A New Class of Sweet Potato Phytoalexins

Josef A. Schneider and Koji Nakanishi*
SUNBOR (Suntory Institute for Bioorganic Research), Wakayamadai, Shimamoto-cho, Mishima-gun, Osaka 618, Japan

Two new compounds, 7-hydroxycostal (**2**) and 7-hydroxycostol (**3**), were isolated from infected sweet potatoes as members of a new class of sweet potato phytoalexins.

When the sweet potato *Ipomea batatas* is infected with the pathogenic black rot fungus *Ceratocystis fimbriata*, ipomeamarone (**1**) rapidly accumulates in the infected tissue. Isolated forty years ago by Hiura,[1] and characterized by Kubota and Matsuura,[2] the biochemistry of (**1**) has been extensively studied.[3,4] In the accompanying communication the absolute configuration of (**1**) has been established as 1*R*,4*S*.[5]

In the course of our investigation of sweet potato phytoalexins, the infected tissue extract ($CHCl_3$) was found to contain a further class of defence compounds, namely sesquiterpenes composed of the eudesmane skeleton. Chromatography of the extract (15 g) on silica gel afforded two new compounds, 7-hydroxycostal (**2**) (450 mg),† and 7-hydroxycostol (**3**) (50

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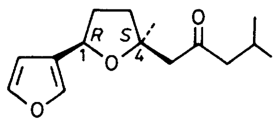
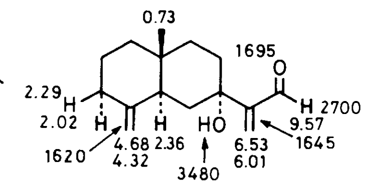
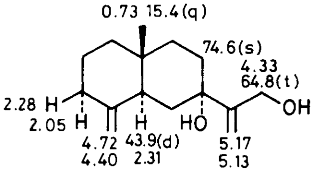
† Physical data for (**2**) ($C_{15}H_{22}O_2$): R_f (20% EtOAc–hexane, silica gel) 0.40; $[\alpha]_D$ + 15.0° (*c* 2.0, CH_2Cl_2); λ_{max} 215 nm, ϵ 5400; mass spectrum (electron impact) *m/z* (rel. intensity): 234 (M^+, 2%), 216 (100), 202 (85), 145 (25), 83 (52), and 55 (8); i.r. (neat): 3480, 2950, 1695, 1645, 1620, 1440, 1305, 1055, and 885 cm^{-1}: ^1H n.m.r. (360 MHz, $CDCl_3$): δ 9.57 (s, 13-H), 6.53 (s, 12-H), 6.01 (s, 12-H), 4.68 (br. s, 14-H), 4.32 (br. s, 14-H), 2.95 (br. s, OH), 2.36 (br. d, *J* 12.5 Hz, 5-H), 2.29 (dt, J_1 14.0, J_2 3.0 Hz, 3β-H), 2.02 (br. dt, J_1 13.5, J_2 7.0 Hz, 3α-H), 1.92 (dt, J_1 14.0, J_2 4.5 Hz, 9α-H), 1.78—1.24 (m, 9 protons), and 0.73 (s, 10-Me).



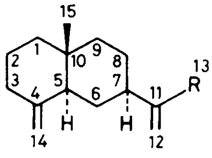
(1)



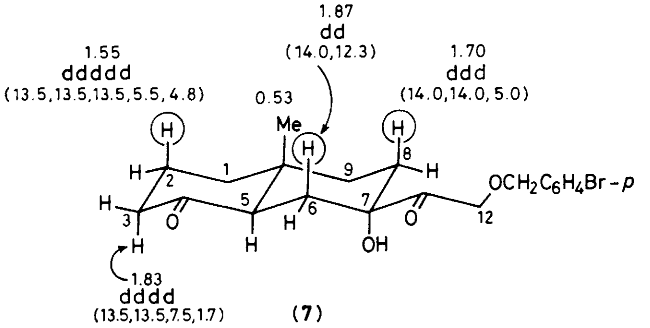
(2) δ(¹H) and ν_{max}/cm⁻¹ (neat)



(3) δ(¹H) and (with multiplicity)¹³C



(4) R = Me
(5) R = CH_2OH
(6) R = CHO



(7)

¹H N.m.r. resonances for (**7**) and coupling constants (*J*/Hz); see Figure 1.

mg).‡ These were accompanied by the known selinene derivatives (**4**), (**5**), and (**6**).[6]

The structure of (**3**) was determined by studying its dioxoderivative (**7**) (i, p-$BrC_6H_4CH_2Cl$, pyridine; ii, O_3–Me_2S), which was more amenable to n.m.r. studies. Application of 2 dimensional *J* spectroscopy,[7] together with double resonance experiments permitted the assignment of most protons and coupling constants (Table 1). In addition to the usual W-type interactions, a 1.7 Hz 1,3 diaxial coupling[8] between 5α-H and 3α-H was resolved in the 2 D *J* spectrum (Figure 1a). Irradiation of 10-Me and measurement of the nuclear Overhauser effect (n.O.e.) difference spectrum isolated the 2β-, 6β-, and 8β-H signals (Figure 1c) from other overlapping signals (Figure 1b).

The stereochemistry at C-7 was determined as α-OH on the basis of the downfield shift of 5α-H in (**2**) and (**3**), δ 2.36 and 2.31, respectively; in compounds (**5**) and (**6**) where the α-OH group is replaced by hydrogen, 5α-H resonates at δ 1.83 and 1.88, respectively. The isolation of β-selinene (**4**), $[\alpha]_D$ +45° (*c* 5.0, CH_2Cl_2), lit.,[9] +49°, and β-costol (**5**), $[\alpha]_D$ +26.8° (*c* 2.0, CH_2Cl_2), lit.,[10] +32.8°, from the same extract provided the basis for assigning the 5*R*,7*S*,10*R*-configuration in (**2**) and (**3**).§

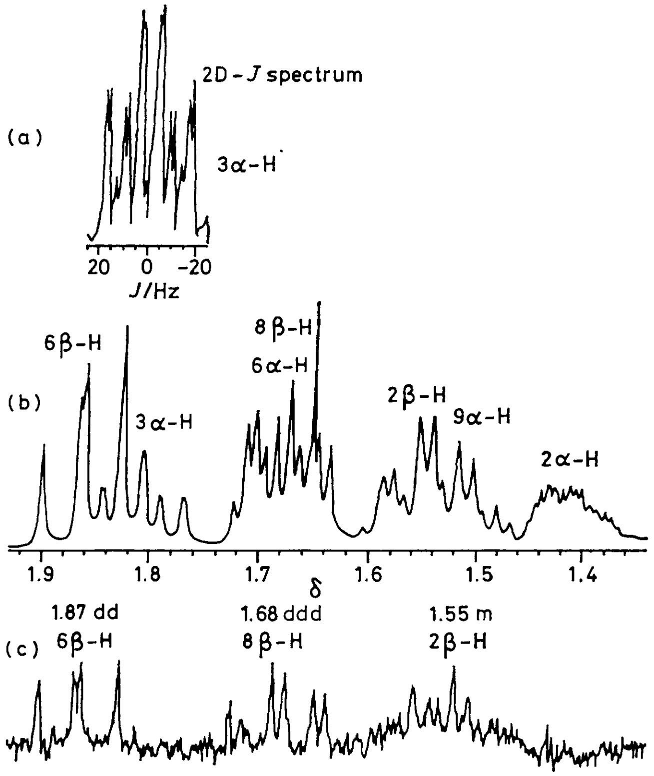
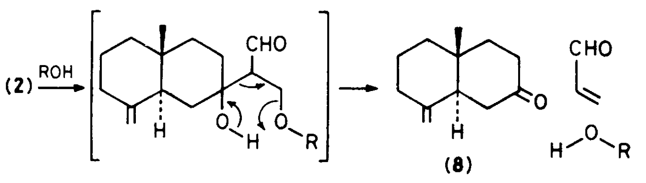


Figure 1. 360 MHz N.m.r. spectrum of (**7**) (¹H; C_6D_6): (a) 2 D *J* resolution of 3α5α coupling; (b) normal spectrum; (c) difference in n.O.e. spectrum (irradiating 10-Me).



Scheme 1. Mechanism for formation of (**8**). R = Me or H (see text).

Incubation experiments in sweet potato culture medium containing endoconidia of *C. fimbriata*,[10] showed (**2**) to be a more effective germination inhibitor than (+)-ipomeamarone (**1**). Interestingly, the 7-deoxy-aldehyde (**6**) was essentially devoid of activity. Clearly, this difference in antifungal properties must be attributable to hydroxylation at C-7. We reasoned that the presence of the 7-OH moiety may facilitate a retro-aldol process to give the ketone (**8**) and acrolein (Scheme 1). Indeed, after incubation for one week, a *ca.* 10% conversion of (**2**) to yield largely (**8**) was observed.¶ We therefore propose

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‡ Physical data for (**3**) ($C_{15}H_{24}O_2$): R_f (20% EtOAc–hexane, silica gel) 0.35; m.p. 123—124 °C; $[\alpha]_D$ + 2.0° (*c* 0.4, CH_2Cl_2); mass spectrum (field desorption) *m/z* (rel. intensity): 236 (M^+, (40%) and 218 (100); i.r. (neat): 3450, 2950, 1640, 1040, 890, and 870 cm⁻¹; ¹H n.m.r. (360 MHz, $CDCl_3$): δ 5.32 (br. s, 12-H), 5.17 (br. s, 12-H), 4.72 (br. s, 14-H), 4.40 (br. s, 14-H), 4.33 (br. s, 13-H), 2.31 (br. d, *J* 13.5 Hz, 5α-H), 2.28 (br. d, *J* 14.0 Hz, 3β-H), 2.12 (br. s, OH), 2.05 (br. dt, J_1 13.5, J_2 7.0 Hz, 3α-H), 1.85—1.30 (m, 11 protons), and 0.73 (s, 10-Me); ¹³C n.m.r. (25.0 MHz, $CDCl_3$): δ 154.8 (s), 150.5 (s), 110.9 (t), 105.3 (t), 74.6 (s), 64.8 (t), 43.9 (d), 41.5 (t), 36.9 (t), 36.1 (t), 35.6 (t, 2 carbons), 32.5 (t), 23.4 (t), and 15.4 (q) p.p.m.

§ That (**2**) and (**3**) differ only in oxidation state at C-13 was established by converting (**2**) into (**3**) by oxidation with CrO_3·2pyridine.

¶ Treatment of (**2**) with a catalytic amount of sodium in methanol gave a 90% yield of (**8**).

Table 1. ^{1}H Chemical shifts and coupling constants (J/Hz) for (**7**) (360 MHz, C_6D_6).

δ				*J*		*J*		*J*		*J*	
				ax.–eq.		*gem.*		*eq.–eq.*		*ax.–ax.*	
1α	1.19	6β	1.87	1α2α	4.8	1α1β	13.5	1β2α	3.0	1α2β	13.5
1β	1.10	8α	1.25	2β1β	4.8	2α2β	13.5	2α3β	2.7	2β3α	13.5
2α	1.42	8β	1.70	2β3β	5.5	3α3β	13.5	9β8α	3.0	5α6β	12.3
2β	1.55	9α	1.56	3α2α	7.5	6α6β	14.0	long range		8β9α	14.0
3α	1.83	9β	0.99	5α6α	3.5	8α8β	14.0	1β3β	1.5	n.O.e. (irr. 10-Me)	
3β	2.17	10-Me	0.53	8β9β	5.0	9α9β	14.0	6α8α	0.5	2β	2.5%
5α	2.48	12-H	3.89	9α8α	4.5			3α5α	1.5	6β	2.7%
			7.13							8β	3.0%
6α	1.68	Ar-H	7.83								

that the release of acrolein accounts for the fungicidal action of (**2**). While (**2**) is present in approximately only one-sixth of the quantity of (**1**), it is obviously an important phytoalexin.

The sweet potato thus appears to represent a rare case of a plant capable of concurrently producing two skeletally different series of antifungal defence compounds.

We thank Professor I. Uritani and Dr. K. Oba of Nagoya University for providing us with infected sweet potato extract, and for helpful discussions. We also thank Dr. T. Iwashita of SUNBOR for 360 MHz n.m.r. measurements.

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