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THE OCCURRENCE OF VOMIFOLIOL, DEHYDROVOMIFOLIOL AND DIHYDROPHASEIC ACID IN THE ROOTS OF "KIDNEY BEAN" (PHASEOLUS VULGARIS L.)[1]

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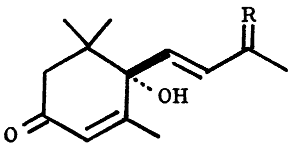
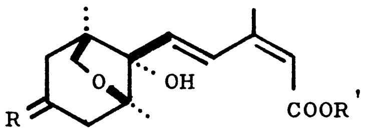
Three abscisic acid-related compounds, vomifoliol, dehydrovomifoliol and dihydrophaseic acid, the latter two being new compounds, have been isolated from the roots of "kidney bean" and proved to possess the same absolute configuration at the carbon atom corresponding to C_6 (= $C_{1'}$) of abscisic acid.

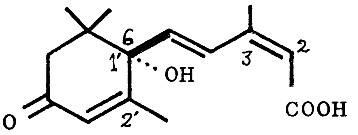
In a continuing study on the components of roots of "kidney bean" (*Phaseolus vulgaris* L.), we have isolated vomifoliol[2-4] (I) and two new compounds, named dehydrovomifoliol (II) and dihydrophaseic acid (III), from the aqueous, acidic extracts of the roots in 2.3, 0.7 and 0.1 × 10^{-5}% yields, respectively.[5] These compounds are regarded as close structural relatives of abscisic acid[6] (IV), but the absolute configuration at the C_6 ($C_{1'}$) atom of IV itself remains not completely solved, one (S, C_6 β-OH) being proposed on the basis of the Mills rule[7] (in 1967) and another (R) being inferred from the ORD and/or CD spectra[8-10] (in 1970-1972). Actually, vomifoliol (I) (and hence II) has been deduced from the ORD spectrum to possess the R-configuration at the relevant carbon atom ($C_{1'}$),[3,4] whereas phaseic acid,[11,12] (V), a dehydro derivative of III (described later), has been assigned the S-configuration (C_6 β-OH) in the 1969's paper.[11] The present paper describes characterization of these compounds as well as identity of the absolute configuration at the carbon atom in question.



I R = OH, H
II R = O



III R = ····OH, -H; R' = H
IIIa R = ····OH, -H; R' = CH_3
V R = O; R' = H
Va (= VII) R = O; R' = CH_3



IV C_2-C_3 cis
VI C_2-C_3 trans

Our vomifoliol (I), mp 112-113°C (from benzene) and $[\alpha]_D$ +220° ($CHCl_3$), showed the following spectra: Mass, m/e 168 (M^+ - 56); CD (MeOH), $\Delta\varepsilon$ -0.65 (318 nm) and +11.9 (240); UV (MeOH), λ_{max} 237 nm (ε 13,900); IR (Nujol), ν_{max} 3400, 1662, 1617 and 973 cm^{-1}; NMR ($CDCl_3$), δ 1.01 and 1.07 (each 3H, s), 1.28 (3H, d J = 6 Hz), 1.88 (3H, d J = 1.5 Hz), 2.07 (2H, D_2O-exchangeable), 2.23 and 2.42 (each 1H, ABq J = 17 Hz), 4.38 (1H, double q J = 6, 6, 6 and 3.5 Hz), 5.75 (1H, d J = 16 Hz), 5.83 (1H, double d J = 16 and 3.5 Hz), and 5.88 (1H, q J = 1.5, 1.5 and 1.5 Hz). This compound was identified as vomifoliol (blumenol A)[2-4] by direct comparison with the sample from <u>Podocarpus</u> <u>blumei</u> Endl.[3]

Dehydrovomifoliol (II), oil and $[\alpha]_D$ +159° ($CHCl_3$), exhibited the following spectra: Mass, m/e 166 (M^+ - 56), CD (EtOH), $\Delta\varepsilon$ -1.95 (318 nm) and +27.6 (240); UV (EtOH), λ_{max} 237 nm (20,000), IR ($CHCl_3$), ν_{max} 3400, 1666, 1626 and 982 cm^{-1}; NMR ($CDCl_3$), δ 1.01 and 1.09 (each 3H, s), 1.87 (3H, d J = 1.5 Hz), 2.29 (3H, s), 2.34 and 2.48 (each 1H, ABq J = 17 Hz), 5.95 (1H, q J = 1.5, 1.5 and 1.5 Hz), and 6.45 and 6.83 (each 1H, ABq J = 16 Hz). These spectral data suggested compound II to be a dehydro derivative[13] of I. This was confirmed by conversion of I into II, oil and $[\alpha]_D$ +172°, by Jones oxidation followed by preparative TLC.

Compound II was treated with carbethoxymethylenetriphenylphosphorane and hydrolyzed in the same manner[14] as the synthetic racemate[13,14] of II. The products (acid mixture) indicated the CD spectrum[15] (0.006N HCl in EtOH) of $\Delta\varepsilon$ -0.92 (318 nm), +28.2 (265) and -21.0 (230) and the VU[16] (0.006N HCl in EtOH) of λ_{max} 262 nm (ε 21,000), and (ester mixture) the NMR spectrum[14] ($CDCl_3$) of δ 2.00 (3H, d J = 1.5 Hz), 5.71 (1H, br s) and 6.12 and 7.83 (each 1H, d J = 16 Hz) for the <u>cis</u>-ester, and of δ 2.27 (3H, d J = 1.0 Hz), 5.80 (1H, br s), and 6.10 and 6.40 (each 1H, d J = 16 Hz) for the <u>trans</u>-ester, and of δ 1.01 and 1.10 (each 6H, s), 1.88 (6H, br s), 2.28 and 2.45 (each 2H, ABq J = 17 Hz), and 5.90 (2H, s) for both the esters. These spectral data, coupled with the gas chromatogram, indicate that the product (acid mixture) is a 1:1 mixture of natural (+)-abscisic acid (IV) and its 2-<u>trans</u>-isomer[14,16] (VI), since IV and VI show virtually identical ORD curves.[15,17]

Dihydrophaseic acid (III), amorphous, showed the following spectra: Mass, m/e 282 (M^+) and 264 (M^+ - 18); CD (MeOH), $\Delta\varepsilon$ -2.8 (265 nm); UV (MeOH), λ_{max} 259 nm (ε 15,500); NMR (CD_3COCD_3), δ 0.90 and 1.06 (each 3H, s), 1.80 (4H, br), 1.95 (3H, d J = 1.5 Hz), 3.60 (1H, d J = 7.5 Hz), 3.73 (1H, double d J = 7.5 and 1.5 Hz), 4.10 (1H, br), 5.66 (1H, br s), and 6.54 and 8.06 (each 1H, d J = 16 Hz). This was further characterized by its methyl ester (IIIa) (with CH_2N_2), amorphous; IR ($CHCl_3$), ν_{max} 3420, 1710, 1674 and 1610 cm^{-1}; NMR ($CDCl_3$), δ 0.95 and 1.17 (each 3H, s), 1.80 (4H, br), 2.05 (3H, d J = 1.5 Hz), 3.72 (3H, s), 3.77 (2H, br), 4.26 (1H, m W_H = 20 Hz), 5.73 (1H, q J = 1.5, 1.5 and 1.5 Hz), and 6.40 and 7.98 (each 1H, d J = 16 Hz). Compound IIIa was oxidized with Jones reagent and purified by preparative TLC to give the dehydro ester (VII), mp 152-155°C (from benzene); ORD (MeOH), $[\phi]_{288}^{peak}$ +3060°, $[\phi]_{246}^{trough}$ -6760°, and a = +98.2; CD (MeOH), $\Delta\varepsilon$ -0.55 (314 nm), +5.2 (262) and -4.2 (230); NMR ($CDCl_3$), δ 2.50 and 2.64 (each 2H, br s), 3.73 (1H, d J = 8 Hz) and 3.95 (1H, double d J = 8 and 1.5 Hz) instead of δ 1.80, 3.77 and 4.26 of IIIa. This compound VII proved to be identical with methyl phaseate[6,11,12] (Va) in the Mass, IR and NMR spectra.[18]

Phaseic acid (V) is a rearranged metabolite$^{11)}$ of abscisic acid (IV) and the configuration of the C_6 atom is apparently retained during the transformation *in vivo* from IV. Thus all the compounds must possess the same absolute configuration at the carbon atoms corresponding to the C_6 ($C_{1'}$) atom of IV, suggesting the R-configuration to be most favorable.

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References and Footnotes

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2) J. -L. Pousset and J. Poisson, *Tetrahedron Lett.*, 1173 (1969).
3) M. N. Galbraith and D. H. S. Horn, *Chem. Comm.*, 113 (1972).
4) Doctor Galbraith stated in his private communication that "blumenol A" in his publication (ref 3) should correctly be named vomifoliol, and also that "a positive ORD $n\text{-}\pi^*$ Cotton effect" was in error and should be revised, but this experimental revision implies no alteration of configurational assignment at C_6 (= $C_{1'}$); cf., CD (MeOH), $\Delta\varepsilon$ -0.85 (318 nm) and +12.9 (240).
5) Compounds I and II were isolated in better yields from the aqueous, neutral extracts.
6) B. V. Milborrow, "Aspects of Terpenoid Chemistry and Biochemistry," ed. by T. W. Goodwin, Academic Press, London and New York (1971), p. 137.
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10) T. Oritani and K. Yamashita, *Ibid.*, 2521 (1972).
11) B. V. Milborrow, *Chem. Comm.*, 966 (1969).
12) J. MacMillan and R. J. Pryce, *Tetrahedron*, **25**, 5893, 5903 (1969). He stated in his private communication that he could detect compound III as one of the metabolites of IV by combined gas chromatography-mass spectrometry.
13) While this (+)-dehydrovomifoliol appears to be a new compound isolated from natural sources, its racemate has recently been prepared independently by Roberts,$^{14)}$ Sakan and their collaborators. See, S. Isoe, S. B. Hyeon, H. Ichikawa, S. Katsumura and T. Sakan, *Tetrahedron Lett.*, 5561 (1968). In fact, both the compounds proved to be identical by direct comparison of UV, IR and NMR spectra, and R_f values on TLC.
14) D. L. Roberts, R. A. Heckman, B. P. Hege and S. T. Bellin, *J. Org. Chem.*, **33**, 3566 (1968).

15) For the CD spectra of (+)-abscisic acid (IV) and related compounds, see, ref 10 and also, B. V. Milborrow, *Planta*, **76**, 93 (1967). For the ORD spectra, see refs 7, 8 and 17, and also, J. W. Cornforth, B. V. Milborrow and G. Ryback, *Nature*, **210**, 627 (1966).

16) For the UV spectra, see, J. W. Cornforth, R. Mallaby and G. Ryback, *J. Chem. Soc.* (C), 1565 (1968).

17) B. V. Milborrow, *J. Exp. Botany*, **21**, 17 (1970), and refs cited therein.

18) The ORD curve of VII showed the same Cotton effect as that of the authentic sample, while the absolute $[\Phi]$ values differed each other. See, B. V. Milborrow, private communication; methyl phaseate (Va), ORD (MeOH), $[\Phi]^{\mathrm{peak}}_{290}$ -1170°, $[\Phi]^{\mathrm{trough}}_{257.5}$ $-16{,}200^{\circ}$, and $[\Phi]^{\mathrm{peak}}_{217.5}$ $+38{,}200^{\circ}$.

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