Note

Flavans from the Pith of Sago Palm

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In the previous paper,¹⁾ we reported the polyphenols responsible for the browning of sago starch. DL-Epicatechin, D-catechin and procyanidin were isolated from the water-soluble fraction of sago palm extracts, and these compounds were shown to be related to the browning of sago starch. The present paper describes the identification of two flavans isolated from the water-insoluble fraction of the same extracts.

From the pith of sago palm two flavans, compounds **1** and **2**, were isolated in the form of colorless prisms by solvent extraction and silica gel column chromatography.

Compound **1** had a melting point of 96~97°C. The molecular formula was found to be C₁₆H₁₆O₃ by MS (M⁺, *m/z* 256) and elementary analysis. The IR spectrum showed the existence of a hydroxyl group and aromatic ring by the absorption bands at 3360 and 1595 cm⁻¹, respectively. In the ¹H-NMR spectrum, the presence of two aromatic rings was recognized. The signal at δ 7.36 (5H, s) corresponded to a mono-substituted aromatic ring, and that at δ 6.04 (2H, d, *J* = 1.0 Hz) indicated an aromatic ring with *meta* positional protons. The singlets at δ 5.20 (1H) and 3.77 (3H) were assigned to the protons of hydroxyl and methoxyl groups, respectively. The signal appearing at δ 4.98 (1H, dd, *J* = 9.6 Hz and 3.0 Hz) showed a coupling with the signal at δ 2.1 (2H, m) and 2.7 (2H, m). The appearance of a double doublet in the relatively low magnetic field at δ 4.98 was probably due to the effect of an oxygen and/or aromatic ring. These facts suggest the partial structure of $\text{O}-\text{CH}-\text{CH}_2-\text{CH}_2-$, and the ¹H-NMR spectral analysis just described suggests that compound **1** is a flavan derivative. This fact is also supported by the ¹³C-NMR spectrum. The mass spectrum indicated that ring A had a hydroxyl group and a methoxyl group by the peaks at *m/z* 165, 152, 124, and that ring B had no substituent by *m/z* 117, 104, 91 and 78.

These results and the CD spectrum were identical with those of (2*S*)-7-hydroxy-5-methoxyflavan reported by Gardillo *et al.*,²⁾ indicating that both compounds had the same structure. Such a structure was also confirmed by spectral analyses of the acetyl derivative.

Compound **2** had a melting point of 134~135°C. The molecular formula was found to be C₁₇H₁₈O₄ by MS (M⁺, *m/z* 286) and elementary analysis. The IR absorption band

at 3380 cm⁻¹ indicated that compound **2** had a hydroxyl group, and the ¹H-NMR spectrum suggested that compound **2** also had a flavan skeleton. Two doublets (2H, *J* = 8.3 Hz) appeared at δ 6.82 and 7.30, indicating the presence of a *para*-substituted aromatic ring. The doublet at δ 6.10 (2H, *J* = 2.0 Hz) suggested the existence of an aromatic ring with *meta* positional protons. The singlets at δ 3.75 (3H) and 3.79 (3H) were assigned to methoxyl groups and δ 5.05 (1H), to a hydroxyl proton. The double doublet at δ 4.91 (1H, *J* = 9.3 and 3.4 Hz) and two multiplets at δ 2.7 (2H) and 2.1 (2H) show the pyran ring of the flavan skeleton. This is also supported by ¹³C-NMR spectral analysis. The mass spectrum of the compound showed the molecular ion peak at *m/z* 286, and major peaks at *m/z* 167 and 133. The peak at *m/z* 167 corresponds to the fragment ion peak, including the structure of ring A of flavan with two methoxyl groups, and the peak at *m/z* 133, that of ring B with a hydroxyl group. The compound was laevorotatory at 589 nm. Its absolute 2*S* configuration was confirmed by comparing the CD curve with that of compound **1**.

As a result, it was concluded that the structure of compound **2** was (2*S*)-5,7-dimethoxy-4'-hydroxyflavan. The structure was also confirmed by spectral analyses of the methyl and acetyl derivatives of the compound.

7-Hydroxy-5-methoxyflavan has been isolated by Gardillo *et al.* from "dragon's blood resin," and is a precursor of the red pigments, dracorbin and nordracorbin.^{2,3)} Compound **2** has not been previously reported and is considered to be a new compound. The responsibility of these two compounds for the browning of sago starch is obscure, since they are insoluble in water.

EXPERIMENTAL

IR spectra were taken on a JASCO IRA-1 spectrometer, and ¹H-NMR and ¹³C-NMR spectra were measured with a JEOL JNM FX-100 spectrometer. Mass spectra were taken on a Hitachi RMS-4 spectrometer. Optical rotations were measured with a JASCO DIP-140 polarimeter and CD spectra were taken on a JASCO J-40A spectrometer.

Isolation of compounds. The pith of sago palm (5 kg) was cut into small pieces and refluxed in methanol for 1 hr. The residue was homogenized in a blender and reextracted twice with 80% methanol for 1 hr. The extract (38 liters) was concentrated under reduced pressure to an aqueous solution and a water-insoluble precipitate (6.8 g) was collected by filtration. The ether soluble portion of this precipitate was chromatographed on a silica gel column (Wakogel C-300, 3.8 × 44 cm). The column was eluted stepwise by benzene-ethyl acetate with an increasing amount of ethyl acetate: 0.5, 1, 3, 5, 8, 12, 17 and 25% (v/v). The volume of each eluant was 500 ml. The eluate was monitored by TLC (Wakogel B-5F; solvent, benzene-ethyl acetate = 20:1) and was divided into thirteen fractions. Each fraction was concentrated under reduced

pressure. Compound **1** was eluted in the 5% eluate and recrystallized from petroleum benzene to give colorless prisms (197 mg). Compound **2** was obtained from the 8% eluate and recrystallized from benzene to give colorless prisms (230 mg).

Properties of compound 1. *Anal.* Found: C, 75.05; H, 6.36. Calcd. for $C_{16}H_{16}O_3$: C, 75.00; H, 6.25%. $[\alpha]_D^{24} -8.22^\circ$ ($c=1.08$, $CHCl_3$). UV λ_{max}^{MeOH} nm (ϵ): 285.5 (sh) (582), 265 (sh) (705), 271.0 (790), UV λ_{max}^{alkali} nm: 279.5, 285.0 (sh). IR ν_{max}^{KBr} cm^{-1} : 3360, 3000~2800, 1595, 1440, 1265, 1145, 1095, 810, 760, 690. 1H -NMR $\delta_{TMS}^{CDCl_3}$: 2.1 (2H, m, $-CH_2-$), 2.7 (2H, m, $-CH_2-$), 3.77 (3H, s, $-OCH_3$), 4.98 (1H, dd, $J=9.6$ and 3.0 Hz, $OCH-R$), 5.20 (1H, s, $-OH$), 6.04 (2H, d, $J=1.0$ Hz, ArH), 7.36 (5H, s, ArH). ^{13}C -NMR $\delta_{TMS}^{CDCl_3}$: 19.2 (t, C-3), 29.5 (t, C-4), 55.5 (q, $-OCH_3$), 77.7 (d, C-2), 91.5 (d, C-6), 96.1 (d, C-8), 103.4 (s, C-4a), 126.0 (d, C-3', 5'), 127.8 (d, C-4'), 128.5 (d, C-2', 6'), 141.6 (s, C-1'), 155.2 (s, C-5), 156.3 (s, C-7), 158.7 (d, C-8a). MS m/z : 256 (M^+), 165, 152, 124, 117, 104, 91, 78. CD λ_{max}^{MeOH} nm ($\Delta\epsilon$): 295 (−3.7), 280 (−16.7), 277* (−18.7), 273* (−20.2), 270 (−18.3), 265 (−10.0), 260 (−3.9), 252* (−1.7), 250 (−2.0), 240* (−33.3), 230 (−11.0), 218* (−7.4), 210 (−44.4).

Acetylation of compound 1. Compound **1** (50 mg) was dissolved in 1 ml of acetic anhydride and a few drops of pyridine, and the mixture was heated at $85^\circ C$ for 30 min. The reaction mixture was poured into chilled water and placed in a refrigerator overnight. The precipitate was filtered and recrystallized from ethanol to give colorless needles (42 mg).

Anal. Found: C, 72.56; H, 6.12. Calcd. for $C_{18}H_{18}O_4$: C, 72.48; H, 6.04%. mp $75 \sim 78^\circ C$. IR ν_{max}^{KBr} cm^{-1} : 3020, 2920, 1755, 1600, 1420, 1365, 1220, 1195, 1100, 895, 810, 755. 1H -NMR $\delta_{TMS}^{CDCl_3}$: 2.07 (2H, m, $-CH_2-$), 2.27 (3H, s, $-OCOCH_3$), 2.71 (2H, m, $-CH_2-$), 3.79 (3H, s, $-OCH_3$), 4.99 (1H, dd, $J=9.8$ and 2.9 Hz, $OCH-R$), 6.19 (1H, d, $J=2.0$ Hz, ArH), 6.32 (1H, d, $J=2.0$ Hz, ArH), 7.37 (5H, s, ArH).

Properties of compound 2. *Anal.* Found: C, 71.26; H, 6.25. Calcd. for $C_{17}H_{18}O_4$: C, 71.31; H, 6.33%. $[\alpha]_D^{21} -8.35^\circ$ ($c=1.16$, MeOH). UV λ_{max}^{MeOH} nm (ϵ): 274 (2200), UV λ_{max}^{alkali} nm: 276, 298 (sh). IR ν_{max}^{KBr} cm^{-1} : 3380, 2940, 1610, 1120, 840, 820, 800. 1H -NMR $\delta_{TMS}^{CDCl_3}$: 2.1 (2H, m, $-CH_2-$), 2.7 (2H, m, $-CH_2-$), 3.75 (3H, s, $-OCH_3$), 3.79 (3H, s, $-OCH_3$), 4.91 (1H, dd, $J=9.3$ and 3.4 Hz, $OCH-R$), 5.05 (1H, s, $-OH$), 6.10 (2H, d, $J=2.0$ Hz, ArH), 6.82 (2H, d, $J=8.3$ Hz, ArH), 7.30 (2H, d, $J=8.3$ Hz, ArH). ^{13}C -NMR $\delta_{TMS}^{CDCl_3}$: 19.3 (t, C-3), 29.3 (t, C-4), 55.3 (q, $-OCH_3$), 77.5 (d, C-2), 91.4 (d, C-6), 93.4 (d, C-8), 103.3 (s, C-4a), 115.2 (d, C-3', 5'), 127.6 (d, C-2', 6'), 133.9 (s, C-

1'), 155.2 (s, C-5), 156.3 (s, C-4'), 158.5 (s, C-8a), 159.2 (s, C-7). MS m/z : 286 (M^+), 167, 133, 120, 91, 77. CD λ_{max}^{MeOH} ($\Delta\epsilon$): 290 (−1.7), 280 (−18.4), 276* (−23.5), 273* (−26.7), 270 (−25.3), 260 (−12.0), 250 (−4.0), 247* (−3.6), 240 (−11.1), 230 (−82.0), 217* (−95.3), 210 (−55.4).

Acetylation of compound 2. Compound **2** (50 mg) was acetylated by the same method as that used for compound **1**, and 32 mg of colorless needles were obtained.

Anal. Found: C, 69.58; H, 6.10. Calcd. for $C_{19}H_{20}O_5$: C, 69.51; H, 6.10%. mp $111 \sim 112^\circ C$. IR ν_{max}^{KBr} cm^{-1} : 2930, 1740, 1610, 1585, 1490, 1430, 1370, 1220, 1195, 1140, 850, 840, 780. 1H -NMR $\delta_{TMS}^{CDCl_3}$: 2.2 (2H, m, $-CH_2-$), 2.3 (3H, s, $-OCOCH_3$), 2.7 (2H, m, $-CH_2-$), 3.76 (3H, s, $-OCH_3$), 3.79 (3H, s, $-OCH_3$), 4.99 (1H, dd, $J=9.8$ and 2.9 Hz, $OCH-R$), 6.10 (2H, d, $J=2.5$ Hz, ArH), 7.11 (2H, d, $J=8.3$ Hz, ArH), 7.44 (2H, d, $J=8.3$ Hz, ArH). MS m/z : 328 (M^+), 286, 200, 167, 154, 133, 120.

Methylation of compound 2. Compound **2** (100 mg) in methanol was treated with an excess of ethereal diazomethane. After the reaction mixture had stood overnight, the excess diazomethane was removed by evaporation. The residual material was crystallized from benzene–hexane (1:5) to give colorless needles (85 mg).

Anal. Found: C, 71.98; H, 6.74. Calcd. for $C_{18}H_{20}O_4$: C, 72.00; H, 6.67%. mp $107 \sim 108^\circ C$. IR ν_{max}^{KBr} cm^{-1} : 2940, 1610, 1510, 1440, 1240, 1200, 1100, 830, 800. 1H -NMR $\delta_{TMS}^{CDCl_3}$: 2.1 (2H, m, $-CH_2-$), 2.7 (2H, m, $-CH_2-$), 3.75 (3H, s, $-OCH_3$), 3.79 (3H, s, $-OCH_3$), 3.81 (3H, s, $-OCH_3$), 4.92 (1H, dd, $J=9.3$ and 3.4 Hz, $OCH-R$), 6.06 (2H, d, $J=2.9$ Hz, ArH), 6.91 (2H, d, $J=8.8$ Hz, ArH), 7.35 (2H, d, $J=8.8$ Hz, ArH). MS m/z : 300 (M^+), 179, 166, 147, 134, 121.

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