Novel Prenylated Xanthones with Antioxidant Property from the Wood of *Garcinia subelliptica*

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Three new prenylated xanthones, garciniaxanthones F (1), G (2) and H (3), have been isolated as antioxidative substances from the wood of *Garcinia subelliptica* (Guttiferae). Their structures have been elucidated on the basis of spectroscopic data involving comparison of their ^{13}C-NMR data with those of previously known xanthones. The antioxidant properties of the new compounds have been evaluated by three assay systems: anti-lipid peroxidation, α,α-diphenyl-β-picrylhydrazyl radical scavenging activity and superoxide radical scavenging activity.

Key words *Garcinia subelliptica*; xanthone; garciniaxanthone F; garciniaxanthone G; garciniaxanthone H; antioxidant

Garcinia subelliptica MERR. (Guttiferae) has been cultivated as a windbreak in the Yaeyama islands of Japan. Its bark had been utilized as a source of a yellow colored dye, and thus the chemical components are known to be abundant in a variety of xanthones[1,2] like other *Garcinia* species.[3] In preceding papers,[4,5] we reported the isolation and structure elucidation of several prenylated xanthones which exhibited antioxidant activity in the *in vitro* three assay systems, anti-lipid peroxidation (LPO), α,α-diphenyl-β-picrylhydrazyl (DPPH) radical scavenging activity (DPPH radical), and superoxide radical scavenging activity (O_2^-). Among them, xanthones bearing 1,4- or 1,2-dihydroxyl groups were most likely to show antioxidant activity. To gain insight into the structure–activity relationship of xanthones we have continued to search for antioxidative xanthones in the methanol extract of *G. subelliptica*, resulting in the isolation of three new xanthones named garciniaxanthones F (**1**), G (**2**) and H (**3**), along with the previously reported garciniaxanthones D (**4**),[5] 1,4,5-trihydroxyxanthone (**5**),[5] symphoxanthone (**6**)[6] and 1-*O*-methylsymphoxanthone (**7**).[7] This paper deals with the structure elucidation of these new compounds and their antioxidative properties.

The methanol extract of the wood of *G. subelliptica* was absorbed on Celite and then packed into a glass column, eluted in turn with *n*-hexane, CH_2Cl_2, AcOEt, and MeOH. Antioxidant activity for each soluble portion was tested by the three assays (Fig. 2), and the AcOEt soluble portion indicated higher inhibition percent than the methanol extract except for DPPH radical. The AcOEt soluble portion was then fractionated by a combination of silica gel and Sephadex LH-20 chromatographies to give three new xanthones **1**—**3**, together with **4**—**7**.

Garciniaxanthone F (**1**), obtained as orange needles, has the molecular formula $C_{24}H_{24}O_6$, established by high resolution electron impact mass spectrum (HR EI-MS). Its UV (232, 267, 293 and 402 nm) and IR (3368, 1630, 1591 and 1449 cm^{-1}) showed absorptions characteristic of a hydroxylated xanthone. The presence of chelated hydroxyl and non-chelated hydroxyl groups was supported by the IR (3368 cm^{-1}) and ^{1}H-NMR data [δ_H 13.0 and 9.74 (each s)]. The ^{1}H-NMR spectrum (Table 1) of **1** contained *ortho*-coupled aromatic protons at δ_H 7.67 (1H, d, J=8.3 Hz) and 8.01 (1H, d, J=8.3 Hz), two singlet signals at δ_H 7.17 and 7.39, and a methoxy signal at δ_H 3.06 (3H, s) and two methyl signal at δ_H 1.64 (6H, s), as well as two methyl and three olefin proton signals at δ_H 1.49 (6H, s) and 5.02 (1H, d, J=17.8 Hz), 5.04 (1H, d, J=10.5 Hz), and 6.26 (1H, dd, J=17.8, 10.5 Hz), respectively, which are typical of a 1,1-dimethyl-2-propenyl group. On the other hand, the ^{13}C-NMR data (Table 2) of **1** had a strong resemblance to those due to the right hand benzene ring of garciniaxanthone D (**4**),

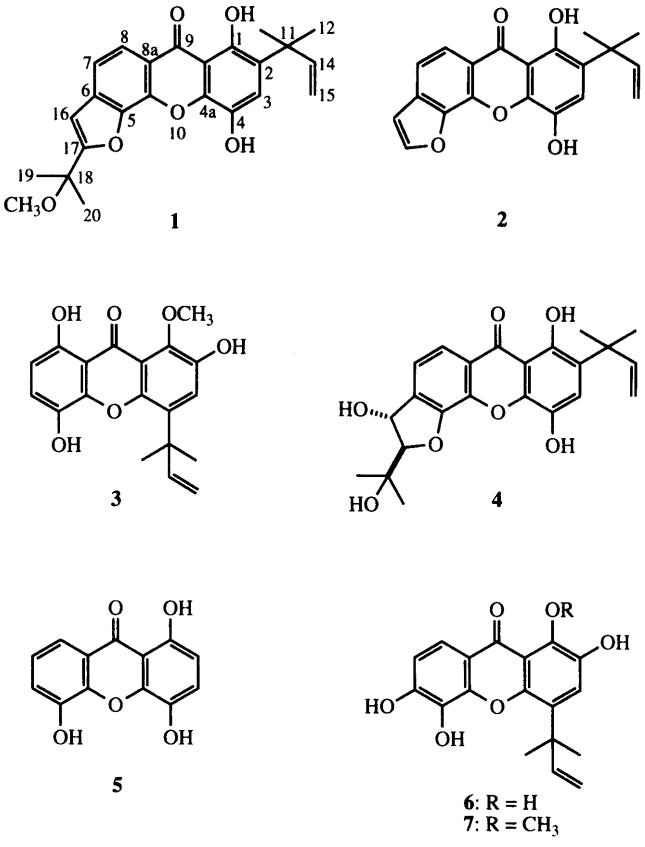

Fig. 1

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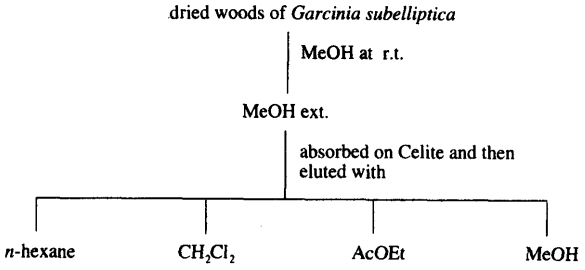
indicating the same substituted pattern on the right ring as in **4**. This was also supported by the ^{1}H-detected multiple-bond heteronuclear multiple quantum coherence spectrum (HMBC), in particular, the correlations *via* three bonds from the two hydroxyl proton signals (δ_H 13.00 and 9.74) and the dimethyl signals (δ_H 1.49) to the carbon signals assignable to the right-hand aromatic ring, as shown in Fig. 3a. This was subsequently substantiated by the observation of a nuclear Overhauser effect (NOE) between the H-3 and the H_3-12 and 13, as shown by dotted arrow in Fig. 3a. The aromatic proton resonated at δ_H 8.01 which was coupled with the proton at δ_H 7.67 should be assigned to H-8, not only on the basis of its low δ value but also because it shows a cross peak with the sole carbonyl carbon signal at δ_C 182.2 in the HMBC (Fig. 3a). This means that the C-5 and C-6 positions must be substituted. The sole methoxy signal and the methyl signal (H_3-19 and H_3-20) at δ_H 1.64 showed the HMBC correlations to a quaternary carbon signal at δ_C 73.0, indicating the presence of a 2-methoxy-2-isopropyl group. This was also supported by the observation of a fragment ion peak at *m/z* 335 (M^+-73), corresponding to the loss of $[Me_2C=OMe]^+$.[8] In the additional HMBC as shown in Fig. 3a, the H_3-19 and H_3-20 correlated to the C-17 sp^2 quaternary carbon signal at δ_C 164.5 and thereby the 2-methoxy-2-isopropyl group must be bonded to C-17. The remaining singlet signal at δ_H 7.17, which caused an NOE enhancement upon irradiation of the H_3-19 and H_3-20, showed correlations with the C-6 and C-5 signals at δ_H 135.1 and 140.9, leading to the formation of an α-substituted benzofuran ring fused at the C-5 and C-6 positions. This was also confirmed by the observation of an NOE between the H-7 and H-16 signals (Fig. 3a). Thus, the structure of garciniaxanthone F (**1**) was determined as shown in Fig. 1.

Garciniaxanthone G (**2**) has the molecular formula $C_{20}H_{16}O_5$ obtained from HR FAB-MS at *m/z* 336.1009 (M^+), and was shown to belong to a 1,4-dihydroxylated xanthone by its IR and UV spectra. The NMR data (Tables 1 and 2) of **2** which were compared with those of **1** implied that the right-hand benzene ring of **2** was closely related to that of **1**. This was unambiguously supported by HMBC and NOE experiments (Fig. 3b). The left-hand benzene ring of **2** carried *ortho*-coupled H- 8 and H-7 at δ_H 8.13 (d, J=8.3 Hz) and 7.57 (d, J=8.3 Hz) and two additional olefinic protons (H-16 and H-17) at δ_H 6.97 (d, J=2.0 Hz) and 7.91 (d, J=2.0 Hz) which coupled to each other, indicating the loss of a 2-methoxy-2-isopropyl group on the benzofuran ring existing in **1**. In fact, the H-16 and H-17 signals showed the HMBC correlations to the two sp^2 quaternary carbon signals (C-6 and C-5) at δ_C 134.5 and 141.8, as shown in Fig 3b, and NOE was



Antioxidant activity (% inhibition) for each soluble portion

Conc. (μg/ml)	LPO[a]	DPPH[b] radical		O_2^-[c]
	10	10	5	10
MeOH ext.	73.8	90.9	22.8	24.4
n-Hexane sol.	6.3	10.1	2.8	0.0
CH_2Cl_2 sol.	78.8	22.4	10.7	27.8
AcOEt sol.	96.4	55.4	30.4	28.5
MeOH sol.	2.9	11.0	14.9	4.5

Fig. 2. Antioxidant Activities for MeOH Ext. and Each Soluble Portion

a) Anti-lipid peroxidation (% inhibition in rat brain homogenates). *b*) Chemical stable radical scavenging (% inhibition of α,α-diphenyl-β-picrylhydrazyl radical). *c*) Superoxide anion scavenging (% inhibition in xanthine and xanthine oxidase system).

Table 1. ^{1}H-NMR Data of Compounds **1**—**3**

Proton No.	**1**[a]	**2**[b]	**3**[b]
3	7.39 (1H, s)	7.42 (1H, s)	7.50 (1H, s)
6	—	—	7.22 (1H, d, J=8.8 Hz)
7	7.67 (1H, d, J=8.3 Hz)	7.57 (1H, d, J=8.3 Hz)	6.53 (1H, d, J=8.8 Hz)
8	8.01 (1H, d, J=8.3 Hz)	8.13 (1H, d, J=8.3 Hz)	—
12	1.49 (3H, s)	1.56 (3H, s)	1.56 (3H, s)
13	1.49 (3H, s)	1.56 (3H, s)	1.56 (3H, s)
14	6.26 (1H, dd, J=17.8, 10.5 Hz)	6.29 (1H, dd, J=17.1, 10.8 Hz)	6.36 (1H, dd, J=17.6, 10.7 Hz)
15	5.02 (1H, dd, J=17.8, 1.0 Hz)	5.05 (1H, dd, J=17.1, 1.1 Hz)	5.21 (1H, dd, J=10.7, 1.0 Hz)
	5.04 (1H, dd, J=10.5, 1.0 Hz)	5.06 (1H, dd, J=10.8, 1.1 Hz)	5.34 (1H, dd, J=17.6, 1.0 Hz)
16	7.17 (1H, s)	6.97 (1H, d, J=2.0 Hz)	—
17	—	7.91 (1H, d, J=2.0 Hz)	—
19	1.64 (3H, s)	—	—
20	1.64 (3H, s)	—	—
OCH_3	3.06 (3H, s)	—	4.02 (3H, s)
1-OH	13.0 (1H, s)	12.81 (1H, s)	—
2-OH	—	—	5.97 (1H, s)
4-OH	9.74 (1H, s)	5.49 (1H, s)	—
5-OH	—	—	5.44 (1H, s)
8-OH	—	—	11.92 (1H, s)

a) In DMSO-d_6. *b*) In $CDCl_3$.

Table 2. ^{13}C-NMR Data of Compounds **1**—**5**

Carbon No.	1[a]	2[b]	3[b]	4[a]	5[a]
1	151.2	153.4	143.0	151.2	152.4
2	127.9	129.7	145.1	127.4	109.1
3	122.4	122.2	121.1	122.6	123.3
4	136.3	134.6	133.5	136.3	137.4
4a	141.3	140.6	148.2	141.8	143.0
5	140.9	141.8	136.0	147.4	146.3
6	135.1	134.5	122.1	137.8	120.9
7	117.1	117.1	109.3	120.7	124.5
8	119.6	120.4	153.9	116.9	114.8
8a	116.1	117.1	108.6	120.5	120.7
9	182.2	182.2	181.9	182.5	182.1
9a	108.7	108.7	115.1	108.6	108.4
10a	142.1	142.4	142.2	141.1	144.7
11	39.3	40.4	40.7	40.0	
12	26.3	26.7	27.6	26.3	
13	26.3	26.7	27.6	26.3	
14	146.6	146.9	150.9	146.6	
15	110.8	110.8	109.0	110.8	
16	105.7	108.1		71.8	
17	164.5	148.6		98.2	
18	73.0			69.7	
19	25.0			25.5	
20	25.0			25.8	
OCH_3	50.5		62.7		

a) In DMSO-d_6. *b*) In $CDCl_3$.

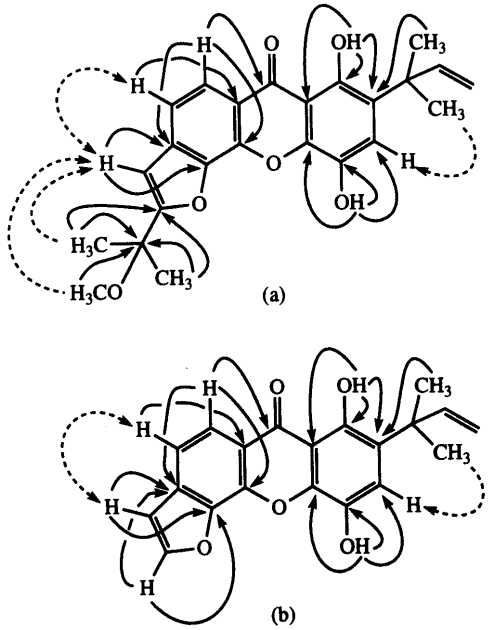


Fig. 3. HMBC Correlations (Bold Arrows) and NOEs (Dotted Arrows) Observed for **1** (a) and **2** (b)

also observed between the H-16 and H-7 signals. This means that a furan ring is fused at the C-5 and C-6 positions. Thus, from the above spectral data the structure of garciniaxanthone G was depicted as **2** (Fig. 1).

Although subellipitinones C and D, furanoxanthones, which are closely related to garciniaxanthones F and G, were isolated earlier from the root bark of the same plant by Iinuma *et al.*,[9] compounds **1** and **2** are the second example of furanoxanthones.

The spectral data for garciniaxanthone H (**3**), $C_{19}H_{18}O_6$, were very similar to those of 1-*O*-methylsymphoxanthone (**7**), in particular, the ^{13}C-NMR data (Table 2) for the right-hand benzene ring of **3** well corresponded to those of **7**,[7] and showed the presence of one chelated hydroxyl group at δ_H 11.92 and two non-chelated hydroxyl groups at δ_H 5.44 and 5.97 as well as of a set of *ortho*-coupled aromatic protons [δ_H 6.53 (d, J=8.8 Hz) and 7.22 (d, J=8.8 Hz); δ_C 109.3 and 122.1]. A sole methoxy group resonated at δ_C 62.7, indicative of the steric crowding around it, and had no NOE interaction on any of the proton signals in the two dimensional nuclear Overhauser and exchange spectroscopy (2D NOESY), so the C-1 position must be occupied by this group. Moreover, one (δ_H 5.97) of two non-chelated hydroxyl signals correlated to C-1 (δ_C 143.0) and C-3 (δ_C 121.1) in the HMBC, and also the H-3 singlet proton signal (δ_H 7.50) showed a distinct NOE upon irradiation of the methyl signals due to a 1,1-dimethyl-2-propenyl group. These spectral data proved the right-hand benzene ring of **3** to be identical to that of **7**. The C-9 carbonyl group, which appeared at a lower field (δ_C 181.9) than normal value (*ca.*175 ppm),[10] forms a hydrogen bond with the C-8 hydroxyl group.[11] Additionally, the ^{13}C-NMR data (Table 2) for the left-hand ring of **3** were very similar to those of the 1,4-dihydroxylated aromatic ring in 1,4,5-trihydroxyxanthone (**5**).[5] The above spectral evidence indicates that the left-hand benzene ring of **3** is substituted with dihydroxyl groups at the C-5 and C-8 positions. This was substantiated by the HMBC correlations of the non-chelated hydroxyl proton at δ_H 5.44 to C-10a, C-5 and C-6.

Accordingly, the structure of garciniaxanthone H (**3**) was determined as 2,5,8-trihydroxy-1-methoxy-4-(1,1-dimethyl-2-propenyl)xanthone.

Table 3. Antioxidant Activity (% Inhibition) of Compounds **1**—**6**

Conc. (μg/ml)	LPO[a]		DPPH radical[b]		O_2^-[c]		
	10	5	10	5	15	5	1
MeOH ext.	73.8	—	90.9	22.8	24.4	—	—
AcOEt sol.	96.4	—	55.4	30.4	28.5	—	—
1	95.5	16.6	18.5	—	44.4[d]	—	—
2	98.0	59.5	27.4	—	11.0[d]	—	—
3	100.0	41.3	17.3	—	74.1[d]	11.0	—
4	80.4	15.8	19.5	—	100.0	44.4	—
5	64.6	25.2	73.3	5.7	96.6	90.4	31.3
6	75.9	30.9	85.0	8.5	93.1	83.3	40.6

a) Anti-lipid peroxidation (% inhibition in rat brain homogenates). *b*) Chemical stable radical scavenging (% inhibition of DPPH radical). *c*) Superoxide anion scavenging (% inhibition in xanthine and xanthine oxidase system). *d*) At 75 μg/ml.

Compounds **1**—**6** were tested for their antioxidative properties using three *in vitro* assays, *viz.*, anti-lipid peroxidation activity in rat brain homogenates (ALP),[12] free radical scavenging activity of the DPPH radical[13] and superoxide anion scavenging activity in the xanthine–xanthine oxidase system (O_2^-).[14] The results are summarized in Table 3. All the compounds which have a 1,4-hydroquinone ring in common exhibited >60% inhibitory activity of lipid peroxidation at 10 μg ml^{-1} with **2**, in particular, showing 59.5% inhibition at 5 μg ml^{-1}. Although compounds **3**— **6** showed O_2^- scavenging

activity at 15 $\mu g\,ml^{-1}$, garciniaxanthones F (**1**) and G (**2**) carrying a benzofuran moiety exhibited no inhibitory activity even at a concentration as high as 15 $\mu g\,ml^{-1}$. On scavenging activity of DPPH radical, however, 1,4-hydroxylated xanthones did not show higher inhibitory activities than a cathecol-type compound such as **6**.[15]

Experimental

UV spectra were recorded on a Hitachi 340 spectrophotometer. IR spectra were measured on a Jasco FT-IR 5300 spectrophotometer. ^1H- and ^{13}C-NMR spectra were obtained at 400 MHz (^1H-NMR) and 100.16 MHz (^{13}C-NMR) using a JEOL GX-400 instrument. Chemical shift values were expressed in δ (ppm) downfield from tetramethylsilane as an internal standard. The MS were recorded on a JEOL AX-500 instrument. Silica gel (Wako, C-300) was used for column chromatography. Silica gel F_{254} (Merck) was used for analytical (0.25 mm) and preparative (0.5 mm) thin-layer chromatographies, and spots were visualized under UV (254 nm) light and by spraying with 40% $CeSO_4$–H_2SO_4 followed by heating.

Extraction and Purification The dried and powdered wood (15 kg) of *G. subelliptica*, collected on Ishigaki island, was immersed in methanol at room temperature for 3 weeks. The MeOH extract was evaporated *in vacuo* to give a gummy extract (212 g), which was mixed with Celite (150 g) and the solvent was completely removed *in vacuo* to give solids, which were pulverized. The resultant powder was packed into a glass column and then eluted in turn with *n*-hexane (1.5 l), CH_2Cl_2 (1.5 l), AcOEt (1 l), and MeOH (1 l) giving 6 fractions (fractions 1—6). The AcOEt soluble portion (70 g) was chromatographed on silica gel with CH_2Cl_2–MeOH (9 : 1) to give 11 fractions (fractions 1—11). Fraction 4 (2.5 g) was chromatographed on silica gel with CH_2Cl_2–MeOH (15 : 1) to divide it into fractions 12—16. Fraction 15 (414 mg) was rechromatographed on silica gel with *n*-hexane–AcOEt (3 : 1) and then $CHCl_3$–ether (12 : 1) to give garciniaxanthone F (**1**) (7.2 mg) and garciniaxanthone H (**3**) (3.4 mg). Fraction 13 (517 mg) was chromatographed on silica gel with *n*-hexane–CH_2Cl_2 (1 : 6) followed by Toyopearl HW-40F with $CHCl_3$–MeOH (1 : 9) to give garciniaxanthone G (**2**) (5.5 mg). Fraction 14 (1.0 g) was subjected to reversed-phase chromatography using Cosmosil 75C_{18}-OPN and eluted with MeOH–MeCN–H_2O (1 : 1 : 2.5) to give fractions 17—19. Fraction 18 (203 mg) was chromatographed on Sephadex LH-20 with MeOH to divide it into fractions 20—24. From fraction 21 was obtained 1,4,5-trihydroxyxanthone (**5**) (13.5 mg) and fraction 22 (61.3 mg) was rechromatographed on silica gel with CH_2Cl_2–AcOEt (3 : 1) to afford symphoxanthone (**6**) (11.0 mg) and 1-*O*-methylsymphoxanthone (**7**) (26.6 mg). Fraction 16 (80 mg) was purified by Sephadex LH-20 with MeOH to give garciniaxanthone D (**4**) (32.6 mg)

Garciniaxanthone F (1) Yellow needles, mp 229—231 °C. IR $\nu_{max}\,cm^{-1}$:3368 (OH), 1630 (C=O), 1591 and 1449 (aroma.). UV λ_{max}^{EtOH} nm (ε): 232 (18600), 237 (18400), 247 (16300), 267 (11500), 293 (19300), 402 (2500). EI-MS (rel. int. %) *m/z*: 408 (M^+, 84), 393 (100), 377 (13), 335 (11). ^1H-NMR and ^{13}C-NMR: see Tables 1 and 2. HR EI-MS *m/z*: 408.1565 (M^+). Calcd for $C_{24}H_{24}O_6$: 408.1573.

Garciniaxanthone G (2) Yellow needles, mp 194—196 °C. IR $\nu_{max}\,cm^{-1}$: 3567 (OH), 1625 (C=O), 1599 and 1450 (aroma.). UV λ_{max}^{EtOH} nm (ε): 232 (13100), 245 (11500), 267 (7890), 288 (14600), 404 (2400). FAB-MS *m/z*: 337 ($M^+ + 1$), 336 (M^+), 321. ^1H-NMR and ^{13}C-NMR: see Tables 1 and 2. HR FAB-MS *m/z*: 336.1009 (M^+). Calcd for $C_{20}H_{16}O_5$: 336.0998.

Garciniaxanthone H (3) Yellow amorphous. IR $\nu_{max}\,cm^{-1}$: 3387 (OH), 1651 (C=O), 1595 and 1485 (aroma.). EIMS (rel. int. %) *m/z*: 342 (M^+, 100), 324 (62). ^1H-NMR and ^{13}C-NMR: see Tables 1 and 2. HR EI-MS *m/z*: 342.1096 (M^+). Calcd for $C_{19}H_{18}O_6$: 342.1104.

Antioxidative Activity on Lipid Peroxidation The method reported by Stocks *et al.*[12] was used for the assay. A sample of the stocked rat brain homogenates was thawed at room temperature and immediately diluted 3-fold with phosphate-saline buffer (pH 7.4) to prepare a 7% (w/v) portion. To 5 ml of this homogenate was added various concentrations of the test samples in 10% dimethyl sulfoxide (DMSO) solution or water (blank). Mixtures were incubated at 37 °C for 1 h. After the addition of 28% trichloroacetic acid solution, each mixture was centrifuged at 3000 rpm for 10 min. To 4 ml supernatant was added 1 ml of 1% thiobarbituric acid solution and then the mixture was heated in a boiled water-bath for 15 min. Absorption (A) was measured at 532 nm.

$$\text{antioxidative activity (\%)} = (1 - A \text{ of sample}/A \text{ of blank}) \times 100$$

Chemically Stable Radical Scavenging Activity DPPH radical was used as an organic radical model.[13] A 0.1 M ethanol solution of DPPH (2.7 ml) and various concentrations (0.3 ml) of the test samples in 10% DMSO solution were mixed and allowed to stand at room temperature for 20 min. The change of A at 517 nm was monitored. Scavenging activity was expressed as the inhibition percentage, calculated as inhibition % = $\Delta B/\Delta A$, where ΔA was the decrease of absorbance when 15 $\mu g\,ml^{-1}$ of ascorbic acid was applied and ΔB was the decrease of absorbance when the sample was applied at the concentration noted.

Superoxide Anion Scavenging Activity The method reported by McCord and Fridovich[14] was used for the assay. To the standard solution, prepared from 250 μl of 0.3 M potassium phosphate buffer at pH 7.8 containing 0.6 M EDTA, 250 μl of 0.06 mM ferricytochrome C, 250 μl of 0.03 mM xanthine, and 500 μl of water were added various concentrations of the samples in 10% DMSO solution or 150 μl of water. After 100 μl of 7.5—1.5 $\times 10^{-4}$ mM xanthine oxidase was added at 25 °C, and absorbance at 550 nm was measured every 10 s for 2 min to make a linear graph. Percent inhibition (%) was expressed as the slope on a linear graph during 1 min.

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References and Notes

1) Fukuyama Y., Kamiyama A., Minami Y., Kodama M., *Phytochemistry*, **30**, 3433—3436 (1991).
2) Iinuma M., Tosa H., Tanaka T., Shimano R., Asai F., Yonemori S., *Phytochemistry*, **35**, 1355—1360 (1994).
3) Bennet G. J., Lee H.-H., *Phytochemistry*, **28**, 967—998 (1989).
4) Minami H., Kinoshita M., Fukuyama Y., Kodama M., Yoshizawa T., Sugiura M., Nakagawa K., Tago H., *Phytochemistry*, **36**, 501—506 (1994).
5) Minami H., Takahashi E., Fukuyama Y., Kodama M., Yoshizawa T., Nakagawa K., *Chem. Pharm. Bull.*, **43**, 347—349 (1995).
6) Locksley H. D., Moore I., Scheinmann F., *J. Chem. Soc.*, (*C*), **1966**, 2186—2190.
7) Minami H., Takahashi E., Kodama M., Fukuyama Y., *Phytochemistry*, **41**, 629—633 (1996).
8) Fukuyama Y., Shida N., Sakurai T., Kodama M., *Phytochemistry*, **31**, 3975—3979 (1992).
9) Iinuma M., Tosa H., Tanaka T., Asai F., Shimano R., *Heterocycles*, **40**, 279—284 (1995).
10) Ikeya Y., Sugawa K., Okada M., Mitsuhashi H., *Phytochemistry*, **30**, 261—264 (1991).
11) Silveir E. R., Falcao M. J. C., Menezes A., Jr., Kingstone D. G. I., Glass T. E., *Phytochemistry*, **39**, 1433—1436 (1995).
12) Stocks J., Gutteridge J. M. C., Sharp R. J., Dormandy T. L., *Clin. Sci. Mol. Med.*, **47**, 215 (1974).
13) Blois M. S., *Nature* (London), **181**, 1199—1120 (1958).
14) McCord J. M., Fridovich I., *J. Biol. Chem.*, **244**, 6049—6055 (1969).
15) Larson R. A., *Phytochemistry*, **27**, 969—1147 (1988).