THE ANTIOXIDANT ACTIVITY OF *APIUM GRAVEOLENS*[1]

Merve BAT-ÖZMATARA
Department of Chemistry, Faculty of Science and Arts,
Gebze Technical University, Kocaeli, Turkey
mervebatt@gmail.com
ORCID ID: 0000-0002-6912-8825

ABSTRACT

Plants are an important source of natural active products that differ depending on the chemical components they contain. Since extracts and phytochemicals isolated from plants show biological activity *in vitro* and *in vivo*, today plants are used as alternative treatment sources. *Apium graveolens* (celery) has powerful antioxidant properties to remove free radicals due to compounds such as coumarin, alkaloids, steroids, phenols, essential oils, sesquiterpene alcohols, caffeic acid, p-coumaric acid, ferulic acid, apigenin, luteolin, tannin, saponin and kaempferol. Celery with different compounds and different concentrations has various healing effects. The aim of this study was to review the antioxidant activity of celery.

Keywords: *Apium graveolens, Celery, Antioxidant activity*

[1]Received: 27.12.2019 – Accepted: 19.01.2020
DOI: 10.17932/IAU.IJFER.2015.003/ijfer_v06i1002

INTRODUCTION

The use of medicinal plants to treat illness has been common since ancient times. Many studies have shown the positive effects of various herbs and different parts of medicinal plants on cancer, infectious diseases, diabetes, atherosclerosis **[1, 2, 3]**. Phenolic and alkaloid compounds in plants and their effects such as antioxidant effects have been investigated in many studies such as cancer **[4, 5, 6]** diabetes **[7, 8]**, liver disorders **[3]**, coronary heart diseases **[9, 10].** Today herbal drugs are used as an alternative to chemical drugs due to their low side effects.

Celery (*Apium graveolens* L) is a plant from the apiaceae family, and is one of the annual or perennial plants that grow throughout Europe, Africa and Asia **[11].** Celery seeds are used as a condiment in the flavoring of food products possessing a characteristic aroma and pungent taste. There are a number of phthalide derivatives that give the celery essential oil a characteristic odor **[12].**

Celery (*Apium graveolens*) is a medicinal plant in traditional medicine with numerous health benefits. Celery can prevent arthritis, rheumatism, gout, urinary tract inflammation, and specifically rheumatoid arthritis with mental depression **[13].** Celery, because of compounds such as caffeic acid, p-coumaric acid, ferulic acid, apigenin, luteolin, tannin, saponin, and kaempferol, has powerful antioxidant characteristics, to remove free radicals. Antioxidants with radical scavenging capacity are thought to have a potential protective effect against free radical damage. These biomolecules inhibit oxidative reactions that prevent the formation of coronary and vascular diseases and tumors **[11, 14].** This oxidative damage is the result of free radical action on, for instance, lipids or DNA. However, the commonly used synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxyl toluene (BHT), are limited by law because of their toxic effects and carcinogenicity **[15].** The elimination of synthetic antioxidants in food applications has provided further impetus to explore the source of natural antioxidants. The objective of the present review is to highlight the antioxidant effects of *Apium graveolens.*

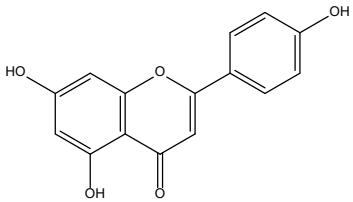
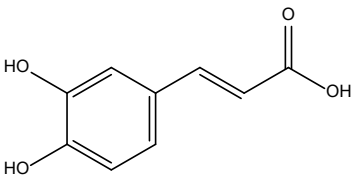
Phytochemical Constituents

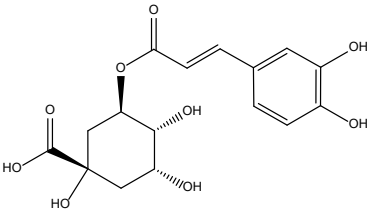
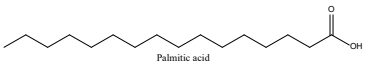
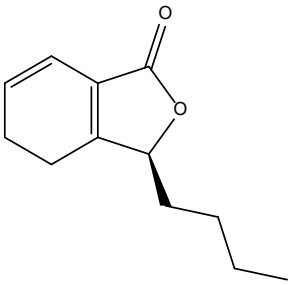
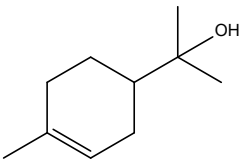
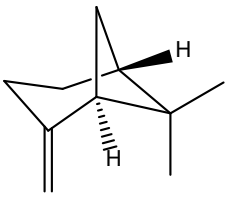
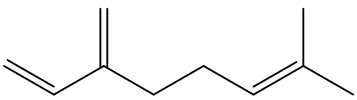
The preliminary phytochemical analysis revealed the presence of carbohydrates, flavonoids, alkaloids, steroids, and glycosides in the methanolic extract of seeds of *Apium graveolens* **[9].** Seeds included flavonoids, volatile oils, coumarins and furanocoumarins. Coumarins contained celerin, bergapten, apiumoside, apiumetin, apigravrin, osthenol, isopimpinellin, isoimperatorin, celereoside, and 5 and 8-hydroxy methoxypsoralen. Flavonoid included apiin, apigenin, isoquercitrin **[13, 16].** The phenolic concentration in different extracts (methanol, ethanol, water) varied significantly. Among the methanol extract of the seeds, *Apium graveolens* methanolic extract had the highest phenolic concentration (73.1 ± 1.23 mg GAE/100g) **[17].** Volatile oils included limonene (60%) and selenine (10–15%), and various sesquiterpene alcohols (1– 3%), e.g. α-eudesmol and ß-eudesmol, santalol. Also, celery includes linoleic, myristic, myristoleic, oleic, palmitic, palmitoleic, petroselinic and stearic acid **[13].** The main chemical constituents present in each part of the plant are as follows: The roots contain falcarinol, falcarindiol, panaxidol, and polyacetylene 8-O-methylfalcarindiol **[18, 19].** The stem contains pectic polysaccharide (apiuman) containing d-galacturonic acid, l-rhamnose, l-arabinose, and d-galactose **[20].** Leaves contain 1-dodecanol, 9-octadecene-12-ynoic acid, methyl ester and tetradecene-1-ol acetate **[21].** Celery seed contains caffeic acid, chlorogenic acid, apigenin, rutaretin, ocimene, bergapten, and isopimpinellin **[22].** The seed oil is composed of palmitic acid, stearic acid, oleic acid, linoleic acid, petroselinic acid, d-limonene, selinene, terpineol, and santalol **[23].**

Table 1. Essential oil composition of celery (*Apium graveolens*) seed. **[9]**

Components	Percentage (%)
D-limonene	57.7
Myrcene	18.7
4-terpineol	8.6
ß-selinene	8.1
ß-pinene	2.4
ß- caryophyllene	0.5
Carnone	0.3
Trans-limonene oxide	0.3
α-terpinolene	0.3
α-selinene	0.2
Trans-3-butylidenephthalide	0.1
α-muuroloene	0.1
Cis-limonene oxide	0.1
Linalool	0.1
α-pinene	0.1
Trans-ocimene	0.1

Table 2. The chemical constituent of the celery (*Apium graveolens)* seed having antioxidant characteristic

Group of Chemicals	Chemical Constituents	Structure	References
Glycosides	Apigenin	 apigenin	**[24, 25]**
Organic acid	Caffeic acid	 caffeic acid	**[26]**

Organic acid ester	Chlorogenic acid	 Chlorogenic acid	**[27]**
Fatty acids	Palmitic acid	 Palmitic acid	**[28, 29]**
Essential oil	Sedanolide	 sedanenolide	**[30]**
Essential oil	Terpineol (2-(4-Methylcyclohex-3-en-1-yl) propan-2-ol)	 2-(4-Methylcyclohex-3-en-1-yl)propan-2-ol	**[31]**
Essential oil	ß-pinene	 ß-pinene	**[32]**
Essential oil	ß-myrcene	 ß-myrcene	**[33]**

Antioxidant Effect

In the study by Kolarovic et al. **[34]** of the antioxidant activities [as measured by the content of reduced glutathione (GSH) and ferric reducing antioxidant power (FRAP)] of celery and parsley leaf and root juices in rats treated with doxorubicin, was investigated**.** Celery root juice increased antioxidative capacity and the total antioxidative capacity (TAOC) in liver homogenate. Celery leaf juice increased GSH content but did not increase FRAP in liver homogenate. Study results show that celery increases antioxidant activity.

The study by Al Sa'aidi et al. **[35]** of antioxidant activity of n-butanol celery extract (*Apium graveolens*) seed in streptozotocin-induced diabetic rats was investigated**.** Thirty-two mature male rats were divided into four groups as diabetic and non-diabetic. Rats ≥ 200 mg/dl of blood glucose were used as diabetic. Diabetic groups were drenched with drinking water, n-butanol extract (60 mg/kg, b.w.), or injected with insulin (4 IU/animal), respectively for 21 days. Blood and liver subcellular fluid were obtained for the evaluation of alanine aminotransferease (ALT), Aspartate aminotransferase (AST), catalase (CAT), Superoxide dismutase (SOD), Glutathione (GSH) -transferase and -reductase enzymes and Malondialdehyde (MDA), glutathione concentrations. N-butanol extract of celery seed or insulin therapy moderated blood glucose within a normal range, enhanced body weight gain and normalized the activities of all antioxidant enzymes. Study results show that n-butanol extract of celery seed has a potent role in ameliorating stressful complications accompanied by diabetes mellitus.

In the study by Li et al. **[24]** *in vitro* and *in vivo* antioxidant activity of ethanol extract of celery leaf was investigated**.** Superoxide dismutase (SOD), glutathione peroxidase (GSH-Px) and catalase and total antioxidant capacity (TAOC) activities were measured in serum, brain, heart, liver, and kidneys. As a result, celery has a radical scavenging effect and SOD, GSH-Px CAT have been shown to significantly increase the activity.

Yıldız et al. **[36]** identified the essential antioxidant compounds and measured the

total antioxidant capacity with CUPRAC (cupric ion reducing antioxidant capacity) and ABTS spectrophotometric methods**.** The CUPRAC spectrophotometric method of TAC assay using copper(II)-neocuproine (2,9-dimethyl-1,10-phenanthroline) was developed. Antioxidant compounds in celery plant extracted by HPLC were analyzed on one column of C18. Study results show that methanolic and ethanolic extract of celery leaves have antioxidant properties.

Yao et al. **[37]** analyzed the phenolic compound composition and antioxidant activities of 11 celery varieties**.** The contents of total phenolics were measured using a Folin–Ciocalteu assay and the total antioxidant capacity was measured with the 1,1-diphenyl-2-picrylhydrazyl radical and 2,2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) methods. The most common flavonoid in celery was apigenin and phenolic acid was p-coumaric acid. The investigated celery varieties had high levels of phenolics and exhibited high antioxidant capacity. Antioxidant activity was found to be proportional to total flavonoids, total phenolic acids or total phenolics.

In the study by Nagella et al. **[21]** essential oil composition of celery leaf, immunotoxicity effects and antioxidant activity were investigated**.** Essential oils contained in *A. graveolens* leaves were found using gas chromatography and mass spectroscopy (GC-MS). The essential oil from the *A. graveolens* leaves was investigated for scavenging of the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical activity. The results showed that the essential oil from the *A. graveolens* has potential as a natural antioxidant and thus inhibit the unwanted oxidation process.

Shanmugapriya and Ushadevi **[38]** studied the antibacterial and antioxidant activity of Methanol, Diethyl ether and aqueous extracts of *Apium graveolens* seeds**.** The antioxidant activity of *A.graveolens* seed extracts was carried out 2, 2-Diphenyl-1- picrylhydrazyl (DPPH) assay method. The methanol extract showed the highest inhibition against bacterial pathogens and higher antioxidant activity than that of standard Gallic acid. The study result showed that A.graveolens seed extract exhibiting enormous significance in therapeutic aspects.

Ud Din et al. **[39]** evaluated the phytochemical screenings, antioxidant activity and antimicrobial assay of *Apium graveolens* L**.** The total phenolic content was slightly higher in methanolic fraction (63.46 ± 12.00 mg GAE/g) than ethanol (36.60 ± 12.28 mg GAE/g) and hexane fractions (34.86 ± 6.96 mg GAE/g). The flavonoid content was high in methanolic extract (56.95 ± 7.14 mg Quercetin/g). Ethanol extract showed good antimicrobial activity. Antioxidant activities of extracts were measured according to DPPH, ABTS and FRAP assays. Antioxidant activity assayed by FRAP was higher in methanolic fraction (12.48 ± 1.06 mmole of FeSO4 equivalent/litre of extract) compared with other extracts.

The study by Hassanen et al. **[40]** the constituents of the essential oil, antioxidant and antimicrobial activity of celery (*Apium graveolens*) was investigated**.** The chemical composition of the essential oils obtained by hydrodistillation was analyzed by GC/MS. The antioxidant activities of volatile oils extracted from the celery were assessed by the Rancimat apparatus and DPPH. Study results show that all essential oils under study at various concentrations exhibited antioxidant activity.

Ksouda et al. **[41]** investigated 25 Tunisian plant species of 13 families based on their oil and total phenolic contents**.** The phenolic content of seed methanolic extracts, measured by Folin–Ciocalteu assay (490 ± 60 mg GAE/100 g Dry Weight). In the ABTS assay, the antioxidant activity value was 1000 ± 150 mg TEAC/100 g DW. In the DPPH assay, the antioxidant activity value of *Apium graveolens* was 480 ± 30 (mg TEAC/100 g DW). The results showed that the seeds of *Apium graveolens* had high oil content, interesting fatty acid profiles and its methanolic extracts displayed high antioxidant capacities.

Jung et al. **[12]** the leaves of *A. graveolens* extracted with methanol and partitioned with water, ethyl acetate and butanol**.** The phenolic content of the extracts was determined by Folin-Coicalteu method. Antioxidant capacity was measured by using α, α-diphenyl-β-picrylhydrazyl (DPPH), β-carotene-linoleate, reducing power, metal chelating effects and phosphomolybdenum method. The phenolic

content of the extracts was expressed as gallic acid equivalents and was found to be highest in methanol (51.09 mg/g). At a concentration of 250 g/ml, methanol extract has the highest free radical scavenging activity and reducing power. The study result showed that celery leaf vegetable is a good source of antioxidants due to its phenolic richness.

Han et al. **[42]** investigated the effect of digestion on the phenolic compounds and antioxidant activity of celery leaf**.** 13 phenolic chemicals were discriminated by HPLC-MS, and content of phenolic and the antioxidant capacity were evaluated after digestion in vitro. The extraction of celery leaf decreased lipid peroxidation and reactive oxygen species level. It was also found that celery leaf increased antioxidant activity of liver, spleen and thymus of mice treated with Dexamethasone.

In the study by Popovic et al. **[43]** the potential protective action of the ether, chloroform, ethyl acetate, n-butanol, and water extracts was assessed by the corresponding *in vitro* and *in vivo* tests**.** In the in vitro experiments crude methanol extracts were tested as potential scavengers of free OH• and DPPH• radicals, as well as inhibitors of liposomal peroxidation (LPx). The results showed that both the extracts of root and leaves are good scavengers of OH• and DPPH• radicals. *In vivo* experiments were concerned with antioxidant systems (activities of GSHPx, GSHR, Px, CAT, SOD, GSH content and intensity of LPx) in liver homogenate and blood of mice after their treatment with extracts of celery leaves, or in combination with CCl_4. On the basis of the results obtained n-butanol extract showed the highest protective effect.

Table 3. Antioxidant Activity of Celery.

Type of extract	Used Parts	Model	Results	References
Aqueous extract	Root and leaves	*In vivo*	- Celery root juice increased antioxidative capacity, - Celery leaf juice increased GSH content	**[34]**
Aqueous extract	Seed	*In vivo*	- n-Butanol extract of celery seed normalized the activities of all antioxidant enzymes	**[35]**
Ethanolic extract	Leaves	*In vivo* and *In vitro*	- Scavenging activity on MDA and LPF. - Enhanced the activities of SOD, GSH-Px, and CAT	**[24]**
Methanolic and ethanolic extracts	Leaves	*In vitro*	Increased total antioxidant capacity	**[36]**
Ethanolic extract	All of the parts	*In vitro*	Excellent free radical scavenging activities	**[37]**
—	Leaves	*In vitro*	Has potential as a natural antioxidant and thus inhibits unwanted oxidation process	**[21]**
Methanolic, diethyl ether and aqueous extracts	Seeds	*In vitro*	Methanol extract showed the highest antioxidant activity	**[38]**
Methanolic, ethanol and hexane extracts	—	*In vitro*	Antioxidant activity was observed	**[39]**

Aqueous extract	Seeds	*In vitro*	Exhibited antioxidant activity	**[40]**
Methanolic extract	Seeds	*In vitro*	Extract exhibited high antioxidant activity	**[41]**
Methanol, water, ethyl acetate and butanol extract	Leaves	*In vitro*	The antioxidant and free radical scavenging activities of the extracts assayed through DPPH and reducing power were found to be highest with methanol	**[12]**
Water extract	Leaves	*In vitro* and *In vivo*	The extraction of celery leaf decreased lipid peroxidation and reactive oxygen species level, and elevated the antioxidant activities	**[42]**
Methanol, ethyl acetate, butanol and water extract	Root and leaves	*In vitro* and *In vivo*	Root and leaves are good scavengers of OH• and DPPH• radicals and reduce liposomal peroxidation intensity in liposomes	**[43]**

CONCLUSION

This study investigated the properties of celery leaves and seeds. Celery is a commercially important seed spice, valued for its medicinal properties. Celery because of compounds such as coumarin, apigenin, luteolin, tannin, kaempferol has powerful antioxidant characteristics. The plant composition and medicinal properties lead to need for further and more research about other useful and unknown properties of it, so used as plant-derived medicine to treat diseases.

REFERENCES

[1] Shirzad, H., Taji, F., & Rafieian-Kopaei, M. (2011). Correlation Between Antioxidant Activity of Garlic Extracts and WEHI-164 Fibrosarcoma Tumor Growth in BALB/c Mice. Journal of Medicinal Food, 14(9), 969–974.

[2] Asgary Sedigheh. (2011). Hypoglycaemic and hypolipidemic effects of pumpkin (*Cucurbita pepo* L.) on alloxan-induced diabetic rats. African Journal of Pharmacy and Pharmacology, 5(23).

[3] Zahoor, A. L., Yaqoob, L., Shaukat, S. K., Aijaz, A. W., & Mohd, I. R. (2015). Hepatoprotective medicinal plants used by the Gond and Bhill tribals of District Raisen Madhya Pradesh, India. Journal of Medicinal Plants Research, 9(12), 400–406.

[4] Asadi-Samani, M., Kooti, W., Aslani, E., & Shirzad, H. (2015). A Systematic Review of Iran's Medicinal Plants With Anticancer Effects. Journal of Evidence-Based Complementary & Alternative Medicine, 21(2), 143–153.

[5] Hazafa, A., Rehman, K.-U.-, Jahan, N., & Jabeen, Z. (2019). The Role of Polyphenol (Flavonoids) Compounds in the Treatment of Cancer Cells. Nutrition and Cancer, 72(3), 386–397.

[6] Tauchen, J., Huml, L., Bortl, L., Doskocil, I., Jarosova, V., Marsik, P., Frankova, A., Clavo Peralta, Z. M., Chuspe Zans, M.-E., Havlik, J., Lapcik, O., & Kokoska, L. (2018). Screening of medicinal plants traditionally used in Peruvian Amazon for in vitro antioxidant and anticancer potential. Natural Product Research, 33(18), 2718–2721.

[7] Perez Gutierrez, R. M., Muñiz-Ramirez, A., Campoy, A. H. G., Flores, J. M. M., & Flores, S. O. (2018). Polyphenols of leaves of Apium graveolens inhibit in vitro protein glycation and protect RINm5F cells against methylglyoxal-induced cytotoxicity. Functional Foods in Health and Disease, 8(3), 193.

[8] Kooti, W., Farokhipour, M., Asadzadeh, Z., Ashtary-Larky, D., & Asadi-Samani, M. (2016). The role of medicinal plants in the treatment of diabetes: a systematic review. Electronic Physician, 8(1), 1832–1842.

[9] Kooti, W., Ali-Akbari, S., Asadi-Samani, M., Ghadery, H., & Ashtary-Larky, D. (2015). A review on medicinal plant of Apium graveolens. Advanced Herbal Medicine, 1(1), 48-59.

[10] Kooti, W., Moradi, M., Ali-Akbari, S., Sharafi-Ahvazi, N., Asadi-Samani, M., & Ashtary-Larky, D. (2015). Therapeutic and pharmacological potential of *Foeniculum vulgare* Mill: a review. Journal of HerbMed Pharmacology, 4(1), 1-9.

[11] Gauri, M., Ali, S. J., & Khan, M. S. (2015). A Review of *Apium graveolens* (Karafs) with special reference to Unani Medicine, 2, 131-136.

[12] W. S. Jung. (2011). In vitro antioxidant activity, total phenolics and flavonoids from celery (*Apium graveolens*) leaves. Journal of Medicinal Plants Research, 5(32).

[13] Barnes, J., Anderson, L. A., & Phillipson, J. D. (2002). Herbal medicines: Joanne Barnes, Linda A. Anderson, J. David Phillipson. A guide for healthcare professionals.

[14] Kris-Etherton, P. M., Hecker, K. D., Bonanome, A., Coval, S. M., Binkoski, A. E., Hilpert, K. F., Griel, A. E., & Etherton, T. D. (2002). Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer. The American Journal of Medicine, 113(9), 71–88.

[15] Labrador, V., Freire, P. F., Martín, J. P., & Hazen, M. J. (2007). Cytotoxicity of butylated hydroxyanisole in Vero cells. Cell biology and toxicology, *23*(3), 189-199.

[16] Khare, C. P. (2008). Indian medicinal plants: London: Springer Science Pub.

[17] Aydemir, T., & Becerik, S. (2011). Phenolic content and antioxidant activity of different extracts from Ocimum basilicum, *Apium graveolens* and *Lepidium sativum* seeds. Journal of Food Biochemistry, 35(1), 62-79.

[18] Bohlmann, F. (1967). Polyacetylenverbindungen, CXXXIX. Notiz über die Inhaltsstoffe von Petersilie-und Sellerie-Wurzeln. Chemische Berichte, 100(10), 3454-3456.

[19] Al-Asmari, A., Athar, Md. T., & Kadasah, S. (2017). An updated phytopharmacological review on medicinal plant of arab region: *Apium graveolens* Linn. Pharmacognosy Reviews, 11(21), 13.

[20] Petrova, I., Petkova, N., Kyobashieva, K., Denev, P., Simitchiev, A., Todorova, M., & Dencheva, N. (2014). Isolation of pectic polysaccharides from celery (*Apium graveolens* var. rapaceum DC) and their application in food emulsions. Türk Tarım ve Doğa Bilimleri Dergisi, *1*(Özel Sayı-2), 1818-1824.

[21] Nagella, P., Ahmad, A., Kim, S.-J., & Chung, I.-M. (2011). Chemical composition, antioxidant activity and larvicidal effects of essential oil from leaves of *Apium graveolens*. Immunopharmacology and Immunotoxicology, 34(2), 205–209.

[22] Beier, R. C., Ivie, G. W., Oertli, E. H., & Holt, D. L. (1983). HPLC analysis of linear furocoumarins (psoralens) in healthy celery (*Apium graveolens*). Food and Chemical Toxicology, 21(2), 163–165.

[23] Ngo-Duy, C.-C., Destaillats, F., Keskitalo, M., Arul, J., & Angers, P. (2009). Triacylglycerols of *Apiaceae* seed oils: Composition and regiodistribution of fatty acids. European Journal of Lipid Science and Technology, 111(2), 164–169.

[24] Li, P., Jia, J., Zhang, D., Xie, J., Xu, X., & Wei, D. (2014). In vitro and in vivo antioxidant activities of a flavonoid isolated from celery (*Apium graveolens* L. var. dulce). Food Funct., 5(1), 50–56.

[25] Birt, D. F., Mitchell, D., Gold, B., Pour, P., & Pinch, H. C. (1997). Inhibition of ultraviolet light induced skin carcinogenesis in SKH-1 mice by apigenin, a plant flavonoid. Anticancer research, *17*(1A), 85-91.

[26] Chen, J. H., & Ho, C.-T. (1997). Antioxidant activities of caffeic acid and its related hydroxycinnamic acid compounds. Journal of Agricultural and Food Chemistry, 45(7), 2374–2378.

[27] Sato, Y., Itagaki, S., Kurokawa, T., Ogura, J., Kobayashi, M., Hirano, T., Sugawara, M., & Iseki, K. (2011). In vitro and in vivo antioxidant properties of chlorogenic acid and caffeic acid. International Journal of Pharmaceutics, 403(1–2), 136–138.

[28] Shukla, S., Mishra, T., Pal, M., Meena, B., Rana, T. S., & Upreti, D. K. (2016). Comparative analysis of fatty acids and antioxidant activity of *Betula utilis* bark collected from different geographical region of India. Free Radicals and Antioxidants, 7(1), 80–85.

[29] Favre, J., Yıldırım, C., Leyen, T. A., Chen, W. J. Y., van Genugten, R. E., van Golen, L. W., Garcia-Vallejo, J.-J., Musters, R., Baggen, J., Fontijn, R., van der Pouw Kraan, T., Serné, E., Koolwijk, P., Diamant, M., & Horrevoets, A. J. G. (2015). Palmitic acid increases pro-oxidant adaptor protein p66Shc expression and affects vascularization factors in angiogenic mononuclear cells: Action of resveratrol., 75, 7–18.

[30] Woods, J. A., Jewell, C., & O'Brien, N. M. (2001). Sedanolide, a Natural Phthalide from Celery Seed Oil: Effect on Hydrogen Peroxide andtert-Butyl Hydroperoxide-Induced Toxicity in HepG2 and CaCo-2 Human Cell Lines. In Vitro & Molecular Toxicology, 14(3), 233–240.

[31] Burits, M., & Bucar, F. (2000). Antioxidant activity of Nigella sativa essential oil. Phytotherapy Research, 14(5), 323–328.

[32] Silva, A. C. R., Lopes, P. M., Azevedo, M. M. B. de, Costa, D. C. M., Alviano, C. S., & Alviano, D. S. (2012). Biological Activities of a-Pinene and β-Pinene Enantiomers. Molecules, 17(6), 6305–6316.

[33] Ciftci, O., Ozdemir, I., Tanyildizi, S., Yildiz, S., & Oguzturk, H. (2011). Antioxidative effects of curcumin, β-myrcene and 1,8-cineole against 2,3,7,8-tetrachlorodibenzo-p-dioxin-induced oxidative stress in rats liver. Toxicology and Industrial Health, 27(5), 447–453.

[34] Kolarovic, J., Popovic, M., Zlinská, J., Trivic, S., & Vojnovic, M. (2010). Antioxidant Activities of Celery and Parsley Juices in Rats Treated with Doxorubicin. Molecules, 15(9), 6193–6204.

[35] Al-Sa'aidi, J. A., Alrodhan, M. N., & Ismael, A. K. (2012). Antioxidant activity of n-butanol extract of celery (*Apium graveolens*) seed in streptozotocin-induced diabetic male rats. Research in Pharmaceutical Biotechnology, *4*(2), 24-29.

[36] Yıldız, L., Başkan, K. S., Tütem, E., & Apak, R. (2008). Combined HPLC-CUPRAC (cupric ion reducing antioxidant capacity) assay of parsley, celery leaves, and nettle. Talanta, *77*(1), 304-313.

[37] Yao, Y., Sang, W., Zhou, M., & Ren, G. (2010). Phenolic Composition and Antioxidant Activities of 11 Celery Cultivars. Journal of Food Science, 75(1), C9–C13.

[38] Shanmugapriya, R., & Ushadevi, T. (2014). In vitro antibacterial and antioxidant activities of *Apium graveolens* L. seed extracts. Int J Drug Dev Res, *6*(3), 165-70.

[39] Ud Din, Z., Shad, A. A., Bakht, J., Ullah, I., & Jan, S. (2015). In vitro antimicrobial, antioxidant activity and phytochemical screening of *Apium graveolens*. Pakistan Journal of Pharmaceutical Sciences, *28*(5).

[40] Hassanen, N. H., Eissa, A. M. F., Hafez, S. A. M., & Mosa, E. A. (2015). Antioxidant and antimicrobial activity of celery (*Apium graveolens*) and coriander (*Coriandrum sativum*) herb and seed essential oils. Int. J. Curr. Microbiol. App. Sci, *4*(3), 284-296.

[41] Ksouda, G., Hajji, M., Sellimi, S., Merlier, F., Falcimaigne-Cordin, A., Nasri, M., & Thomasset, B. (2018). A systematic comparison of 25 Tunisian plant species based on oil and phenolic contents, fatty acid composition and antioxidant activity. Industrial Crops and Products, 123, 768–778.

[42] Han, L., Gao, X., Xia, T., Zhang, X., Li, X., & Gao, W. (2019). Effect of digestion on the phenolic content and antioxidant activity of celery leaf and the antioxidant mechanism via Nrf2/HO-1 signaling pathways against Dexamethasone. Journal of Food Biochemistry, 43(7).

[43] Popović, M., Kaurinović, B., Trivić, S., Mimica-Dukić, N., & Bursać, M. (2006). Effect of celery (*Apium graveolens*) extracts on some biochemical parameters of oxidative Stress in mice treated with carbon tetrachloride. Phytotherapy Research, 20(7), 531–537