Pharmaceutical Biology

ISSN: 1388-0209 (Print) 1744-5116 (Online) Journal homepage: www.tandfonline.com/journals/iphb20

Antioxidant and anticholinesterase activities of eleven edible plants

Mehmet Boğa, Işıl Hacıbekiroğlu & Ufuk Kolak

To cite this article: Mehmet Boğa, Işıl Hacıbekiroğlu & Ufuk Kolak (2011) Antioxidant and anticholinesterase activities of eleven edible plants, Pharmaceutical Biology, 49:3, 290-295, DOI: 10.3109/13880209.2010.517539

To link to this article: https://doi.org/10.3109/13880209.2010.517539

Published online: 02 Feb 2011.

Pharmaceutical Biology, 2011; 49(3): 290–295

ISSN 1388-0209 print/ISSN 1744-5116 online
DOI: 10.3109/13880209.2010.517539

informa
healthcare

RESEARCH ARTICLE

Antioxidant and anticholinesterase activities of eleven edible plants

Mehmet Boğa, Işıl Hacıbekiroğlu, and Ufuk Kolak

Department of Analytical and General Chemistry, Faculty of Pharmacy, Istanbul University, Istanbul, Turkey

Abstract

Context: Consumers have become more interested in beneficial effects of vegetables, fruits, and tea to protect their health.

Objective: The antioxidant potential and anticholinesterase activity of eleven edible plants were investigated.

Material and methods: The dichloromethane, ethanol and water extracts prepared from celery [*Apium graveolens* L. (Umbelliferae)], Jerusalem artichoke [*Helianthus tuberosus* L. (Compositae)], spinach [*Spinacia oleracea* L. (Chenopodiaceae)], chard [*Beta vulgaris* L. var. *cicla* (Chenopodiaceae)], purslane [*Portulaca oleracea* L. (Portulacaceae)], ispit, or borage [*Trachystemon orientale* (L.) G. Don (Boraginaceae)], garden rocket [*Eruca sativa* Mill. (Brassicaceae)], red cabbage [*Brassica oleracea* L. var. *capitata f. rubra* DC. (Cruciferae)], lime flower [*Tilia tomentosa* Moench (Tiliaceae)], cinnamon [*Cinnamomum cassia* Presl. (Lauraceae)], and rosehip [*Rosa canina* L. (Rosaceae)], were tested to determine their antioxidant and anticholinesterase activities by using CUPRAC (cupric reducing antioxidant capacity) and Ellman methods, respectively, for the first time.

Results: As a result, the dichloromethane, ethanol and water extracts of cinnamon showed the best antioxidant effect among the extracts of the tested plants. The ethanol extract of cinnamon exhibited 63.02% inhibition against acetylcholinesterase and 85.11% inhibition against butyrylcholinesterase (BChE) at 200 μg/mL concentration while the dichloromethane extract of garden rocket possessed the highest inhibition (91.27%) against BChE among all the tested extracts.

Discussion and conclusion: This study indicated that the ethanol extract of cinnamon may be a new potential resource of natural antioxidant and anticholinesterase compounds.

Keywords: CUPRAC, edible plants, cinnamon, antioxidant, anticholinesterase

Introduction

Reactive oxygen species (ROS) are generated in specific organelles of cells under normal physiological conditions. In healthy humans, the production of ROS is balanced by the antioxidative defense mechanisms which include radical scavenging enzymes and cellular antioxidants. Various environmental pollutants (smog, cigarette smoke, pesticides, and herbicides), aging and diseases can increase the production of ROS and/or inhibit the antioxidative defense systems (Wong et al., 2006). These reactive oxygen radicals (superoxide, hydroxyl, peroxyl, alkoxy radicals) can cause oxidation of cell lipids and DNA damage that may lead to serious chronic diseases such as diabetes mellitus, cataracts, cancer, neurodegenerative, and cardiovascular diseases (Dudonné et al., 2009). Alzheimer's disease (AD), being one of the neurodegenerative diseases, is an important health problem for elderly people. Since some of the clinical effects of herbs are closely related to their antioxidant activity, the use of antioxidants, especially plants and their constituents, in diet and as supplements, may be relevant in slowing AD progression and minimizing neuronal degeneration (Gu & Weng, 2001; Howes et al., 2003).

Vitamins (β-carotene, vitamins C and E) and polyphenols (flavonoids, tannins, catechins) possess a wide range of biological effects such as antioxidant, antimicrobial,

Address for Correspondence: Ufuk Kolak, Department of Analytical and General Chemistry, Faculty of Pharmacy, Istanbul University, 34116 Istanbul, Turkey. Tel.:+902124400258. Fax: +902124400254. E-mail: ufukkolak@yahoo.com

(Received 07 September 2009; revised 02 June 2010; accepted 18 August 2010)

anti-inflammatory, and vasodilatory actions (Wong et al., 2006). They scavenge radicals and inhibit the chain initiation or break the chain propagation. Epidemiological studies show that a diet rich in vegetables, fruits and tea with high phenolic and vitamin contents can reduce the incidence of certain cancers, cardiovascular disease, and cerebrovascular disease and age-related degenerative brain disorders (Hertog et al., 1997; Podsedek, 2007). For this reason, consumers have become more interested in beneficial effects of vegetables, fruits, and tea to protect their health.

In Turkey, the roots of celery, and Jerusalem artichoke, the aerial parts of spinach, chard, and purslane may be cooked in various ways. Ispit (vernacular name of the plant) is a perennial herb growing in Istanbul and Northern Turkey. In spring, its fresh aerial parts, with a spinach-like taste, are consumed traditionally for culinary use (Baytop, 1984). Garden rocket and red cabbage may be eaten raw in salads. Lime flower and fruit of rosehip may be prepared as tea. The bark of cinnamon is commonly consumed in desserts, cakes, cookies, and tea.

The objectives of this study were to evaluate *in vitro* the antioxidant capacity and anticholinesterase activity of dichloromethane, ethanol and water extracts prepared from eleven edible plants such as celery [*Apium graveolens* L. (Umbelliferae)], Jerusalem artichoke [*Helianthus tuberosus* L. (Compositae)], spinach [*Spinacia oleracea* L. (Chenopodiaceae)], chard [*Beta vulgaris* L. var. *cicla* (Chenopodiaceae)], purslane [*Portulaca oleracea* L. (Portulacaceae)], ispit [*Trachystemon orientale* (L.) G. Don (Boraginaceae)], garden rocket [*Eruca sativa* Mill. (Brassicaceae)], red cabbage [*Brassica oleracea* L. var. *capitata f. rubra* DC. (Cruciferae)], lime flower [*Tilia tomentosa* Moench (Tiliaceae)], cinnamon [*Cinnamomum cassia* Presl. (Lauraceae)], and rosehip [*Rosa canina* L. (Rosaceae)]. The roots of celery, and Jerusalem artichoke, the aerial parts of spinach, chard, purslane, ispit, and garden rocket, the leaves of red cabbage, lime flower, the fruit of rosehip and the bark of cinnamon were used to prepare the extracts. In fact, there are some antioxidant activity studies on these eleven plant extracts (Yildirim et al., 2000; Pyo et al., 2004; Su et al., 2007; Cho et al., 2008; Sacan et al., 2008; Huang et al., 2009; Jagdish et al., 2009). In this study, the antioxidant activity of the selected plants was carried out for the first time using the cupric reducing antioxidant capacity (CUPRAC) method which was introduced and developed by Apak et al. (2004). To date, the antioxidant activity of ispit (*Trachystemon orientale* (L.) G. Don) and Jerusalem artichoke, and the anticholinesterase activity of these plants have not been reported before.

Materials and methods

Chemicals

Dichloromethane, ethanol, methanol, ammonium acetate (NH_4OAc), sodium hydrogen phosphate (Na_2HPO_4), and sodium dihydrogen phosphate (NaH_2PO_4) (Riedel-de Haën), α-tocopherol (Aldrich), DTNB [5,5-dithiobis (2-nitro benzoic acid)], acetylcholinesterase (AChE), butyrylcholinesterase (BChE), copper (II) chloride dihydrate ($CuCl_2.2H_2O$) (Sigma), butylated hydroxytoluene (Merck), neocuproine (2,9-dimethyl-1,10-phenanthroline), galantamine hydrobromide (Sigma-Aldrich), acetylthiocholine iodide (Applichem), butyrylthiocholine iodide (Fluka) were purchased from the indicated sources. Distilled water was used.

Instrumentation

A Thermo pH-meter (USA), an Elma S15 ultrasonic bath (Germany), a vortex (LMS, Japan), and a BioTek Power Wave XS (USA) were used for the activity assays.

Plant materials

Fresh (celery, Jerusalem artichoke, spinach, chard, purslane, ispit, garden rocket, red cabbage) and dried (lime flower, cinnamon, rosehip) plant materials were purchased from a local market in Istanbul in March, 2009. Botanical identification was carried out by E. Akalin (Department of Pharmaceutical Botany, Faculty of Pharmacy, Istanbul University).

Preparation of extracts

The fresh samples were washed with water and damaged portions were removed. Then both fresh and dried plant materials (50 g) were chopped up and separated to three parts for macerating with 150 mL dichloromethane, ethanol, and water at room temperature three times (6 h × 3), individually. After filtration of each extract, the solvents were evaporated to dryness *in vacuo*, and the crude extracts were obtained, separately. The yield of the extracts varied from 0.11 to 5.22% (w/w) (Table 1).

Activity tests

CUPRAC

CUPRAC of the extracts was determined according to the method described by Apak et al. (2004). All crude extracts were dissolved in distilled water to prepare their stock solution at 1000 μg/mL concentration. Aliquots of 61 mL of 1.0×10^{-2} M copper (II) chloride, 61 μL of NH_4OAc

Table 1. Yields of the extracts.

	Yield (w/w%)		
Samples	Dichloromethane	Ethanol	Water
Celery	0.25	3.88	2.49
Jerusalem artichoke	0.15	1.49	3.08
Spinach	0.68	3.08	2.52
Chard	0.34	2.83	4.69
Purslane	0.13	0.91	1.28
Ispit	0.11	0.64	0.8
Garden rocket	0.18	1.28	1.48
Red cabbage	0.13	5.22	3.48
Lime flower	0.94	2.07	3.94
Cinnamon	0.08	2.27	0.95
Rosehip	0.11	3.51	1.74

buffer (1 M, pH 7.0), and 61 μL of 7.5×10^{-3} M neocuproine solution were mixed, x μL sample solution (2.5, 6.25, 12.5, and 25 μL) and (67 – x) μL distilled water were added to make the final volume 250 μL. The tubes were stopped, and after 1 h, the absorbance at 450 nm was measured against a reagent blank using a BioTek Power Wave XS.

Anticholinesterase activity

Acetyl and BChE inhibitory activities were measured by slightly modifying the spectrophotometric method developed by Ellman et al. (1961). Acetylthiocholine iodide and butyrylthiocholine iodide were used as substrates of the reaction and DTNB were used for the measurement of the anticholinesterase activity. All crude extracts were dissolved in ethanol to prepare their stock solution at 4000 μg/mL concentration. Aliquots of 150 mL of 100 mM sodium phosphate buffer (pH 8.0), 10 μL of sample solution and 20 μL AChE (or BChE) solution were mixed and incubated for 15 min at 25°C, and 10 μL of DTNB is added. The reaction was then initiated by the addition of 10 μL acetylthiocholine iodide (or butyrylthiocholine iodide). Final concentration of the tested solutions was 200 μg/mL. The hydrolysis of these substrates were monitored using a BioTek Power Wave XS by the formation of yellow 5-thio-2-nitrobenzoate anion as the result of the reaction of DTNB with thiocholine, released by the enzymatic hydrolysis of acetylthiocholine iodide or butyrylthiocholine iodide, at a wavelength of 412 nm. Ethanol was used as a solvent to dissolve the samples and controls.

Statistical analysis

The results were mean ± SD of three parallel measurements. All statistical comparisons were made by means of Student's t-test, p values < 0.05 were regarded as significant.

Results and discussion

Numerous methods which are based on different mechanisms of reaction are available to determine the antioxidant activity of natural products. In this study, the antioxidant activity was evaluated by using CUPRAC method which is one of the electron transfer-based methods. Due to the lower redox potential of the CUPRAC reagent, reducing sugars and citric acid—which are not true antioxidants but oxidizable substrates in other similar assays—are not oxidized with the CUPRAC reagent. An advantage to other electron transfer-based assays as ABTS and Folin, CUPRAC values were acceptable in regard to its realistic pH close to the physiological pH (Yildiz et al., 2008).

The plant extracts which are prepared by using different solvents possess various kinds of secondary metabolites. In this study, the extracts of the tested plants were prepared with dichloromethane, ethanol, and water to understand which one is much more responsible for the antioxidant and anticholinesterase activities. Since these tested plants are edible, water was especially used as solvent. In addition, further phytochemical studies can be carried out on the active extract to isolate their active compounds.

As seen in Table 2, the dichloromethane extract of cinnamon exhibited the highest antioxidant activity among the tested dichloromethane extracts at all concentrations. The dichloromethane extracts of red cabbage and ispit possessed almost the same effect which was lower than that of the cinnamon extract and standards, BHT and α-tocopherol, but higher than that of the other dichloromethane extracts, at all concentrations. The ethanol extract of cinnamon showed higher antioxidant activity than α-tocopherol as well as than the other tested ethanol extracts at all concentrations (Table 3). The ethanol extract of ispit exhibited the best antioxidant effect among the other ethanol extracts, except for cinnamon extract. The cupric reducing antioxidant capacities of some water extracts were in an increasing order, cinnamon>red cabbage>purslane (Table 4). Dudonné et al. (2009) used DPPH, ABTS, FRAP, ORAC, and SOD assays to determine the antioxidant activity of the aqueous extract of cinnamon and they also

Table 2. Absorbance values of dichloromethane extracts of eleven plants, BHT and α-Toc in the CUPRAC assay[†].

Samples	10 μg/mL	25 μg/mL	50 μg/mL	100 μg/mL
Celery	0.099 ± 0.0014	0.183 ± 0.0028	0.272 ± 0.0007	0.369 ± 0.0035
Jerusalem artichoke	0.073 ± 0.0026	0.129 ± 0.0015	0.228 ± 0.0042	0.335 ± 0.0141
Spinach	0.068 ± 0.0064	0.09 ± 0.0065	0.11 ± 0.0075	0.171 ± 0.003
Chard	0.083 ± 0.0021	0.127 ± 0.0007	0.202 ± 0.0071	0.317 ± 0.0064
Purslane	0.057 ± 0.0006	0.065 ± 0.0012	0.077 ± 0.001	0.098 ± 0.0023
Ispit	0.171 ± 0.0062	0.24 ± 0.0245	0.428 ± 0.0432	0.718 ± 0.0195
Garden rocket	0.057 ± 0.005	0.108 ± 0.0045	0.164 ± 0.0007	0.249 ± 0.0031
Red cabbage	0.128 ± 0.0042	0.275 ± 0.0142	0.403 ± 0.0106	0.729 ± 0.0955
Lime flower	0.104 ± 0.0212	0.161 ± 0.002	0.236 ± 0.0225	0.398 ± 0.049
Cinnamon	0.226 ± 0.0269	0.363 ± 0.0057	0.634 ± 0.0262	1.073 ± 0.0926
Rosehip	0.07 ± 0.0049	0.101 ± 0.0055	0.151 ± 0.0029	0.226 ± 0.0146
BHT[‡]	0.878 ± 0.012	1.837 ± 0.1144	2.839 ± 0.0318	3.9 ± 0.01
α-Toc[‡]	0.307 ± 0.0127	0.657 ± 0.0346	1.08 ± 0.0056	2.011 ± 0.0339

[†]Values expressed are means ± SD of three parallel measurements ($p < 0.05$).
[‡]Reference compounds.

found that it possessed very strong antioxidant effect. In addition, the methanolic extract of *Cinnamomum verum* barks exhibited reducing power, metal chelating, and free radical scavenging activities and total antioxidant activity in linoleic acid emulsion system (Mathew & Abraham, 2006). In this study, the ethanol, water and dichloromethane extracts of cinnamon bark showed good CUPRAC. Here, the phenolic compounds of cinnamon bark may be responsible for this activity as well as in the results of the studies mentioned above.

Twenty-three different anthocyanins, which were cyanidin derivatives highly conjugated with sugars and acylated groups, were the main constituents in red cabbage. Podsedek et al. found that red cabbage possessed strong $O_2^{\cdot-}$, DPPH$^{\cdot}$ and ABTS$^{\cdot-}$ radical scavenging activities and inhibited a lipid peroxidation in linoleic acid emulsion (Podsedek et al., 2006). In this study, the dichloromethane and water extracts of red cabbage showed moderate CUPRAC. The results of this electron transfer-based assay can also be related to the phenolic compounds, especially anthocyanins, which were the major contributor to the free radical scavenging activity of red cabbage.

The antioxidant potential of spinach, chard, purslane, garden rocket, lime flower, and rosehip was also determined by using different methods of previous studies (Yildirim et al., 2000; Pyo et al., 2004; Su et al., 2007; Cho et al., 2008; Sacan et al., 2008; Huang et al., 2009; Jagdish et al., 2009). In this study, none of the tested material exhibited CUPRAC.

The dichloromethane extracts of red cabbage (46.92% inhibition) and rosehip (49.55% inhibition) showed almost the same AChE inhibitory activity. They possessed moderate AChE inhibitory activity at 200 μg/mL (Table 5). Interestingly, although all the red cabbage extracts exhibited moderate activity against AChE, all the celery, Jerusalem artichoke, spinach, chard, purslane, ispit, garden rocket, lime flower extracts, the ethanol, and water extracts of rosehip were found to be inactive against AChE. On the other hand, the ethanol extract of cinnamon exhibited the highest AChE inhibitory activity (63.02% inhibition) among all the tested

Table 3. Absorbance values of ethanol extracts of eleven plants, BHT and α-Toc in the CUPRAC assay[†].

Samples	10 μg/mL	25 μg/mL	50 μg/mL	100 μg/mL
Celery	0.064 ± 0.0049	0.076 ± 0.0014	0.097 ± 0.0007	0.137 ± 0.0066
Jerusalem artichoke	0.079 ± 0.0026	0.105 ± 0.0015	0.156 ± 0.0042	0.251 ± 0.0141
Spinach	0.066 ± 0.0029	0.108 ± 0.0007	0.144 ± 0.0025	0.246 ± 0.0191
Chard	0.099 ± 0.0081	0.165 ± 0.0064	0.307 ± 0.0085	0.394 ± 0.0014
Purslane	0.116 ± 0.0049	0.213 ± 0.0061	0.355 ± 0.0031	0.597 ± 0.0113
Ispit	0.21 ± 0.0471	0.44 ± 0.1055	0.869 ± 0.016	1.48 ± 0.0735
Garden rocket	0.063 ± 0.005	0.121 ± 0.0017	0.172 ± 0.0017	0.297 ± 0.0007
Red cabbage	0.075 ± 0.0014	0.09 ± 0.0014	0.122 ± 0.0014	0.195 ± 0.0021
Lime flower	0.134 ± 0.0231	0.207 ± 0.0206	0.354 ± 0.0246	0.629 ± 0.063
Cinnamon	0.361 ± 0.0007	0.691 ± 0.0028	1.55 ± 0.012	2.257 ± 0.0007
Rosehip	0.077 ± 0.0064	0.101 ± 0.0035	0.16 ± 0.0071	0.235 ± 0.0035
BHT[‡]	0.878 ± 0.012	1.837 ± 0.1144	2.839 ± 0.0318	3.9 ± 0.01
α-Toc[‡]	0.307 ± 0.0127	0.657 ± 0.0346	1.08 ± 0.0056	2.011 ± 0.0339

[†]Values expressed are means ± SD of three parallel measurements ($p < 0.05$).
[‡]Reference compounds.

Table 4. Absorbance values of water extracts of eleven plants, BHT and α-Toc in CUPRAC assay[†].

Samples	10 μg/mL	25 μg/mL	50 μg/mL	100 μg/mL
Celery	0.057 ± 0.0015	0.063 ± 0.001	0.072 ± 0.0014	0.11 ± 0.0078
Jerusalem artichoke	0.063 ± 0.0017	0.075 ± 0.0012	0.096 ± 0.0076	0.131 ± 0.001
Spinach	0.057 ± 0.0046	0.074 ± 0.0021	0.103 ± 0.0028	0.145 ± 0.0021
Chard	0.067 ± 0.0006	0.086 ± 0.001	0.115 ± 0.0014	0.167 ± 0.0042
Purslane	0.084 ± 0.0025	0.13 ± 0.0025	0.201 ± 0.0032	0.348 ± 0.0108
Ispit	0.068 ± 0.0229	0.073 ± 0.0036	0.104 ± 0.041	0.108 ± 0.0031
Garden rocket	0.059 ± 0.0038	0.071 ± 0.0015	0.087 ± 0.0014	0.125 ± 0.0014
Red cabbage	0.1 ± 0.0079	0.152 ± 0.0106	0.357 ± 0.0028	0.562 ± 0.0057
Lime flower	0.088 ± 0.0046	0.14 ± 0.0167	0.203 ± 0.012	0.403 ± 0.1199
Cinnamon	0.195 ± 0.0451	0.421 ± 0.0021	0.741 ± 0.0092	1.325 ± 0.1246
Rosehip	0.062 ± 0.0015	0.077 ± 0.0031	0.094 ± 0.0012	0.134 ± 0.0026
BHT[‡]	0.878 ± 0.012	1.837 ± 0.1144	2.839 ± 0.0318	3.9 ± 0.01
α-Toc[‡]	0.307 ± 0.0127	0.657 ± 0.0346	1.08 ± 0.0056	2.011 ± 0.0339

[†]Values expressed are means ± SD of three parallel measurements ($p < 0.05$).
[‡]Reference compounds.

Table 5. Anticholinesterase activity of eleven plants at 200 μg/mL[†].

Samples	Extracts	Inhibition % against AChE	Inhibition % against BChE
Celery	Dichloromethane	NA	59.91 ± 0.84
	Ethanol	NA	40.39 ± 0.78
	Water	NA	26.73 ± 0.33
Jerusalem artichoke	Dichloromethane	NA	43.73 ± 0.40
	Ethanol	NA	32.42 ± 0.69
	Water	NA	44.96 ± 0.14
Spinach	Dichloromethane	NA	30.60 ± 0.53
	Ethanol	NA	15.94 ± 0.33
	Water	NA	19.05 ± 0.41
Chard	Dichloromethane	NA	38.48 ± 0.75
	Ethanol	NA	29.99 ± 0.83
	Water	NA	11.93 ± 0.10
Purslane	Dichloromethane	NA	20.28 ± 0.07
	Ethanol	NA	30.66 ± 0.13
	Water	NA	3.52 ± 0.72
Ispit	Dichloromethane	NA	46.72 ± 0.20
	Ethanol	NA	20.57 ± 0.05
	Water	NA	7.33 ± 1.00
Garden rocket	Dichloromethane	NA	91.27 ± 0.62
	Ethanol	NA	77.73 ± 0.09
	Water	NA	72.16 ± 0.41
Red cabbage	Dichloromethane	46.92 ± 1.05	52.75 ± 0.13
	Ethanol	49.44 ± 0.19	9.24 ± 0.06
	Water	44.06 ± 0.71	6.55 ± 0.79
Lime flower	Dichloromethane	NA	36.64 ± 0.36
	Ethanol	NA	34.41 ± 0.24
	Water	NA	6.27 ± 0.37
Cinnamon	Dichloromethane	8.19 ± 0.31	59.41 ± 0.26
	Ethanol	63.02 ± 0.55	85.11 ± 0.71
	Water	9.09 ± 0.29	11.14 ± 0.97
Rosehip	Dichloromethane	49.55 ± 0.71	32.06 ± 0.67
	Ethanol	NA	9.38 ± 0.10
	Water	NA	5.51 ± 0.06
Galantamine[‡]		89.99 ± 0.11	87.17 ± 0.83

[†]Values expressed are means ± SD of three parallel measurements ($p < 0.05$).
[‡]Reference compound.
NA: not active at 200 μg/mL.

extracts while its dichloromethane and water extracts were inactive.

The dichloromethane extract of garden rocket exhibited the highest BChE inhibitory activity (91.27% inhibition) among all the tested extracts, although it was inactive against AChE. The ethanol extract of cinnamon showed also strong BChE inhibitory activity (85.11% inhibition) similar to galantamine. Against BChE, almost all the dichloromethane extracts exhibited higher activity than the ethanol and water extracts, except for cinnamon. The non-polar compounds may be responsible for this activity. However, no such a relationship was observed for AChE inhibitory activity.

Cinnamomum species have been applied in folk medicine for their various activities such as anti-inflammatory, cytotoxic, antidiarrheal, antifungal, antipyretic, antimicrobial (Kuo et al., 2008; Lin et al., 2008; Rao et al., 2008). Kim et al. (2007) determined the ability of 27 herbs to protect PC12 rat pheochromocytoma and primary neuronal cells from beta-amyloid (1–42) insult by using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenylterazolium bromide reduction assay and lactate dehydrogenase efflux assay. They found that Chinese cinnamon being one of the tested plants protected cells from beta amyloid (1–42) insult (Kim et al., 2007). Ngoc et al. (2009) also reported that a methanol extract of the twigs of *Cinnamomum cassia* exhibited a strong tyrosinase-inhibitory activity (>85% inhibition at 100 μg/mL). Tyrosinase inhibitors which may have antimelanin synthesis activity offer a potential treatment for Parkinson's disease.

Conclusion

The present report describes that the ethanol extract of cinnamon possessed both strong CUPRAC and anticholinesterase activity, which can be highly related to its

phenolic compounds. Phytochemical studies are needed to characterize the active constituents of the ethanol extract prepared from cinnamon bark. Further laboratory and clinical assays of the active compounds present in the ethanol extract of cinnamon are also required in order to better understand its antioxidant and anticholinesterase potential.

Declaration of interest

This work was supported by the Research Fund of the Istanbul University: Project number: BYP-976. The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

Apak R, Güçlü K, Ozyürek M, Karademir SE. (2004). Novel total antioxidant capacity index for dietary polyphenols and vitamins C and E, using their cupric ion reducing capability in the presence of neocuproine: CUPRAC method. *J Agric Food Chem*, 52, 7970–7981.

Baytop T. (1984). *Therapy with Plants in Turkey (Past and Present)*. Istanbul: Istanbul University Press, pp. 256.

Cho MJ, Howard LR, Prior RL, Morelock T. (2008). Flavonoid content and antioxidant capacity of spinach genotypes determined by high-performance liquid chromatography/mass spectrometry. *J Sci Food Agric*, 88, 1099–1106.

Dudonné S, Vitrac X, Coutière P, Woillez M, Mérillon JM. (2009). Comparative study of antioxidant properties and total phenolic content of 30 plant extracts of industrial interest using DPPH, ABTS, FRAP, SOD, and ORAC assays. *J Agric Food Chem*, 57, 1768–1774.

Ellman GL, Courtney KD, Andres V Jr, Feather-Stone RM. (1961). A new and rapid colorimetric determination of acetylcholinesterase activity. *Biochem Pharmacol*, 7, 88–95.

Gu LW, Weng XC. (2001). Antioxidant activity and components of *Salvia plebeia*. *Food Chem*, 73, 299–305.

Hertog MG, Sweetnam PM, Fehily AM, Elwood PC, Kromhout D. (1997). Antioxidant flavonols and ischemic heart disease in a Welsh population of men: The Caerphilly Study. *Am J Clin Nutr*, 65, 1489–1494.

Howes MJR, Perry NSL, Houghton PJ. (2003). Plants with traditional uses and activities relevant to the management of Alzheimer's disease and other cognitive disorders. *Phytother Res*, 17, 1–18.

Huang Z, Wang B, Eaves DH, Shikany JM, Pace RD. (2009). Total phenolics and antioxidant capacity of indigenous vegetables in the southeast United States: Alabama collaboration for cardiovascular equality project. *Int J Food Sci Nutr*, 60, 100–108.

Jagdish S, Upadhyay AK, Singh S, Rai M. (2009). Total phenolics content and free radical scavenging activity of B*rassica* vegetables. *J Food Sci Technol*, 46, 595–597.

Kim DS, Kim JY, Han YS. (2007). Alzheimer's disease drug discovery from herbs: Neuroprotectivity from beta-amyloid (1-42) insult. *J Altern Complement Med*, 13, 333–340.

Kuo SY, Hsieh TJ, Wang YD, Lo WL, Hsui YR, Chen CY. (2008). Cytotoxic constituents from the leaves of *Cinnamomum subavenium*. *Chem Pharm Bull*, 56, 97–101.

Lin CT, Chen CJ, Lin TY, Tung JC, Wang SY. (2008). Anti-inflammation activity of fruit essential oil from *Cinnamomum insularimontanum* Hayata. *Bioresour Technol*, 99, 8783–8787.

Mathew S, Abraham TE. (2006). Studies on the antioxidant activities of cinnamon (*Cinnamomum verum*) bark extracts, through various *in vitro* models. *Food Chem*, 94, 520–528.

Ngoc TM, Lee I, Ha do T, Kim H, Min B, Bae K. (2009). Tyrosinase-inhibitory constituents from the twigs of *Cinnamomum cassia*. *J Nat Prod*, 72, 1205–1208.

Podsedek A. (2007). Natural antioxidants and antioxidant capacity of *Brassica* vegetables. *LWT-Food Sci Technol*, 40, 1–11.

Podsedek A, Sosnowska D, Redzynia M, Anders B. (2006). Antioxidant capacity and content of *Brassica oleracea* dietary antioxidants. *Int J Food Sci Technol*, 41, 49–58.

Pyo YH, Lee TC, Logendra L, Rosen RT. (2004). Antioxidant activity and phenolic compounds of Swiss chard (*Beta vulgaris* subspecies *cycla*) extracts. *Food Chem*, 85, 19–26.

Rao CV, Vijayakumar M, Sairam K, Kumar V. (2008). Antidiarrhoeal activity of the standardised extract of *Cinnamomum tamala* in experimental rats. *J Nat Med*, 62, 396–402.

Sacan O, Orak H, Yanardag R. (2008). Antioxidant activity of water extract of *Eruca sativa* Mill. *Asian J Chem*, 20, 3462–3474.

Su L, Yin JJ, Charles D, Zhou K, Moore J, Yu L. (2007). Total phenolic contents, chelating capacities, and radical-scavenging properties of black peppercorn, nutmeg, roseship, cinnamon and oregano leaf. *Food Chem*, 100, 990–997.

Wong SP, Leong LP, Koh JHW. (2006). Antioxidant activities of aqueous extracts of selected plants. *Food Chem*, 99, 775–783.

Yildirim A, Mavi A, Oktay M, Kara AA, Algur OF, Bilaloglu V. (2000). Comparison of antioxidant and antimicrobial activities of tilia (*Tilia argentea* Desf ex DC), sage (*Salvia triloba* l.), and black tea (*Camellia sinensis*) extracts. *J Agric Food Chem*, 48, 5030–5034.

Yildiz L, Baskan KS, Tütem E, Apak R. (2008). Combined HPLC-CUPRAC (cupric ion reducing antioxidant capacity) assay of parsley, celery leaves, and nettle. *Talanta*, 77, 304–313.