SUPPORTING INFORMATION FOR:

Structural Modifications of a Flaxseed Lignan in Pursuit of Higher Liposolubility: Evaluation of the Antioxidant and Permeability Properties of the Resulting Derivatives

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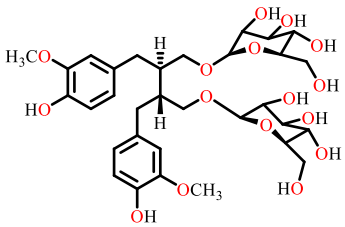
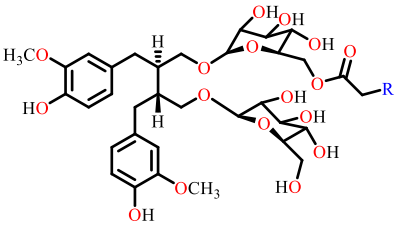
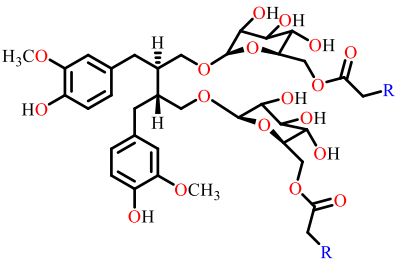
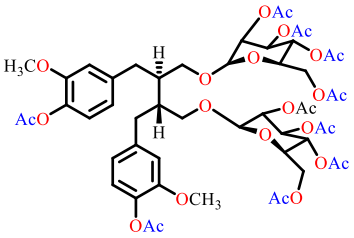
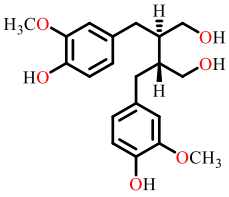
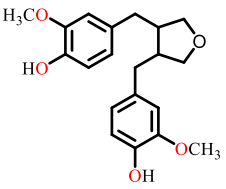
CONTENTS **PAGE**

Table S1 Summary of secoisolariciresinol diglucoside and different types of its derivative as prepared in this study. SDG (**1**): secoisolariciresinol diglucoside. SECO (**2**): secoisolariciresinol. ASECO (**14**): anhydrosecoisolariciresinol.

Compound	Preparation	Chemical structure	No. of C in fatty acids	No. of hydroxyl groups	
				Phenolic	Non-phenolic
SDG	Purified from crude flaxseed lignan		–	2	8
SDG mono-esters	Enzymatic transesterification with fatty acid		8, 12, 16	2	7
SDG diesters	Transesterification with fatty acid vinyl ester (catalyzed by ZnTAC24)		8, 10, 12, 14, 16, 18	2	6
Acetated SDG	Acetylation with acetic anhydride		2	0	0
SECO	Deglycosylation		–	2	2
ASECO	Deglycosylation (over hydrolyzed)		–	2	0

Spectroscopic data for compounds 1, 2 and 4–14

Secoisolariciresinol Diglucoside (1). Yield: 59%, pale-yellow powder. ^{1}H NMR (500 MHz, CD_3OD): δ 6.67 (d, J = 7.9 Hz, 2H, H-5), 6.62 (d, J = 1.9 Hz, 2H, H-2), 6.59 (dd, J = 8.0 and 1.9 Hz, 2H, H-6,6'), 4.26 (d, J = 7.8 Hz, 2H, H-G1,G1'), 4.10 (dd, J = 10.0 and 5.5 Hz, 2H, H-A1b,A1'b), 3.87 (dd, J = 11.9 and 2.3 Hz, 2H, H-G6b,G6'b), 3.76 (s, 6H, 3,3'-O-CH_3), 3.71 (dd, J = 11.8 and 5.6 Hz, 2H, H-G6a,G6'a), 3.50 (dd, J = 10.0 and 6.4 Hz, 2H, H-A1a,A1'a), 3.37 (d, J = 1.5 Hz, 2H, H-G3,G3'), 3.34 (d, J = 1.8 Hz, 2H, H-G4,G4'), 3.27 (dd, J = 5.6 and 2.4 Hz, 2H, H-G5,G5'), 3.23 (dd, J = 8.9 and 7.9 Hz, 2H, H-G2,G2'), 2.71 (dd, J = 13.8 and 6.7 Hz, 2H, H-A3a,A3'a), 2.64 (dd, J = 13.8 and 8.0 Hz, 2H, H-A3b,A3'b), 2.15 (p, J = 5.9 Hz, 2H, H-A2,A2'). ^{13}C NMR (151 MHz, CD_3OD): δ 148.7 (C-3,3'), 145.4 (C-4,4'), 134.0 (C-1,1'), 122.9 (C-6,6'), 115.7 (C-5,5'), 113.6 (C-2,2'), 104.8 (C-G1,G1'), 78.20 (C-G3,G3'), 77.9 (C-G5,G5'), 75.3 (C-G2,G2'), 71.7 (C-G4,G4'), 71.2 (C-A1,A1'), 62.9 (C-G6,G6'), 56.3 (3,3'-O-CH_3), 41.2 (C-A2,A2'), 35.6 (C-A3,A3'). IR (KBr) ν_{max}: 3405, 2931, 1604, 1517, 1451, 1429, 1384, 1273, 1156, 1076, 1032, 798 cm^{-1}. MS (ESI, + ve): m/z 704.3 ($[M + NH_4]^+$, 100), 709 ($[M + Na]^+$, 47).

Secoisolariciresinol (SECO, 2). Yield: 12%, amorphous pale-yellow solid. ^{1}H NMR (600 MHz, CD_3OD): δ 6.67 (d, J = 7.9 Hz, 2H, H-5,5'), 6.60 (d, J = 1.9 Hz, 2H, H-2,2'), 6.56 (dd, J = 8.0 and 2.0 Hz, 2H, H-6,6'), 3.75 (s, 6H, 3,3'-O-CH_3), 3.62–3.58 (m, 4H, H-A1,A1'), 2.67 (dd, J = 13.8 and 6.9 Hz, 2H, H-A3a,A3'a), 2.57 (dd, J = 13.8 and 7.8 Hz, 2H, H-A3b,A3'b), 1.91 (td, J = 5.8, 5.1 and 2.6 Hz, 2H, H-A2,A2'). ^{13}C NMR (126 MHz, CD_3OD): δ 148.8 (C-3,3'), 145.5 (C-4,4'), 133.9 (C-1,1'), 122.7 (C-6,6'), 115.8 (C-5,5'), 113.3 (C-2,2'), 62.1 (C-A1,A1'), 56.2 (3,3'-O-CH_3), 44.1 (C-A2,A2'), 36.0 (C-A3,A3'). IR (KBr) ν_{max}: 3405, 2930, 1604, 1516, 1452, 137, 1273, 1156, 1077, 1031, 895, 798, 633 cm^{-1}. MS (ESI, + ve): m/z 380 ($[M+NH_4]^+$, 100), 385 ($[M+Na]^+$, 54).

G6,G6'-*O*-Octanoyl Secoisolariciresinol Diglucoside Diester (4). Yield: 36%,

amorphous brown solid. ^{1}H NMR (600 MHz, CD_3OD): δ 6.67–6.65 (m, 4H, H-5,5’ and H-2,2’), 6.59 (dd, J = 8.0 and 1.9 Hz, 2H, H-6,6’), 4.40 (dd, J = 11.9 and 2.2 Hz, 2H, H-G6b,G6’b), 4.24 (d, J = 7.8 Hz, 2H, H-G1,G1’), 4.22 (dd, J = 11.9 and 6.0 Hz, 2H, H-G6a,G6’a), 3.97 (dd, J = 9.7 and 6.4 Hz, 2H, H-A1b,A1’b), 3.78 (s, 6H, 3,3’-O-CH_3), 3.52 (dd, J = 9.8 and 5.7 Hz, 2H, H-A1a,A1’a), 3.44 (ddd, J = 9.6, 6.0 and 2.2 Hz, 2H, H-G5,G5’), 3.36 (d, J = 8.9 Hz, 2H, H-G3,G3’), 3.33 (d, J = 1.7 Hz, 2H, H-G4,G4’), 3.23 (dd, J = 9.0 and 7.8 Hz, 2H, H-G2,G2’), 2.70 (dd, J = 13.6 and 6.7 Hz, 2H, H-A3a,A3’a), 2.55 (dd, J = 13.7 and 7.9 Hz, 2H, H-A3b,A3’b), 2.29 (t, J = 7.5 Hz, 4H, H-F2,F2’), 2.22 (t, J = 6.6 Hz, 2H, H-A2,A2’), 1.56 (p, J = 7.3 Hz, 4H, H-F3,F3’), 1.30–1.22 (m, 16H, H-F4–F7 and H-F4’–F7’), 0.89 (t, J = 7.1 Hz, 6H, H-F8,F8’). ^{13}C NMR (151 MHz, CD_3OD): δ 175.4 (C-F1,F1’), 148.7 (C-3,3’), 145.5 (C-4,4’), 133.9 (C-1,1’), 122.9 (C-6,6’), 115.8 (C-5,5’), 113.6 (C-2,2’), 104.5 (C-G1,G1’), 78.1 (C-G3,G3’), 75.2 (C-G5,G5’), 75.2 (C-G2,G2’), 71.8 (C-G4,G4’), 70.8 (C-A1,A1’), 64.7 (C-G6,G6’), 56.4 (3,3’-O-CH_3), 41.3 (C-A2,A2’), 35.0 (C-A3,A3’), 34.9, 32.8, 30.2, 30.1, 26.1, 23.7, 14.5. IR (KBr) ν_{max}: 3378, 2925, 2855, 1719, 1676, 1605, 1514, 1453.45, 1431, 1366, 1268, 1200, 1078, 1029, 799, 721 cm^{-1}. MS (ESI, + ve): m/z 957 ([M + NH_4]$^+$, 100), 962 ([M + Na]$^+$, 50).

G6,G6’-*O*-Decanoyl Secoisolariciresinol Diglucoside Diester (5). Yield: 31%, amorphous brown solid. ^{1}H NMR (600 MHz, CD_3OD): δ 6.64 (dd, J = 4.9 and 3.0 Hz, 4H, H-5,5’ and H-2,2’), 6.57 (dd, J = 8.0 and 1.9 Hz, 2H, H-6,6’), 4.38 (dd, J = 11.9 and 2.2 Hz, 2H, H-G6b,G6’b), 4.22 (d, J = 7.9 Hz, 2H, H-G1,G1’), 4.20 (dd, J = 11.9 and 6.1 Hz, 2H, H-G6a,G6a’), 3.95 (dd, J = 9.8 and 6.5 Hz, 2H, H-A1b,A1’b), 3.76 (s, 6H, 3,3’-O-CH_3), 3.50 (dd, J = 9.8 and 5.7 Hz, 2H, H-A1a,A1’a), 3.42 (ddd, J = 9.6, 6.1 and 2.2 Hz, 2H, H-G5,G5’), 3.34 (d, J = 8.9 Hz, 2H, H-G3,G3’), 3.31 (d, J = 1.7 Hz, 2H, H-G4,G4’), 3.21 (dd, J = 9.0 and 7.8 Hz, 2H, H-G2,G2’), 2.68 (dd, J = 13.6 and 6.6 Hz, 2H, H-A3a,A3’a), 2.52 (dd, J = 13.7 and 7.9 Hz, 2H, H-A3b,A3’b), 2.27 (t, J = 7.5 Hz, 4H, H-F2,F2’), 2.21 (p, J = 7.1 and 6.5 Hz, 2H, H-A2,A2’), 1.54 (p, J = 7.5 Hz, 4H, H-F3,F3’), 1.30–1.24 (m, 24H, H-F4–F9 and H-F4’–F7’), 0.88 (t, J = 7.1 Hz, 6H, H-F10,F10’). ^{13}C NMR (151 MHz, CD_3OD): δ 175.4 (C-F1,F1’), 148.7 (C-3,3’), 145.5

(C-4,4'), 133.9 (C-1,1'), 122.9 (C-6,6'), 115.8 (C-5,5'), 113.7 (C-2,2'), 104.5 (C-G1,G1'), 78.1 (C-G3,G3'), 75.2 (C-G5,G5'), 75.2 (C-G2,G2'), 71.8 (C-G4,G4'), 70.8 (C-A1,A1'), 64.7 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 35.0 (C-A3,A3'), 34.9, 33.1, 30.7, 30.6, 30.5, 30.2, 26.1, 23.8, 14.5. IR (KBr) ν_{max}: 3367, 2923, 2854, 1720, 1675, 1608, 1514, 1454, 1431, 1367, 1269, 1202, 1078, 1028, 798, 721 cm^{-1}. MS (ESI, + ve): *m*/*z* 1013 ($[M + NH_4]^+$, 100), 1018 ($[M + Na]^+$, 70).

G6,G6'-*O*-Lauroyl Secoisolariciresinol Diglucoside Diester (6). Yield: 42%, amorphous brown solid. ^{1}H NMR (600 MHz, CD_3OD): δ 6.66 (dd, *J* = 4.9 and 3.0 Hz, 4H, H-5,5' and H-2,2'), 6.59 (dd, *J* = 8.0 and 1.9 Hz, 2H, H-6,6'), 4.40 (dd, *J* = 11.9 and 2.2 Hz, 2H, H-G6b,G6'b), 4.24 (d, *J* = 7.8 Hz, 2H, H-G1,G1'), 4.23–4.19 (m, 2H, H-G6a,G6'a), 3.97 (dd, *J* = 9.7 and 6.6 Hz, 2H, H-A1b,A1'b), 3.78 (s, 6H, 3,3'-O-CH_3), 3.52 (dd, *J* = 9.8 and 5.7 Hz, 2H, H-A1a,A1'a), 3.45 (ddd, *J* = 9.6, 6.1 and 2.2 Hz, 2H, H-G5,G5'), 3.36 (d, *J* = 9.0 Hz, 2H, H-G3,G3'), 3.34–3.33 (m, 2H, H-G4,G4'), 3.23 (dd, *J* = 9.0 and 7.8 Hz, 2H, H-G2,G2'), 2.70 (dd, *J* = 13.7 and 6.6 Hz, 2H, H-A3a,A3'a), 2.53 (dd, *J* = 13.7 and 8.0 Hz, 2H, H-A3b,A3'b), 2.29 (t, *J* = 7.4 Hz, 4H, H-F2,F2'), 2.23 (t, *J* = 6.4 Hz, 2H, H-A2,A2'), 1.56 (p, *J* = 7.3 Hz, 4H, H-F3,F3'), 1.32–1.25 (m, 32H, H-F4–F11 and H-F4'–F11'), 0.91 (t, *J* = 7.0 Hz, 6H, H-F12,F12'). ^{13}C NMR (151 MHz, CD_3OD): δ 175.4 (C-F1,F1'), 148.7 (C-3,3'), 145.5 (C-4,4'), 133.9 (C-1,1'), 122.9 (C-6,6'), 115.8 (C-5,5'), 113.6 (C-2,2'), 104.5 (C-G1,G1'), 78.1 (C-G3,G3'), 75.2 (C-G5,G5'), 75.2 (C-G2,G2'), 71.8 (C-G4,G4'), 70.8 (C-A1,A1'), 64.7 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 35.0 (C-A3,A3'), 34.9, 33.1, 30.8 (×2), 30.6, 30.5 (×2), 30.2, 26.1, 23.8, 14.5. IR (KBr) ν_{max}: 3385, 2922, 2853, 1723, 1674, 1607, 1514, 1455, 1367, 1268, 1236, 1202, 1078, 1030, 798, 722, 620 cm^{-1}. MS (ESI, + ve): *m*/*z* ($[M + NH_4]^+$, 100), 1074 ($[M + Na]^+$, 65).

G6,G6'-*O*-Myristoyl Secoisolariciresinol Diglucoside Diester (7). Yield: 49%, amorphous brown solid. ^{1}H NMR (600 MHz, CD_3OD): δ 6.68–6.65 (m, 4H, H-5,5' and H-2,2'), 6.59 (dd, *J* = 8.0 and 1.9 Hz, 2H, H-6,6'), 4.41 (dd, *J* = 11.8 and 2.2 Hz, 2H, H-G6b,G6'b), 4.25 (d, *J* = 7.8 Hz, 2H, H-G1,G1'), 4.22 (dd, *J* = 11.9 and 6.2 Hz, 2H, H-G6a,G6'a), 3.97 (dd, *J* = 9.7 and 6.6 Hz, 2H, H-A1b,A1'b), 3.79 (s, 6H, 3,3'-O-CH_3),

3.53 (dd, *J* = 9.7 and 5.6 Hz, 2H, H-A1a,A1'a), 3.45 (ddd, *J* = 9.7, 6.1 and 2.2 Hz, 2H, H-G5), 3.36 (d, *J* = 9.0 Hz, 2H, H-G3,G3'), 3.34 (d, *J* = 1.2 Hz, 2H, H-G4,G4'), 3.23 (dd, *J* = 9.0 and 7.8 Hz, 2H, H-G2,G2'), 2.71 (dd, *J* = 13.6 and 6.5 Hz, 2H, H-A3a,A3'a), 2.53 (dd, *J* = 13.6 and 8.0 Hz, 2H, H-A3b,A3'b), 2.29 (t, *J* = 7.5 Hz, 4H, H-F2,F2'), 2.24 (t, *J* = 6.5 Hz, 2H, H-A2,A2'), 1.59–1.55 (m, 4H, H-F3,F3'), 1.28 (m, *J* = 11.0 Hz, 40H, H-F4–F13 and H-F4'–F13'), 0.91 (t, *J* = 7.1 Hz, 6H, H-F14,F14'). ^{13}C NMR (151 MHz, CD_3OD): *δ* 175.4 (C-F1,F1'), 148.7 (C-3,3'), 145.5 (C-4,4'), 133.9 (C-1,1'), 122.9 (C-6,6'), 115.8 (C-5,5'), 113.7 (C-2,2'), 104.5 (C-G1,G1'), 78.1 (C-G3,G3'), 75.2 (C-G5,G5'), 75.2 (C-G2,G2'), 71.9 (C-G4,G4'), 70.8 (C-A1,A1'), 64.7 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 35.0 (C-A3,A3'), 34.9, 33.1, 30.8 (×4), 30.6, 30.5 (×2), 30.2, 26.1, 23.8, 23.8, 14.5. IR (KBr) ν_{max}: 3378, 2922, 2853, 1720, 1677, 1514, 1455, 1431, 1367, 1270, 1203, 1137, 1080.06, 1034, 801, 722, 622 cm^{-1}. MS (ESI, + ve): *m*/*z* 1125 ($[M + NH_4]^+$, 100), 1130 ($[M + Na]^+$, 97).

G6,G6'-*O*-Palmitoyl Secoisolariciresinol Diglucoside Diester (8). Yield: 55%, amorphous brown solid. ^{1}H NMR (600 MHz, CD_3OD): *δ* 6.67–6.64 (m, 4H, H-5,5' and H-2,2'), 6.58 (dd, *J* = 8.0, 1.9 Hz, 2H, H-6,6'), 4.40 (dd, *J* = 11.9 and 2.2 Hz, 2H, H-G6b,G6'b), 4.24 (d, *J* = 7.8 Hz, 2H, H-G1,G1'), 4.21 (dd, *J* = 11.9 and 6.2 Hz, 2H, H-G6a,G6'a), 3.96 (dd, *J* = 9.7 and 6.7 Hz, 2H, H-A1b,A1'b), 3.78 (s, 6H, 3,3'-O-C$\underline{H}_3$), 3.52 (dd, *J* = 9.7 and 5.6 Hz, 2H, H-A1a,A1'a), 3.44 (ddd, *J* = 9.6, 6.2 and 2.2 Hz, 2H, H-G5,G5'), 3.35 (d, *J* = 9.0 Hz, 2H, H-G3,G3'), 3.34–3.32 (m, 2H, H-G4,G4,), 3.23 (dd, *J* = 9.0 and 7.8 Hz, 2H, H-G2,G2'), 2.70 (dd, *J* = 13.6 and 6.5 Hz, 2H, H-A3a,A3'a), 2.51 (dd, *J* = 13.6 and 8.1 Hz, 2H, H-A3b,A3'b), 2.28 (t, *J* = 7.5 Hz, 4H, H-F2,F2'), 2.24 (q, *J* = 6.2 Hz, 2H, H-A2,A2'), 1.56 (p, *J* = 7.4 Hz, 4H, H-F3,F3'), 1.35–1.27 (m, 48H, H-F4–F15 and H-F4'–F15'), 0.91 (t, *J* = 7.0 Hz, 6H, H-F16,F16'). ^{13}C NMR (151 MHz, CD_3OD): *δ* 175.4 (C-F1,F1'), 148.7 (C-3,3'), 145.5 (C-4,4'), 133.9 (C-1,1'), 122.9 (C-6,6'), 115.8 (C-5,5'), 113.7 (C-2,2'), 104.5 (C-G1,G1'), 78.1 (C-G3,G3'), 75.2 (C-G5,G5'), 75.2 (C-G2,G2'), 71.9 (C-G4,G4'), 70.8 (C-A1,A1'), 64.7 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 35.0 (C-A3,A3'), 34.9, 33.1, 30.8 (×6), 30.6, 30.5 (×2), 30.2, 26.1, 23.8, 14.5. IR (KBr) ν_{max}: 3395, 2922.51, 2853, 1733, 1606, 1514,

1462, 1431, 1367, 1269, 1237, 1206, 1080, 1034, 798.15, 721, 622 cm^{-1}. MS (ESI, + ve): *m*/*z* ($[M + NH_4]^+$, 96), 1186($[M + Na]^+$, 100).

G6,G6'-*O*-Stearoyl Secoisolariciresinol Diglucoside Diester (9). Yield: 38%, amorphous brown solid. ^{1}H NMR (600 MHz, CD_3OD): δ 6.67–6.65 (m, 4H, H-5,5' and H-2,2'), 6.59 (dd, *J* = 8.0 and 1.9 Hz, 2H, H-6,6'), 4.40 (dd, *J* = 11.9 and 2.2 Hz, 2H, H-G6b,G6'b), 4.24 (d, *J* = 7.9 Hz, 2H, H-G1,G1'), 4.21 (dd, *J* = 11.9 and 6.2 Hz, 2H, H-G6a,G6a), 3.96 (dd, *J* = 9.7 and 6.7 Hz, 2H, H-A1b,A1'b), 3.78 (s, 6H, 3,3'-O-CH_3), 3.52 (dd, *J* = 9.7 and 5.6 Hz, 2H, H-A1a,A1'a), 3.44 (ddd, *J* = 9.6, 6.2 and 2.2 Hz, 2H, H-G5,G5'), 3.36 (d, *J* = 9.0 Hz, 2H, H-G3,G3'), 3.33 (m, 2H, H-G4,G4'), 3.23 (dd, *J* = 9.1 and 7.8 Hz, 2H, H-G2,G2'), 2.71 (dd, *J* = 13.6 and 6.4 Hz, 2H, H-A3a,A3'a), 2.51 (dd, *J* = 13.6 and 8.1 Hz, 2H, H-A3b,A3'b), 2.28 (t, *J* = 7.5 Hz, 4H, H-F2,F2'), 2.24 (t, *J* = 6.5 Hz, 2H, H-A2,A2'), 1.58–1.54 (m, 4H, H-F3,F3'), 1.34–1.26 (m, 56H, H-F4–F17 and H-F4'–F17'), 0.91 (t, *J* = 7.0 Hz, 6H, H-F18,F18'). ^{13}C NMR (151 MHz, CD_3OD): δ 175.4 (C-F1,F1'), 148.8 (C-3,3'), 145.5 (C-4,4'), 133.9 (C-1,1'), 122.9 (C-6,6'), 115.8 (C-5,5'), 113.7 (C-2,2'), 104.4 (C-G1,G1'), 78.1 (C-G3,G3'), 75.2 (C-G5,G5'), 75.2 (C-G2,G2'), 71.9 (C-G4,G4'), 70.8 (C-A1,A1'), 64.8 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 35.0 (C-A3,A3'), 34.9, 33.1, 30.8 (×8), 30.6, 30.5 (×2), 30.2, 26.1, 23.8, 14.5. IR (KBr) ν_{max}: 3401, 2922.31, 2853, 1734, 1678, 1608, 1514, 1464, 1368, 1270, 1237, 1205, 1080, 1035, 799, 722, 625 cm^{-1}. MS (ESI, + ve): *m*/*z* 1237 ($[M + NH_4]^+$, 100), 1242 ($[M + Na]^+$, 73).

SDG Peracetate (SDGAA, 10). Yield: 60%, amorphous white solid. ^{1}H NMR (500 MHz, CD_3OD): δ 6.91 (d, *J* = 8.0 Hz, 2H, H-5,5'), 6.81 (d, *J* = 1.8 Hz, 2H, H-2,2'), 6.72 (dd, *J* = 8.0 and 1.9 Hz, 2H, H-6,6'), 5.29 (t, *J* = 9.5 Hz, 2H, H-G3,G3'), 5.06 (dd, *J* = 10.1 and 9.4 Hz, 2H, H-G2,G2'), 4.97 (dd, *J* = 9.7 and 8.0 Hz, 2H, H-G4,G4'), 4.65 (d, *J* = 8.0 Hz, 2H, H-G1,G1'), 4.31 (dd, *J* = 12.4 and 4.5 Hz, 2H, H-G6b,G6'b), 4.13 (dd, *J* = 12.4 and 2.4 Hz, 2H, H-G6a,G6'a), 3.93 (dt, *J* = 8.2 and 4.1 Hz, 2H, H-A1b,A1'b), 3.86 (ddd, *J* = 10.1, 4.4 and 2.4 Hz, 2H, H-G5,G5'), 3.80 (s, 6H, 3,3'-O-CH_3), 3.52 (dd, *J* = 9.9 and 5.2 Hz, 2H, H-A1a,A1'a), 2.79 (dd, *J* = 13.6 and 6.3 Hz, 2H, H-A3a,A3'a), 2.61 (dd, *J* = 13.7 and 7.8 Hz, 2H, H-A3b,A3'b), 2.27 (s, 6H,

4,4'-COO-C<u>H</u>$_3$), 2.12 (dq, *J* = 8.9, 5.2 and 4.3 Hz, 2H, H-A2,A2'), 2.03 (d, *J* = 1.1 Hz, 12H, G2,G2'-COO-C<u>H</u>$_3$ and G3,G3'-COO-C<u>H</u>$_3$), 1.99 (s, 6H, G6,G6'-COO-C<u>H</u>$_3$), 1.96 (s, 6H, G4,G4'-COO-C<u>H</u>$_3$). ^{13}C NMR (126 MHz, CD_3OD): δ 172.3, 171.6, 171.3, 171.2, 170.9, 152.4 (C-3,3'), 141.1 (C-1,1'), 139.4 (C-4,4'), 123.4 (C-5,5'), 122.4 (C-6,6'), 114.3 (C-2,2'), 101.6 (C-G1,G1'), 74.3 (C-G5,G5'), 73.0 (C-G3,G3'), 72.8 (C-A1,A1'), 70.3 (C-G2,G2'), 69.9 (C-G4,G4'), 63.0 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 35.3 (C-A3,A3'), 20.8, 20.7, 20.6, 20.5 (×2). IR (KBr) ν_{max}: 2942, 1758, 1604, 1510, 1420, 1370, 1223, 1153, 1124, 1038, 906, 831, 600 cm^{-1}. MS (ESI, + ve): *m*/*z* 1124 ([M + NH_4]$^+$, 100), 1129 ([M + Na]$^+$, 50).

G6'-*O*-Octanoyl Secoisolariciresinol Diglucoside Monoester (11). Yield: 52%, amorphous pale-yellow solid. ^{1}H NMR (500 MHz, CD_3OD): δ 6.64 (dd, *J* = 7.9 and 2.1 Hz, 2H, H-5,5'), 6.61 (dd, *J* = 5.4 and 1.9 Hz, 2H, H-2,2'), 6.57 (ddd, *J* = 9.7, 8.1 and 1.9 Hz, 2H, H-6,6'), 4.38 (dd, *J* = 11.8 and 2.2 Hz, 1H, H-G6'b), 4.23 (dd, *J* = 7.8 and 3.1 Hz, 2H, H-G1,G1'), 4.20 (dd, *J* = 11.8 and 5.6 Hz, 1H, H-G6'a), 4.07 (dd, *J* = 9.9 and 6.0 Hz, 1H, H-A1'b), 3.96 (dd, *J* = 9.8 and 5.9 Hz, 1H, H-A1b), 3.85 (dd, *J* = 11.8 and 2.3 Hz, 1H, H-G6b), 3.75 (s, 3H, 3'-O-C<u>H</u>$_3$), 3.74 (s, 3H, 3-O-C<u>H</u>$_3$), 3.68 (dd, *J* = 11.8 and 5.6 Hz, 1H, H-G6a), 3.50 (dd, *J* = 9.8 and 6.0 Hz, 1H, H-A1'a), 3.46 (dd, *J* = 9.8 and 6.4 Hz, 1H, H-A1a), 3.42 (m, 1H, H-G5'), 3.34 (dd, *J* = 9.1 and 3.5 Hz, 2H, H-G3,G3'), 3.29 (m, 2H, H-G4,G4'), 3.24 (dd, *J* = 5.6 and 2.3 Hz, 1H, H-G5), 3.21 (ddd, *J* = 9.0, 7.9 and 3.1 Hz, 2H, H-G2,G2'), 2.68–2.57 (m, 4H, H-A3,A3'), 2.30–2.26 (m, 2H, H-F2), 2.16 (tt, *J* = 7.0 and 3.7 Hz, 2H, H-A2' and H-A2), 1.55 (p, *J* = 7.4 Hz, 2H, H-F3), 1.28 – 1.25 (m, 8H, H-F4–F7), 0.87 (t, *J* = 7.0 Hz, 3H, H-F8). ^{13}C NMR (126 MHz, CD_3OD): δ 175.4 (C-F1), 148.7 (C-3' and C-3), 145.4 (×2, C-4,4'), 133.9 (×2, C-1,1'), 122.9 (C-6'), 122.8 (C-6), 115.7 (×2, C-5,5'), 113.6 (C-2'), 113.5 (C-2), 104.7 (C-G1'), 104.6 (C-G1), 78.2 (C-G3'), 78.0 (C-G3), 77.9 (C-G5), 75.3 (C-G5'), 75.2 (×2, C-G2,G2'), 71.7 (×2, C-G4,G4'), 71.1 (C-A1'), 70.9 (C-A1), 64.6 (C-G6'), 62.8 (C-G6), 56.3 (3,3'-O-<u>C</u>H_3), 41.3 (C-A2'), 41.2 (C-A2), 35.2 (C-A3,A3'), 35.0, 32.9, 30.2, 30.1, 26.1, 23.7, 14.5. IR (KBr) ν_{max}: 3409, 2928, 1725, 1605, 1515, 1455, 1430, 1370, 1271, 1236, 1156, 1078, 1034, 817, 798, 636 cm^{-1}. MS (ESI, + ve): *m*/*z* 831

([M + NH_4]$^+$, 93)，836 ([M + Na]$^+$, 100).

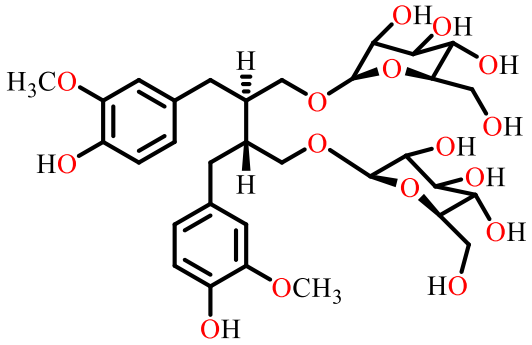
G6'-*O*-Lauroyl Secoisolariciresinol Diglucoside Monoester (12). Yield: 61%, amorphous pale-yellow solid. **^{1}H NMR** (600 MHz, CD_3OD) δ: 6.66 (dd, J = 7.9 and 2.1 Hz, 2H, H-5,5'), 6.64 (dd, J = 5.7 and1.9 Hz, 2H, H-2,2'), 6.59 (ddd, J = 10.0, 7.9 and 1.9 Hz, 2H, H-6,6'), 4.40 (dd, J = 11.9 and 2.2 Hz, 1H, H-G6b,G6'b), 4.25 (dd, J = 7.9 and 3.1 Hz, 2H, H-G1,G1'), 4.24–4.21 (m, 1H, H-G6'a), 4.08 (dd, J = 9.9 and 6.1 Hz, 1H, H-A1'b), 3.98 (dd, J = 9.8 and 6.0 Hz, 1H, H-A1b), 3.87 (dd, J = 11.8 and 2.3 Hz, 1H, H-G6b), 3.77 (s, 3H, 3'-O-C$\underline{H}_3$), 3.76 (s, 3H, 3-O-C$\underline{H}_3$), 3.70 (dd, J = 11.8 and 5.6 Hz, 1H, H-G6a), 3.53 (dd, J = 9.8 and 5.9 Hz, 1H, H-A1'a), 3.49 (dd, J = 9.9 and 6.3 Hz, 1H, H-A1a), 3.44 (ddd, J = 9.6, 5.9 and 2.2 Hz, 1H, H-G5'), 3.38–3.34 (m, 2H, H-G3,G3'), 3.33 (d, J = 1.7 Hz, 2H, H-G4,G4'), 3.26 (dt, J = 6.2 and 3.1 Hz, 1H, H-G5), 3.23 (ddd, J = 9.0, 7.8 and 4.0 Hz, 2H, H-G2,G2'), 2.72–2.57 (m, 4H, H-A3,A3'), 2.30 (t, J = 7.5 Hz, 2H, H-F2), 2.19 (q, J = 7.8 and 7.0 Hz, 2H, H-A2,A2'), 1.57 (p, J = 7.4 Hz, 2H, H-F3), 1.27 (m, 16H, H-F4–F11), 0.91 (t, J = 7.1 Hz, 3H, H-F8). ^{13}C NMR (151 MHz, CD_3OD): δ 175.5 (C-F1), 148.7 (C-3,3'), 145.5 (C-4'), 145.4 (C-4), 133.9 (C-1'), 133.9 (C-1), 122.9 (C-6'), 122.9 (C-6), 115.7 (C-5'), 115.7 (C-5), 113.6 (C-2'), 113.6 (C-2), 104.7 (C-G1'), 104.6 (C-G1), 78.2 (C-G3'), 78.0 (C-G3), 77.9 (C-G5), 75.3 (C-G5'), 75.2 (C-G2'), 75.2 (C-G2), 71.8 (C-G4'), 71.7 (C-G4), 71.1 (C-A1'), 70.9 (C-A1), 64.7 (C-G6'), 62.8 (C-G6), 56.3 (3'-O-$\underline{C}H_3$), 56.3 (3-O-$\underline{C}H_3$), 41.3 (C-A2'), 41.3 (C-A2), 35.3 (C-A3,A3'), 35.0, 33.1, 30.8, 30.7, 30.6, 30.5, 30.4, 30.2, 26.1, 23.7, 14.5. IR (KBr) ν_{max}: 3416, 2925, 2854, 1735, 1605, 1515, 1465, 1431, 1370, 1271, 1237, 1208, 1155, 1078, 1034, 817, 799, 637, 618 cm^{-1}. MS (ESI, + ve): m/z 887 ([M + NH_4]$^+$, 100)，892 ([M + Na]$^+$, 75).

G6'-*O*-Palmitoyl Secoisolariciresinol Diglucoside Monoester (13). Yield: 67%, amorphous pale-yellow solid, yield 25.0%. ^{1}H NMR (500 MHz, CD_3OD): δ 6.91 (d, J = 8.0 Hz, 2H, H-5,5'), 6.81 (d, J = 1.8 Hz, 2H, H-2,2'), 6.72 (dd, J = 8.0 and 1.9 Hz, 2H, H-6,6'), 5.29 (t, J = 9.5 Hz, 2H, H-G3,G3'), 5.06 (dd, J = 10.1 and 9.4 Hz, 2H, H-G2,G2'), 4.97 (dd, J = 9.7 and 8.0 Hz, 2H, H-G4,G4'), 4.65 (d, J = 8.0 Hz, 2H, H-G1,G1'), 4.31 (dd, J = 12.4 and 4.5 Hz, 2H, H-G6b,G6'b), 4.13 (dd, J = 12.4 and 2.4

Hz, 2H, H-G6a,G6'a), 3.93 (dt, *J* = 8.2 and 4.1 Hz, 2H, H-A1b,A1'b), 3.86 (ddd, *J* = 10.1, 4.4 and 2.4 Hz, 2H, H-G5,G5'), 3.80 (s, 6H, 3,3'-O-CH_3), 3.52 (dd, *J* = 9.9 and 5.2 Hz, 2H, H-A1a,A1'a), 2.79 (dd, *J* = 13.6 and 6.3 Hz, 2H, H-A3a,A3'a), 2.61 (dd, *J* = 13.7 and 7.8 Hz, 2H, H-A3b,A3'b), 2.27 (s, 6H, 4-COO-C$\underline{H}_3$), 2.12 (dq, *J* = 8.9, 5.2 and 4.3 Hz, 2H, H-A2,A2'), 2.03 (d, *J* = 1.1 Hz, 12H, G2-COO-C$\underline{H}_3$ and G3-COO-C$\underline{H}_3$), 1.99 (s, 6H, G6-COO-C$\underline{H}_3$), 1.96 (s, 6H, G4-COO-C$\underline{H}_3$). ^{13}C NMR (126 MHz, CD_3OD): δ 175.4 (C-F1), 152.4 (C-3,3'), 141.1 (C-1,1'), 139.4 (C-4,4'), 123.4 (C-5,5'), 122.4 (C-6,6'), 114.3 (C-2,2'), 101.6 (C-G1,G1'), 74.3 (C-G5,G5'), 73.0 (C-G3,G3'), 72.8 (C-A1,A1'), 70.3 (C-G2,G2'), 69.9 (C-G4,G4'), 63.0 (C-G6,G6'), 56.4 (3,3'-O-CH_3), 41.3 (C-A2,A2'), 41.2, 35.3 (C-A3,A3'), 35.0, 33.1, 30.8 (×6), 30.6, 30.5, 30.4, 30.2, 26.1, 23.7, 14.5. IR (KBr) ν_{max}: 2942, 1758, 1604, 1510, 1420, 1370, 1223, 1153, 1124, 1038, 906, 831, 600 cm^{-1}. MS (ESI, + ve): *m*/*z* 943 ($[M + NH_4]^+$, 100)，948 ($[M + Na]^+$, 78).

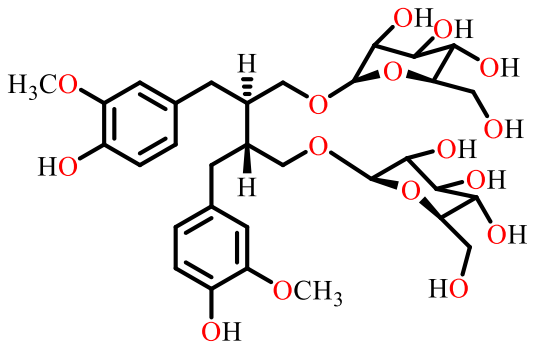
Anhydrosecoisolariciresinol (ASECO, 14). Yield: 58%, amorphous pale-yellow crystals. ^{1}H NMR (600 MHz, CD_3OD): δ 6.70 (d, *J* = 8.0 Hz, 2H, H-5,5'), 6.62 (d, *J* = 2.0 Hz, 2H, H-2,2'), 6.55 (dd, *J* = 8.0 and 2.0 Hz, 2H, H-6,6'), 3.89 (dd, *J* = 8.5 and 6.6 Hz, 2H, H-A1b,A1'b), 3.80 (s, 6H, 3,3'-O-CH_3), 3.55–3.48 (m, 2H, H-A1a,A1'a), 2.57–2.47 (m, 4H, H-A3,A3'), 2.19 (ddd, *J* = 12.1, 7.0 and 5.5 Hz, 2H, H-A2,A2'). ^{13}C NMR (126 MHz, CD_3OD): δ 148.9 (C-3,3'), 145.8 (C-4,4'), 133.3 (C-1,1'), 122.2 (C-6,6'), 116.0 (C-5,5'), 113.3 (C-2,2'), 74.3 (C-A1,A1'), 56.3 (3,3'-O-CH_3), 47.7 (C-A2,A2'), 39.9 (C-A3,A3'). IR (KBr) ν_{max}: 3351, 2979.81, 2939, 291, 2847, 1605, 1517, 1432, 1379, 1311, 1267, 1241, 1155, 1119, 1069, 1038, 979, 931, 879, 850, 821, 802, 698, 623, 564, 455 cm^{-1}. MS (ESI, + ve): *m*/*z* ($[M+NH_4]^+$, 100), 367 ($[M+Na]^+$, 46).

Figure S1. 500 MHz ^{1}H NMR spectrum of compound **1** (recorded in CD_3OD).



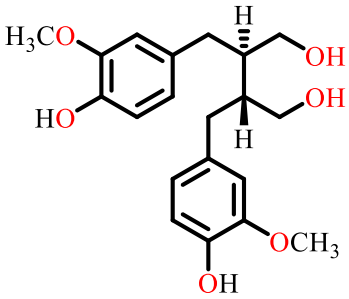
Secoisolariciresinol diglucoside, **1**
(SDG)

Figure S2. 151 MHz ^{13}C NMR spectrum of compound **1** (recorded in CD_3OD).



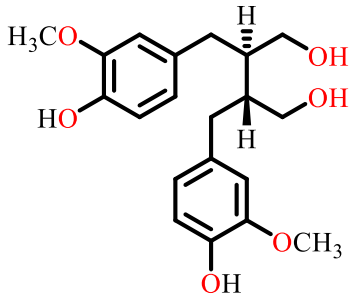
Secoisolariciresinol diglucoside, **1**
(SDG)

Figure S3. 600 MHz ^{1}H NMR spectrum of compound **2** (recorded in CD_3OD).



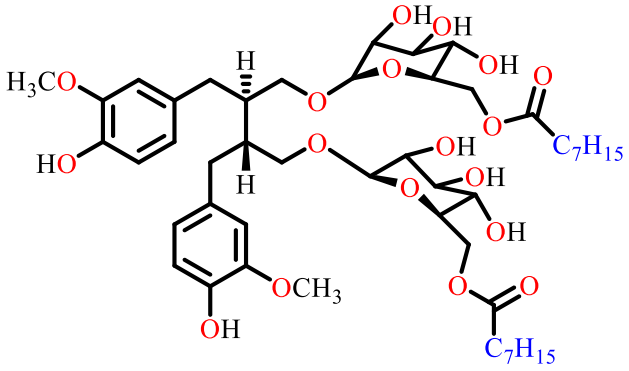
Secoisolariciresinol, **2**
(SECO)

Figure S4. 126 MHz ^{13}C NMR spectrum of compound **2** (recorded in CD_3OD).



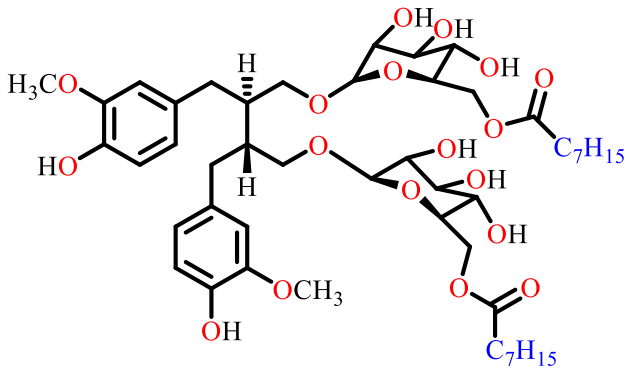
Secoisolariciresinol, **2**
(SECO)

Figure S5. 600 MHz ^{1}H NMR spectrum of compound **4** (recorded in CD_3OD).



G6,6'-*O*-octanoyl secoisolariciresinol diglucoside diester, **4**

Figure S6. 151 MHz ^{13}C NMR spectrum of compound **4** (recorded in CD_3OD).



G6,6'-*O*-octanoyl secoisolariciresinol diglucoside diester, **4**

Figure S7. Key HMBC correlations of compound **4**.

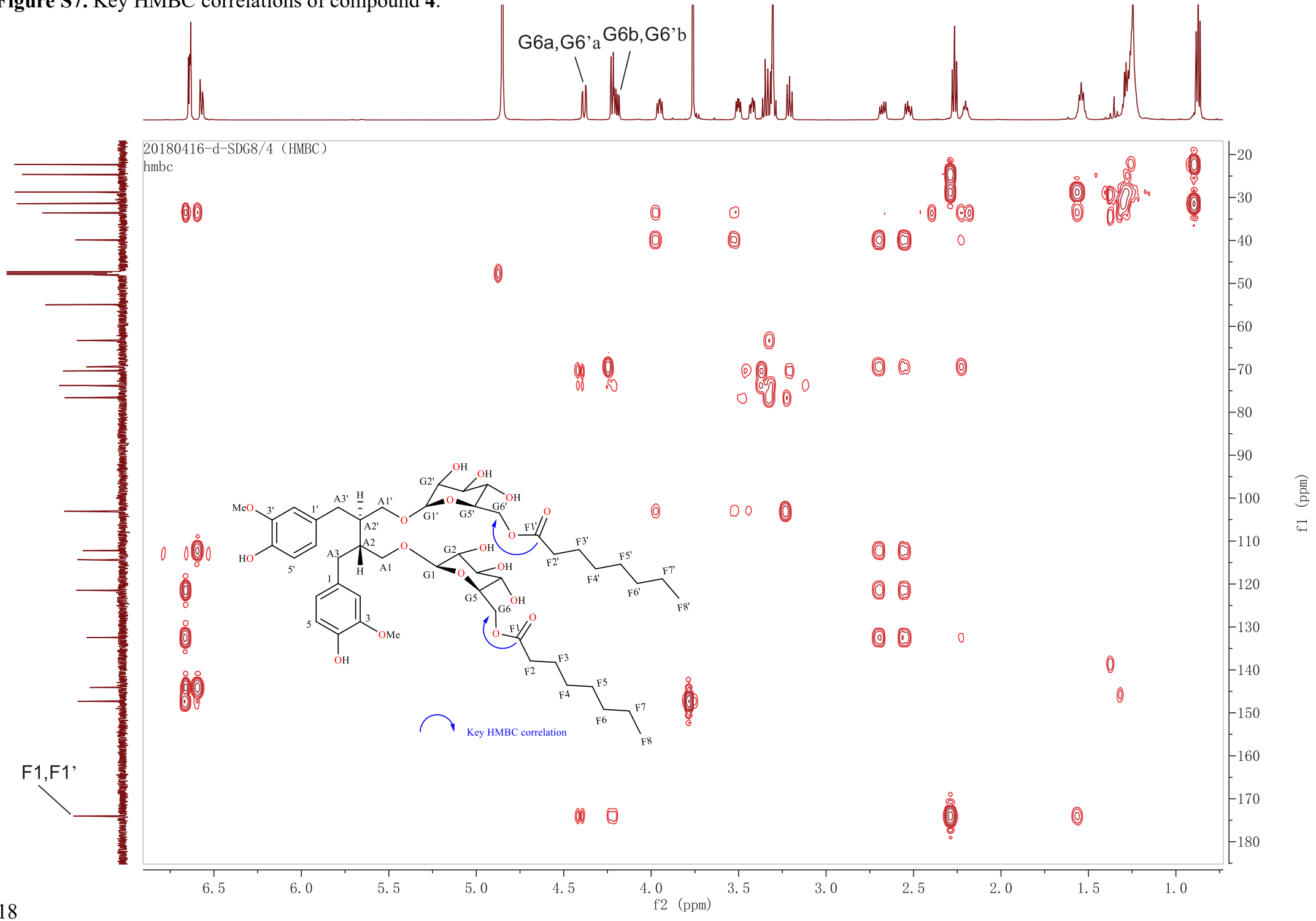
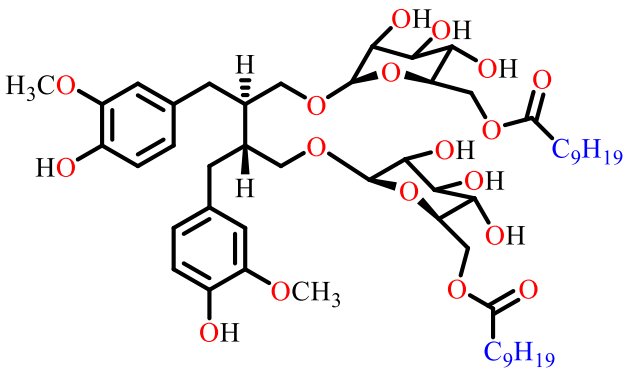
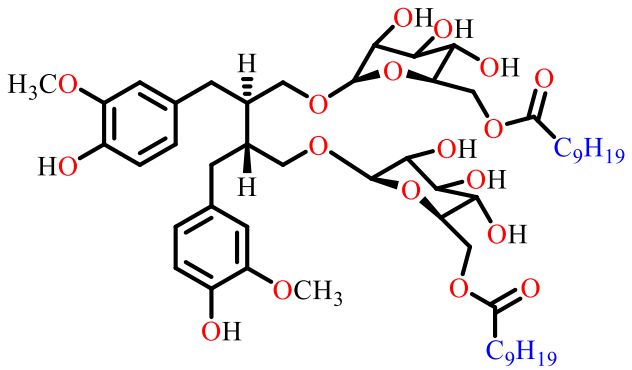


Figure S8. 600 MHz ^{1}H NMR spectrum of compound **5** (recorded in CD_3OD).



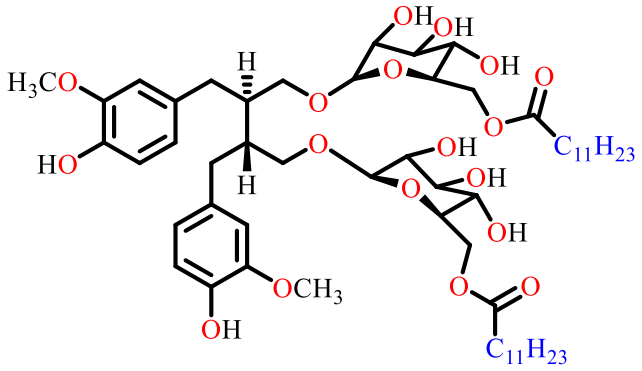
G6,6'-*O*-decanoly secoisolariciresinol diglucoside diester, **5**

Figure S9. 151 MHz ^{13}C NMR spectrum of compound **5** (recorded in CD_3OD).



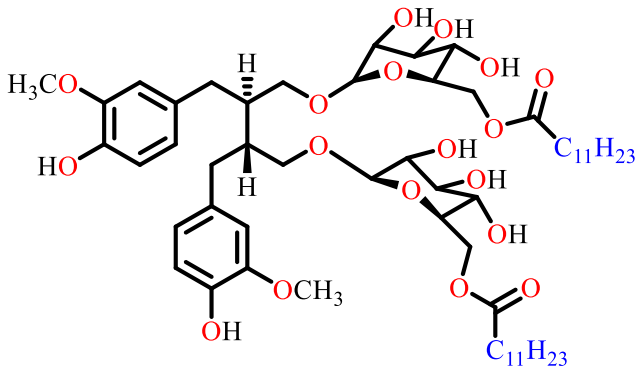
G6,6'-*O*-decanoly secoisolariciresinol diglucoside diester, **5**

Figure S10. 600 MHz ^{1}H NMR spectrum of compound **6** (recorded in CD_3OD).



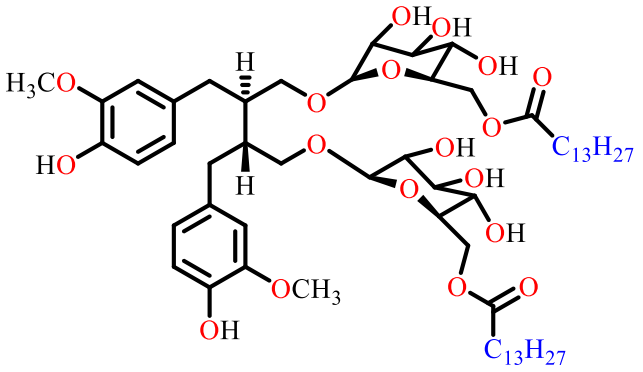
G6,6'-*O*-lauroyl secoisolariciresinol diglucoside diester, **6**

Figure S10. 151 MHz ^{13}C NMR spectrum compound **6** (recorded in CD_3OD).



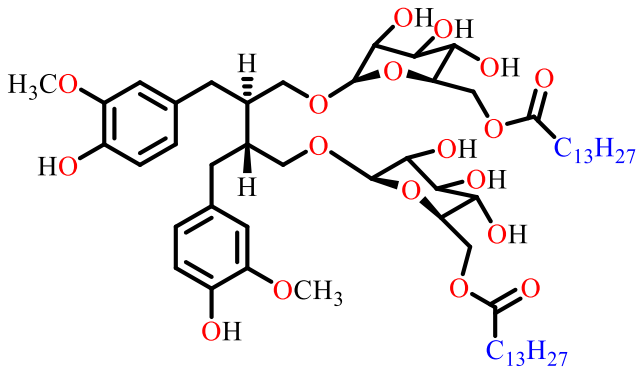
G6,6'-*O*-lauroyl secoisolariciresinol diglucoside diester, **6**

Figure S12. 600 MHz ^{1}H NMR spectrum of compound **7** (recorded in CD_3OD).



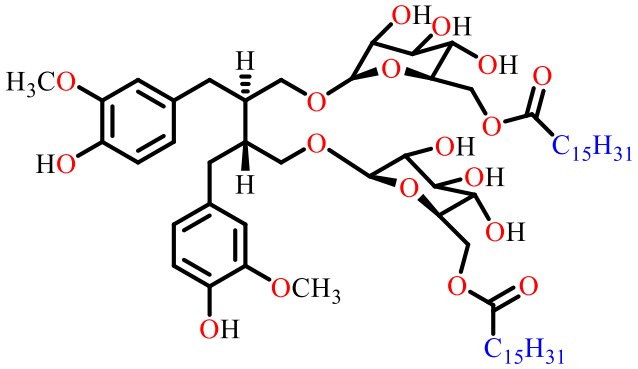
G6,6'-*O*-myristoyl secoisolariciresinol diglucoside diester, **7**

Figure S13. 151 MHz ^{13}C NMR spectrum of compound **7** (recorded in CD_3OD).



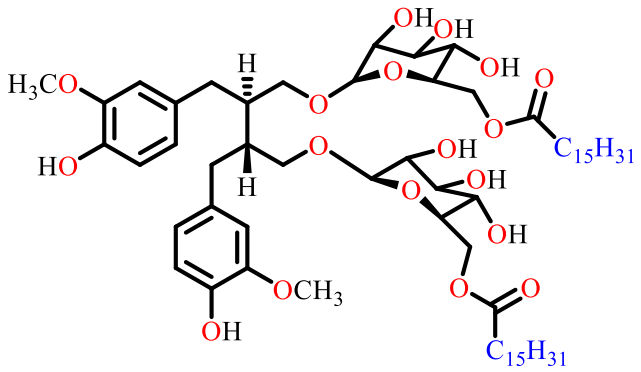
G6,6'-*O*-myristoyl secoisolariciresinol diglucoside diester, **7**

Figure S14. 600 MHz ^{1}H NMR spectrum of compound **8** (recorded in CD_3OD).



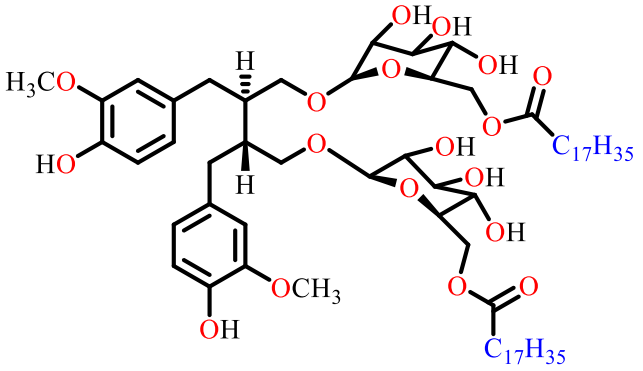
G6,6'-*O*-palmitoyl secoisolariciresinol diglucoside diester, **8**

Figure S15. 151 MHz ^{13}C NMR spectrum of compound **8** (recorded in CD_3OD).



G6,6'-*O*-palmitoyl secoisolariciresinol diglucoside diester, **8**

Figure S16. 600 MHz ^{1}H NMR spectrum of compound **9** (recorded in CD_3OD).



G6,6'-*O*-stearoyl secoisolariciresinol diglucoside diester, **9**

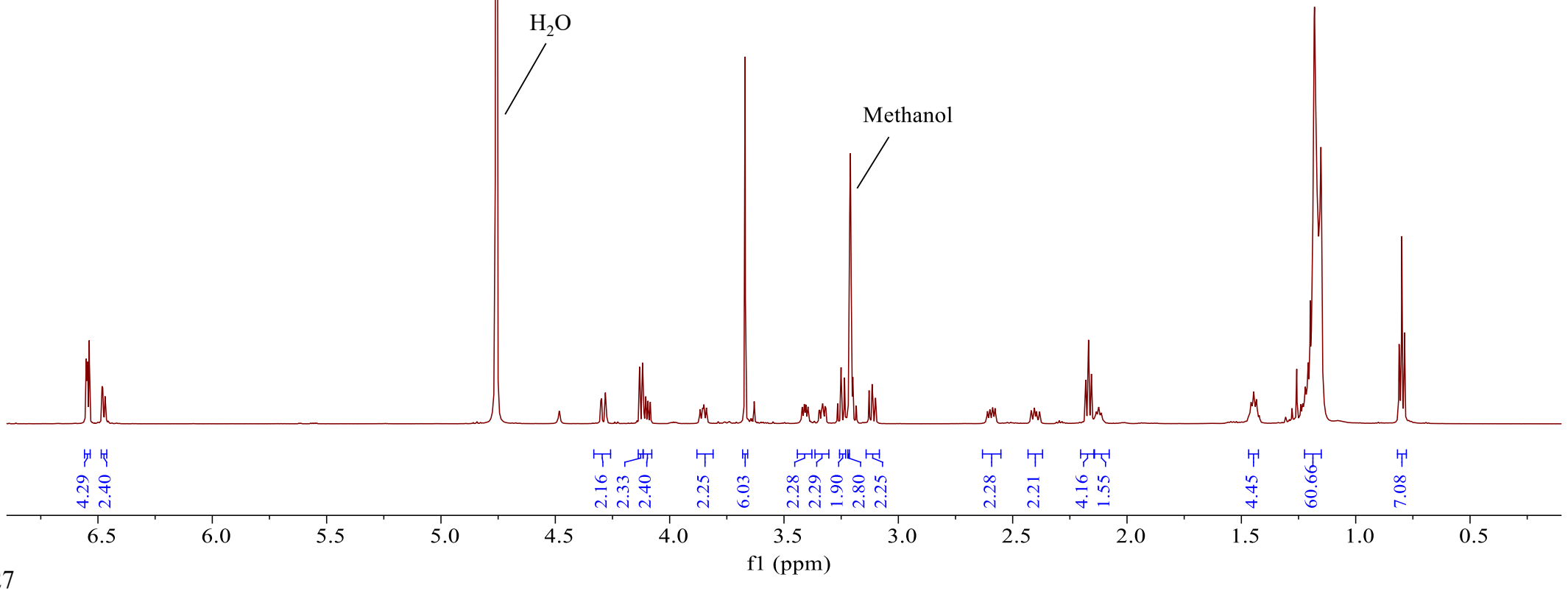
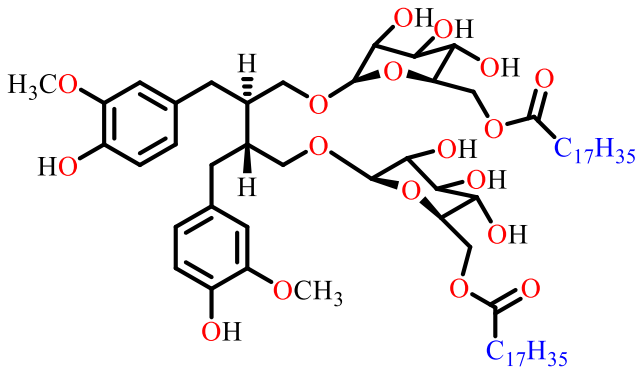
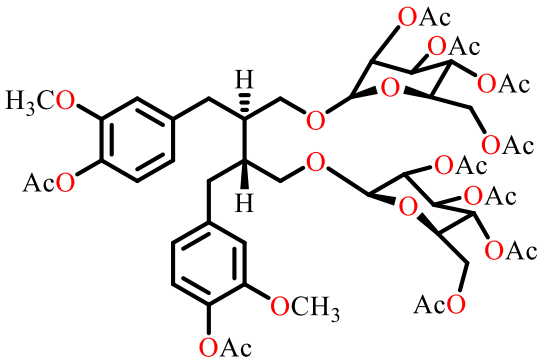


Figure S17. 151 MHz ^{13}C NMR spectrum of compound **9** (recorded in CD_3OD).



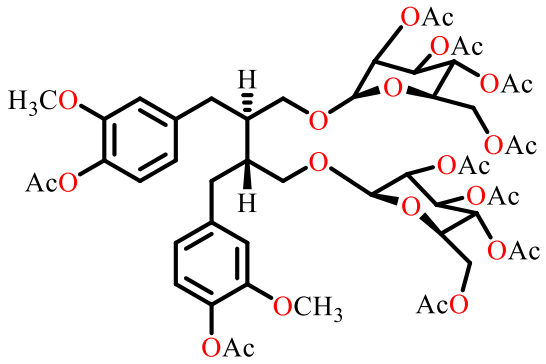
G6,6'-*O*-stearoyl secoisolariciresinol diglucoside diester, **9**

Figure S18. 500 MHz ^{1}H NMR spectrum of compound **10** (recorded in CD_3OD).



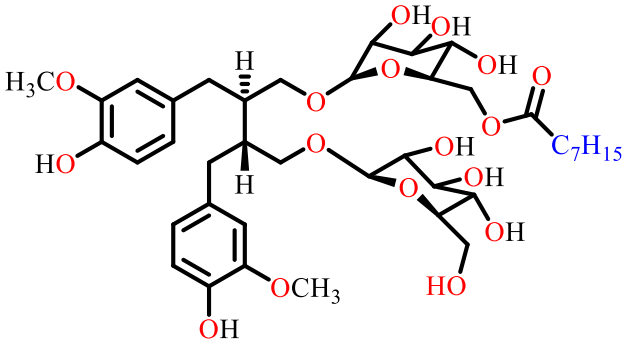
Secoisolariciresinol diglucoside acetate, **10**

Figure S19. 126 MHz ^{13}C NMR spectrum of compound **10** (recorded in CD_3OD).



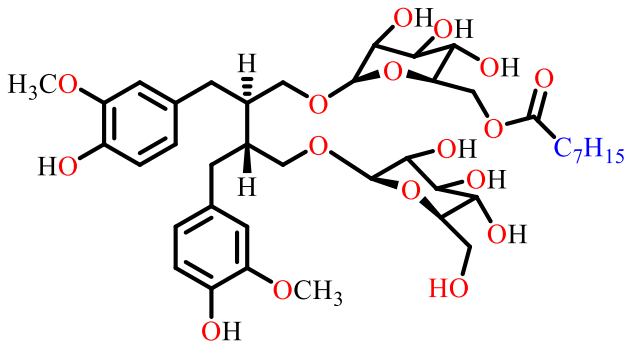
Secoisolariciresinol
diglucoside acetate, **10**

Figure S20. 600 MHz ^{1}H NMR spectrum of compound **11** (recorded in CD_3OD).



G6'-*O*-octanoyl secoisolariciresinol diglucoside monoester, **11**

Figure S21. 151 MHz ^{13}C NMR spectrum of compound **11** (recorded in CD_3OD).



G6'-*O*-octanoyl secoisolariciresinol diglucoside monoester, **11**

Figure S22. Key HMBC correlation of compound **11**.

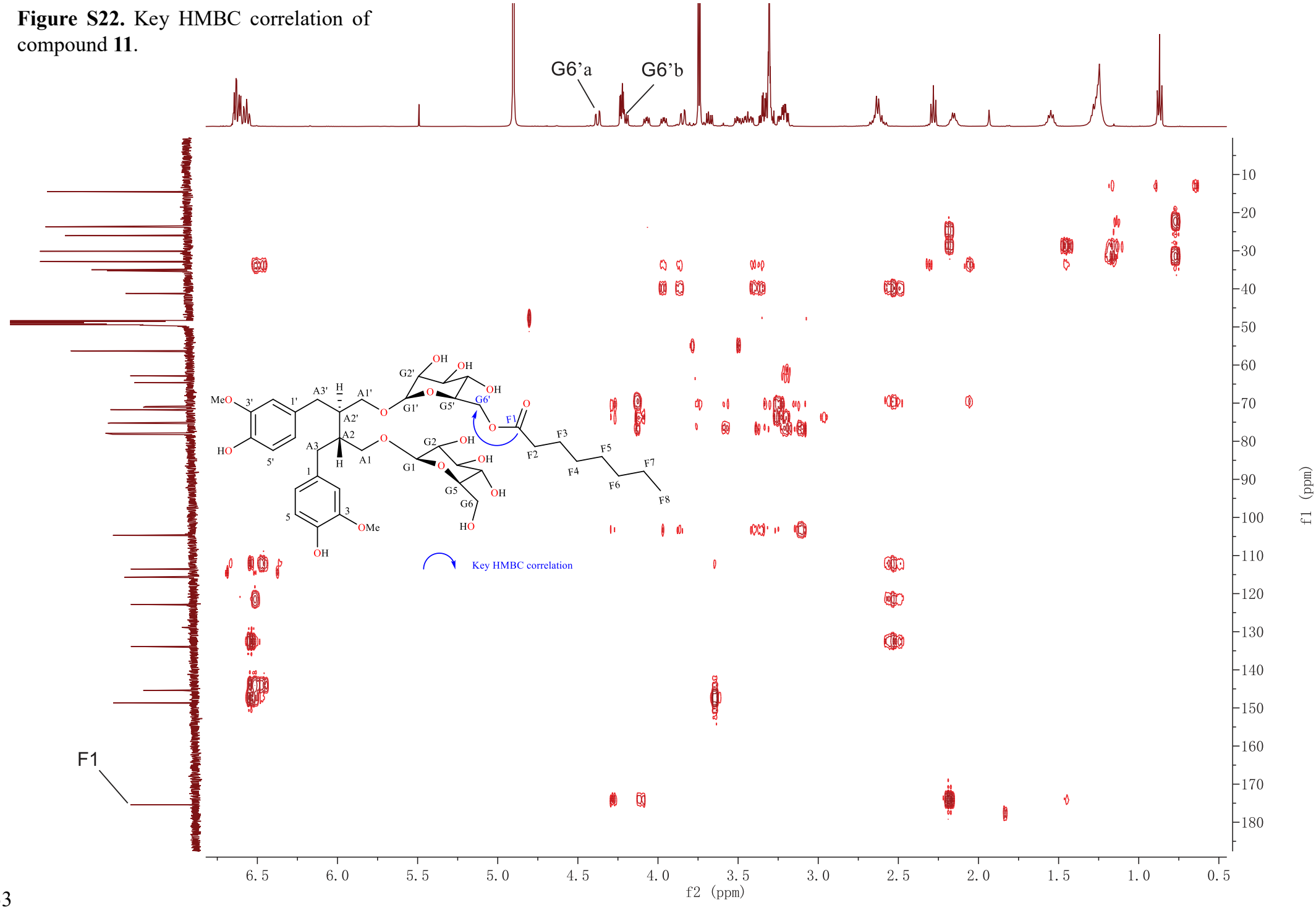
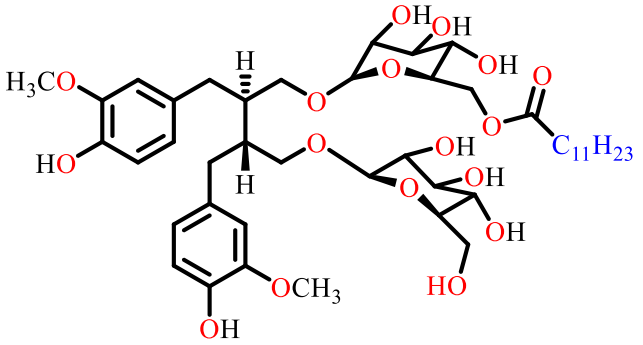
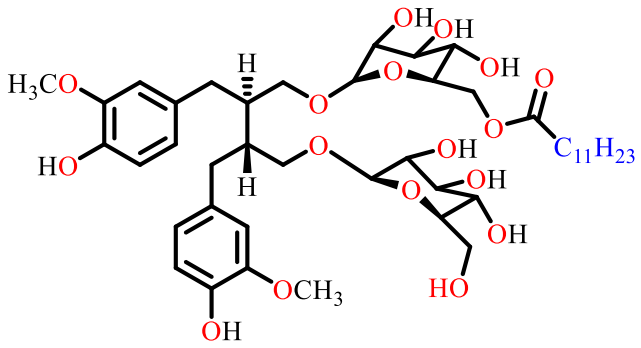


Figure S23. 600 MHz ^{1}H NMR spectrum of compound **12** (recorded in CD_3OD).



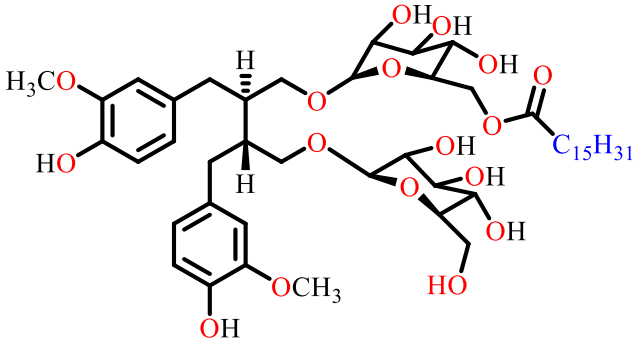
G6'-*O*-lauroyl secoisolariciresinol diglucoside monoester, **12**

Figure 24. 151 MHz ^{13}C NMR spectrum of compound **12** (recorded in CD_3OD).



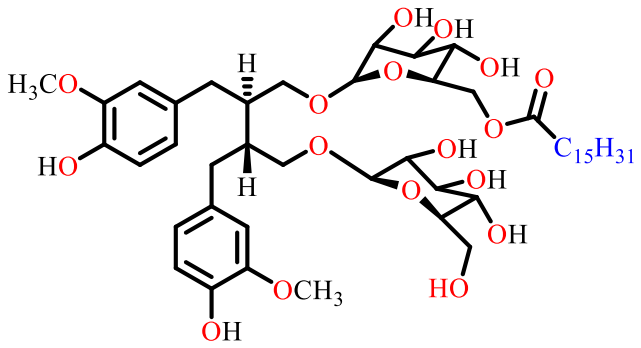
G6'-*O*-lauroyl secoisolariciresinol diglucoside monoester, **12**

Figure S25. 600 MHz ^{1}H NMR spectrum of compound **13** (recorded in CD_3OD).



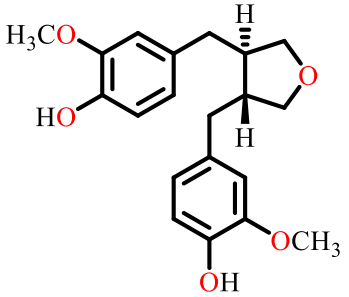
G6'-*O*-palmitoyl secoisolariciresinol diglucoside monoester, **13**

Figure S26. 151 MHz ^{13}C NMR spectrum of compound **13** (recorded in CD_3OD).



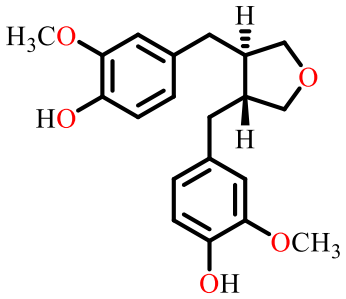
G6'-*O*-palmitoyl secoisolariciresinol diglucoside monoester, **13**

Figure S27. 600 MHz ^{1}H NMR spectrum of compound **14**, (recorded in CD_3OD).



Anhydrosecoisolariciresinol, **14**
(ASECO)

Figure S28. 126 MHz ^{13}C NMR spectrum of compound **14**, (recorded in CD_3OD).



Anhydrosecoisolariciresinol, **14**
(ASECO)