Three New Oligostilbenes from the Seeds of *Paeonia suffruticosa*

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Three new oligostilbenes, *trans*-suffruticosol D (1), *cis*-suffruticosol D (2), and *cis*-gnetin H (7), were isolated along with the eight known stilbenes, *trans*-resveratrol (3), *trans*-ε-viniferin (4), *cis*-ε-viniferin (5), gnetin H (6), suffruticosol A (8), suffruticosol B (9), suffruticosol C (10), and *cis*-ampelopsin E (11) from the seeds of *Paeonia suffruticosa*. Compounds 3—6 were isolated for the first time from this plant species, and compound 11 was isolated for the first time from the genus *Paeonia*. The structures of the new compounds were elucidated based on spectral analyses, including 1D and 2D NMR experiments. The absolute configuration of compound 1 was determined by quantum chemical calculation of the electronic circular dichroism and comparison with the experimental circular dichroism spectrum.

Key words *Paeonia suffruticosa*; oligostilbene; *trans*-suffruticosol D; *cis*-suffruticosol D; *cis*-gnetin H

Paeonia suffruticosa Andr. (Paeoniaceae) is found extensively in China. It is an important Chinese medicinal plant from the section *Moutan* of the genus *Paeonia*. This genus consists of *ca.* 35 species placed in three sections: *Moutan*, *Oneapia*, and *Paeonia*.[1] The root cortex of this plant (Chinese name: mudanpi) is a well-known Chinese herbal medicine widely used as an analgesic, anaphylactic, antioxidative, and antiinflammatory agent. Numerous studies on the chemistry and pharmacology of this species have been performed.[2] Previous phytochemical studies indicated that stilbenes were the primary bioactivity constituents of peony seeds. These stilbenes exhibit potent biological activities such as cytotoxic, antimutagenic, ecdysteroid antagonist, antioxidant, hyperpigmentation, antitumor, and anti-inflammatory activity and can improve bone disease.[3—8] In the course of searching for new bioactive natural products from the seeds of this plant, 11 stilbenes, *trans*- (**1**) and *cis*-suffruticosol D (**2**), *trans*-resveratrol (**3**),[9] *trans*-ε-viniferin (**4**),[7] *cis*-ε-viniferin (**5**),[7] gnetin H (**6**),[7] *cis*-gnetin H (**7**), suffruticosol A (**8**),[3] suffruticosol B (**9**),[3] suffruticosol C (**10**),[3] and *cis*-ampelopsin E (**11**),[10] were isolated from the ethyl acetate extract of the seeds of *P. suffruticosa*. Among them, **1**, **2**, and **7** were new compounds. Here, we report the isolation and extensive structural elucidation of the new compounds.

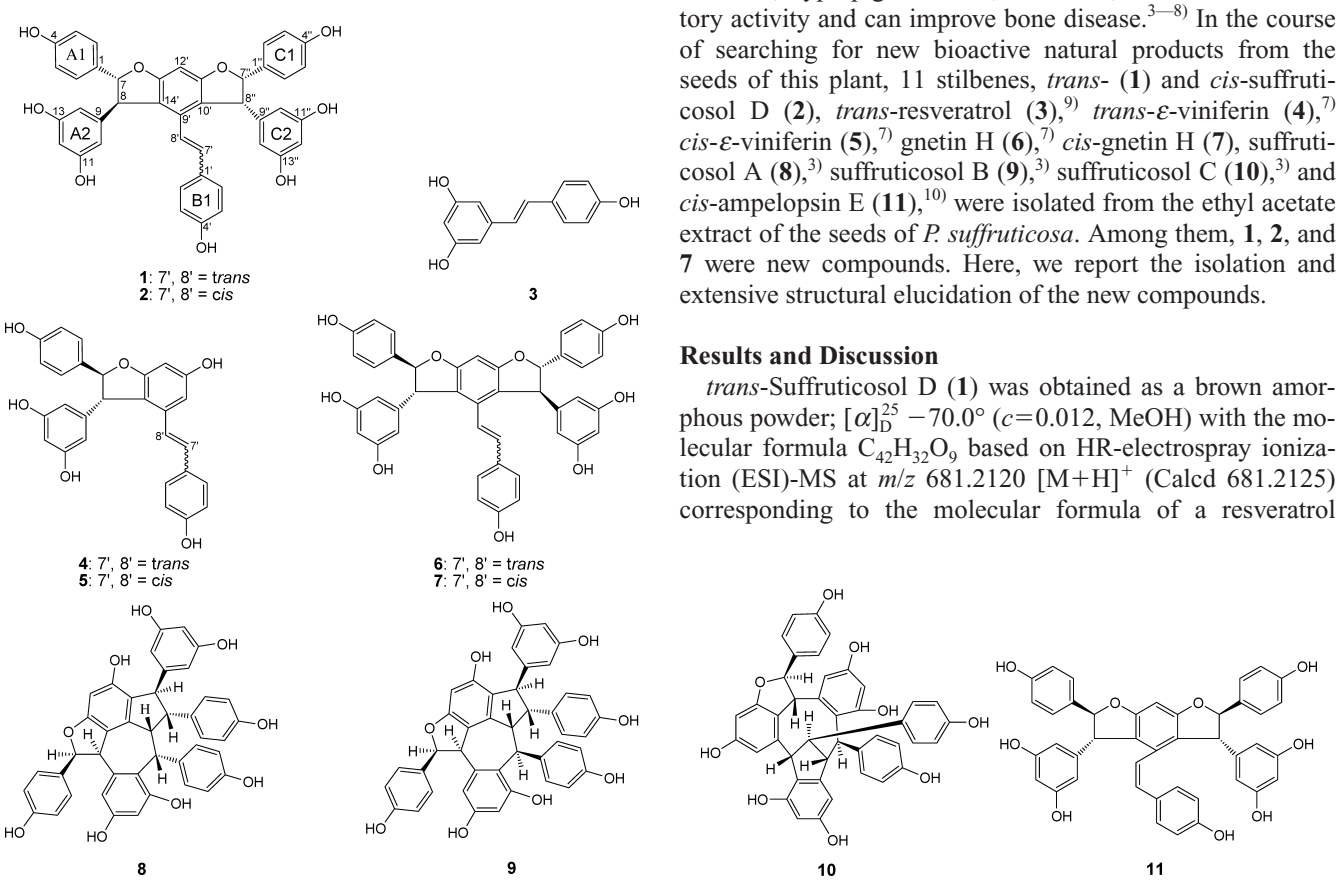

Fig. 1. Structures of Compounds **1**—**11**

Results and Discussion

trans-Suffruticosol D (**1**) was obtained as a brown amorphous powder; $[\alpha]_D^{25}$ −70.0° (c=0.012, MeOH) with the molecular formula $C_{42}H_{32}O_9$ based on HR-electrospray ionization (ESI)-MS at m/z 681.2120 $[M+H]^+$ (Calcd 681.2125) corresponding to the molecular formula of a resveratrol

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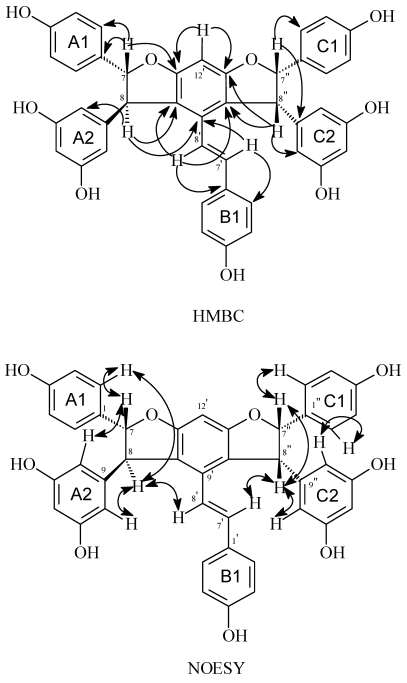

Fig. 2. Key HMBC and NOESY Correlations of **1**

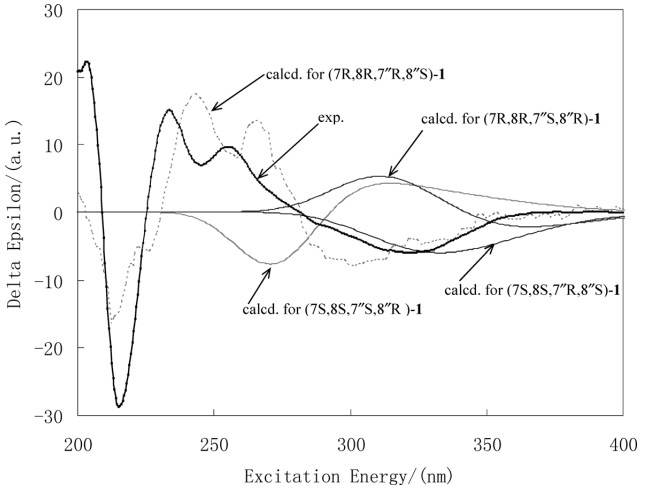

Fig. 3. Comparison of the Experimental CD Spectrum of **1** with the Spectra Calculated for Its Four Possible Enantiomers, (7*S*,8*S*,7″*S*,8″*R*)-**1**, (7*S*,8*S*,7″*R*,8″*S*)-**1**, (7*R*,8*R*,7″*R*,8″*S*)-**1**, and (7*R*,8*R*,7″*S*,8″*R*)-**1**, Using the TD DFT/PBEPBE 6-31+G*//DFT B3LYP/6-311+G* Method

trimer. The UV spectrum showed λ_{max} (MeOH) (log ε) at 203 (5.19), 230 (sh) (5.16), 283 (4.05), 328 (4.37); ESI-MS^n (negative ion) *m*/*z*: 715 $[M+Cl-H]^-$, 679 $[M-H]^-$, 585 [M−*p*-hydroxyl-Ph−H]$^-$. The IR spectrum λ_{max} (3416, 1605, 1512, 1448, 1236, 1160, 1083, 998 cm^{-1}) were similar to those of other oligostilbenes. The characteristic ^{1}H-NMR signals for a dihydrobenzofuran moiety bearing 3,5-dihydroxyphenyl and 4-hydroxyphenyl groups indicated that it was a resveratrol trimer. The ^{1}H-NMR spectrum of **1** showed the following signals: three sets of signals for 4-hydroxyphenyl moieties at δ 7.19 (2H, d, *J*=8.5 Hz) and δ 6.79 (2H, d, *J*=8.5 Hz), δ 6.98 (2H, d, *J*=8.5 Hz) and δ 6.56 (2H, d, *J*=8.5 Hz), δ 6.75 (2H, d, *J*=8.5 Hz) and δ 6.54 (2H, d, *J*=8.5 Hz); two sets of signals for 3,5-dihydroxyphenyl moieties at δ 6.17 (2H, d, *J*=2.0 Hz) and δ 6.19 (1H, t, *J*=2.0 Hz), δ 5.78 (2H, d, *J*=2.0 Hz) and δ 5.94 (1H, t, *J*=2.0 Hz); one aromatic proton singlet at δ 6.46; two *trans* olefin protons at δ 6.51 (1H, d, *J*=16.0 Hz) and 6.43 (1H, d, *J*=16.0 Hz); and two sets of signals for two dihydrobenzofuran moieties at δ 5.83 (1H, d, *J*=8.0 Hz) and δ 4.52 (1H, d, *J*=8.0 Hz), δ 5.43 (1H, d, J=6.0 Hz) and δ 4.39 (1H, d, *J*=6.0 Hz). The NMR spectral data also disclosed the presence of two sets of aliphatic proton signals characteristic of 2,3-diaryldihydrobenzofuran moieties (H-7/H-8 and H-7″/H-8″), in addition to a *trans*-1,2-disubstituted vinyl group (*J*=16.0 Hz, H-7′, H-8′). These NMR spectroscopic data of **1** resemble those of gnetin H (**6**)[11] and amurensin B,[12,13] which revealed that **1** possessed the same planar structure as gnetin H and amurensin B (Fig. 1). The heteronuclear multiple bond correlation (HMBC) spectrum (Fig. 2) confirmed our conclusion.

The relative stereochemistry at H-7/H-8 and H-7″/H-8″ of **1** was determined in nuclear Overhauser enhancement spectroscopy (NOESY) experiments (Fig. 2). Significant NOE interactions between H-7/H-10(14) and H-8/H-2(6) confirmed the *trans* relationship of H-7/H-8; The NOEs between H-7″/H-8″ and H-2″(6″)/H-10″(14″) suggested a *cis* orientation of H-7″/H-8″.

For an assignment of the absolute configuration of **1**, circular dichroism (CD) spectra were calculated for four possible enantiomers, (7*S*,8*S*,7″*S*,8″*R*)-**1**, (7*S*,8*S*,7″*R*,8″*S*)-**1**, (7*R*,8*R*,7″*R*,8″*S*)-**1** and (7*R*,8*R*,7″*S*,8″*R*)-**1** based on the relative stereochemistry at H-7/H-8 and H-7″/H-8″ of **1**, and TD-DFT calculations of the electronic circular dichroism (ECD) spectra were performed using the Gaussian 03 program.[14,15] As shown in Fig. 3, the calculations of the ECD spectra for these structures and their arithmetical averaging provided the overall theoretical ECD spectrum. Its comparison witn the experimental data showed good agreement with the spectrum calculated for (7*R*,8*R*,7″*R*,8″*S*)-**1**.

cis-Suffruticosol D (**2**) was obtained as a brown amorphous powder; $[\alpha]_D^{25}$ +211.0° (*c*=0.009, MeOH); and the molecular formula was established to be $C_{42}H_{32}O_9$ by HR-ESI-MS at *m*/*z* 681.2121 $[M+H]^+$ (Calcd 681.2125). The UV spectrum showed λ_{max} (MeOH) (log ε) at 203 (5.21), 230 (sh) (5.09), and 282 (3.95). The IR spectrum showed λ_{max} at 3415, 1604, 1514, 1449, 1237, 1159, 1085, and 999 cm^{-1}. The mass fragmentation patterns of **2** were found to be very similar to those of **1**, indicating that these two compounds a close relatives. When the ^{1}H-NMR spectra of these compounds were compared, compound **2** differed distinctly from **1** in the olefinic hydrogen signal [compound **2**: δ 6.42 and δ 6.36 (1H, d, *J*=12.0 Hz); **1**: δ 6.51 and δ 6.43 (1H, d, *J*=16.0 Hz)]. In addition, the NOEs observed between H-7′/H-8′ implying that **2** has the structure of a *Z*-isomer of **1**. The heteronuclear multiple quantum correlation (HMQC) and HMBC spectra confirmed the structure of **2**, while the relative stereochemistry was determined based on the NOESY spectrum as shown in Fig. 4. The CD spectrum of compound **2** (Fig. 5) was similar to that of compound **1**, implying that **2** has the same 7*S*, 8*S*, 7″*R*, 8″*S* absolute configuration. Furthermore, **1** can be converted to **2** under UV irradiation, similar to other oligostilbenes,[16—18] and *trans*-ε-viniferin (**4**) can also be converted to *cis*-ε-viniferin (**5**) with UV irradiation in

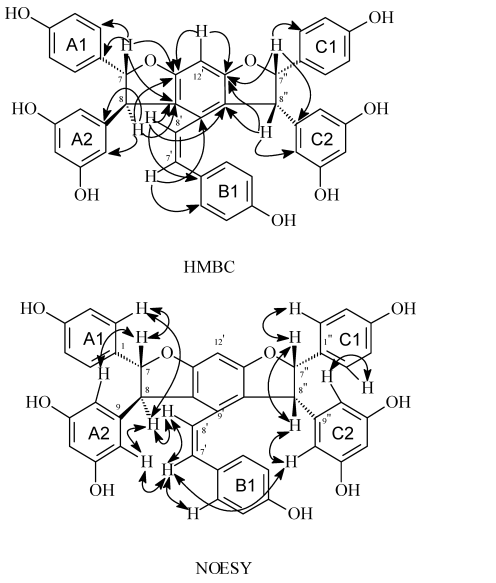

Fig. 4. Key HMBC and NOESY Correlations of **2**

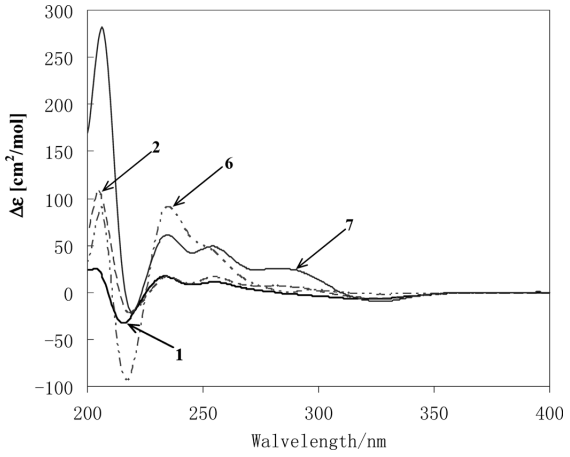

Fig. 5. CD Spectra in MeOH Solution of **1**, **2**, **6**, and **7**

our experiment (data not shown). Thus the structure of **2** was established to be *cis*-suffruticosol D.

cis-Gnetin H (**7**) was obtained as a brown amorphous powder; $[\alpha]_D^{25}$ +357.1° (c=0.013, MeOH) and had the molecular formula of $C_{42}H_{32}O_9$ based on HR-ESI-MS at *m*/*z* 681.2118 $[M+H]^+$ (Calcd 681.2125). The UV spectrum showed λ_{max} (MeOH) (log ε) at 203 (5.35), 230 (sh) (5.13), and 282 (4.01). When the ^{1}H- and ^{13}C-NMR spectra of these compounds were compared, compound **7** differed distinctly from **6** in the olefinic hydrogen signal [compound **7**: δ 5.92 and δ 5.74 (1H, d, J=12.0 Hz); **6**: δ 6.38 (2H, s)]. In addition, the CD spectrum of compound **7** was similar to that of compound **6** (Fig. 5), implying that *cis*-gnetin H has the same structure as **7**. This assumption was substantiated by the fact that gnetin H was converted to *cis*-gnetin H under UV irradiation in our experiment (data not shown).

Comparison of chemical shift data and coupling constants of **1**, **2**, and their analogues (Table 1), especially the methine hydrogens of the four chiral centers H-7, H-8, H-7″, and H-8″, revealed that different relative configurations had different chemical shift data and coupling constants. When the relative configurations were in the *trans* orientation, H-7(7″) and H-8(8″) signals at about δ 5.40—5.43 and δ 4.39 (1H, each d, J=5.0—6.0 Hz), and C-7(7″) and C-8(8″) signals at about δ 95.3—95.7 and δ 59.4, respectively were seen. However, the C_2-axial symmetrical structure *cis*-ampelopsin E had H-7(7″) and H-8(8″) signals at about δ 5.20 and δ 3.84 and the C-8(8″) signal at about δ 58.2 when the relative configuration was in the *cis* orientation; H-7(7″) and H-8(8″) signals at about δ 5.82 and δ 4.52 (1H, each d, J=8.0 Hz); and C-7(7″) and C-8(8″) signals at about δ 91.6—91.9 and δ 54.7—55.3, respectively. In addition, in contrast to the signals of C-1″ and C-9″ in the *cis* orientation at δ 130.0 and δ 144.1, the C-1 and C-9 signals in the *trans* orientation were shifted downfield at δ 134.1 and δ 148.1 ($\Delta\delta\approx$4.0 ppm).

Because dihydrobenzofuran moieties of the molecule were relatively rigid, the relative configurations of H-7″/H-8″ were deduced as follows: *cis*, *endo–endo*, and *exo–exo*; *trans*, *exo–endo*. The dihedral torsion angles, calculated using the Karplus–Conroy equation [$^3J_{H,H}=a\cos^2\phi-0.28$ ($\phi\leq$90°, a=8.5; $\phi\geq$90°, a=9.5, ϕ: dihedral angle)][19] on the basis of coupling constants $^3J_{H7'',H8''}$, have two values: $\varphi_{H\text{-}C7''\text{-}C8''\text{-}H}$=18° ($^3J_{H7'',H8''}$=8.0, *cis* orientation) and $\varphi_{H\text{-}C7''\text{-}C8''\text{-}H}$=141° ($^3J_{H7'',H8''}$=6.0, *trans* orientation), respectively. Hence, the dihedral angles of compounds **1** and **2** were $\varphi_{H\text{-}C7''\text{-}C8''\text{-}H}$=18° and $\varphi_{H\text{-}C7\text{-}C8\text{-}H}$=141°, respectively. It is possible that the relative configuration of H-7″/H-8″ was *endo–endo* or *exo–exo*, although the potential of the higher stereohindrance between the rings-C1 and C2 where the dihedral angles of H-7/H-8 were not 0° but 18°, may lessen the stereohindrance effect between rings-C1 and C2.

Four stilbene trimers (compounds **6**, **8**—**10**) and two resveratrol dimers (compounds **4**, **5**) have been isolated from *P. suffruticosa* and *P. lactiflora*[3,7] together with *trans*-suffruticosol D (**1**), *cis*-suffruticosol D (**2**), *cis*-gnetin H (**7**), and *cis*-ampelopsin E (**11**), and there were eight resveratrol trimers from *Paeonia*. Meanwhile, stilbenes have not been isolated from other parts of peony plants except for the seeds.

Furthermore, to the best of our knowledge, compounds **3**—**6** were first time isolated from this plant species, and compound **11** was first time isolated from the genus *Paeonia*.

Experimental

General CD spectra were recorded on a spectropolarimeter (JASCO-815). UV spectra were measured on a Shimadzu UV-2550 UV–visible spectrophotometer. Optical rotations were recorded on a Perkin-Elmer 341 polarimeter. IR spectra were taken on a Shimadzu FTIR-8400S infrared spectrometer recorded as KBr patches. ^{1}H-, ^{13}C-, and 2D-NMR spectra were measured on a Bruker Avance DRX-500 spectrometer (^{1}H at 500 MHz and ^{13}C at 125 MHz) in MeOH-d_4. Chemical shifts are given in δ values (ppm) relative to tetramethylsilane (TMS) as an internal standard. HR-ESI-MS and ESI-MS spectra were recorded on an ABI Qtrap spectrometer. All solvents used were of analytical grade (Beijing Chemical Plant, Beijing, P. R. China). Silica gel (300—400 mesh, Qingdao Marine Chemical Plant, Qingdao, P. R. China), ODS-A C18 reversed-phase silica gel (75 μm, YMC), Sephadex LH-20 gel (pharmacia), and MCI gel (CHP20P, 75—150 μm, Mitsubishi Chemical Industries Ltd.) were used for column chromatography, and precoated silica gel GF254 plates (Qingdao Marine Chemical Plant) were used for TLC.

Plant Material The seeds of *P. suffruticosa* Andr. were collected in Tongling, Anhui province, P. R. China, in October 2007, and identified by Prof. Zheng-An Liu (Institute of Botany, Chinese Academy of Sciences,

Table 1. ^{1}H- and ^{13}C-NMR Data of Compounds **1**, **2**, **6**, **7**, and **11** in CD_3OD (500 MHz for ^{1}H and 125 MHz for ^{13}C)[a,b]

Position	**1**		**2**		**6**		**7**		**11**	
	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C	δ_H	δ_C
1		134.6		134.7		134.7		134.1		134.1
2, 6	7.19 (d, 8.5)	128.6	7.17 (d, 8.5)	128.7	7.18 (dd, 2.0, 8.5)	128.6	6.98 (d, 8.5)	128.6	6.93 (d, 8.5)	129.2
3, 5	6.79 (d, 8.5)	116.9	6.78 (d, 8.5)	116.7	6.78 (dd, 2.0, 8.5)	116.9	6.69 (d, 8.5)	116.8	6.67 (d, 8.5)	116.7
4		159.1		158.9		159.0		158.8		158.8
7	5.43 (d, 6.0)	95.4	5.43 (d, 6.0)	95.7	5.40 (d, 5.5)	95.3	5.24 (d, 5.0)	95.6	5.20 (d, 5.0)	95.5
8	4.39 (d, 6.0)	59.3	4.39 (d, 6.0)	59.3	4.40 (d, 5.5)	59.4	3.86 (d, 5.0)	59.2	3.84 (d, 5.0)	58.2
9		148.1		148.3		148.0		148.2		148.1
10, 14	6.17 (d, 2.0)	107.9	6.17 (d, 2.0)	107.9	6.14 (s)	107.8	5.95 (d, 2.0)	107.6	5.90 (d, 2.0)	107.8
11, 13		160.7		159.9		160.6		159.9		159.9
12	6.19 (t, 2.0)	102.7	6.19 (t, 2.0)	102.3	6.14 (s)	102.7	6.05 (t, 2.0)	102.4	6.03 (t, 2.0)	102.3
1′		131.1		131.1		131.1		131.1		135.0
2′, 6′	6.75 (d, 8.5)	129.1	6.75 (d, 8.5)	129.5	6.69 (d, 8.5)	129.2	6.77 (d, 8.5)	129.5	6.79 (d, 8.5)	131.0
3′, 5′	6.54 (d, 8.5)	115.8	6.54 (d, 8.5)	115.8	6.51 (d, 8.5)	116.7	6.50 (d, 8.5)	116.6	6.51 (d, 8.5)	116.3
4′		158.9		158.4		158.8		158.7		158.3
7′	6.51 (d, 16.0)	134.9	6.42 (d, 12.0)	135.1	6.38 (s)	129.2	5.92 (d, 12.0)	132.3	5.93 (d, 12.0)	132.9
8′	6.43 (d, 16.0)	122.9	6.36 (d, 12.0)	125.0	6.38 (s)	123.0	5.74 (d, 12.0)	124.6	5.78 (d, 12.0)	124.9
9′		134.1		133.9		135.0		135.1		130.9
10′		121.7		121.6		120.8		121.2		122.2
11′		162.8		162.6		163.5		163.6		162.6
12′	6.46 (s)	92.4	6.46 (s)	92.3	6.42 (s)	92.0	6.35 (s)	92.3	6.35 (s)	91.8
13′		163.4		162.6		163.5		163.6		162.6
14′		122.6		122.4		120.8		121.2		122.2
1″		130.0		130.1		134.2		134.1		134.1
2″, 6″	6.98 (d, 8.5)	129.8	6.95 (d, 8.5)	129.8	7.18 (dd, 2.0, 8.5)	128.6	6.98 (d, 8.5)	128.6	6.93 (d, 8.5)	129.2
3″, 5″	6.56 (d, 8.5)	116.8	6.55 (d, 8.5)	116.4	6.78 (dd, 2.0, 8.5)	116.9	6.69 (d, 8.5)	116.8	6.67 (d, 8.5)	116.7
4″		158.2		157.9		159.0		158.8		158.8
7″	5.83 (d, 8.0)	91.9	5.82 (d, 8.0)	91.6	5.40 (d, 5.5)	95.3	5.24 (d, 5.0)	95.6	5.20 (d, 5.0)	95.5
8″	4.52 (d, 8.0)	55.3	4.50 (d, 8.0)	54.7	4.40 (d, 5.5)	59.4	3.86 (d, 5.0)	59.2	3.84 (d, 5.0)	58.2
9″		144.1		143.9		148.0		148.2		148.1
10″, 14″	5.78 (d, 2.0)	109.7	5.78 (d, 2.0)	109.8	6.14 (s)	107.8	5.95 (d, 2.0)	107.6	5.90 (d, 2.0)	107.8
11″, 13″		159.5		159.0		160.6		159.9		159.9
12″	5.94 (t, 2.0)	102.3	5.94 (t, 2.0)	102.0	6.14 (s)	102.7	6.05 (t, 2.0)	102.4	6.03 (t, 2.0)	102.3

a) Chemical shift values were in ppm and *J* values (in Hz) were presented in parentheses. *b*) The assignments were based on HMQC and HMBC.

Beijing, P. R. China). A voucher specimen (2007001) has been deposited in the Seed Resource Bank of the Institute of Medicinal Plant Development, Chinese Academy of Medical Sciences and Peking Union Medical College.

Extraction and Isolation The dried seeds of *P. suffruticosa* (4.0 kg) were pulverized and extracted successively with 90% EtOH (4×6 l) and 70% EtOH (2×6 l) by soaking at room temperature for 24 h each time. The combined EtOH extract was concentrated under reduced pressure at 60 °C to afford a dark-brown residue (840 g). The residue was diluted with water and partitioned successively with cyclohexane, $CHCl_3$, and EtOAc. The EtOAc fraction (185 g) was first subjected to silica gel column chromatography and then eluted with $CHCl_3$–MeOH (100 : 0→30 : 70, v/v) gradient to afford several subfractions. The subfractions were further purified on ODS-A C18 reversed-phase silica gel (MeOH–H_2O) and then purified by Sephadex LH-20 column chromatography to give compounds **1** (15 mg), **2** (12 mg), **3** (20 mg), **4** (20 mg), **5** (8 mg), **6** (100 mg), **7** (13 mg), **8** (150 mg), **9** (10 mg), **10** (22 mg), and **11** (7 mg).

trans-Suffruticosol D (**1**): Brown amorphous powder; $[\alpha]_D^{25}$ −70.0° (*c*= 0.012, MeOH); UV λ_{max} (MeOH) (nm) (log ε): 203 (5.19), 230 (sh) (5.16), 283 (4.05), 328 (4.37); IR ν_{max} (KBr) (cm^{-1}): 3416, 1605, 1512, 1448, 1236, 1160, 1083, 998; ESI-MS^n (negative ion) *m/z*: 715 [M+Cl−H]$^-$, 679 [M−H]$^-$, 585 [M−*p*-hydroxyl-Ph−H]$^-$; HR-ESI-MS at *m/z* 681.2120 [M+H]$^+$ (Calcd for $C_{42}H_{33}O_9$: 681.2125); CD (*c*=0.00027, MeOH): 321 [$\Delta\varepsilon$=−6.8], 282 [0], 255 [+11.1], 245 [+8.0], 233.5 [+17.3], 225 [0], 215 [−32.8], 209 [0], 203 [+25.5] nm. ^{1}H- and ^{13}C-NMR data (CD_3OD): see Table 1.

cis-Suffruticosol D (**2**): Brown amorphous powder; $[\alpha]_D^{25}$ +211.0° (*c*= 0.0091, MeOH); UV λ_{max} (MeOH) (nm) (log ε): 203 (5.21), 230 (sh) (5.09), 282 (3.95); IR ν_{max} (KBr) (cm^{-1}): 3415, 1604, 1514, 1449, 1237, 1159, 1085, 999; ESI-MS^n (negative ion) *m/z*: 715 [M+Cl−H]$^-$, 679 [M−H]$^-$, 585 [M−*p*-hydroxyl-Ph−H]$^-$; HR-ESI-MS at *m/z* 681.2121 [M+H]$^+$ (Calcd for $C_{42}H_{33}O_9$: 681.2125); CD (*c*=0.00025, MeOH): 328 [$\Delta\varepsilon$=−5.7], 304 [0], 280 [+8.0], 273.5 [+7.7], 255 [+17.1], 225 [+17.1], 244.5 [+10.0], 234.5 [+17.5], 226 [0], 218 [−20.8], 214 [0], 204.5 [+108.9] nm. ^{1}H- and ^{13}C-NMR data (CD_3OD): see Table 1.

cis-Gnetin H (**7**): Brown amorphous powder; $[\alpha]_D^{25}$ +357.1° (*c*=0.013, MeOH), UV λ_{max} (MeOH) (nm) (log ε): 203 (5.35), 230 (sh) (5.13), 282 (4.01); IR ν_{max} (KBr) (cm^{-1}): 3415, 1605, 1516, 1449, 1238, 1156, 1084, 999; ESI-MS^n (negative ion) *m/z*: 715 [M+Cl−H]$^-$, 679 [M−H]$^-$, 585 [M−*p*-hydroxyl-Ph−H]$^-$; HR-ESI-MS at *m/z* 681.2118 [M+H]$^+$ (Calcd for $C_{42}H_{33}O_9$: 681.2125); CD (*c*=0.00012, MeOH): 328.5 [$\Delta\varepsilon$=−9.6], 310 [0], 282.5 [+25.7], 273.5 [+24.0], 254 [+49.0], 245 [+42.0], 234.5 [+60.8], 223 [0], 219.5 [−21.6], 206 [+282.1] nm. ^{1}H- and ^{13}C-NMR data (CD_3OD): see Table 1.

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References

1) Hong D. Y., Pan K. Y., *Acta Phyto-tax. Sin.*, **37**, 351—368 (1999).
2) Xiao P. G., "Modern Chinese Materia Medica," Vol. 3, Chemical Industry Press, Beijing, 2002, pp. 601—606.
3) Sarker S. D., Whiting P., Dinant L., *Tetrahedron*, **55**, 513—524 (1999).
4) Kim H. J., Chung S. K., Choi S. W., *J. Food Sci. Nutr.*, **3**, 315—319 (1998).
5) Kim H. J., Chung S. K., Choi S. W., *J. Food Sci. Nutr.*, **4**, 163—166 (1999).
6) Kim H. J., Chang E. J., Cho S. H., Chung S. K., Park H. D., Choi, S. W., *Biosci. Biotechnol. Biochem.*, **66**, 1990—1993 (2002).

7) Kim H. J., Chang E. J., Bae S. J., Shim S. M., Park H. D., Rhee C. H., Park J. H., Choi S. W., *Arch. Pharm. Res.*, **25**, 293—299 (2002).
8) Kim H. J., Ha S. C., Choi S. W., *Nutraceut. Food*, **7**, 447—450 (2002).
9) Chen P., Yang J. S., *Chin. Pharm. J.*, **43**, 1852—1855 (2008).
10) Oshima Y., Ueno Y., *Phytochemistry*, **33**, 179—182 (1993).
11) Lins A. P., Yoshida M., Gottlieb O. R., Gottlieb H. E., Kubitzki K., *Bull. Soc. Chim. Belg.*, **95**, 737—748 (1986).
12) Huang K. S., Lin M., *J. Asian Nat. Prod. Res.*, **2**, 21—28 (1999).
13) Ha D. T., Chen Q. C., Hung T. M., Youn U. J., Ngoc T. M., Thuong P. T., Kim H. J., Seong Y. H., Min B. S., Bae K., *Arch. Pharm. Res.*, **32**, 177—183 (2009).
14) Abbate S., Burgi L. F., Castiglioni E., Lebon F., Longhi G., Toscano E., Caccamese S., *Chirality*, **21**, 436—441 (2009).
15) Casarini D., Lunazzi L., Mancinelli M., Mazzanti A., Scafato P., *Chirality*, **21**, 16—23 (2009).
16) Ito J., Niwa M., *Tetrahedron*, **52**, 9991—9998 (1996).
17) Zhou L. X., Lin M., *Acta Pharm. Sin.*, **35**, 669—674 (2000).
18) Yu C. K., Lam C. N., Springob K., Schmidt J., Chu I. K., Lo C., *Plant Cell Physiol.*, **47**, 1017—1021(2006).
19) Karplus M., *J. Am. Chem. Soc.*, **85**, 2870—2871 (1963).