BOOK CHAPTER – PARSLEY

Chapter · February 2018

CITATIONS
0

READS
4,893

2 authors:

Ghazi Daradkeh
Hamad Medical Corporation
26 PUBLICATIONS **139** CITATIONS
SEE PROFILE

Mohamed Essa Musthafa
Sultan Qaboos University
296 PUBLICATIONS **3,058** CITATIONS
SEE PROFILE

16 Parsley

Ghazi Daradkeh[1,2] and Musthafa Mohamed Essa[1]*
[1]*Sultan Qaboos University, Muscat, Oman;* [2]*Hamad Medical Corporation, Doha, Qatar*

16.1 Botany

16.1.1 Introduction

Parsley (*Petroselinum crispum*) is a herb belonging to the Apiaceae (formerly Umbelliferae) family (Fig. 16.1). It is native to the Mediterranean region where it is found in the wild form. It is mostly grown outdoors and is seasonally harvested (Navazio, 2012). Parsley is a leafy vegetable, rich in many biologically active compounds, and its name (*Petroselinum*) is derived from the Greek for 'rock celery'; it can be distinguished from other leafy green herbs by its unique aroma. In sunny areas with suitable environmental conditions – in a humid soil with a pH of 5.3–7.3 – parsley may grow up to 60–120 cm tall (Navazio, 2012).

Parsley is sensitive to water stress, especially if it is planted in the summer and at the end of spring, and to increase production and improve quality, a permanent source of water should be provided. Both growth stage and parsley type determine the susceptibility of the plants to water stress (Petropoulos *et al.*, 2006; Najla *et al.*, 2012).

Fresh parsley has been reported to have a storage life of 1–2 months at 0°C and 95–100% RH (Cantwell, 2001) and of over 12 days in a cold store at 0–2°C and RH 95–97% (Lisiewska *et al.*, 1997). However, at 18–20°C and 85–90% RH, it can only be stored for 3 days (Lisiewska *et al.*, 1997). As already noted, parsley can be cold stored, but it is sensitive to chilling injury.

16.1.2 History

The botanical name *Petroselinum* is derived from the Greek words 'petros', meaning stone (it grows on rocky hillsides) and 'selinon' (parsley or celery). Parsley is mentioned in Greek historical records as being used for cheering sportsmen by wearing crowns made of parsley; wreaths made from parsley were also used to adorn graves. Parsley was also used in Roman rituals. There are reports of it being sprinkled over dead bodies to remove the smell too. Parsley is used in the Jewish celebration of the Passover as well. It is mentioned as one of the plants in the gardens of Charlemagne and Catherine de Medici, and there is a rumour that parsley was popularized in France by Catherine de Medici.

*Corresponding author, e-mail: drmdessa@squ.edu.om

 Leafy Medicinal Herbs: Botany, Chemistry, Postharvest Technology and Uses (eds D.C.P. Ambrose *et al.*)

Fig. 16.1. A parsley plant and leaves.

16.1.3 Location

Parsley is believed to be native to southern Europe, but it is now found throughout the world. It has been grown in Britain since at least the 16th century. Parsley has now become naturalized throughout Europe, North America, the West Indies, Algeria and Lebanon.

16.1.4 Morphology

There are three varieties of parsley: curly-leaved or common parsley, Italian or flat-leaved parsley and root (Hamburg) parsley, which is grown for its edible root. The leaves are compound, alternately arranged, and are divided into two to three leaflets and the plant can grow to over 1 m tall, and as an annual (in tropical regions) or a biennial crop (in temperate areas). The typical flowering period is in the warmer months and the ideal temperature for pollination and seed production is 29–30°C (Teuscher, 2005).

The roots are a faint yellow colour and carrot shaped. They can grow up to 20 cm in length and 5 cm in width. Hamburg root parsley has larger roots and is commonly used in European cuisine (Teuscher, 2005).

16.2 Chemistry

16.2.1 Chemical (nutritional) composition

Parsley is a 'powerhouse' of nutrition, and is rich in B vitamins, vitamin C, β-carotene and zinc; it is an important dietary component for strengthening bone due to its high content of boron and fluorine, and also contains iron and calcium in an absorbable form (Table 16.1).

16.2.2 Phytochemistry

Parsley has anti-inflammatory, antimicrobial, diuretic and hypoglycaemic properties due to its content of essential oil and phenolic compounds (Taiz and Zeiger, 1998). Yoshikawa *et al*. (2000) reported several flavone glycosides with oestrogenic activity from the aerial parts of parsley, along with a new monoterpene glucoside, petroside.

The leaves contain 0.04–0.4% of volatile oil, and this includes as major constituents α-pinene, β-pinene, myrcene, β-phellandrene, 1,3,8-*p*-menthatriene and myristicin (Charles, 2004). The aroma of parsley is due to the presence of terpenes, which are toxic to many insects. Myristicin (see Fig. 16.2) is a toxic phenylpropene/allylbenzene compound (also known as 5-methoxysafrole) and has hallucinogenic properties, acting as a psychoactive at high intake levels (Hallström and Thuvander, 1997).

The seeds contain 2–8% of volatile oil and 13–22% of fixed oil, and the major compounds found in the volatile oil are α-pinene, β-pinene, myristicin, elemicin, 2,3,4,5-tetramethoxy-allylbenzene and apiol (Charles, 2004). Apiol, a phenylpropene (also known as apiole and as dimethoxysafrole; see Fig. 16.3), is responsible for the

Table 16.1. Nutritional value of parsley for one serving (60 g). Adapted from SELFNutritionData (2016); original source USDA National Nutrient Database for Standard Reference, Release 21 (USDA ARS, 2008).

Nutrient	Amount		
Calories	21.6	**Vitamins**	
From carbohydrate	13.3	Vitamin A	5055 IU
From fat	4.0	Vitamin B	
From protein	4.3	Thiamine (B_1)	0.1 mg
From alcohol	0.0	Riboflavin (B_2)	0.1 mg
Carbohydrates		Niacin (B_3)	0.8 mg
Total carbohydrate	3.8 g	Vitamin B_6	0.1 mg
Dietary fibre	2.0 g	Pantothenic acid (B_5)	0.2 mg
Starch	~[a]	Folate (B_9)	91.2 mcg
Sugar	0.5 g	Vitamin B_{12}	0.0 mcg
Fats and fatty acids		Vitamin C	79.8 mg
Total fat	0.5 g	Vitamin D	~
Saturated fat	0.1 g	Vitamin E (α-tocopherol)	0.4 mg
Monounsaturated fat	0.2 g	Vitamin K	984 mcg
Polyunsaturated fat	0.1 g	Choline	7.7 mg
Omega-3 fatty acids	4.8 mg	Betaine	~
Omega-6 fatty acids	69.0 mg	**Minerals**	
Protein and amino acids		Calcium	82.8 mcg
Protein	1.8 g	Iron	3.7 mg
Sterols		Magnesium	30.0 mg
Cholesterol	0.0 mg	Phosphorus	34.8 mg
Phytosterols	3.0 mg	Potassium	332 mg
Other constituents		Sodium	33.6 mg
Alcohol	0.0 mg	Zinc	0.1 mg
Ash	1.3 g	Copper	0.1 mg
Caffeine	0.0 mg	Manganese	0.1 mg
Theobromine	0.0 mg	Selenium	0.1 mcg
Water	52.6 g	Fluoride	~

[a]Signifies missing or incomplete data.

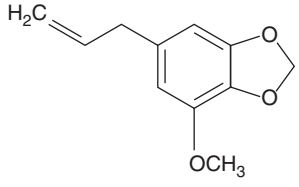

Fig. 16.2. The chemical structure of myristicin. Adapted from Zhang *et al*., 2006.

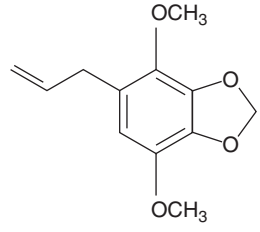

Fig. 16.3. The chemical structure of apiol. Adapted from Zhang *et al*., 2006.

abortifacient properties of parsley, and the herb may be used to treat menstrual disorders (Castleman, 2009).

Parsley roots contain 0.2–0.75% of essential oil, which has as its main components terpinolene, apiol and myristicin (Orav *et al*., 2003), while apiin (apigenin-7-apioglucoside; see Fig. 16.4) makes up to 0.2–1.6% of the roots (Taiz and Zeiger, 1998).

Table 16.2 compares the constituents of commercial samples of parsley leaf oil and seed oil.

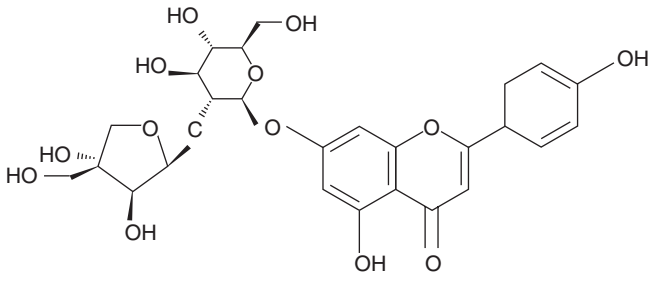

Fig. 16.4. The chemical structure of apiin. From Hostetler *et al*., 2013.

Table 16.2. Composition of commercial samples of parsley essential oil. Adapted from Charles, 2004.

Compounds	Leaf oil (%)	Seed oil (%)
Apiol	0.27	18.32
Elemicin	2.71	4.84
1,3,8-*p*-Mentha-triene	16.41	0.12
Myrcene	4.24	0.22
Myristicin	11.92	39.65
α-Phellandrene	0.51	0.12
β-Phellandrene	6.48	2.14
α-Pinene	26.42	15.73
β-Pinene	18.04	10.01
Sabinene	1.1	0.64
Terpinolene	2.52	0.01
2,3,4,5-Tetramethoxy-allylbenzene	0.72	7.82

16.3 Postharvest Technology

16.3.1 Extraction of phenolic compounds

Plant phenolics have several health benefits, including: antioxidant, anti-inflammatory, antimicrobial, antitumour and hepatoprotective activities (Rice-Evans *et al.*, 1996; Middleton *et al.*, 2000; Hinneburg *et al.*, 2006). They vary in structure from monomers to complex polymeric tannins, and their isolation from plants involves various steps (including sample grinding, extraction, pre-concentration, hydrolysis and derivatization) that it is important to get right. Luthria and co-workers have investigated the process in dried parsley flakes. First (Luthria *et al.*, 2006), they evaluated the influence of extraction solvents and techniques, and the number of extraction cycles on the quantity of phenolic compounds obtained, and determined that pressurized liquid extraction (PLE), used with four extractions and 50:50 ethanol:water, was the best method. Second, Luthria (2008) examined the influence of six additional PLE parameters (particle size, extraction temperature and pressure, flush volume, static time, and solid:solvent ratio), and showed that the phenolic compounds obtained were influenced by temperature, particle size and solid:solvent ratio, with temperature having the major effect on the phenolic profile (Luthria, 2008). When the extraction temperature was higher, malonyl apiin was partially degraded to acetylapiin and apiin, while flush volume showed marginal influence on the extracted yield (Luthria, 2008).

16.3.2 Minimal processing

Fresh plant food can either be minimally processed or not further processed at all prior to consumption. In a test of the storage of fresh parsley, leaves were sealed in polyethylene bags and stored at 4°C for 12 days. Quality characteristics colour, appearance (succulence and firmness) and aroma (odour, taste) were evaluated on a scale of 1 to 5 on the 1st, 5th, 8th and 12th days. The scores were used to produce life curves, from which it was estimated that minimally processed parsley could stay fresh for a period of 23 days (Cătunescu *et al.*, 2012).

16.4 Uses

16.4.1 Traditional/medicinal benefits

The medicinal benefits of parsley have been long known, and Hippocrates classified parsley

as a diuretic. Wine boiled with parsley was recommended in medieval times as a treatment for arthritis and chest pain. Parsley was recommended to alleviate menstrual symptoms in the 17th century (Lis-Balchin, 2006), and was documented as a laxative, diuretic and quinine substitute by the US Pharmacopeia in 1850 (Castleman, 2009). Parsley infusions were used to treat and regulate menstrual pain by Colombian immigrants in London (Ceuterick *et al.*, 2008). Parsley has also been reported as beneficial for postmenopausal women.

The use of both parsley seed powder and parsley juice have been reported for the stimulation of hair growth when used to massage the scalp, and also for the treatment and prevention of insect bites (Charles, 2004).

16.4.2 Pharmacological uses

Antioxidant properties

Parsley was reported to protect cells by decreasing the ageing process due to its antioxidant properties, with the major contributors to its antioxidant activity being myristicin and apiol (Chevallier, 1996; Taiz and Zeiger 1998). Parsley essential oil was found to have β-carotene bleaching and free radical scavenging activities. Apiol contributes more free radical scavenging activity than myristicin, even though it is present at a lower concentration (contrast Fig. 16.3, which shows the methoxy electron donor groups of apiol, with the structure of myristicin shown in Fig. 16.2) (Zhang *et al.*, 2006).

The high content of flavonoids such as apiin, other apigenin glycosides and luteolin, tocopherol, ascorbic acid and essential oils in parsley could encourage antioxidant activity and might decrease any harm caused by oxidation (Nielsen *et al.*, 1999). Myristicin, which is found in parsley oil, activates glutathione-*S*-transferase, which catalyses the action of glutathione in fighting against oxidized molecules (Ozsoy-Sacan *et al.*, 2006; Kolarovic *et al.*, 2010).

Wong and Kitts (2006) reported on the antioxidant (and antibacterial) activities of methanol and water extracts of freeze-dried and irradiated parsley leaves and stems.

Anti-inflammatory properties

Parsley has been traditionally used for the treatment of allergies and autoimmune and chronic inflammatory disorders (Yousofi *et al.*, 2012). Tissue damage, neuropathological diseases and autoimmune disorders may result from chronic activation of the immune system, and myristicin oil from parsley can reduce the immune inflammation by inhibiting nitric oxide, cytokine production and the release of inflammatory proteins (Lee and Park, 2011). Yousofi *et al.* (2012) investigated the suppressive effects of parsley essential oil on mouse splenocytes and macrophages, and found that it could suppress nitric oxide production and the immune functions of macrophages.

Antimicrobial effects

Parsley plays an important role in the defence mechanisms against microbes such as bacteria and fungi. For example, Manderfeld *et al.* (1997) reported that photoactive coumarins from fresh and freeze-dried parsley leaves protected against various human pathogens and food spoilage organisms in a photobiological assay.

The addition of fresh parsley leaves to 'Kareish' cheese reduced the amount of yeast present within 2 h. Additionally parsley extracts showed a significant inhibitory activity against *Staphylococcus aureus* and antibacterial activity against other microbial flora in the cheese (Wahba *et al.*, 2010).

Wong and Kitts (2006) reported on the antibacterial activities of methanol and water extracts of freeze-dried and irradiated parsley leaves and stems against *Bacillus subtilis* and *Escherichia coli*.

Diuretic effect

The diuretic effect of parsley has long been noticed in traditional medicine. More recently, Marczal *et al.* (1997) studied the phenol ether components of the diuretic effect of parsley. Also, in rat *in vivo* and *in vitro* experiments, Kreydiyyeh and Usta (2002) found that parsley extracts increased the urine output/day by inhibiting Na^+-K^+-ATPase, thus leading

to an increased K^+ concentration in the kidney lumen that leads to an osmotic water flow into the lumen and diuresis.

The German Commission E has accepted the use of parsley for the treatment of kidney stones (Charles, 2004), most likely because the consumption of parsley tea can increase urine output, although it is recommended not to exceed three cups of parsley seed tea a day (Kreydiyyeh and Usta, 2002).

Hypoglycaemic effect

The hypoglycaemic effect of parsley has been reported by various researchers. Studies in other plants suggested that terpenoids have the ability to enhance insulin for the stimulation of glucose disposal and exert their antidiabetic actions via α-glucosidase modulation, a typical extra-pancreatic mechanism (Luo *et al.*, 1999; Kumar *et al.*, 2011).

It has also been reported that coumarins and flavonoid glucosides (as found in parsley) act in the scavenging or quenching of free radicals (Anand *et al.*, 1981), and that parsley, also being a good source of vitamin C, would also be effective in preventing the non-enzymatic glycosylation of proteins (Afkhami-Ardekani *et al.*, 2003).

Hepatoprotective effect

Ozsoy-Sacan *et al.* (2006) showed that parsley has a hepatoprotective effect on the liver tissue of streptozotocin (STZ)-induced diabetic rats by decreasing blood glucose and lipid peroxidation, along with elevating the level of liver glutathione.

Anti-platelet aggregating effect

Gadi *et al.* (2009) reported that parsley extract inhibited *in vitro* and *ex vivo* platelet aggregation and prolonged bleeding time in rats. Later, Chaves *et al.* (2011) have isolated and identified the flavonoids apigenin, apigenin-7-*O*-glucoside (cosmosiin) and apiin, and the coumarin 2″,3″-dihydroxyfuranocoumarin (oxypeucedanin hydrate) from aqueous extracts of the leaves of flat-leaved parsley. The extract, and apigenin and cosmosiin, all interfered with haemostasis-inhibiting platelet aggregation in human platelets.

Contraindications

Parsley is best avoided by pregnant women because its myristicin and apiol content may stimulate the uterus. The availability of these components in the leaves, stalks and roots is lower than in the seed oil, so these are safe to consume. Those with allergies to plants in the Apiaceae family should avoid all parsley components and constituents (Castleman, 2009; Fig. 16.5).

Drug interactions

Parsley is rich in vitamin K, which interferes with warfarin, so those who are taking the blood thinner warfarin should monitor parsley intake closely (Heck *et al.*, 2000).

Parsley should also be avoided by those on diuretic drugs, because it will exacerbate the diuretic action of the drugs, thus increasing urine output and possibly causing too much fluid loss, leading to dehydration, dizziness and hypotension.

In studies on mice, Jakovljvic *et al.* (2002) have reported on the effect of parsley juice on pharmacodynamic activity of drugs involving cytochrome P450 in their metabolism (the hypnotic pentobarbital and the analgesics paracetamol and aminopyrine).

16.5 Summary

Parsley is used as a table garnish worldwide, but its heath-promoting uses are often ignored, like its valuable medicinal effects. It has great demand in the food and cosmetic industries, and the expansion of its cultivation is of prime importance.

Acknowledgement

The support provided by Internal grant from CAMS, Sultan Qaboos University (IG/AGR/FOOD/14/01) is highly acknowledged. The authors state that there is no conflict of interest in this article.

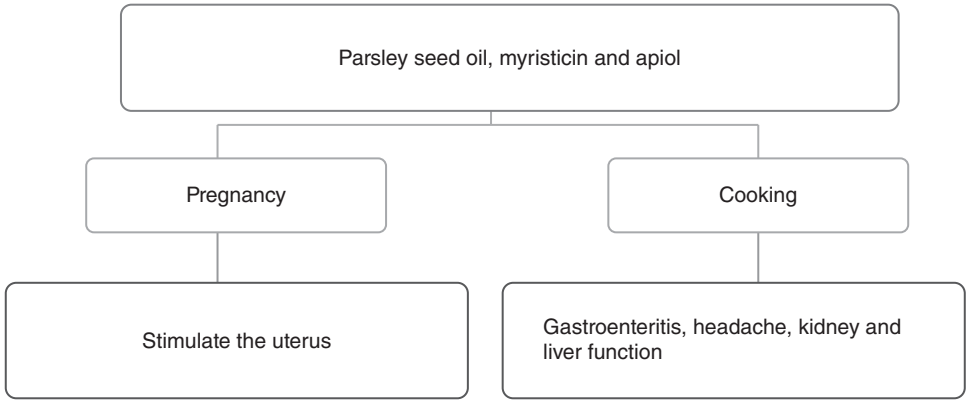

Fig. 16.5. Contraindications for parsley seed oil and seed oil components. From/after Castleman, 2009.

References

Afkhami-Ardekani, M., Vahidi, A.R., Borjian, L. and Borjian, L. (2003) Effect of vitamin C supplement on glycosylated hemoglobin in patients with type 2 diabetes. *Journal of Shah Sad University* 10, 15–18.

Anand, N.K., Sharma, N.D. and Gupta, S.R. (1981) Coumarins from *Apium petroselinum* seeds. *National Academy Science Letters (India)* 4, 249–251.

Cantwell, M. (2001) *Properties and Recommended Conditions for Storage of Fresh Fruit and Vegetables.* Available at: http://postharvest.ucdavis.edu/files/109107.pdf (accessed 26 January 2016).

Castleman, M. (2009) Chapter 5: The healing herbs – Parsley. In: Castleman, M. *The New Healing Herbs: The Essential Guide to More Than 125 of Nature's Most Potent Herbal Remedies*. Rodale, Emmaus, Pennsylvania, pp. 354–357.

Cătunescu, G.M., Tofană, M., Mureşan, C., David, A. and Stănilă, S. (2012) Sensory evaluation of minimally processed parsley (*Petroselinum crispum*), dill (*Anethum graveolens*) and lovage (*Levisticum officinale*) stored at refrigeration temperatures. *Bulletin UASVM Agriculture* 69, 205–212.

Ceuterick, M., Vanderbroek, I., Tony, B. and Pieroni, A. (2008) Cross-cultural adaptation in urban ethnobotany: the Columbian folk pharmacopeia in London. *Journal of Ethnopharmacology* 120, 342–359.

Charles, D.J. (2004) Parsley. In: Peter, K.V. (ed.) Handbook of Herbs and Spices, Volume 2. Woodhead Publishing, Abington, Cambridge, UK and CRC Press, Boca Raton Florida, pp. 231–234.

Chaves, D.S., Frattani, F.S., Assafim, M., Almeida, A.P. de, Zingali, R.B. and Costa, S.S. (2011) Phenolic chemical composition of *Petroselinum crispum* extract and its effect on haemostasis. *Natural Product Communications* 6, 961–964.

Chevallier, A. (1996) *The Encyclopedia of Medicinal Plants*. Dorling Kindersley, London.

Gadi, D., Bnouham, M., Aziz, M., Ziyyat, A., Legssyer, A., Legrand, C., Lafeve, F.F. and Mekhfi, H. (2009) Parsley extract inhibits *in vitro* and *ex vivo* platelet aggregation and prolongs bleeding time in rats. *Journal of Ethnopharmacology* 125, 170–174.

Hallström, H. and Thuvander, A. (1997) Toxicological evaluation of myristicin. *Natural Toxins* 5, 186–192.

Heck, A., DeWitt, B. and Lukes, A. (2000) Potential interactions between alternative therapies and warfarin. *American Journal of Health-System Pharmacy* 57, 1221–1227.

Hinneburg, I., Dorman, H.J.D. and Hiltunen, R. (2006) Antioxidant activities of extracts from selected culinary herbs and spices. *Food Chemistry* 97, 122–129.

Hostetler, G.L., Riedl, K.M. and Schwartz, S.J. (2013) Effects of food formulation and thermal processing on flavones in celery and chamomile. *Food Chemistry* 141, 1406–1411.

Jakovljvic, V., Raskovic, A., Popovic, M. and Sabo, J. (2002) The effect of celery and parsley juice on pharmacodynamic activity of drugs involving cytochrome P450 in their metabolism. *European Journal of Drug Metabolism and Pharmacokinetics* 27, 153–156.

Kolarovic, J., Popovic, M., Zlinská, J., Trivic, S. and Vojnovic, M. (2010) Antioxidant activities of celery and parsley juices in rats treated with doxorubicin. *Molecules* 15, 6193–6204.
Kreydiyyeh, S.I. and Usta, J. (2002) Diuretic effect and mechanism of action of parsley. *Journal of Ethnopharmacology* 79, 353–357.
Kumar, S., Narwal, S., Kumar, V. and Prakash, O. (2011) α-Glucosidase inhibitors from plants: a natural approach to treat diabetes. *Pharmacological Reviews* 5(9), 19–29.
Lee, J. and Park, W. (2011) Anti-inflammatory effect of myristicin on RAW 264.7 macrophages stimulated with polyinosinic-polycytidylic acid. *Molecules* 16, 7132–7142.
Lis-Balchin, M. (2006) Parsley oil. In: Lis-Balchin, M. *Aromatherapy Science: A Guide for Healthcare Professionals*, 1st edn. Pharmaceutical Press, London, pp. 267–269.
Lisiewska, Z., Kmieccik, W. and Budnik, A. (1997) Effect of condition and time of storage on technological quality changes of parsley leaves. *Folia Horticulturae* 9, 21–29.
Luo, J., Cheung, J., Yevich, E.M., Clark, J.P., Tsai, J., Lapresca, P., Ubillas, R.P., Fort, D.M., Carlson, T.J., Hector, R.F. *et al*. (1999) Novel terpenoid-type quinones isolated from *Pycnanthus angolensis* of potential utility in the treatment of type 2 diabetes. *The Journal of Pharmacology and Experimental Therapeutics* 288, 529–534.
Luthria, D.L. (2008) Influence of experimental conditions on the extraction of phenolic compounds from parsley (*Petroselinum crispum*) flakes using a pressurized liquid extractor. *Food Chemistry* 107, 745–752.
Luthria, D.L., Mukhopadhyay, S. and Kwansa, A.L. (2006) A systematic approach for extraction of phenolic compounds using parsley (*Petroselinum crispum*) flakes as model substrate. *Journal of Science of Food and Agriculture* 86, 1350–1358.
Manderfeld, M.M., Schafer, H.W., Davidson, P.M. and Zottola, E.A. (1997) Isolation and identification of antimicrobial furocoumarins from parsley. *Journal of Food Protection* 60, 72–77.
Marczal, G., Balogh, M. and Verzar-Petri, G. (1997) Phenolether components of diuretic effect in parsley I. *Acta Agronomica Academiae Scientiarum Hungaricae* 26, 7–13.
Middleton, E., Kandaswami, C. and Theoharides, T.C. (2000) The effects of plant flavonoids on mammalian cells: implications for inflammations, heart disease, and cancer. *Pharmacology Reviews* 52, 673–751.
Najla, S., Sanoubar, R. and Murshed, R. (2012) Morphological and biochemical changes in two parsley varieties upon water stress. *Physiology and Molecular Biology of Plants* 18, 133–139.
Navazio, J. (2012) Apiaceae. In: Navazio, J. *The Organic Seed Grower: A Farmer's Guide to Vegetable Seed Production*. Chelsea Green Publishing, White River Junction, Vermont, pp. 108–111.
Nielsen, S.E., Young, J.F., Daneshvar, B., Lauridsen, S.T., Knuthsen, P., Sandstrom, B. and Dragsted, L.O. (1999) Effect of parsley (*Petroselinum crispum*) intake on urinary apigenin excretion, blood antioxidant enzymes and biomarkers for oxidative stress in human subjects. *The British Journal of Nutrition* 81, 447–455.
Orav, A., Kailas, T. and Jegorova, A. (2003) Composition of the essential oil of dill, celery, and parsley from Estonia. *Proceedings of the Estonian Academy of Sciences: Chemistry* 52, 147–154.
Ozsoy-Sacan, O., Yanardag, R., Orak, H., Ozgey, Y., Yarat, A. and Tunali, T. (2006) Effects of parsley (*Petroselinum crispum*) extract versus glibornuride on the liver of streptozotocin-induced diabetic rats. *Journal of Ethnopharmacology* 104, 175–181.
Petropoulos, S.A., Akoumianakis, C.A. and Passam, H.C. (2006) Evaluation of turnip-rooted parsley (*Petroselinum crispum* ssp. *tuberosum*) for root and foliage production under a warm Mediterranean climate. *Scientia Horticulturae* 109, 282–287.
Rice-Evans, C.A., Miller, N.J. and Paganga, G. (1996) Structure–antioxidant activity relationships of flavonoids and phenolic acids. *Free Radical Biology and Medicine* 20, 933–956.
SELFNutritionData (2016) Nutrition Facts and Analysis for Parsley, raw. Available at: http://nutritiondata.self.com/facts/vegetables-and-vegetable-products/2513/2 (accessed 26 January 2016).
Taiz, L. and Zeiger, E. (1998) Chapter 13. Secondary metabolites and plant defense. In: Taiz, L. and Zeiger, E. *Plant Physiology*, 2nd edn. Sinauer Associates, Sunderland, Massachusetts, pp. 320–344.
Teuscher, E. (2005) *Medicinal Spices: A Handbook of Culinary Herbs, Spices, Spice Mixtures and their Essential Oils*. (1st edn). Medpharm Scientific, Stuttgart, Germany and CRC Press, Boca Raton, Florida.
USDA ARS (2008) *USDA National Nutrient Database for Standard Reference*, Release 21. Nutrient Data Laboratory, Agricultural Research Service, US Department of Agriculture, Beltsville, Maryland. Available via: http://www.ars.usda.gov/News/docs.htm?docid=18880 (accessed 26 January

2016). *Nutrient Data Laboratory home page* available at: http://www.ars.usda.gov/ba/bhnrc/ndl (accessed 26 January 2016).

Wahba, N.M., Ahmed, A.S. and Ebraheim, Z.Z. (2010) Antimicrobial effects of pepper, parsley, and dill and their roles in the microbiological quality enhancement of traditional Egyptian Kareish cheese. *Foodborne Pathogens and Disease* 7, 411–418.

Wong, P. and Kitts, D. (2006) Studies on the dual antioxidant and antibacterial properties of parsley (*Petroselinum crispum*) and cilantro (*Coriandrum sativum*) extracts. *Food Chemistry* 97, 505–515.

Yoshikawa, M., Uemura, T., Shimoda, H., Kishi, A., Kawahara, Y. and Matsuda, H. (2000) Medicinal foodstuffs. XVIII. Phytoestrogens from the aerial part of *Petroselinum crispum* Mill (parsley) and structures of 6-acetylapiin and a new monoterpene glycoside petroside. *Chemical and Pharmaceutical Bulletin (Tokyo)* 48, 1039–1044.

Yousofi, A., Daneshmandi, S., Soleimani, N., Bagheri, K. and Karimi, M.H. (2012) Immunomodulatory effect of parsley (*Petroselinum crispum*) essential oil on immune cells: mitogen-activated splenocytes and peritoneal macrophages. *Immunopharmacology and Immunotoxicology* 34, 303–308.

Zhang, H., Chen, F., Xi, W. and Yao, H. (2006). Evaluation of antioxidant capacity of parsley (*Petroselinum crispum*) essential oil and identification of its antioxidant constitutents. *Food Research International* 39, 833–839.