Supporting Information

Synthesis of Phytuberin. 4-*Endo-Tet* Acid-catalyzed Cyclization of α -Hydroxy-epoxides

Thierry Prangé,[†] María S. Rodríguez,[‡] and Ernesto Suárez[§]

[§]Instituto de Productos Naturales y Agrobiología del C.S.I.C., Carretera de La Esperanza 3, 38206 La Laguna, Tenerife, Spain, [‡]Departamento de Química Orgánica, Universidad de La Laguna, Tenerife, Spain, and [†]LURE, Université Paris-Sud, Paris, 91405 Orsay Cedex, France

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General. Melting points were determined with a hot-stage apparatus. Optical rotation measurements were recorded at room temperature in CHCl_3 . IR spectra were recorded in CHCl_3 solutions unless otherwise indicated. ^1H NMR spectra were determined at 200, 400, or 500 MHz for CDCl_3 solutions in parts per million from residual CHCl_3 (7.26 ppm) as internal reference unless otherwise indicated. Homonuclear coupling constants (J) were confirmed by COSY or single-frequency decoupling experiments. ^{13}C NMR spectra were recorded at 50.3, 100.6, or 125.7 MHz and chemical shifts are reported in ppm from the central peak of CDCl_3 ($\delta = 77.0$) as internal reference. Signal chemical shift and multiplicity assignments were made from DEPT, HETCOR, and HMBC spectra. Mass spectra were determined at 70 eV. Merck silica gel 60 (0.040–0.063 mm) was used for flash chromatography. Circular layers of 1 mm of Merck silica gel 60 PF₂₅₄ containing gypsum were used on a Chromatotron for centrifugally assisted chromatography. Commercial reagents and solvents were analytical grade or were purified by standard procedures prior to use. All reactions involving air- or moisture-sensitive materials were carried out under a nitrogen atmosphere. The spray reagent for TLC was vanillin (1 g) in H_2SO_4 –EtOH (4:1; 200 mL).

Methyl (11S)-4 β ,5 β -Epoxy-3 β -hydroxy-1 β -(phenylsulfinyl)-eudesman-13-oate (15) and Methyl (11S)-4 β ,5 β -Epoxy-3 β -hydroxy-1 β -(phenylsulfonyl)-eudesman-13-oate (16). To a solution of ester **4** (100 mg, 0.27 mmol) and vanadyl acetylacetonate (1.4 mg, 0.0054 mmol) in benzene (2 mL) was added dropwise over 10 min *tert*-butyl hydroperoxide (2.7 M in toluene, 0.5 mL, 1.35 mmol). The mixture was stirred at room temperature for 3 h, poured into a 2% aqueous solution of sodium bisulfite and extracted with CH_2Cl_2 . The organic layer was dried (Na_2SO_4), and the solvent evaporated in vacuo to give a crude product which was purified by Chromatotron chromatography (hexanes–EtOAc, 1:1) to give sulfoxide **15** (94 mg, 0.23 mmol, 85%) and sulfone **16** (11 mg, 10%).

Sulfoxide **15**: R_f = 0.27 (hexanes–EtOAc, 1:1); mp 114.4–115.4 °C (from *n*-pentane–acetone); $[\alpha]_D -89$ (c = 0.22), IR 3560; 3520–3200, 1740 cm^{-1} ; ^1H NMR (200 MHz) 1.18 (3H, d, J = 7.1 Hz), 1.45 (3H, s), 1.52 (3H, s), 3.68 (3H, s), 7.51 (5H, m); ^{13}C NMR (50.3 MHz) 14.3 (CH_3), 16.2 (CH_3), 19.3 (CH_3), 22.6 (CH_2), 24.1 (CH_2), 31.4 (CH_2), 37.3 (C), 38.8 (CH_2), 39.7 (CH), 44.6 (CH), 51.6 (CH_3), 67.1 (C), 69.1 (CH), 69.5 (C), 74.4 (CH), 124.2 ($2 \times \text{CH}$), 129.2 ($2 \times \text{CH}$), 130.6 (CH), 144.1 (C), 176.0 (C); MS m/z (rel intensity) 391 ($\text{M}^+ - \text{CH}_3$, 2), 376 (2), 281 (29), 263 (36), 247 (32), 159 (76); HRMS calcd for $\text{C}_{16}\text{H}_{25}\text{O}_4$ 281.1753, found 281.1697. Anal. Calcd for $\text{C}_{22}\text{H}_{30}\text{O}_5\text{S}$: C, 65.00; H, 7.44; S, 7.89. Found: C, 65.12; H, 7.41; S, 7.85. Sulfone **16**: R_f = 0.42 (hexanes–EtOAc, 1:1); ^1H NMR (200 MHz) 1.16 (3H, d, J = 7.1 Hz), 1.41 (3H, s), 1.54 (3H, s), 2.68 (1H, dd, J = 13.1, 2.7 Hz), 3.67 (3H, s), 7.70 (5H, m); ^{13}C NMR (20.1 MHz) 14.0 (CH_3), 14.4 (CH_3), 15.8 (CH_3), 24.3 (CH_2), 27.7 (CH_2), 32.7 (CH_2), 37.4 (C), 39.3 (CH), 40.4 (CH_2), 44.6 (CH), 51.4 (CH_3), 67.8 (C), 70.2 (CH), 70.7 (C), 71.9 (CH), 128.6 ($2 \times \text{CH}$), 129.2 ($2 \times \text{CH}$), 133.5 (CH), 139.6 (C), 176.1 (C); MS m/z (rel intensity) 281 ($\text{M}^+ - \text{C}_6\text{H}_5\text{O}_2\text{S}$, 11), 263 (20), 249 (18), 231 (15). Anal. Calcd for $\text{C}_{22}\text{H}_{30}\text{O}_6\text{S}$: C, 62.54; H, 7.16; S, 7.59. Found: C, 65.44; H, 7.31; S, 7.45.

Methyl (11S)-4 β ,5 β -Epoxy-3 β -hydroxy-eudesm-1-en-13-oate (17). To a solution of sulfoxide **15** (233 mg, 0.57 mmol) in benzene (20 mL) was refluxed for 3.5 h. After this time the reaction mixture was concentrated in vacuo to give a crude product which was purified by Chromatotron chromatography (hexanes–EtOAc, 8:2) to give ester olefin **17** (147 mg, 0.53 mmol, 93%): R_f = 0.58 (hexanes–EtOAc, 4:6); IR 3560, 3520–3360, 1725 cm^{-1} ; ^1H NMR (200 MHz) 1.09 (3H, s), 1.15 (3H, d, J = 7.0 Hz), 1.53 (3H, s), 3.66 (3H, s), 4.11 (1H, m), 5.26 (1H, dd, J = 10.4, 1.6 Hz), 5.35 (1H, dd, J = 10.5, 2.1 Hz); ^{13}C NMR (50.3 MHz) 14.5 (CH_3), 16.0 (CH_3), 20.6 (CH_3), 24.5 (CH_2), 31.1 (CH_2), 36.6 (C), 38.2 (CH_2), 40.6 (CH), 45.0 (CH), 51.7 (CH_3), 66.3 (C), 68.9 (C), 69.2 (CH), 123.2 (CH), 136.7

(CH), 176.3 (C); MS m/z (rel intensity) 280 (M^+ , 1), 265 (10), 247 (1), 237 (10), 219 (8), 205 (30), 177 (29), 159 (32); HRMS calcd for $C_{16}H_{24}O_4$ 280.1702, found 280.1688. Anal. Calcd for $C_{16}H_{24}O_4$: C, 68.55; H, 8.63. Found: C, 68.49; H, 8.57.

Methyl (11S)-3 β -Acetoxy-4 β ,5 β -epoxy-eudesm-1-en-13-oate (18). To a solution of olefin **17** (147 mg, 0.525 mmol) in pyridine (3 mL) was added acetic anhydride (1 mL, 10.6 mmol) and the reaction mixture stirred at room temperature overnight. The solution was then poured into 10% aqueous HCl solution and extracted with EtOAc. The organic extracts were washed with $NaCO_3H$ and brine, dried over Na_2SO_4 and evaporated in vacuo. The reaction crude was purified by Chromatotron chromatography (hexanes–EtOAc, 8:2) to give acetate **18** (158 mg, 0.49 mmol, 94%): R_f = 0.64 (hexanes–EtOAc, 1:1); IR 1725 cm^{-1} ; 1H NMR (200 MHz) 1.15 (3H, s), 1.17 (3H, d, J = 6.9 Hz), 1.41 (3H, s), 2.16 (3H, s), 3.67 (3H, s), 5.26 (1H, dd, J = 10.5, 2.1 Hz), 5.40 (1H, dd, J = 10.5, 2.1 Hz), 5.57 (1H, dd, J = 2.2, 2.2 Hz), ^{13}C NMR (50.3 MHz) 14.5 (CH_3), 15.8 (CH_3), 20.5 (CH_3), 21.1 (CH_3), 24.3 (CH_2), 30.7 (CH_2), 36.9 (C), 37.8 (CH_2), 40.5 (CH), 44.9 (CH), 51.6 (CH_3), 63.6 (C), 67.2 (C), 71.5 (CH), 119.6 (CH), 138.2 (CH), 171.0 (C), 176.1 (C); MS m/z (rel intensity) 322 (M^+ , 1), 307 (1), 280 (47), 263 (10), 248 (9), 237 (6); HRMS calcd for $C_{18}H_{26}O_5$ 322.1780, found 322.1735. Anal. Calcd for $C_{18}H_{26}O_5$: C, 67.06; H, 8.13. Found: C, 67.12; H, 8.10.

Methyl (3S,4S,5R,11S)-3-Acetoxy-1,2-dihydroxy-4,5-epoxy-1,2-secoeudesman-13-oate (19). A solution of compound **18** (50 mg, 0.155 mmol) in $CH_2Cl_2/MeOH$ (10 mL, 1:1) was cooled to $-78\text{ }^\circ\text{C}$, and a slow stream of ozone was introduced into the solution until it became blue. Excess of ozone was removed by flushing the solution with argon. Me_2S (0.14 mL, 1.9 mmol) was then added and the resulting mixture stirred for 20 min at this temperature before being treated with sodium borohydride (18 mg, 0.47 mmol). The temperature of the reaction mixture was allowed to rise to rt and stirring continued for 1.5

h. The reaction was quenched by the addition of 5% aqueous HCl solution and extracted with CH₂Cl₂. The organic extracts were washed with brine, dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by Chromatotron chromatography (hexanes–EtOAc, 6:4) to give diol **19** (45 mg, 0.127 mmol, 82%): oil; *R*_f = 0.21 (hexanes–EtOAc, 1:1); ¹H NMR (200 MHz) 1.11 (3H, s), 1.14 (3H, d, *J* = 7.0 Hz), 1.31 (3H, s), 2.10 (3H, s), 3.66 (3H, s), 3.51 (1H, d, *J* = 11.3 Hz); 3.71 (1H, d, *J* = 11.3 Hz), 4.12 (1H, dd, *J* = 7.7, 3.2 Hz), 4.25 (1H, dd, *J* = 11.3, 3.0 Hz), 4.33 (1H, dd, *J* = 11.3, 7.7 Hz). Anal. Calcd for C₁₈H₃₀O₇: C, 60.32; H, 8.44. Found: C, 60.28; H, 8.50.

Methyl (3*S*,4*S*,5*S*,11*S*)-2-Acetoxy-1,4-dihydroxy-3,5-epoxy-1,2-secoeudesman-13-oate (20). To a solution of diol **19** (65 mg, 0.182 mmol) in CH₂Cl₂ (4.5 mL) was added methanesulfonic acid (6 μL, 0.091 mmol) and the solution stirred at 0 °C for 30 min. The reaction mixture was then poured into aqueous saturated NaCO₃H and extracted with EtOAc. The organic layer was washed with brine, dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by Chromatotron chromatography (hexanes–EtOAc, 6:4) to give ester **20** (30 mg, 0.084 mmol, 46%): oil; *R*_f = 0.27 (hexanes–EtOAc, 1:1); ¹H NMR (80 MHz) 1.11 (3H, d, *J* = 6.9 Hz), 1.12 (3H, s), 1.29 (3H, s), 2.08 (3H, s), 3.67 (3H, s), 3.28 (1H, d, *J* = 11.1 Hz), 4.17 (1H, d, *J* = 11.1 Hz), 4.05 (1H, dd, *J* = 12.2, 7.1 Hz), 4.33 (1H, dd, *J* = 12.2, 4.1 Hz), 4.66 (1H, dd, *J* = 7.0, 4.0 Hz). Anal. Calcd for C₁₈H₃₀O₇: C, 60.32; H, 8.44. Found: C, 60.18; H, 8.21.

Methyl (3*S*,4*S*,5*S*,11*S*)-2-Acetoxy-1,4:3,5-diepoxy-1,2-secoeudesman-13-oate (21). To a solution of ester **20** (30 mg, 0.084 mmol) and triphenylphosphine (55 mg, 0.21 mmol) in dry CHCl₃ (4.5 mL) was added dropwise a solution of DEAD (30 μL, 0.21 mmol) at room temperature under argon. After 15 min the reaction mixture was poured into 1% aqueous solution of sodium hydroxide and extracted with CH₂Cl₂. The organic layer was washed with 10% aqueous HCl solution, and water, dried (Na₂SO₄), and the solvent evaporated in

vacuo to give a crude product which was purified by Chromatotron chromatography (hexanes–EtOAc, 7:3) to yield ester **21** (26 mg, 0.076 mmol, 91%): oil; R_f = 0.57 (hexanes–EtOAc, 1:1); ^1H NMR (200 MHz) 0.95 (3H, br s), 1.17 (3H, d, J = 7.0 Hz), 1.25 (3H, s), 2.11 (3H, s), 3.68 (3H, s), 3.72 (1H, d, J = 8.0 Hz), 3.98 (1H, dd, J = 8.0, 4J = 0.7 Hz), 4.19 (1H, d, J = 4.6 Hz), 4.19 (1H, d, J = 6.5 Hz), 4.29 (1H, dd, J = 6.5, 4.5 Hz); ^{13}C NMR (50.3 MHz) 14.3 (CH₃), 14.8 (CH₃), 20.2 (CH₃), 21.0 (CH₃), 23.3 (CH₂), 26.1 (CH₂), 29.8 (CH₂), 34.4 (CH), 44.1 (C), 44.4 (CH), 51.5 (CH₃), 64.5 (CH₂), 77.1 (CH₂), 83.3 (CH), 84.3 (C), 98.7 (C), 170.9 (C), 176.2 (C); MS m/z (rel intensity) 309 (M^+ – OMe, 1), 297 (2), 280 (2), 263 (1), 251 (1), 249 (1), 238 (35), 223 (76); HRMS calcd for C₁₈H₂₈O₆ 340.1886, found 340.1868. Anal. Calcd for C₁₈H₂₈O₆: C, 63.51; H, 8.29. Found: C, 63.68; H, 8.33.

Methyl (3S,4S,5S,11S)-2-Hydroxy-1,4:3,5-diepoxy-1,2-secoeudesman-13-oate (22).

Acetate **21** (3 mg, 0.0088 mmol) in 2% of K₂CO₃ in MeOH (0.5 mL) was stirred at rt for 15 min, poured into a saturated aqueous solution of NaHSO₄ and extracted with CHCl₃. The organic layer was washed twice with brine, dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by Chromatotron chromatography (hexanes–EtOAc, 6:4) to give alcohol **22** (2.2 mg, 0.0074 mmol, 84%): R_f = 0.30 (hexanes–EtOAc, 6:4); ^1H NMR (400 MHz) 0.95 (3H, br s), 1.17 (3H, d, J = 7.2 Hz), 1.28 (3H, s), 2.11 (3H, s), 3.69 (3H, s), 3.70 (1H, dd, J = 12.9, 5.0 Hz), 3.72 (1H, d, J = 7.9 Hz), 3.74 (1H, dd, J = 12.5, 3.9 Hz), 3.98 (1H, dd, J = 7.9, 4J = 0.8 Hz), 4.16 (1H, dd, J = 5.0, 4.5 Hz); ^{13}C NMR (100.6 MHz) 14.4 (CH₃), 14.6 (CH₃), 20.2 (CH₃), 23.2 (CH₂), 26.1 (CH₂), 29.7 (CH₂), 34.4 (CH), 44.0 (C), 44.6 (CH), 51.5 (CH₃), 62.3 (CH₂), 76.9 (CH₂), 84.3 (C), 86.0 (CH), 98.4 (C), 176.4 (C); MS m/z (rel intensity) 280 (M^+ – H₂O, <1), 267 (2), 262 (4), 255 (3), 249 (2), 238 (45), 223 (100); HRMS calcd for C₁₆H₂₄O₄ 280.1675, found 280.1671. Anal. Calcd for C₁₆H₂₆O₅: C, 64.41; H, 8.78. Found: C, 64.22; H, 8.51.

Methyl (3*S*,4*R*,5*R*,11*S*)-1,4:3,5-Diepoxy-2-iodo-1,2-secoeudesman-13-oate (23). To a solution of the alcohol **14** (5 mg, 0.0168 mmol) in toluene (0.84 mL) were added sequentially imidazole (4.6 mg, 0.067 mmol), triphenylphosphine (17.6 mg, 0.067 mmol) and iodine (14 mg, 0.055 mmol). The reaction mixture was stirred at rt until the reagents were completely dissolved and then heated at reflux temperature for 2 h, poured into an ice-cooled aqueous solution of sodium thiosulfate, and extracted with ether. The combined extracts were washed with brine, dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by Chromatotron chromatography (benzene–EtOAc, 97:3) to give the title compound **23** (6.7 mg, 0.016 mmol, 97%): *R*_f = 0.45 (hexanes–EtOAc, 6:4); IR 1726, 1151 cm⁻¹; ¹H NMR (200 MHz) 0.94 (3H, s), 1.13 (3H, d, *J* = 7.1 Hz), 1.42 (3H, s), 3.19 (1H, d, *J* = 8.2 Hz), 3.21 (1H, d, *J* = 6.4 Hz), 3.63 (1H, d, *J* = 8.8 Hz), 3.67 (3H, s), 3.68 (1H, d, *J* = 8.8 Hz), 4.42 (1H, dd, *J* = 8.1, 6.4 Hz); ¹³C NMR (50.3 MHz) 5.3 (CH₂), 13.2 (CH₃), 14.4 (CH₃), 15.1 (CH₃), 23.7 (CH₂), 34.0 (CH₂), 34.6 (CH₂), 38.5 (CH), 43.3 (C), 44.9 (CH), 51.6 (CH₃), 76.9 (CH₂), 84.5 (CH), 86.2 (C), 94.5 (C), 176.2 (C); MS *m/z* (rel intensity) 377 (*M*⁺ – OMe, 5), 281 (9), 237 (100), 211 (23); HRMS calcd for C₁₅H₂₂IO₃ 377.06137, found 377.06237. Anal. Calcd for C₁₆H₂₅IO₄: C, 47.07; H, 6.17. Found: C, 46.91; H, 6.22.

Methyl (4*R*,5*R*,11*S*)-1,4-Epoxy-5-hydroxy-1,2-secoeudesman-2-en-13-oate (24). To a solution of the alcohol **14** (5.1 mg, 0.017 mmol) in toluene (0.86 mL) were added sequentially imidazole (4.3 mg, 0.063 mmol), triphenylphosphine (18 mg, 0.068 mmol) and iodine (13 mg, 0.051 mmol). The reaction mixture was stirred at rt until the reagents were completely dissolved and then heated at reflux temperature for 4 h, poured into an ice-cooled aqueous solution of sodium thiosulfate, and extracted with ether. The combined extracts were washed with brine, dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by Chromatotron

chromatography (benzene–EtOAc, 9:1) to give the olefin **24** (3.3 mg, 0.012 mmol, 70%): R_f = 0.32 (hexanes–EtOAc, 6:4); IR 1730, 1609, 1285 cm^{-1} ; ^1H NMR (200 MHz) 0.99 (3H, s), 1.16 (3H, d, J = 7.0 Hz), 1.47 (3H, s), 3.59 (1H, d, J = 8.5 Hz), 3.68 (1H, d, J = 8.2 Hz), 3.69 (3H, s), 5.13 (1H, ddd, J = 10.6, 1.9, 1.9 Hz), 5.36 (1H, ddd, J = 17.3, 1.9, 1.9 Hz), 5.93 (1H, dd, J = 17.4, 10.7 Hz); ^{13}C NMR (50.3 MHz) 14.7 (CH_3), 17.6 (CH_3), 23.7 (CH_2), 26.5 (CH_3), 34.4 (CH_2), 36.8 (CH_2), 37.8 (CH), 45.2 (C), 46.0 (CH), 51.5 (CH_3), 76.9 (CH_2), 81.0 (C), 89.5 (C), 112.4 (CH_2), 140.9 (CH), 176.6 (C); MS m/z (rel intensity) 282 (M^+ , 3), 265 (4), 251 (10), 238 (12), 223 (14), 211 (50); HRMS calcd for $\text{C}_{16}\text{H}_{26}\text{O}_4$ 282.18311, found 282.18299. Anal. Calcd for $\text{C}_{16}\text{H}_{26}\text{O}_4$: C, 68.06; H, 9.28. Found: C, 68.27; H, 9.38.

Methyl (3*S*,4*S*,5*R*,11*S*)-1,4:2,5-Diepoxy-3-phenylselanyl-1,2-secoeudesman-13-oate (25). To a solution of compound **24** (6.3 mg, 0.022 mmol) and *p*-TsOH (2.1 mg, 0.011 mmol) in CH_2Cl_2 (0.35 mL) was added dropwise a solution of *N*-(phenylseleno)phthalimide (10 mg, 0.033 mmol) in CH_2Cl_2 (0.2 mL). The reaction mixture was stirred at rt for 7 h under inert atmosphere, poured into a saturated aqueous solution of NaHCO_3 , and extracted with CH_2Cl_2 . The organic extracts were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by a short chromatography column (hexanes) for elimination of the $(\text{PhSe})_2$ and then by Chromatotron chromatography (hexanes–EtOAc, 9:1) to give compound **25** (7.2 mg, 0.016 mmol, 75%): R_f = 0.36 (hexanes–EtOAc, 8:2); IR 1730, 1382 cm^{-1} ; ^1H NMR (500 MHz) 1.02 (3H, s), 1.14 (3H, d, J = 7.0 Hz), 1.66 (3H, s), 2.19 (1H, dddd, J = 7.7, 7.7, 7.7, 7.7 Hz), 3.40 (1H, dd, J = 11.4, 8.1 Hz), 3.58 (1H, d, J = 8.5 Hz), 3.60 (1H, d, J = 8.5 Hz), 3.66 (3H, s), 3.79 (1H, dd, J = 11.4, 9.0 Hz), 4.18 (1H, dd, J = 8.5, 8.5 Hz), 7.26 (3H, m), 7.54 (2H, m); ^{13}C NMR (125.7 MHz) 14.1 (CH_3), 14.7 (CH_3), 16.4 (CH_3), 22.8 (CH_3), 23.7 (CH_2), 31.9 (C), 35.0 (CH_2), 35.4 (CH_2), 37.0 (CH), 45.7 (CH), 46.6 (C), 56.1

(CH), 73.6 (CH₂), 80.4 (CH₂), 91.9 (C), 127.3 (CH), 129.1 (2 × CH), 129.9 (C), 133.8 (2 × CH), 176.5 (C); MS *m/z* (rel intensity) 438 (M⁺, 6), 340 (1), 277 (5), 237 (5), 211 (17); HRMS calcd for C₂₂H₃₀O₄⁸⁰Se 438.13093, found 438.13172. Anal. Calcd for C₂₂H₃₀O₄Se: C, 60.41; H, 6.91. Found: C, 60.47; H, 6.83.

Methyl (4*R*,5*R*,11*S*)-1,4:2,5-Diepoxy-1,2-secoeudesm-2-en-13-oate (26). A solution of compound **25** (6.7 mg, 0.015 mmol) in CH₂Cl₂ (2.2 mL) was cooled to −78 °C, and ozone was bubbled through it until the solution turned light blue. Then nitrogen was bubbled through the solution to expel excess ozone, the mixture was allowed to warm to rt, and TEA (30.3 mg, 0.042 mL, 0.3 mmol) was added. This mixture was then added dropwise to preheated (85 °C) cyclohexane, and the solution refluxed for 30 min. The solution was washed consecutively with saturated aqueous solutions of NaHSO₄, NaHCO₃, and brine. The organic extracts were dried over Na₂SO₄ and concentrated under reduced pressure. The residue was purified by a short chromatography column (hexanes–EtOAc, 9:1) to afford compound **26** (2.5 mg, 0.009 mmol, 60%): *R*_f = 0.42 (hexanes–EtOAc, 8:2); IR 1737, 1620, 1462, 1377, 1157 cm^{−1}; ¹H NMR (200 MHz) 0.99 (3H, s), 1.17 (3H, d, *J* = 6.9 Hz), 1.56 (3H, s), 3.27 (1H, d, *J* = 8.6 Hz), 3.39 (1H, d, *J* = 8.6 Hz), 3.69 (3H, s), 4.66 (1H, d, *J* = 2.7 Hz), 6.41 (1H, d, *J* = 2.6 Hz); MS *m/z* (rel intensity) 280 (M⁺, 17), 265 (10), 251 (28), 235 (54); HRMS calcd for C₁₆H₂₄O₄ 280.16746, found 280.16726. Anal. Calcd for C₁₆H₂₄O₄: C, 68.54; H, 8.63. Found: C, 68.31; H, 8.83.

Isolation of Phytuberin (1). Following essentially the method previously described,¹ 27 mature potato tubers (*Solanum tuberosum* var. King Edward, 6.4 kg) were washed with water, dipped in ethanol, and air dried. The tubers were each inoculated by the deep wound method² with 0.3 mL of a suspension (10⁹ cells mL^{−1}) of *Erwinia*

(1) Coxon, D. T.; Price, K. R.; Howard, B.; Curtis, R. F. *J. Chem. Soc., Perkin Trans 1* **1977**, 53–59.

(2) Lyon, G. D. *Physiol. Plant Pathol.* **1972**, 2, 411–416.

carotovora var. *carotovora*. Inoculated tubers were stored under aerobic conditions at 10 °C and 95–100% relative humidity for 14 days. The rotted tissue scraped from the tuber was lyophilized, and the dry tissue extracted with EtOAc in a Soxhlet apparatus. The extract was dried (Na_2SO_4) and evaporated in vacuo to give a crude product (492 mg) which was purified by column chromatography (hexanes–EtOAc, 9:1 $\rightarrow$ 1:1) to give phytuberin (10 mg), deacetylphytuberin (14 mg), and rishitin (15 mg).

Compound **14**

Crystal data: A crystal of 0.1x0.3x0.5 mm³ was grown from methanol. C₁₆H₂₆O₅, orthorhombic, space groups *P*2₁2₁2₁, *Z* = 4, *a* = 25.656(4), *b* = 6.288(2), *c* = 9.913(3) Å. The data were measured on a Philips PW-1100 four-circle automatic diffractometer operating with CuK_α radiation (λ = 1.5418 Å) monochromated by graphite, at room temperature, up to 2θ = 126°. Two equivalent portions of the reciprocal space were recorded (2528 intensities). The structure was solved by direct methods and refined with anisotropic thermal factors for non-hydrogen atoms to *R* = 6.5 % (unitary weights) and *R*_w = 5.8 % [weights = 5.3/ σ (*F*)²]. All the hydrogens were located on Fourier-difference syntheses. Data merging and processing led to a unique set of 1285 structure factors (*R*_{symm} = 2.8 %) of which 1025 were observed [*I* ≥ 2σ(*I*)]. No decomposition corrections were applied but empirical absorption corrections were made at the end of the isotropic refinements, using the unmerged data set.

Table 1: Positional parameters ($\times 10^4$) and mean recalculated isotropic factors ($\times 10^3$) for non-hydrogen atoms

ATOM	X	Y	Z	<U>
O12	3168 (3)	306 (7)	6616 (6)	35 (7)
O6	3004 (3)	-4317 (7)	7284 (6)	44 (7)
O1''	3871 (5)	105 (13)	11929 (9)	118 (17)
O19	2653 (3)	2269 (7)	8846 (6)	51 (8)
O2''	4169 (5)	3286 (11)	11089 (9)	114 (17)
C2	4531 (4)	-2596 (13)	8238 (9)	51 (14)
C3	4165 (5)	-3962 (11)	7348 (10)	51 (14)
C2'	4914 (5)	-1112 (18)	11022 (10)	83 (19)
C4	3765 (4)	-2665 (13)	6511 (7)	35 (10)
C5	3331 (5)	-4143 (13)	6109 (9)	53 (12)
C9	3832 (5)	202 (13)	8348 (10)	42 (9)
C8	3504 (4)	-1125 (10)	7461 (8)	33 (9)
C7	3008 (4)	-2304 (13)	7951 (8)	34 (9)
C1	4212 (5)	-1247 (15)	9253 (10)	53 (12)
C1''	4136 (6)	1239 (17)	11235 (11)	65 (18)
C4'	4042 (5)	-1667 (15)	5307 (8)	54 (14)
C1'	4537 (5)	171 (13)	10161 (10)	50 (15)
C10	2897 (5)	-2611 (11)	9443 (7)	51 (10)
C2''	3752 (7)	4012 (16)	12088 (12)	106 (21)
C21	2358 (5)	963 (14)	7943 (10)	56 (15)
C23	2697 (5)	-637 (13)	7184 (8)	42 (13)

Table 2: Positional parameters ($\times 10^3$) and mean isotropic factors ($\times 10^3$) for hydrogen atoms*

ATOM	X	Y	Z	U
H19	295	142	925	102
H2	473	-327	902	102
H2	478	-155	780	102
H3	447	-471	693	102
H3	402	-485	810	102
H2'	525	-153	1066	107
H2'	469	-238	1127	107
H2'	494	-14	1181	107
H5	344	-556	573	102
H5	312	-337	540	102
H9	413	97	782	102
H9	380	110	921	102
H1	402	-166	1011	102
H4'	441	-107	521	107
H4'	381	-78	471	107
H4'	406	-312	479	107
H1'	463	163	979	102
H10	296	-132	1002	107
H10	312	-380	980	107
H10	252	-305	955	107
H2''	369	538	1254	107
H2''	391	293	1271	107
H2''	341	342	1175	107
H21	205	32	843	102
H21	221	213	733	102
H23	250	-151	651	102

*Refined in two blocks: a) Primary and secondary carbon hydrogens; b) Methyl group hydrogens.

Table 3: Anisotropic thermal parameters ($\times 10^4$) for non-hydrogen atoms

ATOM	U11	U22	U33	U23	U13	U12
O12	285 (53)	360 (51)	407 (57)	137 (43)	-9 (39)	-18 (40)
O6	554 (60)	288 (48)	480 (64)	-94 (42)	-14 (50)	17 (45)
O1''	1344 (87)	1325 (77)	884 (78)	-99 (97)	132 (82)	-230 (92)
O19	554 (61)	405 (63)	582 (74)	-59 (54)	-62 (53)	19 (50)
O2''	1098 (88)	732 (88)	1094 (88)	-165 (85)	-576 (75)	230 (90)
C2	521 (90)	764 (95)	249 (95)	-59 (92)	-91 (67)	313 (92)
C3	449 (98)	408 (88)	683 (83)	158 (80)	-191 (79)	13 (74)
C2'	576 (81)	1028 (96)	702 (84)	199 (76)	-203 (93)	-23 (70)
C4	342 (82)	457 (85)	256 (82)	53 (75)	-64 (60)	50 (68)
C5	332 (96)	421 (91)	853 (79)	-140 (88)	198 (81)	10 (70)
C9	338 (92)	370 (82)	578 (85)	123 (70)	-206 (68)	-94 (68)
C8	430 (81)	314 (78)	275 (82)	-34 (68)	-67 (64)	56 (65)
C7	157 (67)	486 (86)	391 (80)	-12 (71)	-98 (63)	-8 (70)
C1	420 (98)	549 (94)	633 (90)	120 (86)	37 (78)	188 (78)
C1''	535 (83)	1084 (94)	333 (81)	-138 (78)	-169 (88)	56 (74)
C4'	660 (98)	618 (90)	352 (85)	63 (69)	139 (74)	-170 (81)
C1'	462 (84)	489 (91)	560 (87)	16 (84)	-27 (78)	-145 (76)
C10	673 (97)	412 (85)	458 (96)	46 (78)	102 (76)	76 (77)
C2''	967 (91)	896 (89)	1044 (90)	-144 (78)	-79 (74)	133 (83)
C21	603 (84)	336 (95)	763 (81)	32 (73)	30 (87)	132 (80)
C23	371 (91)	475 (93)	424 (87)	29 (73)	43 (72)	6 (71)

Table-4: Distances (Å) for non-hydrogen atoms with e.s.d.'s given in parentheses

O12 - C8	1.501 (8)	C4 - C5	1.504 (8)
O12 - C23	1.459 (8)	C4 - C8	1.507 (8)
O6 - C5	1.439 (7)	C4 - C4'	1.524 (8)
O6 - C7	1.428 (8)	C9 - C8	1.476 (9)
O1" - Cl"	1.202 (7)	C9 - C1	1.607 (10)
O19 - C21	1.430 (7)	C8 - C7	1.550 (8)
O2" - Cl"	1.298 (7)	C7 - C10	1.518 (8)
O2" - C2"	1.528 (7)	C7 - C23	1.521 (9)
C2 - C3	1.548 (9)	C1 - Cl'	1.517 (10)
C2 - C1	1.550 (9)	Cl" - Cl'	1.625 (10)
C3 - C4	1.553 (8)	C21 - C23	1.527 (10)
C2' - Cl'	1.521 (9)		

Table 5: Bond angles (degr.) for non-hydrogen atoms with e.s.d.'s given in parentheses

C8 - O12 - C23	90.9 (4)	O6 - C7 - C10	109.7 (4)
C5 - O6 - C7	107.7 (5)	O6 - C7 - C23	112.1 (4)
C1" - O2" - C2"	100.3 (7)	C8 - C7 - C10	121.4 (5)
C3 - C2 - C1	110.7 (6)	C8 - C7 - C23	86.8 (4)
C2 - C3 - C4	114.5 (5)	C10 - C7 - C23	118.4 (5)
C3 - C4 - C5	107.9 (5)	C2 - C1 - C9	105.5 (6)
C3 - C4 - C8	107.3 (5)	C2 - C1 - Cl'	114.6 (6)
C3 - C4 - C4'	109.0 (5)	C9 - C1 - Cl'	109.4 (5)
C5 - C4 - C8	103.6 (5)	O1" - Cl" - O2"	133.6 (9)
C5 - C4 - C4'	113.1 (5)	O1" - Cl" - Cl'	119.2 (7)
C8 - C4 - C4'	115.6 (5)	O2" - Cl" - Cl'	107.2 (7)
O6 - C5 - C4	105.2 (5)	C2' - Cl' - C1	111.8 (6)
C8 - C9 - C1	111.0 (6)	C2' - Cl' - Cl"	104.7 (6)
O12 - C8 - C4	107.0 (4)	C1 - Cl' - Cl"	106.5 (6)
O12 - C8 - C9	108.7 (4)	O19 - C21 - C23	112.7 (5)
O12 - C8 - C7	89.5 (4)	O12 - C23 - C7	92.2 (4)
C4 - C8 - C9	118.8 (5)	O12 - C23 - C21	113.2 (5)
C4 - C8 - C7	104.6(4)	C7 - C23 - C21	120.4 (6)
C9 - C8 - C7	123.5(5)	O6 - C7 - C8	106.5 (4)