), 2.77 (3H, s, H-14), 2.59 (3H, s, H-11), 2.49-2.45 (1H, m, H-2), 1.32 (3H, d, *J*=7.2 Hz, H-10). $^{13}$C-NMR (150 MHz, $CD_3OD$): $\delta_C$ 207.52 (C-1), 155.34 (C-9), 146.43 (C-5), 140.33 (C-7), 138.66 (C-6), 132.81 (C-8), 126.69 (C-4), 75.74 (C-3), 72.73 (C-12), 65.56 (C-13), 54.79 (C-2), 22.35 (C-11), 15.06 (C-14), 13.26 (C-10).

*(2R,3S)-Pterosin C* ***(2)****:* ESI-MS *m/z* 235.3 $[M+H]^+$. $^1$H-NMR (600 MHz, $CD_3OD$): $\delta_H$ 7.38 (1H, s, H-4), 5.16 (1H, d, *J*=6.6 Hz, H-3), 3.63 (2H, t, *J*=7.8 Hz, H-13), 3.03 (2H, t, *J*=7.8 Hz, H-12), 2.79-2.74 (1H, m, H-2), 2.66 (3H, s, H-14), 2.49 (3H, s, H-11), 1.19 (3H, d, *J*=7.2 Hz, H-10). $^{13}$C-NMR (150 MHz, $CD_3OD$): $\delta_C$ 210.31 (C-1), 155.13 (C-9), 146.24 (C-5), 138.54 (C-7), 138.07 (C-6), 132.22 (C-8), 126.68 (C-4), 70.23 (C-3), 61.61 (C-13), 49.66 (C-2), 33.04 (C-12), 21.37 (C-11), 14.00 (C-14), 10.70 (C-10).

*(2S,3S)-Pterosin C* ***(3)****:* ESI-MS *m/z* 235.3 $[M+H]^+$. $^1$H-NMR (600 MHz, $CD_3OD$): $\delta_H$ 7.37 (1H, s, H-4), 4.70 (1H, d, *J*=4.2 Hz, H-3), 3.62 (2H, t, *J*=7.8 Hz, H-13), 3.02 (2H, t, *J*=7.8 Hz, H-12), 2.66 (3H, s, H-14), 2.49 (3H, s, H-11), 2.48-2.43 (1H, m, H-2), 1.32 (3H, d, *J*=7.2 Hz, H-10). $^{13}$C-NMR (150 MHz, $CD_3OD$): $\delta_C$ 207.59 (C-1), 154.53 (C-9), 146.24 (C-5), 138.21 (C-7), 137.85 (C-6), 132.39 (C-8), 125.63 (C-4), 75.90 (C-3), 61.61 (C-13), 54.68 (C-2), 33.04 (C-12), 21.41 (C-11), 14.07 (C-14), 13.28 (C-10).

*Pinoresinol* ***(4)****:* White powder. ESI-MS *m/z* 359.3**.** $^1$H-NMR (600 MHz, DMSO-$d_6$): $\delta_H$ 6.88 (2H, d, *J*=1.8 Hz, H-2, H-2′), 6.75 (2H, dd, *J*=8.4, 1.8 Hz, H-6, H-6′), 6.72 (2H, d, *J*=8.4 Hz, H-5, H-5′), 4.60 (2H, d, *J*=4.2 Hz, H-7, H-7′), 4.11 (2H, dd, *J*=9.0, 6.6 Hz, H-9a, H-9′a), 3.76 (6H, s, 2x$OCH_3$), 3.72 (2H, dd, *J*=9.0, 4.2 Hz, H-9b, H-9′b), 3.04-3.02 (2H, m, H-8, H-8′). $^{13}$C-NMR (150 MHz, DMSO-$d_6$): $\delta_C$ 147.50 (C-3, C-3′), 145.88 (C-4, C-4′), 132.21 (C-1, C-1′), 118.61 (C-6, C-6′), 115.11 (C-5, C-5′), 110.39 (C-2, C-2′), 85.13 (C-7, C-7′), 70.87 (C-9, C-9′), 55.58 (2x$OCH_3$), 53.56 (C-8, C-8′).

*Lariciresinol 9-O-β-glucopyranoside* ***(5)****:* White powder. ESI-MS *m/z* 545.3 $[M+Na]^+$. $^1$H-NMR (600 MHz, $CD_3OD$): $\delta_H$ 6.95 (1H, d, *J*=1.8 Hz, H-2), 6.82 (1H, dd, *J*=7.8, 1.8 Hz, H-6), 6.81 (1H, d, *J*=1.8 Hz, H-2′), 6.78 (1H, d, *J*=7.8 Hz, H-5), 6.73 (1H, d, *J*=8.4 Hz, H-5′), 6.67 (1H, dd, *J*=8.4, 1.8 Hz, H-6′), 4.32 (1H, d, *J*=7.8 Hz, H-1″), 4.23 (1H, dd, *J*=9.6, 7.2 Hz, H-9a), 3.99 (1H, dd, *J*=8.4, 6.6 Hz, H-9′a), 3.89 (1H, dd, *J*=11.4, 1.8 Hz, H-6″a), 3.87 (3H, s, $OCH_3$), 3.86 (3H, s, $OCH_3$), 3.76 (1H, dd, *J*=8.4, 6.6 Hz, H-9′b), 3.69 (1H, dd, *J*=11.4, 5.4 Hz, H-6″b), 3.62 (1H, dd, *J*=9.6, 6.0 Hz, H-9b), 3.38-3.36 (1H, m, H-3″), 3.32-3.30 (2H, m, H-4″, H-5″), 3.27-3.24 (1H, m, H-2″), 3.02 (1H, dd, *J*=13.8, 4.8 Hz, H-7′a), 2.78-2.75 (1H, m, H-8′), 2.57-2.51 (2H, m, H-7′b, H-8). $^{13}$C-NMR (150 MHz, $CD_3OD$): $\delta_C$ 149.00 (C-3, C-3′), 147.07 (C-4), 145.76 (C-4′), 135.65 (C-1), 133.82 (C-1′), 122.19 (C-6′), 119.89 (C-5), 116.19 (C-5′), 115.99 (C-6), 113.52 (C-2′), 110.80 (C-2), 104.60 (C-1″), 84.15 (C-7), 78.29 (C-3″), 78.04 (C-5″), 75.18 (C-2″), 73.69 (C-9′), 71.71 (C-4″), 68.47 (C-9), 62.84 (C-6″), 56.45, 56.44 (2x$OCH_3$), 51.70 (C-8), 44.04 (C-8′), 33.72 (C-7′).

*Naringenin* ***(6)****:* White powder. $^1$H-NMR (600 MHz, DMSO-$d_6$): $\delta_H$ 12.15 (1H, s, 5-OH), 7.31 (2H, d, *J*=9.0 Hz, H-2′, H-6′), 6.79 (2H, d, *J*=9.0 Hz, H-3′, H-5′), 5.88 (1H, d, *J*=2.4 Hz, H-8), 5.87 (1H, d, *J*=2.4 Hz, H-6), 5.44 (1H, dd, *J*=12.6, 3.0 Hz, H-2), 3.26 (1H, dd, *J*=16.8, 12.6 Hz, H-3a), 2.67 (1H, dd, *J*=16.8, 3.0 Hz, H-3b). $^{13}$C-NMR (150 MHz, DMSO-$d_6$): $\delta_C$ 196.40 (C-4), 166.63 (C-7), 163.47 (C-5), 162.93 (C-9), 157.71 (C-4′), 128.84 (C-1′), 128.33 (C-2′, C-6′), 115.14 (C-3′, C-5′), 101.75 (C-10), 95.76 (C-6), 94.94 (C-8), 78.41 (C-2), 41.95 (C-3).

*Apigenin* ***(7)****:* Yellow powder. $^1$H-NMR (600 MHz, $CD_3OD$): $\delta_H$ 7.87 (2H, d, *J*=8.4 Hz, H-2′, H-6′), 6.95 (2H, d, *J*=8.4 Hz, H-3′, H-5′), 6.61 (1H, s, H-3), 6.48 (1H, d, *J*=1.8 Hz, H-8), 6.23 (1H, d, *J*=1.8 Hz, H-6). $^{13}$C-NMR (150 MHz, $CD_3OD$): $\delta_C$ 184.05 (C-4), 166.14 (C-7), 166.27 (C-2), 163.23 (C-5), 162.67 (C-4′), 159.53 (C-9), 129.53 (C-2′, C-6′), 123.28 (C-1′), 117.11 (C-3′, C-5′), 105.32 (C-10), 102.87 (C-3), 100.17 (C-6), 94.97 (C-8).

*Luteolin* ***(8)****:* Yellow powder. $^1$H-NMR (600 MHz, $CD_3OD$): $\delta_H$ 7.40 (1H, dd, *J*=7.8, 2.4 Hz, H-6′), 7.39 (1H, d, *J*=2.4 Hz, H-2′), 6.92 (1H, d, *J*=7.8 Hz, H-5′), 6.55 (1H, s, H-3), 6.45 (1H, d, *J*=1.8

Hz, H-8), 6.22 (1H, d, *J*=1.8 Hz, H-6). $^{13}$C-NMR (150 MHz, $CD_3OD$): $\delta_C$ 183.93 (C-4), 166.39 (C-7), 166.10 (C-2), 163.18 (C-5), 159.45 (C-9), 150.98 (C-4′), 147.03 (C-3′), 123.75 (C-1′), 120.38 (C-6′), 116.78 (C-5′), 114.15 (C-2′), 105.32 (C-10), 103.88 (C-3), 100.19 (C-6), 95.06 (C-8).

Chemical structures of compounds **1-8** obtained from *P. multifida* are presented in Fig. 1.

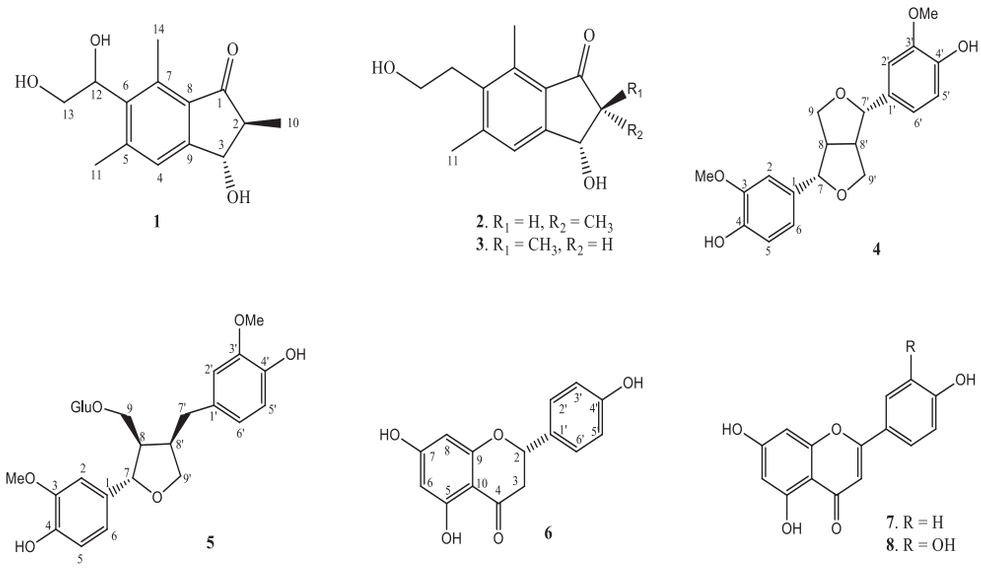


**Fig. 1. Chemical structures of compounds 1-8 obtained from *P. multifida*.**

## 3. Results and discussion

Compound **1** was isolated as a white powder and its molecular formula was established as $C_{14}H_{18}O_4$ based on a pseudo-molecular ion peak at 251.2 $[M+H]^+$ and NMR data. The carbon-13 nuclear magnetic resonance ($^{13}$C-NMR) and heteronuclear single quantum coherence (HSQC) of **1** displayed 14 carbon signals including one ketone group at $\delta_C$ 207.52 (C-1), 5 quaternary aromatic carbons, one aromatic methine carbon, 3 aliphatic methine carbons in which two oxygenated methines, 1 oxygenated methylene carbon, and three methyl groups. The $^1$H-NMR spectrum showed signals of one aromatic proton [$\delta_H$7.36 (1H, s, H-4)], one oxygenated methylene [$\delta_H$ 3.94 (1H, dd, *J*=11.4, 8.4 Hz, H-13a), 3.65 (1H, dd, *J*=11.4, 5.4 Hz, H-13b)], three methine protons [$\delta_H$ 5.34 (1H, dd, *J*=8.4, 5.4 Hz, H-12), 4.70 (1H, d, *J*=4.2 Hz, H-3), and 2.49-2.45 (1H, m, H-2)] and three methyl groups [$\delta_H$ 2.77 (3H, s, H-14), 2.59 (3H, s, H-11), and 1.32 (3H, d, *J*=7.2 Hz, H-10)]. These indicated compound **1** was a pterosin sesquiterpene. The small coupling constant $J_{2\text{-}3}$=4.2 Hz suggested the *trans*-configuration for the protons at C-2 and C-3 in **1** [9]. The HMBC spectrum showed correlations of H-10 to C-1, C-2, and C-3; of H-12 to C-6, C-7, C-13; of H-11 to C-4 and C-5; and of H-4 to C-3 and C-8. Based on the above results, the structure of compound **1** was identified as (2*S*,3*S*)-pretosin Q. This compound was previously obtained from *P. multifida* [3].

Compounds **2** and **3** were obtained as a mixture with a ratio of 1:3 (based on the peak intensities in their $^1$H- and $^{13}$C-NMR spectra). The ESI-MS spectrum showed only one *pseudo*-molecular ion peak at *m/z* 235.3 $[M+H]^+$ suggesting that **2** and **3** are isomers. The $^1$H- and $^{13}$C-NMR spectral data of compounds **2** and **3** were similar to those of **1** except for the presence of an additional methylene group and the absence of one oxymethine group at C-12. The coupling constants ($J_{2\text{-}3}$=6.6 Hz and $J_{2\text{-}3}$=4.2 Hz) confirmed the *cis*-, *trans*-configurations for the protons at C-2 and C-3 in **2** and **3**, respectively. Additionally, the $^{13}$C-NMR spectral data of **2** and **3** were similar to those of the (2*R*,3*S*)-acetylpterosin C and (2*S*,3*S*)-acetylpterosin C, except for the absence of signals of the acetyl groups at C-13 and the chemical shifts of C-13 and C-12 significantly changed by -2.2 and +4.1 ppm, respectively [11]. As a result, the chemical structures of **2** and **3** were established as (2*R*,3*S*)-pterosin C and (2*S*,3*S*)-pterosin C, respectively.

The ESI-MS spectrum of **4** showed a *pseudo*-molecular ion peak at *m/z* 359.3 $[M+H]^+$. The $^{13}$C NMR and HSQC spectra indicated the presence of only ten carbon peaks, including three aromatic quaternary carbons, three methine carbons, one oxymethylene, one oxymethine, one methine, and one methoxy group. These suggested that compound **4** was a symmetrical molecule and its molecular formula as $C_{20}H_{22}O_6$. The $^1$H-NMR revealed six aromatic protons in a pair of ABX systems at $\delta_H$ 6.88 (2H, d, *J*=1.8 Hz, H-2, H-2′), 6.75 (2H, dd, *J*=8.4, 1.8 Hz, H-6, H-6′), 6.72 (2H, d, *J*=8.4 Hz, H-5, H-5′), two methoxy groups at $\delta_H$ 3.76 (6H, s), and aliphatic protons at $\delta_H$ 4.60 (2H, d, *J*=4.2 Hz, H-7, H-7′), 4.11 (2H, dd, *J*=9.0, 6.6 Hz, H-9a, H-9′a), 3.72 (2H, dd, *J*=9.0, 4.2 Hz, H-9b, H-9′b), 3.04-3.02 (2H, m, H-8, H-8′). Therefore, the structure of **4** was determined to be pinoresinol. The $^{13}$C-NMR data (in DMSO-*d6*) of **4** were in good agreement with those of pinoresinol in [15].

The molecular formula of **5** was determined as $C_{26}H_{34}O_{11}$ from an ESI-MS pseudo-molecular ion peak at 545.3 $[M+Na]^+$ and NMR spectral data. The $^{13}$C-NMR and HSQC spectra showed a total 26 carbon signals, which included three methines ($\delta_C$ 84.15, 51.70 and 44.04), three methylenes ($\delta_C$73.69, 68.47 and 33.72), two methoxy groups ($\delta_C$ 56.45, 56.44), twelve signals for two aromatic rings ($\delta_C$ 149.00- 110.80), and six signals for one glucose unit with an anomeric carbon at $\delta_C$ 104.60. The $^1$H-NMR spectrum of **5** revealed the presence of two 1,3,4-trisubstitued benzenes

[$\delta_H$ 6.95 (1H, d, *J*=1.8 Hz, H-2), 6.82 (1H, dd, *J*=7.8, 1.8 Hz, H-6), 6.78 (1H, d, *J*=7.8 Hz, H-5); 6.81 (1H, d, *J*=1.8 Hz, H-2′), 6.73 (1H, d, *J*=8.4 Hz, H-5′), 6.67 (1H, dd, *J*=8.4, 1.8 Hz, H-6′)], two methoxy groups [$\delta_H$ 3.87 and 3.86 (each 3H, s)]. In addition, the $^1$H-NMR spectrum also supported the presence of one *β*-glucose moiety with an anomeric proton signal at $\delta_H$ 4.32 (1H, d, *J*=7.8 Hz, H-1″). The HMBC correlations between H-1″ ($\delta_H$ 4.32) with C-9 ($\delta_C$ 68.47) indicated that the sugar unit was attached at the C-9 position. The NOE correlations between H-8 and H-8′ and between H-7 and H-9 confirmed the benzyl group and the glucosyl group were on the same side, while the phenyl group was oriented to the other side of tetrahydrofuran ring. The $^{13}$C-NMR data of **5** were similar with those of lariciresinol [16] except for the presence of an additional β-glucose unit. Based on above evidence, the structure of **5** was elucidated to be lariciresinol 9-O-β-glucopyranoside.

Compound **6** was obtained as white powder. The $^{13}$C-NMR and HSQC spectra showed 15 carbon signals comprising one carbonyl carbon ($\delta_C$ 196.40), six quaternary carbons, seven methine carbons, and one methylene carbon. These suggested **6** was a flavonoid. The $^1$H-NMR spectrum exhibited a one-proton singlet [$\delta_H$ 12.15] for a chelated hydroxyl group at C-5, two *meta*-coupled proton signals [$\delta_H$ 5.88 (1H, d, *J*=2.4 Hz) and 5.87 (1H, d, *J*=2.4 Hz)] corresponding to H-8 and H-6 of ring A, one AA′BB′ spin systems of 1',4'-disubstituted aromatic ring B [$\delta_H$ 7.31 and 6.79 (both 2H, d, *J*=7.5 Hz)], and other proton signals of ring C [$\delta_H$ 5.44 (1H, dd, *J*=12.6, 3.0 Hz, H-2), 3.26 (1H, dd, *J*=16.8, 12.6 Hz, H-3a), 2.67 (1H, dd, *J*=16.8, 3.0 Hz, H-3b)]. $^1$H- and $^{13}$C-NMR data of **6** were in good agreement with those reported for naringenin [17]. Therefore, **6** was determined to be naringenin.

The structures of the remaining two compounds, **7** and **8,** were determined to be apigenin [18] and luteolin [19], respectively, based on the analysis NMR data and by comparison with the literature. These flavonoids have been found in several plant species and have been previously obtained from *P. multifida.*

Figure 2 shows in simplified form the pathways involved in the biosynthesis of all isolated compounds starting primary metabolism. Farnesyl pyrophosphate is the starting material for all other sesquiterpenes including compounds **1**, **2**, and **3**. The lignan biosynthesis of **4** and **5** were developed through a long sequence of reactions involving the shikimic acid pathway from cinnamic acid to feruloyl-CoA. Flavonoids **6**, **7**, and **8** are synthesised via shikimic acid and HAc-malonic acid pathways, respectively [20-22].

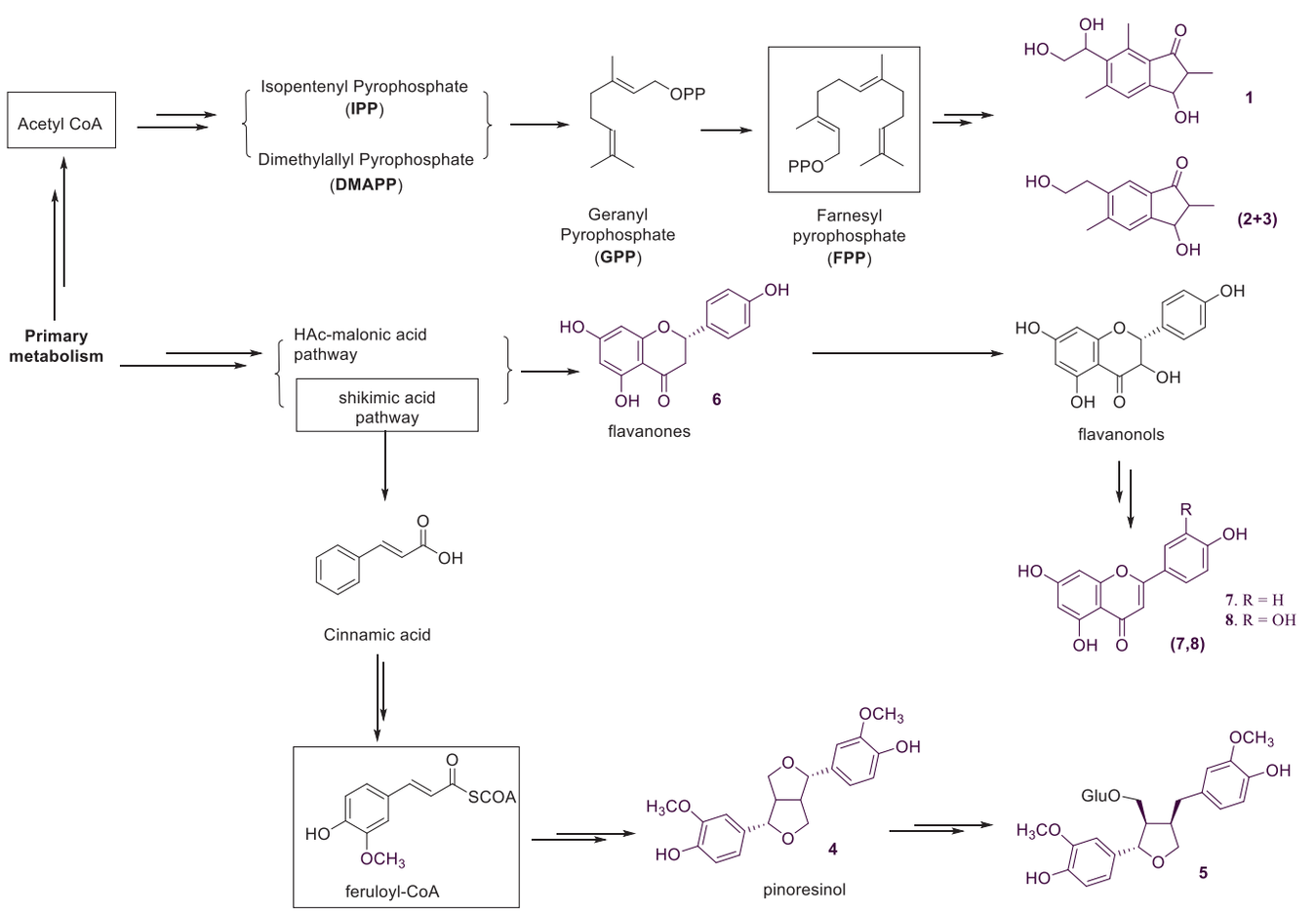


**Fig. 2. The proposed biosynthetic pathways of compounds 1-8.**

## 4. Conclusions

The chromatographic investigation of the ethyl acetate extract of the entire whole of *P. multifida* plant collected in the Nam Dinh province, Vietnam, led to the isolation of eight compounds. Their structures were identified as (2*S*,3*S*)-pretosin Q (**1**), (2*R*,3*S*)-pterosin C (**2**), (2*S*,3*S*)-pterosin C (**3**), pinoresinol (**4**), lariciresinol 9-O-*β*-glucopyranoside (**5**), naringenin (**6**), apigenin (**7**), and luteolin (**8**) by analysis of their 1D-NMR ($^{1}$H-, $^{13}$C-NMR), 2D-NMR (HSQC, HMBC, NOESY), ESI-MS spectra, and comparison with published data. This is the first report of the isolation of compounds **4**-**6** from *P. multifida*.

## CRediT author statement

Duc Thien Dao: Methodology, Data curation, Writing - Original draft preparation; Hoang Sa Nguyen: Data curation, Writing - Original draft preparation; Huu Thu Do: Investigation; Thanh Tam Nguyen: Writing - Reviewing and Editing.

## ACKNOWLEDGEMENTS

This research was supported by Institute of Chemistry, Vietnam Academy of Science and Technology under grant number VHH.2022.14.

## COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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