# Phenolic Glycosides from Berries of *Pimenta dioica*

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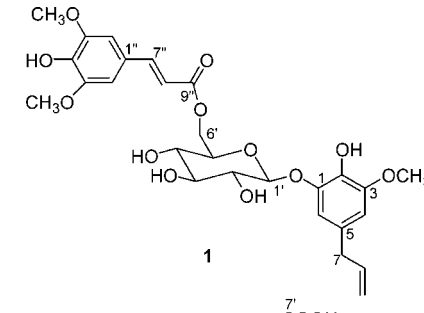
Four new phenolic glycosides, (2-hydroxy-3-methoxy-5-allyl)phenyl β-D-(6-*O*-*E*-sinapoyl)glucopyranoside (**1**), (1′*R*,5′*R*)-5-(5-carboxymethyl-2-oxocyclopentyl)-3*Z*-pentenyl β-D-(6-*O*-galloyl)glucopyranoside (**2**), (*S*)-α-terpinyl [α-L-(2-*O*-galloyl)arabinofuranosyl]-(1→6)-β-D-glucopyranoside (**3**), and (*R*)-α-terpinyl [α-L-(2-*O*-galloyl)arabinofuranosyl]-(1→6)-β-D-glucopyranoside (**4**), were isolated from the berries of *Pimenta dioica* together with eight known flavonoids. The structures of **1**−**4** were elucidated on the basis of MS and NMR data and enzymatic hydrolysis. All four glycosides showed radical-scavenging activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals.

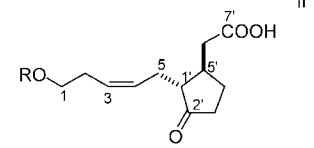
Allspice, made from the berries of *Pimenta dioica* Merr. belonging to Myrtaceae, is used as a spice in foods, and its essential oil, which is rich in eugenol, has been used as an antimicrobial and a digestive agent. In our previous studies, several phenylpropanoids and galloylglucosides were isolated from this plant.[1−3] Herein, we report the isolation and characterization of four new phenolic glycosides (**1**−**4**) from allspice and their free radical-scavenging effects on 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals.

The EtOAc-soluble fraction obtained from a 70% aqueous acetone extract of allspice was subjected to successive column chromatography using Sephadex LH-20, Si gel, and Chromatorex ODS to give four new glycosides (**1**−**4**) together with eight known compounds. These known compounds were identified by comparison of spectroscopic data as quercetin, quercetin 3-*O*-galactoside (hyperoside),[4] quercetin 3-*O*-α-L-arabinoside (avicularin),[5] quercetin 3-*O*-(2-*O*-galloyl)-β-D-glucoside,[6] quercetin 3-*O*-β-D-glucuronide 6″-methyl ester,[7] myricetin, myricetin 3-*O*-galactoside,[8] and (+)-ampelopsin.[9]

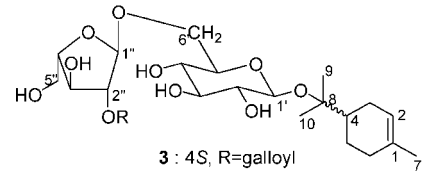
Compound **1** exhibited an $[M - H]^-$ peak at *m*/*z* 547.1798 in agreement with the molecular formula of $C_{27}H_{32}O_{12}$ by negative ion HRFABMS measurement. The IR spectrum revealed hydroxy (3600–3100 $cm^{-1}$) and ester (1717 $cm^{-1}$) functions and an aromatic ring (1604 and 1510 $cm^{-1}$). The UV spectrum showed an absorption peak at 328 nm, indicating the presence of a cinnamoyl moiety. In the $^1H$ NMR spectrum, a two-proton singlet at δ 7.04, a 6H singlet at δ 3.90, and two 1H doublets at δ 7.63 and 6.48 with a coupling constant of 15.9 Hz were indicative of a sinapoyl group. The $^{13}C$ NMR spectrum showed six carbons corresponding to a glucose moiety (δ 104.3, 77.0, 75.0, 74.4, 70.9, and 63.8) and one methylene (δ 40.2), one *O*-methyl (δ 56.2), two olefinic (δ 138.4 and 115.3), and six aromatic (δ 148.8, 146.1, 136.5, 130.9, 112.2, and 108.9) carbons, which suggested the presence of another phenylpropanoid moiety as well as the sinapoyl group. Resonances of a 1,2,3,5-tetrasubstituted aromatic ring [δ 6.68 (1H, d, $J = 1.7$ Hz) and 6.55 (1H, d, $J = 1.7$ Hz)], a vinyl group [δ 5.89 (1H, ddt, $J = 16.8$, 10.0, 6.7 Hz), 4.99 (1H, ddt, $J = 16.8$, 3.4, 1.5 Hz), and 4.93 (1H, ddt, $J = 10.0$, 3.4, 1.5 Hz)], an *O*-methyl group [δ 3.77 (3H, s)], and a methylene group [δ 3.22 (2H, br d, $J = 6.7$ Hz)] in the $^1H$ NMR spectrum along with mass fragment ions at *m*/*z* 367 $[M - H - 180]^-$ and 179 in the negative ion FABMS spectrum suggested the presence of a 5-hydroxyeugenol framework. In the HMBC spectrum, the anomeric proton [δ 4.76 (1H, d, $J = 7.6$ Hz)] showed a correlation with an aromatic carbon (δ 146.1) attributed to C-1.



**1**



**2** : R=-β-D-(6-O-galloyl)glucopyranose
**5** : R=H (*trans*-tuberonic acid)



**3** : 4*S*, R=galloyl
**4** : 4*R*, R=galloyl
**6** : 4*S*, R=H

Furthermore, the deshielded 6′-methylene protons [δ 4.53 (dd, $J = 12.0$, 2.2 Hz) and 4.39 (dd, $J = 12.0$, 6.6 Hz)] of the glucose moiety due to the esterification correlated with the carbonyl carbon (δ 167.1) of the sinapoyl group (Figure 1). Consequently, compound **1** was defined as (2-hydroxy-3-methoxy-5-allyl)phenyl β-D-(6-*O*-*E*-sinapoyl)glucopyranoside.

Compound **2** showed an $[M - H]^-$ at *m*/*z* 539.1776 corresponding to the molecular formula $C_{25}H_{32}O_{13}$ in the negative ion HRFABMS. The IR spectrum revealed absorption bands due to hydroxy (3600–3000 $cm^{-1}$), carboxylic hydroxy (3000–2500 $cm^{-1}$), ketone (1715 $cm^{-1}$), carboxylic carbonyl (1710 $cm^{-1}$), and aromatic ester (1701 $cm^{-1}$) functions and an aromatic ring (1614 and 1520 $cm^{-1}$). The presence of a galloyl group was supported by a two-proton singlet at δ 7.07 in the $^1H$ NMR spectrum and five carbon signals (δ 168.3, 146.5, 139.8, 121.4, and 110.2) (Table 1). The $^1H$ and $^{13}C$ NMR spectra indicated the presence of a β-glucopyranose moiety as in **1**. The 6″-methylene protons (δ 4.52 and 4.40) showed HMBC correlation with the carbonyl carbon (δ 168.3) of the galloyl group, indicating the acylation of the C-6″ hydroxy function (Figure 2). In the HMQC spectrum, the remaining 12 carbons corresponded to one ketone (δ 222.0), one carboxyl (δ

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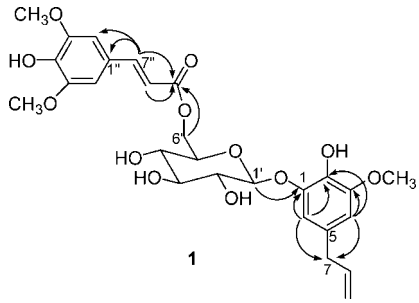


**Figure 1.** Key HMBC correlations for compound **1**.

**Table 1.** NMR Data (500 MHz, $CD_3OD$) for Compounds **2** and **5**[a]

| | **2** | | **5** |
|---|---|---|---|
| position | $\delta_C$ | $\delta_H$ ($J$ in Hz) | $\delta_H$ ($J$ in Hz) |
| 1a | 70.5 | 3.78, m | 3.54, td (7.0, 0.7) |
| 1b | | 3.57, dt (14.1, 7.1) | 3.54, td (7.0, 0.7) |
| 2a,b | 29.1 | 2.38, br dt (7.3, 7.1) | 2.30, dt (7.0, 7.0) |
| 3 | 128.9 | 5.46, dtt (10.7, 7.3, 1.5) | 5.48, dtt (11.0, 7.0, 0.7) |
| 4 | 128.9 | 5.36, dtt (10.7, 7.3, 1.5) | 5.42, dtt (11.0, 7.0, 0.7) |
| 5a,b | 26.2 | 2.32, m | 2.39, dd (7.0, 5.4) |
| 1′ | 55.1 | 1.91, dtd (9.5, 4.9, 1.4) | 1.99, dtd (10.8, 5.4, 0.7) |
| 2′ | 222.0 | | |
| 3′a | 38.7 | 2.28, m | 2.32, m |
| 3′b | | 2.06, ddd (18.8, 11.5, 8.5) | 2.08, ddd (18.8, 11.5, 8.8) |
| 4′a | 28.1 | 2.20, m | 2.23, m |
| 4′b | | 1.49, m | 1.53, m |
| 5′ | 39.0 | 2.24, m | 2.30, m |
| 6′a | 39.9 | 2.62, dd (18.8, 8.8) | 2.67, dd (18.8, 8.8) |
| 6′b | | 2.26, m | 2.32, m |
| 7′ | 176.4 | | |
| 1″ | 104.6 | 4.31, d (7.4) | |
| 2″ | 75.1 | 3.20, dd (9.2, 7.4) | |
| 3″ | 77.9 | 3.41, dd (9.2, 9.2) | |
| 4″ | 71.7 | 3.38, dd (9.2, 9.2) | |
| 5″ | 75.5 | 3.55, ddd (9.2, 5.8, 2.2) | |
| 6″a | 64.8 | 4.52, dd (11.7, 2.2) | |
| 6″b | | 4.40, dd (11.7, 5.8) | |
| 1‴ | 139.8 | | |
| 2‴,6‴ | 110.2 | 7.07, s | |
| 3‴,5‴ | 146.5 | | |
| 4‴ | 121.4 | | |
| 7‴ | 168.3 | | |

[a] Chemical shifts are shown in $\delta$ values (ppm) relative to solvent peak.

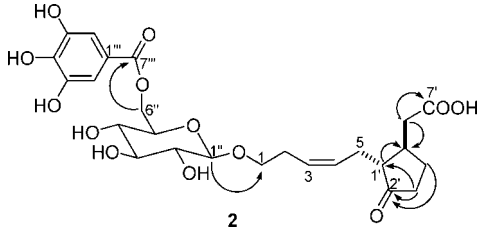


**Figure 2.** Key HMBC correlations for compound **2**.

176.4), two olefinic ($\delta$ 128.9 × 2C), one oxymethylene ($\delta$ 70.5), five methylene ($\delta$ 39.9, 38.7, 29.1, 28.1, and 26.2), and two methine ($\delta$ 55.1 and 39.0) carbons. In the $^1$H NMR spectrum, two olefinic proton signals at $\delta$ 5.46 (dtt, $J$ = 10.7, 7.3, 1.5 Hz) and 5.36 (dtt, $J$ = 10.7, 7.3, 1.5 Hz) indicated the presence of a *cis* double bond. The proton sequence in the $^1$H−$^1$H COSY spectrum showed the presence of a framework of −$OCH_2CH_2CH$=$CHCH_2CHCH$-$CH_2CH_2$−. In the HMBC spectrum, vicinal methylene protons [$\delta$ 2.28 (H-3′a) and 2.20 (H-4′a)] correlated with the carbonyl carbon at $\delta$ 222.0, and H-3′a also correlated with a methine carbon at $\delta$ 55.1, indicating the presence of a cyclopentanone structure. Furthermore, geminal methylene protons at $\delta$ 2.62 and 2.26 correlated with both carboxylic carbon ($\delta$ 176.4) and C-5′ ($\delta$ 39.0), which showed that a carboxymethyl group was attached to C-5′. These NMR data indicated **2** had a 5-(5-carboxymethyl-2-oxocyclopentyl)-3*Z*-pentenol moiety. In the $^1$H NMR spectrum, H-1′ and H-5′ resonated at $\delta$ 1.91 and 2.24, respectively. Resonances for H-1′ and H-5′ of the 1′,5′-*cis* isomer were reported at $\delta$ 2.35–2.45 and 2.80,[10–13] whereas the *trans* isomer showed chemical shifts of H-1′ and H-5′ at $\delta$ 2.20 and 2.30, respectively.[14] Thus **2** possesses 1′,5′-*trans* relative configuration. The HMBC correlation of the anomeric proton at $\delta$ 4.31 and the oxymethylene carbon at C-1 ($\delta$ 70.5) confirmed the glucose moiety was attached to C-1. Thus, compound **2** was characterized as *trans*-1′,5′-5-(5-carboxymethyl-2-oxocyclopentyl)-3*Z*-pentenyl $\beta$-(6-*O*-galloyl)glucopyranoside.

To determine the absolute configuration at C-1′ and C-5′, **2** was first treated with tannase. After recognizing the production of gallic acid by HPLC analysis, the enzymatic reaction mixture was subsequently treated with $\beta$-glucosidase to give **5** and glucose. The $^1$H NMR spectrum of **5** corresponded to *trans*-tuberonic acid,[14] and the specific rotation ($[\alpha]^{26}_D$ −67.1) was consistent with that of the authentic compound with 1′*R*, 5′*R* configuration ($[\alpha]^{24}_D$ −67).[15] Thus, **2** was concluded to be (1′*R*,5′*R*)-5-(5-carboxymethyl-2-oxocyclopentyl)-3*Z*-pentenyl $\beta$-D-(6-*O*-galloyl)glucopyranoside.

Compound **3** exhibited a specific rotation of −36.6 and was found to have a molecular formula of $C_{28}H_{40}O_{14}$ based on an $[M - H]^-$ peak at *m*/*z* 599.2339 in HRFABMS. The $^1$H and $^{13}$C NMR spectra of **3** indicated that **3** consisted of a galloyl, a $\beta$-glucopyranose, a pentofuranose, and monoterpene moieties (Table 2). The observed protons due to the monoterpene in the $^1$H NMR spectrum were one olefinic ($\delta$ 5.30), one methine ($\delta$ 1.58), three methyl ($\delta$ 1.58, 1.16, and 1.14) protons, and three pairs of geminal protons corresponding to three methylenes, suggesting the presence of an α-terpinyl moiety.[2] The HMBC correlation between the anomeric proton of $\beta$-glucopyranose [$\delta$ 4.49 (d, $J$ = 7.6 Hz)] and the C-8 resonance ($\delta$ 79.8) indicated that the partial structure was α-terpinyl $\beta$-glucoside (Figure 3). Furthermore, the chemical shifts of C-9 and C-10 ($\delta$ 23.0 and 25.0) were characteristic of a moiety with 4*S* configuration.[2,16] The 6′-methylene protons [$\delta$ 4.01 (dd, $J$ = 11.0, 2.7 Hz) and 3.62 (dd, $J$ = 11.0, 6.4 Hz)] showed an HMBC correlation with the anomeric carbon of the pentose ($\delta$ 106.8) and the anomeric proton of the pentose ($\delta$ 5.18 br s) with C-6′ ($\delta$ 67.7), which confirmed a glycosidic linkage between C-1″ and C-6′. An oxymethine proton at $\delta$ 5.14 (dd, $J$ = 2.4, 1.0 Hz) was attributable to H-2″ based on $^1$H−$^1$H COSY and HMBC measurements. The downfield shift of H-2″ and the HMBC correlation between H-2″ and the carbonyl carbon of the galloyl group ($\delta$ 166.0) indicated esterification at C-2″. The anomeric proton of the pentose (H-1″) appeared at $\delta$ 5.18 as a broad singlet. In addition, correlations were observed between H-1″ and H-3″ [$\delta$ 4.15 (dd, $J$ = 6.0, 2.4 Hz)] and between H-2″ and H-4″ [$\delta$ 4.10 (ddd, $J$ = 6.0, 5.5, 4.2 Hz)] in the NOESY spectrum, suggesting that the pentofuranose might be α-arabinofuranose.[17]

To confirm the structure of the pentose moiety, **3** was treated with tannase to give **6** and gallic acid. Compound **6** showed an $[M + H]^+$ peak at *m*/*z* 449.2389 in the HRFABMS spectrum, which was 152 mass units, corresponding to $C_7H_4O_4$, smaller than that of **3**. The two-proton singlet observed in the $^1$H NMR spectrum of **3**, attributed to a galloyl group, was absent in the spectrum of **6**. In addition, the 2″-methine proton was shielded in **6** [$\delta$ 3.98 (dd, $J$ = 3.2, 1.2 Hz)] compared to **3**. Acetylation of **6** gave a hexaacetyl derivative (**6a**). In the $^1$H NMR spectrum of **6a**, the signals due to the pentose moiety showed the same coupling constants ($J_{1'',2''} < 1$ Hz, $J_{2'',3''} = 1.7$ Hz, $J_{3'',4''} = 5.1$ Hz) as those of synthetic α-terpinyl 2,3,4-tri-*O*-acetyl-6-*O*-(2,3,5-tri-*O*-acetyl-α-L-arabinofuranosyl)-$\beta$-D-glucopyranoside, and the proton and carbon chemical shifts of the sugar parts in **6a** were consistent with those of the synthetic one,[16] which confirmed that pentofuranose was α-L-arabinofuranose.

**Table 2.** NMR Data (500 MHz) for Compounds **3** and **4** in $CD_3COCD_3$ and **6** in $CD_3OD$[a]

| | 3 | | 4 | | 6 | |
|---|---|---|---|---|---|---|
| position | $\delta_C$ | $\delta_H$ ($J$ in Hz) | $\delta_C$ | $\delta_H$ ($J$ in Hz) | $\delta_C$ | $\delta_H$ ($J$ in Hz) |
| 1 | 134.2 | | 134.1 | | 134.9 | |
| 2 | 121.7 | 5.30, m | 121.7 | 5.30, m | 121.9 | 5.35, m |
| 3a | 27.5 | 1.98, m | 27.5 | 2.03, m | 28.1 | 2.05, m |
| 3b | | 1.72, m | | 1.73, m | | 1.78, m |
| 4 | 44.7 | 1.58, dddd (11.8, 11.8, 4.9, 2.0) | 44.7 | 1.54, dddd (11.5, 11.5, 5.0, 2.0) | 45.0 | 1.67, dddd (12.2, 12.2, 4.6, 2.2) |
| 5a | 24.5 | 1.96, m | 24.4 | 1.93, m | 25.1 | 2.03, m |
| 5b | | 1.15, m | | 1.16, m | | 1.22, m |
| 6a | 31.6 | 1.87, br d (15.6) | 31.6 | 1.89, m | 32.1 | 2.06, m |
| 6b | | 1.87, m | | 1.84, m | | 1.90, m |
| 7 | 23.6 | 1.58, br s | 23.5 | 1.58, br s | 23.6 | 1.62, br s |
| 8 | 79.8 | | 79.6 | | 81.2 | |
| 9 | 23.0 | 1.14, s | 23.8 | 1.13, s | 23.0 | 1.17, s |
| 10 | 25.0 | 1.16, s | 24.2 | 1.16, s | 25.2 | 1.22, s |
| 1′ | 98.1 | 4.49, d (7.6) | 98.0 | 4.49, d (7.6) | 98.5 | 4.46, d (7.6) |
| 2′ | 75.0 | 3.14, dd (8.8, 7.6) | 75.0 | 3.13, dd (9.0, 7.6) | 75.3 | 3.12, dd (9.0, 7.6) |
| 3′ | 78.1 | 3.40, dd (8.8, 8.8) | 78.2 | 3.39, dd (9.0, 9.0) | 78.2 | 3.34, dd (9.0, 9.0) |
| 4′ | 72.0 | 3.29, dd (8.8, 8.8) | 72.1 | 3.28, dd (9.0, 9.0) | 72.0 | 3.27, dd (9.0, 9.0) |
| 5′ | 75.9 | 3.47, ddd (8.8, 6.4, 2.7) | 76.0 | 3.46, ddd (9.0, 6.4, 2.7) | 76.2 | 3.39, ddd (9.0, 5.9, 2.4) |
| 6′a | 67.7 | 4.01, dd (11.0, 2.7) | 67.6 | 4.01, dd (11.0, 2.7) | 68.2 | 3.97, dd (11.0, 2.4) |
| 6′b | | 3.62, dd (11.0, 6.4) | | 3.62, dd (11.0, 6.4) | | 3.54, dd (11.0, 5.9) |
| 1″ | 106.8 | 5.18, br s | 106.9 | 5.20, br s | 109.9 | 4.91, d (1.2) |
| 2″ | 85.2 | 5.14, dd (2.4, 1.0) | 85.1 | 5.14, dd (2.2, 0.7) | 83.2 | 3.98, dd (3.2, 1.2) |
| 3″ | 77.0 | 4.15, dd (6.0, 2.4) | 77.0 | 4.14, dd (4.2, 2.2) | 79.0 | 3.81, dd (5.9, 3.2) |
| 4″ | 85.9 | 4.10, ddd (6.0, 5.5, 4.2) | 86.0 | 4.10, ddd (6.6, 5.6, 4.2) | 85.9 | 3.94, ddd (5.9, 5.1, 3.4) |
| 5″a | 62.6 | 3.77, dd (11.5, 4.2) | 62.7 | 3.77, dd (11.7, 5.6) | 63.0 | 3.73, dd (12.0, 3.4) |
| 5″b | | 3.71, dd (11.5, 5.5) | | 3.71, dd (11.7, 6.6) | | 3.63, dd (12.0, 5.1) |
| 1‴ | 139.1 | | 139.1 | | | |
| 2‴,6‴ | 110.0 | 7.12, s | 110.0 | 7.11, s | | |
| 3‴,5‴ | 146.1 | | 146.1 | | | |
| 4‴ | 121.1 | | 121.2 | | | |
| 7″ | 166.0 | | 166.0 | | | |

[a] Chemical shifts are shown in $\delta$ values (ppm) relative to solvent peak.

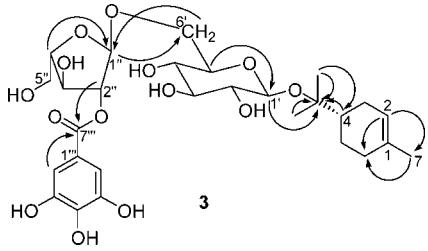


**Figure 3.** Key HMBC correlations for compound **3**.

On the basis of all the above data, compound **3** was concluded to be (*S*)-α-terpinyl [α-L-(2-*O*-galloyl)arabinofuranosyl]-(1→6)-*β*-D-glucopyranoside.

Compound **4** exhibited a specific rotation of +14.1 and an [M − H]$^-$ peak at *m*/*z* 599.2350 corresponding to the same molecular formula ($C_{28}H_{40}O_{14}$) as **3**. The $^1$H and $^{13}$C NMR data of **4** were similar to those of **3**. A difference in specific rotations suggested that **4** was a diastereomer of **3**. Comparing the $^1$H and $^{13}$C NMR spectra of **3** and **4**, differences were due to the protons of C-3−C-6 and the C-9 and C-10 resonances, corresponding to the α-terpinyl moiety (Table 2). In the $^{13}$C NMR spectrum of **4**, C-9 and C-10 were observed at $\delta$ 23.8 and 24.2, which were in good agreement with those of (*R*)-α-terpinyl glucoside as previously reported.[2] Thus, compound **4** was identified as (*R*)-α-terpinyl [α-L-(2-*O*-galloyl)arabinofuranosyl]-(1→6)-*β*-D-glucopyranoside.

The radical-scavenging properties of compounds **1**−**4** together with gallic acid, sinapic acid, and eugenol were evaluated against DPPH radicals in a spectrophotometric assay.[18,19] As shown in Table 3, compound **1** showed higher activity than eugenol and sinapic acid, the constituent units of **1**. Compounds **2**−**4**, which possess galloyl groups, were more active than **1**, but slightly less active than gallic acid.

**Table 3.** DPPH Radical Scavenging Activity of Compounds **1**−**4** and Related Compounds[a]

| | $IC_{50}$ ($\mu$M) |
|---|---|
| **1** | $15.0 \pm 0.3^e$ |
| **2** | $11.2 \pm 0.7^d$ |
| **3** | $10.5 \pm 0.4^c$ |
| **4** | $11.6 \pm 0.5^d$ |
| gallic acid | $8.0 \pm 0.5^b$ |
| sinapic acid | $25.7 \pm 0.7^f$ |
| eugenol | $27.5 \pm 0.3^g$ |

[a] The concentration of DPPH radical was 100 $\mu$M in EtOH. The absorbance of the reaction mixture at 520 nm against a blank of EtOH without DPPH was measured by a multilabel counter after 180 min. [b–g] Values with different letters are significantly different ($p < 0.05$).

## Experimental Section

**General Experimental Procedures.** Melting points were measured using a Yanagimoto micromelting point apparatus and were uncorrected. Optical rotations were measured using a Jasco P1030 polarimeter (Tokyo, Japan). UV spectra were recorded on a Shimadzu UV-2500PC UV–vis spectrophotometer (Kyoto, Japan). IR spectra were run on a Jasco FT/IR685V (Tokyo, Japan). The $^1$H, $^{13}$C, and 2D NMR spectra were recorded on a Varian Unity Plus 500 (500 MHz, Varian Inc., Palo Alto, CA) spectrometer. FABMS (matrix: glycerol) and HRFABMS were measured on a JEOL JMS-700T mass spectrometer (Tokyo, Japan). Si gel 60 (70–230 mesh, Merck), Sephadex LH-20 (Pharmacia), and Chromatorex ODS DM1020T (100–200 mesh, Fuji Silysia Chemical) were used for column chromatography, and Si gel 60 $F_{254}$ plates (Merck) and ODS plates (Merck) were used for TLC. HPLC analysis was carried out with a pump and a system controller (Jasco) connected to a UV detector (Jasco) operating at 280 nm. The column was a Mightysil RH-18 (5 $\mu$m, 4.6 × 250 nm). For measuring the DPPH radical scavenging activity, a Wallac 1420 Arvosx multilevel counter (Perkin-Elmer Life Sciences Inc., Boston, MA) was employed. Sinapic acid and 1,1-diphenyl-2-picrylhydrazyl (DPPH) were purchased from Wako Pure Chemical Industries, Ltd. Gallic acid and eugenol were previously isolated from allspice.[1,2]

**Plant Material.** Commercially available berries of *Pimenta dioica* Merr., Myrtaceae, from Jamaica were kindly supplied by Taiyo Corporation, Osaka, Japan. A voucher specimen (PD-0302) was deposited at the Graduate School of Human Life Science, Osaka City University.

**Extraction and Isolation.** Dried and ground berries of *P. dioica* (1890 g) were successively extracted with *n*-hexane (6 × 3 L) and 70% aqueous $Me_2CO$ (6 × 3 L) at room temperature. For each extraction, the plant material was soaked in the solvent and allowed to stand overnight. Acetone from the combined 70% aqueous $Me_2CO$ extract was evaporated *in vacuo*, and the resulting aqueous residue was partitioned consecutively with *n*-hexane and EtOAc to obtain *n*-hexane-soluble, EtOAc-soluble, and $H_2O$-soluble fractions. The EtOAc-soluble fraction (43.9 g) was subjected to Sephadex LH-20 column chromatography (CC) using 2-propanol to give five fractions. Fraction 4 (10.7 g) was rechromatographed over ODS gel ($CH_3CN-H_2O$, 3:7) to give 10 fractions, A−J. Fraction B (3.38 g) was subjected to Sephadex LH-20 CC using $CH_3OH$ to yield fractions B1−B6. Fraction B2 (240 mg) was purified by Sephadex LH-20 CC ($Me_2CO-H_2O$, 7:3) followed by ODS CC ($CH_3CN-H_2O$, 13:87) to give compound **2** (22 mg). Fraction B3 (547 mg) was purified by Sephadex LH-20 CC using $CH_3OH$ repeatedly to afford quercetin 3-*O*-*β*-glucuronide 6″-methyl ester[7] (8.5 mg). Fraction B4 (977 mg) was rechromatographed over ODS gel ($CH_3CN-H_2O$, 15:85) followed by Sephadex LH-20 ($CH_3OH$) to give hyperoside[4] (68.4 mg), myricetin 3-*O*-galactoside[8] (8.7 mg), and (+)-ampelopsin[9] (5.9 mg). Fraction C (1.78 g) was subjected to Sephadex LH-20 CC using $CH_3OH$ followed by ODS CC ($CH_3CN-H_2O$, 15:85) to give avicularin[5] (11.0 mg), hyperoside (165.5 mg), (+)-ampelopsin (4.0 mg), quercetin 3-*O*-(2-*O*-galloyl)-*β*-D-glucoside[6] (7.2 mg), and myricetin (3.7 mg). Fraction E (675 mg) was rechromatographed on Si gel ($CH_2Cl_2-CH_3OH$, 9:1) to give 10 fractions, E1−E10. Fraction E8 (72 mg) was further subjected to repeated column chromatography over ODS gel ($CH_3CN-H_2O$, 25:75) to afford **3** (20 mg) and **4** (8.6 mg). Fraction H (70 mg) was subjected to Sephadex LH-20 CC eluted with $Me_2CO$ to give **1** (10.0 mg) and quercetin (22.0 mg).

**Compound 1:** colorless viscous liquid; $[\alpha]^{25}_D$ −21.2 (*c* 0.82, MeOH); UV (MeOH) $\lambda_{max}$ (log $\epsilon$) 283 (3.75), 328 (3.94) nm; IR (Nujol) $\nu_{max}$ 3600–3100, 1717, 1604, 1510 $cm^{-1}$; $^1H$ NMR [$(CD_3)_2CO$, 500 MHz] $\delta$ 7.63 (1H, d, $J$ = 15.9 Hz, H-7″), 7.04 (2H, s, H-2″, 6″), 6.68 (1H, d, $J$ = 1.7 Hz, H-6), 6.55 (1H, d, $J$ = 1.7 Hz, H-4), 6.48 (1H, d, $J$ = 15.9 Hz, H-8″), 5.89 (1H, ddt, $J$ = 16.8, 10.0, 6.7 Hz, H-8), 4.99 (1H, ddt, $J$ = 16.8, 3.4, 1.5 Hz, H-9a), 4.93 (1H, ddt, $J$ = 10.0, 3.4, 1.5 Hz, H-9b), 4.76 (1H, d, $J$ = 7.6 Hz, H-1′), 4.53 (1H, dd, $J$ = 12.0, 2.2 Hz, H-6′a), 4.39 (1H, dd, $J$ = 12.0, 6.6 Hz, H-6′b), 3.90 (6H, s, 3″-OC$H_3$, 5″-OC$H_3$), 3.77 (3H, s, 3-OC$H_3$), 3.74 (1H, ddd, $J$ = 9.3, 6.6, 2.0 Hz, H-5′), 3.56 (1H, dd, $J$ = 9.9, 9.0 Hz, H-3′), 3.52 (1H, dd, $J$ = 9.0, 7.6 Hz, H-2′), 3.47 (1H, dd, $J$ = 9.3, 9.0 Hz, H-4′), 3.22 (2H, br d, $J$ = 6.7 Hz, H-7a,b); $^{13}C$ NMR [$(CD_3)_2CO$, 125 MHz] $\delta$ 167.1 (C-9″), 148.8 (C-3), 148.6 (C-3″, C-5″), 146.1 (C-1, C-7″), 139.2 (C-4″), 138.4 (C-8), 136.5 (C-2), 130.9 (C-5), 125.8 (C-1″), 115.4 (C-8″), 115.3 (C-9), 112.2 (C-6), 108.9 (C-4), 106.6 (C-2″, C-6″), 104.3 (C-1′), 77.0 (C-3′), 75.0 (C-5′), 74.4 (C-2′), 70.9 (C-4′), 63.8 (C-6′), 56.4 (3″-OC$H_3$, 5″-OC$H_3$), 56.2 (3-OC$H_3$), 40.2 (C-7); FABMS *m*/*z* 547 $[M - H]^-$, 367 $[M - H - 180]^-$, 341 $[M - H - 206]^-$, 223, 205, 179, 164; HRFABMS *m*/*z* 547.1798 (calcd for $C_{27}H_{31}O_{12}$, 547.1815).

**Compound 2:** colorless, viscous liquid; $[\alpha]^{20}_D$ −27.7 (*c* 0.30, MeOH); UV (MeOH) $\lambda_{max}$ (log $\epsilon$) 276 (4.14) nm; IR (film) $\nu_{max}$ 3600–3000, 3000–2500, 1715, 1710, 1701, 1614, 1520, 1322, 1232, 1039, 874 $cm^{-1}$; $\delta_H$ and $\delta_C$ (Table 1); FABMS *m*/*z* 539 $[M - H]^-$, 169; HRFABMS *m*/*z* 539.1776 (calcd for $C_{25}H_{31}O_{13}$, 539.1765).

**Enzymatic Hydrolysis of 2.** A solution of **2** (5 mg) in $H_2O$ (3 mL) was incubated with 5 mg of tannase (49 units/mg, *Aspergillus oryzae*, Wako) at 30 °C for 1.5 h. HPLC analysis [solvent: $CH_3CN-0.1\%$ HOAc in $H_2O$ (15:85, v/v); flow rate: 0.7 mL/min] showed that **1** ($t_R$ 26.5 min) disappeared and gallic acid ($t_R$ 6.2 min) was formed. Then, *β*-glucosidase (5 mg) was added to the reaction mixture followed by incubation at 37 °C for 3 h. The reaction mixture was extracted with EtOAc (3 × 3 mL) and the EtOAc extract (3.1 mg) was chromatographed on Si gel ($CH_2Cl_2-CH_3OH$ = 85:15) to obtain gallic acid and **5** (2.1 mg): $\delta_H$ (Table 1); FABMS *m*/*z* 215 $[M - H]^-$; $[\alpha]^{26}_D$ −67.1 (*c* 0.21, MeOH) [lit.[15], $[\alpha]^{24}_D$ −67].

**Compound 3:** white powder (acetone−benzene); mp 122–123 °C; $\delta_H$ and $\delta_C$ (Table 2); $[\alpha]^{25}_D$ −36.6 (*c* 0.78, MeOH); IR (Nujol) $\nu_{max}$ 3600–3100, 1692, 1604, 1525 $cm^{-1}$; FABMS *m*/*z* 599 $[M - H]^-$, 169; HRFABMS *m*/*z* 599.2339 $[M - H]^-$ (calcd for $C_{28}H_{39}O_{14}$, 599.2340).

**Enzymatic Hydrolysis of 3.** A solution of **3** (4.6 mg) in $H_2O$ (2 mL) was preincubated at 30 °C for 2 h; then 2 mg of tannase (49 units/mg, *Aspergillus oryzae*, Wako) was added, and the sample solution was incubated at 30 °C for 1 h. HPLC analysis [solvent, $CH_3CN-0.1\%$ HOAc in $H_2O$ (30:70, v/v); flow rate, 0.5 mL/min] showed that **3** ($t_R$ 17.0 min) disappeared and gallic acid ($t_R$ 7.8 min) was formed. The reaction mixture was concentrated *in vacuo*, and then 1 mL of MeOH was added to the residue. After sonication and subsequent filtration, the filtrate was purified on Sephadex LH-20 CC ($CH_3OH$) to give **6** (2.4 mg); $\delta_H$ and $\delta_C$ (Table 2); $[\alpha]^{29}_D$ −41.3 (*c* 0.24, MeOH); FABMS *m*/*z* 449 $[M + H]^+$, 313, 295; HRFABMS *m*/*z* 449.2389 $[M + H]^+$ (calcd for $C_{21}H_{37}O_{10}$, 449.2387).

**Acetylation of 6.** A solution of **6** (1.6 mg) in pyridine (0.3 mL) and $Ac_2O$ (0.3 mL) was allowed to stand overnight at room temperature. The reaction mixture was poured into cold 2 N HCl and then extracted with EtOAc. The organic layer was washed with saturated NaCl(aq), dried over anhydrous $Na_2SO_4$, and evaporated to dryness to give **6a** (2.4 mg): $^1H$ NMR [$CDCl_3$, 500 MHz] $\delta$ 5.33 (1H, m, H-2), 5.20 (1H, dd, $J$ = 9.8, 9.5 Hz, H-3′), 5.072 (1H, br d, $J$ = 1.7 Hz, H-2″), 5.070 (1H, br s, H-1″), 5.01 (1H, dd, $J$ = 9.7, 9.5 Hz, H-4′), 4.96 (1H, ddd, $J$ = 5.1, 1.7, 0.7 Hz, H-3″), 4.93 (1H, dd, $J$ = 9.8, 8.1 Hz, H-2′), 4.67 (1H, d, $J$ = 8.1 Hz, H-1′), 4.41 (1H, dd, $J$ = 12.0, 3.2 Hz, H-5″a), 4.28 (1H, ddd, $J$ = 5.6, 5.1, 3.2 Hz, H-4″), 4.21 (1H, dd, $J$ = 12.0, 5.6 Hz, H-5″b), 3.75 (1H, dd, $J$ = 11.0, 2.2 Hz, H-6′a), 3.65 (1H, ddd, $J$ = 9.7, 6.1, 2.2 Hz, H-5′), 3.59 (1H, dd, $J$ = 11.0, 5.9 Hz, H-6′b), 2.14 (3H, s, 3″-OCOC$H_3$), 2.10 (3H, s, 5″-O OCOC$H_3$), 2.08 (3H, s, 2″-OCOC$H_3$), 2.03 (3H, s, 4′-OCOC$H_3$), 2.02 (3H, s, 2′-OCOC$H_3$), 2.00 (3H, s, 3′-OCOC$H_3$), 1.99 (1H, m, H-6a), 1.96 (1H, m, H-3a), 1.90 (1H, m, H-6b), 1.85 (1H, ddddd, $J$ = 12.7, 2.4, 2.4, 2.4, 0.7 Hz, H-5eq), 1.72 (1H, m, H-3b), 1.63 (3H, br s, H-7-C$H_3$), 1.54 (1H, dddd, $J$ = 11.7, 11.7, 4.4, 2.4 Hz, H-4), 1.18 (1H, dddd, $J$ = 12.0, 11.7, 11.7, 5.6 Hz, H-5ax), 1.17 (3H, s, 10-C$H_3$), 1.12 (3H, s, 9-C$H_3$); $^{13}C$ NMR [$CDCl_3$, 125 MHz] $\delta$ 170.7 (5″-OCOCH$_3$), 170.5 (3′-OCOCH$_3$), 170.3 (3″-OCOCH$_3$), 169.5 (4′-OCOCH$_3$, 2″-OCOCH$_3$), 169.2 (2′-OCOCH$_3$), 134.2 (C-1), 120.3 (C-2), 105.7 (C-1″), 95.1 (C-1′), 81.0 (C-2″), 80.4 (C-8, C-4″), 77.2 (C-3″), 73.2 (C-3′), 72.8 (C-5′), 71.5 (C-2′), 69.2 (C-4′), 65.9 (C-6′), 63.3 (C-5″), 43.9 (C-4), 30.9(C-6), 26.7 (C-3), 24.9 (C-10), 23.5 (C-5), 23.4 (C-7), 22.1 (C-9), 20.8, 20.77, 20.76, 20.74, 20.73, 20.70 (2′, 3′, 4′, 2″, 3″, 5″-OCOC$H_3$).

**Compound 4:** white powder (acetone−benzene); mp 128–129 °C; $\delta_H$ and $\delta_C$ (Table 2); $[\alpha]^{25}_D$ +14.1 (*c* 0.12, MeOH); FABMS *m*/*z* 599 $[M - H]^-$, 169; HRFABMS *m*/*z* 599.2350 $[M - H]^-$ (calcd for $C_{28}H_{39}O_{14}$, 599.2340).

**Determination of the Scavenging Effect on DPPH Radicals.**[19] To 75 $\mu$L of the EtOH solution of each test compound at different final concentrations (3.125, 6.25, 12.5, 25.0, and 50.0 $\mu$M) in a 96-well flat-bottom microplate was added 75 $\mu$L of an EtOH solution of DPPH radical (final concentration, 100 $\mu$M). Neat EtOH (75 $\mu$L) was used as a control. After the reaction mixtures were slightly shaken and held for 180 min at room temperature in a multilabel counter, the absorbance of test compounds was measured at 520 nm against a blank of EtOH without DPPH. DPPH radical scavenging activity was calculated according to the following equation: DPPH radical scavenging activity (%) = [(absorbance of control − absorbance of test compound)/absorbance of control] × 100. $IC_{50}$ was defined as the concentration of compounds that showed 50% DPPH radical scavenging activity. All analyses were carried out in triplicate, and the values were averaged. A factorial analysis of variance (ANOVA) with multiple comparisons and linear regression were used. Significance was established at $p < 0.05$.

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