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Antioxidant Effects of Plant Extracts on Free Radicals and Lipid Peroxidation

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Abstract – Reactive oxygen species damage biomolecules such as lipids, proteins, sugars and DNA, which can not only lead to various diseases but also oxidative damage resulting aging. In order to search for antioxidants from plants, the antioxidant effects of the MeOH extracts from 182 plants were evaluated. The results showed that thirteen plant extracts exhibited antioxidant activity (>80%) in DPPH radical assay, seven plant extracts demonstrated antioxidant activity (>40%) in the hydroxyl radical assay and eighteen plant extracts were active (>80%) in the lipid peroxidation assay. In particular, the extracts of *Distylium racemosum* (Hamamelidaceae), *Astilbe koreana* (Saxifragaceae), *Astilbe chinensis* and *Euphorbia supina* (Euphorbiaceae) were identified as potent principles of antioxidant activity in all the assay systems.
Keywords – Antioxidant; *Distylium racemosum*; *Astilbe koreana*; *Astilbe chinensis*; *Euphorbia supina*

Introduction

Reactive oxygen species (ROS) generated during the metabolic pathway damage biomolecules such as lipids, proteins, sugars and DNA, which can not only lead to various diseases (Halliwell *et al.*, 1984; Vishwanath, 1995) but also in cumulative oxidative damage resulting aging (Barja, 2002; Sohal *et al.*, 2002). Indeed, oxidized biomolecules such as 8-oxo-2'-deoxyguanosine residues in DNA (Ozawa, 1995; Lezza *et al.*, 1999), carbonyls and dityrosines in proteins (Berlett and Stedtman, 1997; Leeuwenburgh *et al.*, 1997) and hydroperoxides in lipids (Blair, 2001; Tahara *et al.*, 2001) have been reported to accumulate in the tissues of aged animals. It has also been reported that the defensive ability against ROS decreases with age (Sohal *et al.*, 2002). The oxidative stress theory of aging has been supported by many studies, and it is now accepted one of the most important theories of aging (Barja, 2002; Sohal *et al.*, 2002). Accordingly, antioxidants, which can prevent oxidative damage from ROS, are expected to control the various diseases caused by ROS as well as inhibit the aging process.

Since plants also generate ROS in the photosynthetic process, it is expected that they will have a defensive system of secondary metabolic products to protect themselves from oxidative damage. Accordingly, plants may become an important resource containing antioxidants and so it would be meaningful to seek antioxidants from plants. In order to provide basic data, in this report, the antioxidant activity of the MeOH extracts from 182 plants were evaluated against DPPH radicals, hydroxyl radicals and lipid peroxidation.

Materials and Methods

Plant materials – Plant materials were collected from the mountainous regions in Korea from 1998 to 2000. Voucher specimens were identified by Prof. KiHwan Bae and deposited in the herbarium of the College of Pharmacy, Chungnam National University. Each of the dried plants was extracted with MeOH at room temperature for two weeks, and concentrated under reduced pressure. The extracts were dissolved in DMSO and adjusted to a final concentration of 100 μg/ml.

2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity – The DPPH radical scavenging activity was measured using a method described previously (Na *et al.*, 2002). Briefly, 10 μl of each sample dissolved in DMSO was prepared in 96 well plates and then 190 μl of 200 μM ethanolic DPPH solution was added. The mixture was incubated at room temperature for 30 minutes and the absorbance of the reaction mixture was measured at 517 nm.

Hydroxyl radical (HO) scavenging activity – The

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hydroxyl radical scavenging activity was measured according to the described method (Halliwell *et al.*, 1987; Abuja *et al.*, 1998). The reaction mixture (1 ml) contained 10 μl of sample (DMSO), 20 mM phosphate buffer (pH 7.4), 5.6 mM deoxyribose, 0.1 mM $FeCl_3$, 1 mM H_2O_2. The reaction was triggered by the addition of 0.1 mM ascorbate and the mixture was incubated at 37°C for 60 min. The extent of deoxyribose degradation by hydroxyl radical was measured using the thiobarbituric acid (TBA) method.

Preparation of rat brain homogenate – A rat brain homogenate was prepared according to the described method with some modifications (Huong *et al.*, 1998). Sprague-Dawley rat brain was removed and washed with ice-cold saline. The brain was homogenized in 9 volume of ice-cold phosphate buffer (pH 7.4) using a glass homogenizer and then centrifuged at 1000 rpm for 10 minutes. The supernatant was stored at –70°C until the lipid peroxidation experiment.

Lipid peroxidation inhibitory activity – The lipid peroxidation inhibitory activity in a rat brain homogenate was evaluated using the TBA method described previously (Na *et al.*, 2002). Briefly, the reaction mixture was composed of 10 μl of sample (DMSO), 740 μl of 50 mM-phosphate buffer (pH 7.4), 50 μl of rat brain homogenate (10 mg protein/ml) and 200 μl of the free radical generating system: 0.1 mM $FeSO_4 \cdot 7H_2O$ + 1 mM ascorbic acid. The reaction mixture was incubated at 37°C for 30 minutes and the reaction was terminated by adding 250 μl of 20% TCA and 250 μl of 1% TBA (in 50 mM NaOH). After boiling at 95°C for 5 minutes, the mixture was centrifuged at 10000 rpm for 10 minutes. The absorbance of supernatant was measured at 532 nm

Results and Discussion

It is well known that reactive oxygen species (ROS) are considered to be implicated in many diseases and aging (Halliwell *et al.*, 1984; Vishwanath, 1995; Barja, 2002; Sohal *et al.*, 2002). Accordingly, antioxidants are expected to play a role in the prevention and treatment of various diseases caused by ROS and further, to inhibit of aging.

The free radical scavenging activity of plant extracts was evaluated according to the colorimetrical decrease in the absorbance of DPPH due to the trapping of unpaired electrons, and the results are shown in Table 1. *Lindera*

Table 1. Antioxidant activity of the plant extracts on the free radicals and the lipid peroxidation

Serial number	Botanical name[a)]	Family name	Used part[b)]	DPPH radical scavenging activity (%)	Hydroxyl radical scavenging activity (%)	Lipid peroxidation inhibitory activity (%)
0036A	*Osmunda japonica*	Osmundaceae	Ap	8.4 ± 1.2[c)]	0.0	10.1
0036B	*Osmunda japonica*	Osmundaceae	R	36.2	32.5 ± 3.8	20.9
0112	*Dryopteris crassirhizoma*	Aspidiaceae	R	48.4 ± 3.8	0.0	13.2
0179	*Lemmaphyllum microphyllum*	Polypodiaceae	Wp	50.1 ± 10.8	0.0	18.4
0197	*Salvinia natans*	Salviniaceae	Wp	3.6	0.0	1.8
0243	*Cephalotaxus harringtonia*	Cephalotaxaceae	L	13.4	0.0	6.2
0251	*Platycarya strobilacea*	Juglandaceae	Ap	76.2 ± 2.5	56.2 ± 3.0	91.4 ± 5.5
0308	*Alnus fruticosa*	Betulaceae	St, L	60.7 ± 2.1	0.0	82.5 ± 2.1
0379	*Broussonetia kazinoki*	Moraceae	L	27.9	0.0	9.1
0397	*Boehmeria pannosa*	Urticaceae	Wp	10.1	0.0	2.8
0400	*Boehmeria spicata*	Urticaceae	Wp	18.8	0.0	6.3
0402	*Boehmeria tricuspis*	Urticaceae	Wp	26.9	0.0	2.1
0406	*Nanocnide japonica*	Urticaceae	Wp	4.5	0.0	0.0
0477	*Pleuropterus cilinervis*	Polygonaceae	R	49.6 ± 1.8	38.1 ± 2.6	68.5 ± 3.2
0508	*Dianthus chinensis*	Caryophyllaceae	Wp	13.5	10.0 ± 2.8	19.5
0517	*Lychnis cognata*	Caryophyllaceae	Wp	37.2	7.8 ± 1.6	25.0
0522	*Melandryum firmum*	Caryophyllaceae	Wp	0.0	0.0	0.0
0574	*Salsola collina*	Chenopodiaceae	Wp	6.3	0.0	0.0
0575	*Salsola komarovii*	Chenopodiaceae	Wp	33.0	0.0	10.7
0579	*Achyranthes japonica*	Amaranthaceae	Wp	4.9	0.0	0.0
0590	*Magnolia denudata*	Magnoliaceae	Fr	61.2 ± 3.1	0.0	83.0 ± 3.5
0601	*Cinnamomum camphora*	Lauraceae	Fr	6.0	3.4 ± 2.1	0.0
0606	*Lindera obtusiloba*	Lauraceae	St, L	85.6 ± 2.0	1.4 ± 1.0	87.3 ± 2.9
0608	*Litsea japonica*	Lauraceae	L	9.0	0.0	0.0
0650	*Cimicifuga simplex*	Ranunculaceae	R	78.2 ± 1.4	3.4 ± 1.5	92.0 ± 1.8
0651	*Clematis apiifolia*	Ranunculaceae	Wp	31.4	16.0 ± 4.1	18.5
0659	*Clematis heracleifolia*	Ranunculaceae	St, L	51.6 ± 3.7	18.8 ± 3.3	40.4 ± 5.2
0685	*Pulsatilla koreana*	Ranunculaceae	Wp	14.3	9.1 ± 1.9	10.0
0699	*Semiaquilegia*	Ranunculaceae	St, L	0.0	0.0	0.0

Table 1. Continued

Serial number	Botanical name	Family name	Used part	DPPH radical scavenging activity (%)	Hydroxyl radical scavenging activity (%)	Lipid peroxidation inhibitory activity (%)
0717	*Berberis amurensis*	Berberidaceae	Wp	56.6 ± 2.3	15.9 ± 1.5	25.5
0729	*Cocculus trilobus*	Menispermaceae	St	37.9	39.8 ± 3.8	40.2 ± 2.9
0730	*Menispermum dahuricum*	Menispermaceae	L	19.8	0.0	6.9
0745	*Chloranthus japonicus*	Chloranthaceae	Wp	3.8	0.0	0.0
0881A	*Astilbe chinensis*	Saxifragaceae	Rh	90.6 ± 1.6	42.1 ± 1.9	90.5 ± 1.1
0881B	*Astilbe chinensis*	Saxifragaceae	Ap	27.1	15.6 ± 2.1	30.0
0902	*Hydrangea serrata*	Saxifragaceae	Ap	35.2	21.6 ± 2.1	38.5
0908	*Aceriphyllum rossii*	Saxifragaceae	R	50.0 ± 2.1	18.3 ± 1.4	44.1 ± 4.5
0911	*Parnassia palustris*	Saxifragaceae	Wp	0.0	6.3 ± 2.0	15.6
0916	*Philadelphus schrenckii*	Saxifragaceae	L	27.1	9.0 ± 1.8	19.1
0929	*Rodgersia podophylla*	Saxifragaceae	R	34.2	42.7 ± 1.5	59.9 ± 2.2
0938	*Saxifraga stolonifera*	Saxifragaceae	Wp	30.7	10.6 ± 2.5	20.7
0943	*Agrimonia pilosa*	Rosaceae	Wp	22.1	7.9 ± 2.9	12.9
0967	*Geum japonicum*	Rosaceae	Wp	42.1	11.7 ± 1.3	31.9
0968	*Kerria japonica*	Rosaceae	Ap	30.4	32.2 ± 3.0	13.8
0982	*Potentilla chinensis*	Rosaceae	Wp	24.7	0.0	16.0
0983	*Potentilla cryptotaeniae*	Rosaceae	Wp	0.0	0.0	0.0
0988	*Potentilla fragarioides*	Rosaceae	Wp	49.6 ± 2.8	0.0	21.2
1058	*Rubus oldhamii*	Rosaceae	Wp	23.8	0.0	17.0
1081	*Sorbus commixta*	Rosaceae	Sb	52.1 ± 2.1	19.5 ± 1.7	57.7 ± 1.8
1087	*Spiraea betulifolia*	Rosaceae	Wp	23.6	0.0	5.5
1097	*Stephanandra incisa*	Rosaceae	Ap	33.7	0.0	12.6
1101	*Albizzia julibrissin*	Leguminosae	Ap	30.9	0.0	10.5
1106	*Amorpha fruticosa*	Leguminosae	Ap	15.3	0.0	0.0
1119A	*Cassiae tora*	Leguminosae	R	39.0	8.2 ± 2.4	26.9
1119B	*Cassiae tora*	Leguminosae	Ap	88.8 ± 4.8	24.9 ± 1.9	98.0 ± 1.6
1122	*Cercis chinensis*	Leguminosae	Ap	75.3 ± 2.6	0.0	81.2 ± 4.5
1143	*Kummerowia striata*	Leguminosae	St, L	30.8	0.0	10.2
1153	*Lespedeza cuneata*	Leguminosae	Wp	28.9	0.0	9.2
1166	*Maackia amurensis*	Leguminosae	St	18.1	0.0	0.0
1200	*Vicia unijuga*	Leguminosae	Wp	24.8	0.0	0.0
1208	*Wisteria floribunda*	Leguminosae	Wp	21.3	0.0	0.0
1233	*Daphniphyllum macropodum*	Euphorbiaceae	Fr	14.1	0.0	0.0
1243	*Euphorbia sieboldiana*	Euphorbiaceae	Wp	19.4	1.1 ± 0.8	3.9
1240	*Euphorbia pekinensis*	Euphorbiaceae	Wp	44.9 ± 1.1	5.1 ± 1.1	37.6
1244	*Euphorbia supina*	Euphorbiaceae	Wp	91.8 ± 1.2	56.5 ± 3.1	72.8 ± 5.2
1245	*Mallotus japonicus*	Euphorbiaceae	Ap	18.1	0.0	5.1
1250	*Sapium japonicum*	Euphorbiaceae	St, L	90.0 ± 3.0	58.0 ± 1.9	27.3
1258	*Orixa japonica*	Rutaceae	St, L	8.6	0.0	0.0
1261	*Zanthoxylum ailanthoides*	Rutaceae	Ap	12.2	0.0	0.0
1269	*Toona sinensis*	Rutaceae	L	11.3	0.0	0.0
1305	*Aesculus turbinata*	Hippocastanaceae	L	87.9 ± 1.3	1.4 ± 0.8	86.5 ± 3.4
1317	*Celastrus orbiculatus*	Celastraceae	St	42.5	0.0	20.9
1324	*Euonymus japonicus*	Celastraceae	Fr	10.9	0.0	10.5
1334	*Euscaphis japonica*	Buxaceae	Ap	83.4 ± 2.2	53.0 ± 2.4	43.4 ± 3.1
1337	*Buxus microphylla*	Buxaceae	St, L	36.1	12.0 ± 1.5	30.4
1345	*Rhamnus davurica*	Rhamnaceae	St	29.8	10.2 ± 0.9	28.8
1345A	*Rhamnus davurica*	Rhamnaceae	L	43.0	16.5 ± 1.1	30.1
1356	*Cayratia japonica*	Vitaceae	Wp	0.0	0.0	0.0
1357	*Vitis thunbergii*	Vitaceae	Ap	48.6 ± 4.2	0.0	20.4
1358	*Vitis amurensis*	Vitaceae	Ap	15.8	0.0	0.0
1364	*Corchoropsis tomentosa*	Sterculiaceae	Ap	12.3	0.0	0.0
1447	*Trichosanthes kirilowii*	Cucurbitaceae	Ap	14.5	27.0 ± 2.1	22.0
1450A	*Lythrum anceps*	Lythraceae	Wp	14.2	0.0	6.7
1455	*Trapa japonica*	Trapaceae	Wp	77.9 ± 2.3	19.4 ± 2.1	79.5 ± 1.7
1475	*Oneothera laciniata*	Onagraceae	Wp	49.7 ± 1.5	3.3 ± 1.8	28.8
1476	*Oenothera odorata*	Onagraceae	Ap	56.5 ± 3.3	6.7 ± 1.0	30.8
1483	*Alangium platanifolium*	Alangiaceae	St, L	17.0	0.0	0.0

Table 1. Continued

Serial number	Botanical name	Family name	Used part	DPPH radical scavenging activity (%)	Hydroxyl radical scavenging activity (%)	Lipid peroxidation inhibitory activity (%)
1484	*Aucuba japonica*	Cornaceae	St, L	4.2	0.0	0.0
1487	*Cornus controversa*	Cornaceae	St	20.9	9.1 ± 2.7	15.3
1501	*Dendropanax morbifera*	Araliaceae	Fr	28.7	7.9 ± 2.0	19.8
1502	*Fatsia japonica*	Araliaceae	St	24.9	3.8 ± 1.1	16.6
1524	*Bupleurum falcatum*	Umbelliferae	Wp	34.5	12.1 ± 1.9	21.8
1526	*Bupleurum longiradiatum*	Umbelliferae	Wp	33.7	17.6 ± 2.2	22.3
1546	*Hydrocotyle japonica*	Umbelliferae	Wp	10.2	0.0	0.0
1550	*Ligusticum tenuissimum*	Umbelliferae	R	4.6	0.0	0.0
1575	*Torilis japonica*	Umbelliferae	Wp	5.6	0.0	0.0
1584	*Pyrola japonica*	Pyrolaceae	Wp	36.4	45.0 ± 2.4	20.0
1593	*Rhododendron brachycarpum*	Ericaceae	St, L	88.5 ± 2.3	0.0	89.0 ± 1.1
1624	*Lysimachia chlethroides*	Primulaceae	St	20.2	0.0	1.8
1644	*Styrax obassia*	Styracaceae	Wp	42.8	14.6 ± 2.1	30.3
1696	*Eucommia ulmoides*	Eucommiaceae	Wp	28.9	5.5 ± 1.2	24.1
1705	*Nymphoides indica*	Menyanthaceae	Wp	15.6	0.0	6.2
1709A	*Trachelospermum asiaticum*	Apocynaceae	Ap	25.2	0.0	16.8
1709B	*Trachelospermum asiaticum*	Apocynaceae	Fr	62.4 ± 2.0	18.3 ± 1.8	70.8 ± 2.9
1720	*Cynanchum wilfordii*	Asclepiadaceae	Ap	15.5	0.0	0.0
1753A	*Rubia akane*	Rubiaceae	R	2.4	0.0	0.0
1753B	*Rubia akane*	Rubiaceae	Ap	0.0	0.0	0.0
1787	*Callicarpa japonica*	Verbenaceae	St	88.4 ± 1.4	1.4 ± 0.8	90.0 ± 1.0
1801	*Ajuga decumbens*	Verbenaceae	St, L	3.2	0.0	0.0
1814	*Elsholtzia splendens*	Labiatae	Wp	30.1	8.9 ± 1.1	24.9
1820	*Lamium album*	Labiatae	Ap	10.4	0.0	0.0
1825	*Leonurus macranthus*	Labiatae	Ap	5.3	0.0	0.0
1836	*Mosla punctulata*	Labiatae	Wp	84.6 ± 3.1	6.8 ± 2.7	86.9 ± 1.8
1842	*Plectranthus excisus*	Labiatae	L	18.4	2.1 ± 0.7	10.5
1842	*Plectranthus excisus*	Labiatae	St	22.0	7.5 ± 1.9	10.8
1911	*Paulownia tomentosa*	Scrophulariaceae	St	62.2 ± 4.9	0.0	83.5 ± 3.0
1911A	*Paulownia tomentosa*	Scrophulariaceae	Fr	75.2 ± 2.7	0.0	89.0 ± 1.5
1911B	*Paulownia tomentosa*	Scrophulariaceae	L	77.5 ± 1.0	0.0	90.0 ± 0.7
2892	*Veronica persica*	Scrophulariaceae	St, L	36.4	0.0	3.8
1919	*Pedicularis resupinata*	Scrophulariaceae	Wp	26.0	2.1 ± 1.2	19.5
1951	*Catalpa ovata*	Bignoniaceae	St	18.2	0.0	10.4
1983	*Lonicera japonica*	Caprifoliaceae	Wp	20.6	3.2 ± 1.1	22.5
2013	*Sambucus williamsii*	Caprifoliaceae	St	42.8	5.8 ± 1.6	40.8
2018	*Patrinia scabiosaefolia*	Valerianaceae	R	42.9	12.0 ± 3.4	45.3 ± 2.6
2056	*Adenocaulon himalaicum*	Compositae	Wp	21.8	20.5 ± 1.5	57.1 ± 3.0
2058B	*Ainsliaea acerifolia*	Compositae	St, L	20.8	10.2 ± 2.6	18.9
2058C	*Ainsliaea acerifolia*	Compositae	R	31.0	22.8 ± 1.2	24.0
2071	*Artemisia capillaris*	Compositae	Wp	53.2 ± 2.9	20.1 ± 3.0	33.5
2078	*Artemisia japonica*	Compositae	Wp	26.9	6.1 ± 1.4	0.0
2080	*Artemisia keiskeana*	Compositae	Wp	21.2	0.0	0.0
2102B	*Aster scaber*	Compositae	R	10.1	0.0	6.9
2102C	*Aster scaber*	Compositae	Ap	34.3	3.9 ± 1.7	28.3
2108	*Bidens bipinnata*	Compositae	Wp	10.2	0.0	0.0
2115	*Breea segeta*	Compositae	Wp	45.8 ± 2.8	0.0	21.0
2128	*Carpesium divaricatum*	Compositae	Wp	60.0 ± 3.9	10.2 ± 1.6	42.2 ± 2.0
2130	*Carpesium macrocephalum*	Compositae	L	78.3 ± 7.1	11.7 ± 1.0	53.0 ± 2.4
2135	*Chrysanthemum boreale*	Compositae	Fl	40.2	4.5 ± 0.9	30.8
2142	*Chrysanthemum zawadskii*	Compositae	Wp	25.4	4.0 ± 1.4	19.9
2146A	*Cirsium japonicum*	Compositae	Fl	18.3	10.1 ± 2.5	22.4
2146B	*Cirsium japonicum*	Compositae	Ap	31.2	10.8 ± 1.3	30.5
2157	*Erechtites hieracifolia*	Compositae	Wp	10.6	0.0	0.0
2163	*Eupatorium chinensis*	Compositae	Wp	16.4	0.0	0.0
2167	*Gnaphalium affine*	Compositae	Wp	33.7	0.0	0.0
2173	*Helianthus tuberosus*	Compositae	Ap	0.0	0.0	0.0
2174	*Hemistepta lyrata*	Compositae	Wp	12.0	0.0	4.6

Table 1. Continued

Serial number	Botanical name	Family name	Used part	DPPH radical scavenging activity (%)	Hydroxyl radical scavenging activity (%)	Lipid peroxidation inhibitory activity (%)
2180	*Inula britannica*	Compositae	Ap	75.0 ± 2.0	17.8 ± 1.8	85.4 ± 5.1
2195	*Lactuca indica*	Compositae	Wp	22.9	0.0	17.8
2201	*Leibnitzia anandria*	Compositae	Wp	19.1	0.0	5.6
2206	*Ligularia fischeri*	Compositae	Wp	18.0	0.0	5.6
2265	*Siegesbeckia glabrescens*	Compositae	St, L	11.3	0.0	9.5
2267	*Siegesbeckia orientalis*	Compositae	St	3.7	0.0	9.0
2268	*Solidago virga-aurea*	Compositae	Wp	16.3	0.0	4.9
2274	*Syneilesis palmata*	Compositae	Wp	6.7	0.0	0.0
2286	*Xanthium strumarium*	Compositae	Wp	23.4	0.0	0.0
2288	*Youngia denticulata*	Compositae	Wp	34.5	2.8 ± 0.9	10.1
2133	*Carthamus tinctorius*	Compositae	Wp	12.8	0.0	6.4
2293	*Alisma plantago-aquatica*	Alismataceae	Rh	9.1	5.6 ± 1.1	8.5
2300	*Hydrocharis dubia*	Hydrocharitaceae	Wp	5.6	0.0	0.0
2347	*Convallaria keiskei*	Liliaceae	Wp	7.7	0.0	0.0
2359	*Hemerocallis fulva*	Liliaceae	R	3.8	12.3 ± 0.9	21.0
2365	*Hosta longipes*	Liliaceae	R	3.0	0.0	6.2
2389	*Paris verticillata*	Liliaceae	Wp	0.0	21.7 ± 1.8	29.0
2397	*Scilla scilloides*	Liliaceae	Wp	12.4	1.6 ± 0.8	9.8
2418	*Veratrum maackii*	Liliaceae	R	24.7	2.0 ± 1.0	10.0
2421	*Veratrum patulum*	Liliaceae	R	12.6	6.9 ± 2.0	10.6
2424	*Crinum asiaticum*	Amaryllidaceae	R	13.3	0.0	0.0
2433	*Dioscorea quinqueloba*	Dioscoreaceae	Ap	11.7	0.0	0.0
2431	*Dioscorea japonica*	Dioscoreaceae	Ap	21.5	0.0	0.0
2460	*Juncus effusus*	Juncaceae	Wp	22.9	0.0	0.0
	BHA			90.8 ± 2.0	26.1 ± 1.6	93.5 ± 3.1
	α-tocopherol			81.8 ± 1.2	0.0	80.5 ± 0.7

[a]Each MeOH extract of plant was treated at 100 μg/ml as the final concentration.
[b]Ap: aerial part, Fl: flower, Fr: fruit, L: leaf, R: root, Rh: rhizome, Sb: stem bark, St: stem, Wp: whole plant.
[c]The values represent the mean ± standard deviation of three independent experiments.

obtusiloba, Hypericum ascyron, D. racemosum, A. koreana, A. chinensis, Cassiae tora, E. supina, Sapium japonicum, Aesculus turbinata, Euscaphis japonica, Rhododendron brachycarpum, Callicarpa japonica and *Mosla punctulata* exhibited potent activity with more than 80% inhibition at a final concentration of 100 μg/ml.

The hydroxyl radical is so reactive that it can damage biomolecules by direct oxidation such as the hydroxylation of aromatic amino acids and the oxidation of thiols, and induce lipid peroxidation. Hydroxyl radicals generated by the Fenton system (Fe^{3+}/H_2O_2/ascorbate) attack deoxyribose to form malondialdehyde (MDA)-like thiobarbituric acid reactive substances (TBARS) (Halliwell *et al.*, 1987). As shown in Table 1, *Platycarya strobilacea, D. racemosum, A. koreana, A. chinensis, Rodgersia podophylla, E. supina* and *E. japonica* exhibited inhibitory activity of more than 40% at 100 μg/ml. The scavenging activity (%) of BHA was 26.1±1.6% at 100 μg/ml. α-tocopherol was inactive in this assay system because of its low solubility.

Lipid peroxidation can be initiated by ROS such as hydroxyl radicals by extracting a hydrogen atom from lipids, and forming a conjugated lipid radical. This reacts rapidly with oxygen to form a lipid hydroperoxide and another lipid radical until the chain reaction is terminated. The lipid peroxidation adducts may induce the oxidation of biomolecules such as DNA, proteins and another lipids, resulting in cellular damage (Blair, 2001; Spiteller, 2001). In order to find out an effective lipid peroxidation inhibitor, ability of plant extracts to inhibit lipid peroxidation was investigated using a rat brain homogenate. As shown in Table I, *P. strobilacea, Alnus fruticosa, Magnolia denudata, L. obtusiloba, Cimicifuga simplex, H. ascyron, H. erectum, D. racemosum, A. koreana, A. chinensis, C. tora, Cercis chinensis, Aesculus turbinate, R. brachycarpum, C. japonica, M. punctulata, Paulownia tomentosa* and *Inula Britannica* exhibited potent activity with more than 80% inhibition at 100 μg/ml. The brain homogenates exposed to Fe^{2+} ions exhibited lipid peroxidation in air by a mechanism, possibly involving the site-bound iron-mediated decomposition of lipid hydroperoxides to yield alkoxyl or peroxyl radicals, leading to a chain reaction of lipid peroxidation (Braughler *et al*, 1987). Therefore, their potent activity was considered to be implicated in metal ion chelation, free radical scavenging or membrane stabilization. In particular, since *D. racemosum* (Hamamelidaceae), *A.*

koreana (Saxifragaceae), *A. chinensis* and *E. supina* (Euphorbiaceae) exhibited potent activity in all the tests, further study into identifying the active principles from these active lead plants might be expected.

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