Global Journal of Agriculture and Food Sciences Research
Vol.1, No.1, pp.28-37, March 2014
Published by British Research Institute UK (www.gbjournals.org)

EFFECT OF MICROWAVE TREATMENT ON SOME BIOACTIVE COMPOUNDS OF PARSLEY (*PETROSELINUM CRISPUM*) AND DILL (*ANETHUM GRAVEOLENS*) LEAVES

Sahar M, Kamel

Food Technology Research Institute, Agricultural Research Center, Ministry of Agriculture, Giza, Egypt

ABSTRACT: *The aim of this study was to assess the effect of microwave heating and drying on some bioactive compounds of parsley (Petroselinum crispum) and dill (Anethum graveolens) leaves. The water blended of parsley and dill were heated for one, two and three min, while the whole leaves were drying for two min. Total phenols, chlorophyll, carotenoids, antioxidant activity and color indices were determined before and after treatments. Dill leaves had higher total phenols, chlorophyll, carotenoid and antioxidant activity (1287.00 mg / 100g, 33.97 mg/kg, 45.98 mg/kg and 48.14%, respectively) than parsley leaves (1031.39 mg / 100g, 32.47 mg/kg, 40.00mg/kg and 40.10%, respectively). Total phenols and antioxidants activity of water blended parsley leaves were decreased after 2 min by 32.4 and 8%, as well as after 3 min by 80.2 and 38.27% respectively compared to the unheated sample. Meanwhile, the decrease in total phenols and antioxidants activity of dill sample was 23.7and 30.3% after 2 min this decrease was 33.0 and 54.8% after 3 min. Microwave drying process induced significant (P < 0.05) decrease in all tested parameters compared to the fresh state. Antioxidant activity decreased 20% in dried parsley and 30.3% in dried dill compared to fresh samples. This work indicated that the tested bioactive compounds of parsley and dill was stable only after only one min of microwave heating , however, after 3 min of heating as well as drying a marked decrease was observed in these parameters.*

KEYWORDS: Microwave, Green vegetables, Antioxidant activity, DPPH, pigments.

INTRODUCTION

Recently special attention has been paid towards edible plants that are rich in secondary metabolites (frequently called phytochemicals) and there is now increasing interest in antioxidant activity of such phytochemicals present in the diet. Phenolic compounds are broadly distributed in the plant kingdom and are the most abundant secondary metabolites of plants, with more than 8,000 phenolic structures currently known, ranging from simple molecules such as phenolic acids to highly polymerized substances such as tannins. Plant phenolics are generally involved in defense against ultraviolet radiation or aggression by pathogens, parasites and predators, as well as contributing to plants' colors. They are ubiquitous in all plant organs and are therefore an integral part of the human diet. Phenolics are widespread constituents of plant foods (fruits, vegetables, cereals, olive, legumes, chocolate, *etc.*) and beverages (tea, coffee, *etc.*), and partially responsible for the overall organoleptic properties of plant foods. Antioxidants are important in prevention of pollution damage of plants, disease prevention in both plants and animals and play a very important role in the body defense system and reactive oxygen species (Ahmed and Beigh 2009). The bioactive compounds including polyphenolic and photosyntethtic pigments like chlorophylls and carotenoids have been shown to have possible health benefits with antioxidative,

anticarcinogenic, antihypertensive, antimutagenic, and antimicrobial activities. Based on the scientific arguments, supplementation of diet with various herbs is recommended among individual consumers, both for its healing properties and nutritive value Yen *et al*., (2002) The biological importance of carotenoids lies is the fact that carotenoids can also serve as antioxidants, and many reports indicated that carotenoids may possess some anticarcinogenic properties, which may be related to their ability to interact with and quench various radical species that can be generated within cells (Krinsky , 1989). Deep-coloured vegetables and fruits are known to be good sources of phenolics, including flavonoid, anthocyanin, and carotenoids (Cieslik, 2006). Green leafy vegetables are popularly used for food in many countries of the world, being a rich source of ß-carotene, ascorbic acid, minerals and dietary fiber (Sun *et al*., 2002; Oboh, 2005; Oboh and Akindahunsi, 2004 and Oboh and Rocha, 2007).

Parsley (*Petroselinum crispum*) and dill (*Anethum graveolens L*.), annual herbs of the parsley family (Apaceae or Umbelliferae), are popular herb widely used in many regions find their applications as culinary herb or as minor adjuncts to salads (fresh herbs) and herbal teas (dry leaves/ shoots) and as aromatic agents in the food, pharmaceutical, perfumery and cosmetic, functional food and nutraceuticals industries (Tian *et al*., 2011).

Many investigations point out to the antioxidant properties of parsley. The flavonoid apigenin, one of the components of parsley plant, was shown to express strong antioxidant effects by increasing the activities of antioxidant enzymes and related to that, decreasing the oxidative damage to tissues. Potential for anticancer activity by parsley was reported as well (Lombaert *et al*., 2001 and Mimica-Dukic and Popovic, 2007). Dill contains range of phytochemicals, such as vitamin C and polyphenols, which significantly contribute to their total antioxidant activity (Duthie *et al*., 2003). The popular thinking is that fresh fruits and vegetables are better for us than cooked ones nutrition wise. Despite this thinking, most vegetables are usually cooked before consumption. These cooking processes could bring many changes in physical characteristics and chemical composition of vegetables (Rehman *et al*., 2003; Zhang and Hamauzu, 2004). However, processing can also lead to disruption of the food matrix, increasing the inaccessibility of many phytochemicals and thus improving the nutritional quality of vegetables (Pellegrini, *et al*., 2010). Moreover, the attention should be also paid to the processing methods in order to preserve the desirable antioxidant properties of foods (Gorinstein *et al*., 2009).

The use of the microwave oven increased constantly, both at home and in the industry sector, due to its advantages, that includes capacity to rapidly transmit heat (Hassanein *et al*., 2003; Burfoot *et al*., 1990), convenience, ease of use (Caponio *et al*., 2003; Cossignani *et al*., 1998) and time and energy savings (Albi *et al*., 1997a). Another reason to use of the microwave oven is the tendency of the industry to produce pre-prepared food products especially to defrost heat or cook (Albi *et al*., 1997b). The microwave heating process could accelerate oxidative reactions which promote the involvement of free radicals (Albi *et al*., 1997a). The effects of microwave on food constituents (Cossignani *et al*., 1998), including in lipid fraction of animal fats, vegetable oils and some raw and cooked vegetables (Yoshida *et al*., 1990; Yoshida *et al*., 1992,Turkmen *et al*., 2006, Malheiro *et al*., 2009) have been studied.

The objectives of this study were to confirm the effect of different microwave heating times on the total phenols, antioxidant activity, carotenoids, chlorophylls and color indices of two green leafy vegetables liquors, parsley and dill, are popularly used in many countries of the

world as spices to flavor food and also in medicinal purposes. The effect of microwave drying process on the same parameters has been also studied on the same parameters.

MATERIAL AND METHODS

Sample preparation for microwave heating

Fresh plant materials of parsley and dill were purchased from local supermarket in Cairo, Egypt. Samples were washed under tap water and inedible parts and stems were removed. Four samples for each plant of parsley and dill leaves (3g for each) were blended with 50 ml distilled water in a laboratory blender, placed in 100 ml glass beaker. One beaker left as control (corresponding to 0 min) and the second, third and fourth beakers were heated in Panasonic microwave oven at full power (750 W) for 1, 2 and 3 min, respectively. The samples were then cooled for a few minutes at room temperature, filtered and adjusted to 100ml.

Microwave drying process

The edible parts of parsley and dill leaves were dried using a microwave oven. The characteristic parameters of drying program were as follows: rotation speed – 6 rpm; product mass per load – 3 g; drying time – 2min.

Table 1. Different methods of drying

	Parsley leaves	Dill leaves
Weight of sample(g)	5	5
Microwave (minute)	2	2
Moisture content (%)		
Dry leaves	6.65	5.93
Fresh leaves	87.54	83.4

Determination of total content of phenolic compounds

The total content of phenolic compounds (TPC) in samples was determined according to the method reported by Boyer and Hai Liu (2004). One ml of extract was mixed with 5 ml of 10 % Folin-Ciocalteu reagent in distilled water and 4 ml of 7.5 % sodium carbonate solution. The samples were maintained at room temperature for 30 min with periodical mixing, the absorbance at 765 nm was measured. The calibration curve was constructed within the concentration range 0.075−0.6 mg/ml of gallic acid. Mean values were calculated from three parallel analyses. Results were calculated as gallic acid equivalents in mg/100 g of dry plant material using the following equation:

$C = a \times \gamma \times (V/m) \times 100$,

Where: C = total amount of phenolic compounds, mg/100g as gallic acid; a = dilution number; γ = concentration obtained from calibration curve (mg/ml); V = volume of aqueous ethanol used for extraction; m = weight of sample (g).

DPPH free radical scavenging ability

The free radical scavenging ability of samples against DPPH (1, 1-diphenyl-2 picryl hydrazyl) free radical was evaluated as described by Zhang and Hamauzu (2004). One ml extracts was mixed with 1 ml of 0.4 mmol l−1 methanolic solution containing DPPH radicals. The mixture was left in the dark for 30 min and the absorbance was measured at 516 nm. The DPPH free radical scavenging ability was subsequently calculated with respect to the reference (which contains all the reagents without the test sample).

Color Analysis

Objective color measurements were made by using a Hunter colorimeter (Hunter Associates Laboratory Inc., Reston, USA) on the basis of three color values, namely L, a and b. The instrument (45°/0° geometry, D25 optical sensor, 10° observer) was calibrated against a standard white reference tile (L.90.55, a.±0.71, b.0.39). A glass cell containing the microwave-treated or untreated samples was placed above the light source and covered with a white plate and L, a and b values were recorded (Ahmed *et al*., 2002).

Chlorophylls and carotenoids content

Following the procedures described by Mosquera *et al*., (1991) the chlorophyll fraction was measured in a UV spectrophotometer at 670 nm and the carotenoid fraction at 470 nm.

Statistical Analysis.

All determinations were conducted in triplicate. Differences between means of data were compared by least significant difference (LSD) calculated using the SAS for Windows 2000 Version 8.2 (Little *et al*., 1996).

RESULTS AND DISCUSSION

Effect of microwave heating on total phenols, antioxidants activity, chlorophyll and carotenoid contents of parsley and dill leaves liquor

The total phenols content of the liquor from microwaved parsley and dill leaves are presented in table2. The data revealed that total phenols in parsley leaves increased from 1031.39mg/100g heating to 1371.84mg/100g after treated with microwave for one min. Total phenols in dill leaves increased from 1287.00 to 1636.80 after one min. Data in same table showed significant increase after 1min of heating in antioxidants activity (from 40.10 to 51.83% and from 48.14 to50.71% of parsley and dill leaves liquors, respectively). Dramatic decrease was recorded in parsley (482.81and 204.60 mg/100g) and dill (981.75 and 861.63 mg/100g) liquors after two and three min, respectively. Gradual decrease was recorded also after 2and 3 min of heating in antioxidant activity. Heating or cooking in water seems to cause a leakage of vegetable antioxidants like phenols into the cooking water, then

degradation of these antioxidant compounds may take place with prolonged time to microwave heating. Gahler *et al*. (2003) reported an improvement in the antioxidant activity of tomatoes after heat treatment than in raw tomato. These results are in agreement with Wachtel-Galor *et al*., (2008) who concluded that microwaving led to a greater loss of antioxidants into the liquor than did boiling. Our results in a line with Turkmen *et al*., (2005) who found that after 1.5 min microwaving the antioxidant activity increased by 15.90% and 16.68% in some fresh vegetables. These results are also in accordance with Jimnez-Monreal *et al*., (2009) who evaluate the influence of cooking methods on antioxidant activity of vegetables. They found that the scavenging capacity decreased between 30% and 50% when they were submitted to microwaves. The same trend was appeared with caronenoids contents (table 2). Carotenoids content increased after one minby 7.86 and 5.52% then decreased about 27% and 76% after 3min in parsley and dill leaves, respectively. The increase after one min may be due to the heat treatment that enhances the libration and the bioavailability of carotenoids as investigated by Rock *et al*., (1998). In the same table chlorophyll contents decreased significantly ($p < 0.05$) after, 2 and 3min in parsley and after 3min in dill. The same findings were stated by Pellegrini, *et al*., (2010) who found that total chlorophyll content of raw fresh broccoli, was significantly decreased by all the cooking methods include microwaving except for oven steaming.

Effect of microwave heating on the color indices of parsley and dill leaves liquor

Hunterlab colorimeter was used here to assess the effect of microwave heating on the change of color in parsley and dill leaves. Data in table 3 showed that microwave heating for 1, 2 and 3min induced significant decrease in L-value for parsley and dill. Loss of greenness (-a) was recorded in both parsley and dill leaves after all heating time. Yellowness (b-value) increased after 1min of cooking from 1.98 to 2.68 and 2.07 in parsley and dill leaves, respectively. However after 3 min of cooking the yellowness decreased. Conversion of chlorophylls to pheophytins during thermal processing seemed to be the main reason of the darkening and the decrease in greenness. These results are in a line with Pellegrini *et al*., (2010) who studied the effect of different cooking methods on color, phytochemical concentration, and antioxidant capacity of raw and frozen Brassica vegetables and their results showed loss of greenness (-a) in microwaved vegetables. The increase in yellowness may be referring to the liberation of carotenoids after imin. Then degradation of carotenoids with increasing the exposure time led to decrease in yellowness. In agreement with these results microwaving induced a significant decrease of both lutein and β-carotene was recorded by Zhang and Hamauzu (2004).

The present results are in accordance with Rocha *et al*., (1993) and Ihl *et al*., (1998) who stated that the color changes from bright green to olive-brown during thermal and microwave processing are caused by the conversion of chlorophylls to pheophytins.

Effect of microwave drying process on total phenols, antioxidants activity, chlorophyll and carotenoid contents of parsley and dill

Data in table 4 revealed that total phenols were affected obviously with the microwave drying process in both parsley and dill leaves. Significant decrease ($P>0.05$) was observed in total phenols content of both microwave dried samples compared to the fresh state (12.73% in parsley and 12.18% in dill). Antioxidant activity decreased 20% in dried parsley and 30.3% in dried dill compared to fresh samples. This decrease may due to the decrease in total phenols and the thermal labile components content of samples such as carotenoids, (table 4).

Data in the same table showed a noticeable decrease in chlorophyll content in dried parsley and dill compared to fresh samples (on dried weight). This data are in parallel and ensure the data above. The same results were obtained by Annamalai *et al*., (2011) who found a significant reduction in antioxidant property for microwave dried plant material when compared to other drying treatments. Bejar *et al*., (2011) studied the effect of microwave drying on orange peel and leaves and stated that microwave drying decreased the total phenol content of the dried leaves compared to the fresh one.

Effect of microwave drying process on the color Indices of parsley and dill

The effect of microwave drying on color parameters was showed in table 5. Compared to the fresh state of parsley, the applied microwave drying process has no significant effect on degree of brightness (L) however, significant decrease was noticed on a ($P>0.05$) and b ($P>0.05$) as greenness and yellowness degree, respectively. In dill sample the degree of brightness and greenness were significantly ($P>0.05$) decreased but microwave drying has not a significant effect on b ($P>0.05$). This decrease can be explained by Maillard and the non-enzymatic browning reactions occurred essentially during microwave drying and the degradation of carotenoids and chlorophyll pigments responsible of the leaves color. These results are in parallel with that by Dwivedy *et al*, (2012) their study indicated that the therapeutic values (total phenols and antioxidant activity) of dried Indian Borage (Coleus aromaticus) leaves were significantly less than that of fresh leaves.

CONCLUSION

The present work showed that microwave heating for 2 or 3 min of liquor and drying induces significant loss in some bioactive components such as total phenols, carotenoids and chlorophyll and also in their activities in parsley and dill. However the appearance quality as brightness and greenness does not extremely affected. More research should be investigated in more foods in order to better guide food preparation methods that preserve food of their rich bioactive components and antioxidant capacity.

ACKNOWLEDGEMENTS

The authors would like to thank all members in Food Technology Research Institute, ARC, Giza, Egypt and the Faculty of Agriculture and Food Science, KFU, Saudi Arabia, for the laboratory facilities.

REFERENCE

Ahmed S, and Beigh SH 2009. Ascorbic acid, Carotenoids, Total Phenolic content and Antioxidant activity of various genotypes of Brassica Oleracea encephala. J. Med. Biol. Sci., 3: 1-8.

Ahmed, J., Shivhare, U. S. and Debnath, S. 2002. Colour degradation and rheology of green chilli puree during thermal processing. International Journal of Food Science and Technology, 37: 57.

Albi, T., Lanzón, A., Guinda, A., Léon, M., and Pérez-Camino, M.C., 1997a. Microwave and conventional heating effects on thermoxidative degradation of edible fats. Journal of Agricultural and Food Chemistry 45: 3795–3798.

Albi, T., Lanzón, A., Guinda, A., Pérez-Camino, M.C., Léon, M., 1997b: Microwave and conventional heating effects on some physical and chemical parameters of edible fats. Journal of Agriculture and Food Chemistry. 45: 3000–3003.

Annamalai, A., Ponmari, G., Sathishkumar, R., and Lakshmi,P. T. V. 2011. Effect of drying treatment on the contents of antioxidants in Cardiospermum halicacabum Linn. International Journal of Pharma and Bio Sciences 2: 304 – 313.

Bejar, A. K., Kechaou N. and Mihoubi N. P. 2011. Effect of microwave treatment on physical and functional properties of orange (*Citrus sinensis)* peel and leaves. Journal of Food Processing and Technology. 2: 109-115.

Boyer J., and Hai Liu R. 2004. Apple phytochemicals and their health benefits. Nutrition Journal. 3: 1−15.

Burfoot, D., James, S.J., Foster, A.M., Self, K.P., Wilkins, T.J., and Philips, I. 1990: In: Field, R.W., Howell,J.A. (Eds.), Temperature Uniformity After Reheating in Microwave Ovens, Processing Engineering in the Food Industry, vol. 2. Elsevier Applied Science, New York. pp. 1–4.

Caponio, F., Pasqualone, A., and Gomes, T., 2003. Changes in fatty acid composition of vegetables oils in model doughs submitted to conventional or microwave heating. International Journal of Food Science and Technology 38: 481–486.

Cieslik, E., Greda, A. and Adamus, W. 2006. Contents of polyphenols in fruit and vegetables. Food Chemistry 94: 135–142.

Cossignani, L., Simonette, M.S., Neri, A., and Damiani, P., 1998: Changes in olive oil composition due to microwave heating. Journal of American Oil Chemists'Society 75: 931–937.

Duthie, G. G., Gardner, P. T., and Kyle, J. A. M. 2003. Plant polyphenols: are they the new magic bullet", Proceedings of the Nutrition Society. 62: 599–603.

Dwivedy, S., Rayaguru, K., Sahoo, G.R. 2012. Effect of Drying Methods on Quality Characteristics of Medicinal Indian Borage (Coleus aromaticus) Leaves. J Food Process Technol 3:188.

Gahler, S., Otto, K. and Bohm, V. 2003. Alterations of vitamin C, total phenolics, and antioxidant capacity as affected by processing tomatoes to different products. Journal of Agriculture and Food Chemistry. 51: 7962–7968.

Gorinstein, S., Jastrzebski, Z., Leontowicz, H., Leontowicz, M., Namiesnik, J., and Najman, K., 2009. Comparative control of the bioactivity of some frequently consumed vegetables subjected to different processing conditions. Food Control 20: 407–413.

Hassanein, M.M., El-Shami, S.M., and El-Mallah, M.H., 2003. Changes occurring in vegetable oils composition due to microwave heating. Grasas y Aceites 54: 343–349.

Ihl, M., Monslaves, M. and Bifani, V. 1998. Chlorophyllase inactivation as a measure of blanching efficacy and colour retention of Artichokes (Cynara scolymus L.). Lebensmittel-Wissenschaft und-Technologie, 31: 50-56.

Jimenez-Monreal, A. M., García-Diz, L., Martínez-Tomé, M., Mariscal, M. and Murcia M. A. 2009. Influence of cooking methods on antioxidant activity of vegetables. Journal of Food Science.74: 97–103.

Krinsky N. I. 1989. Antioxidant functions of carotenoids. Free Radical Biology and Medicine, 7: 617-635.

Little, R.C., Milliken, G.A., Stroup, W.W. and Wolfinger, R.D. 1996. SAS Systems forbMixed Models. Cary, NC: SAS Institute Inc.

Lombaert, G.A., Siemens, K.H., Pellaers, P., Mankotia, M. and Ng, W. 2001. Furanocoumarins in celery and parsnips: method and multiyear Canadian survey. Journal of the Association of Official Agricultural Chemists Intternational 84: 1135-1143.

Malheiro, R.; Oliveira, I.; Vilas-Boas, M.; Falcão, S.; Bento, A. and Pereira, J.A. 2009. Effect of microwave heating with different exposure times on physical and chemical parameters of olive oil. Food and Chemical Toxicology. 47: 92-97.

Mimica-Dukic, N., and Popovic, M., 2007. Apiaceae Species. A promising sources of pharmacologically active compounds and Petrosellinum crispum, Apium greveolens and Pastinaca sativa. In Recent Progress in Medicinal Plant Species; Govil, J.N., Singh, V.K., Eds.; Phytopharmacology and Therapeutic Values III, LLC: Houston, TX, USA, Volume 21, pp. 132-133.

Mosquera, M.M.L., Rejano, N.L., Gandul, R.B., Sánchez, G.A., and Garrido, F.J., 1991. Color pigment correlation in virgin olive oil. Journal of the American Oil Chemists' Society 68: 332–336.

Oboh, G. 2005. Effect of blanching on the antioxidant property of some tropical green leafy vegetables. Lebensm Wiss Technol. 38: 513-517.

Oboh, G. and Akindahunsi, A. A. 2004. Change in the ascorbic acid, total phenol and antioxidant activity of some sun-dried green leafy vegetables in Nigeria. Nutrition and Health 18: 29-36.

Oboh, G., and Rocha, J. B. T. 2007. Antioxidant in Foods: A New Challenge for Food processors. Leading Edge Antioxidants Research, Nova Science Publishers Inc. New York US, pp. 35-64.

Pellegrini,N., Chiavaro, E., Gardana, C., Contino, D., Gallo, M., Riso, P., Fogliano, V., and Porrini, M. 2010. Effect of Different Cooking Methods on Color, Phytochemical Concentration, and Antioxidant Capacity of Raw and Frozen Brassica Vegetables Journal of Agricultural and Food Chemistry 58: 4310–4321

Rehman, Z.U., Islam, M., and Shah, W.H. 2003. Effect of microwave and conventional cooking on insoluble dietary fibre components of vegetables. Food Chemistry 80: 237-240

Rock, C. L., Lovalvo, J. L., Emenhise, C., Ruffin, M. T., Flatt, S. W. and Schwartz, S. J. 1998. Bioavailability of b-carotene is lower in raw rather than in processed carrots and spinach in women. Journal of Nutrition 128: 913–916.

Rocha, T., Lebert, A. and Marty-Audouin, C. 1993. Effect of pre-treatments and drying conditions on drying rate and colour retention of basil. Lebensmittel-Wissenschaft und-Technologie 26: 456-463.

Sun, J., Chu, Y., Wu, X., and Liu, R. 2002. Antioxidant and antiproliferative activities of common fruits. Journal of Agricultural and Food Chemistry 50: 7449-7454.

Tian, J., Ban, X., Zong, H., Huang, B., He, J. and Wang, Y. 2011. In vitro and in vivo activity of essential oil from dill (Anethum graveolens L.) against fungal spoilage of cherry tomatoes, Food Control, 22: 1992–1999.

Turkmen, N., Poyrazoglu, E. S., Sari, F., and Velioglu, Y. S. 2006. Effects of cooking methods on chlorophylls, pheophytins and color of selected green vegetables. International Journal of Food Science and Technology.41: 281–288.

Turkmen, N., Sari, F., and Velioglu, S. 2005. The effect of cooking methods on total phenolics and antioxidant activity of selected green vegetables. Food Chemistry. 93: 713–718.

Wachtel-Galor, S. Wong, K. W. and Benzie, I. F. F. 2008. The effect of cooking on Brassica vegetables. Food Chemistry 110: 706–710.

Yen, G. C., Duh P. D. and Tsai H. L. 2002. Antioxidant and pro-oxidant properties of ascorbic acid and gallic acid. Food Chemistry, 79: 307–313.

Yoshida, H., Hirooka, N., and Kajimoto, G. 1990. Microwave energy effects on quality of some seed oils. Journal of Food Science 55: 1412-1416.

Yoshida, H., Tatsumi, M., and Kajimoto, G. 1992. Influence of fatty acids on the tocopherol stability in vegetable oils during microwave heating. Journal of the American Oil Chemists' Society. 69: 119-125.

Zhang, D., and Hamauzu, Y. 2004. Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. Food Chemistry. 88: 503-509.

APPENDICES

Table 2. Effect of microwave heating on the total phenols, antioxidant activity, chlorophyll and carotenoid contents of parsley and dill

Treatments	Total phenols (as mg gallic acid/100g)	Antioxidant activity (%)	Chlorophyll (mg/kg)	Carotenoids (mg/kg)
Parsley (0min)	1031.39^{b}	40.10^{b}	32.47^{a}	40.00^{a}
Parsley (1min)	1371.84^{ab}	51.83^{a}	28.83^{ab}	43.41^{a}
Parsley (2min)	282.81^{c}	36.89^{bc}	28.12^{ab}	35.83^{ab}
Parsley (3min)	204.60^{c}	24.78^{c}	11.96^{c}	29.02^{b}
Dill (0 min)	1287.00^{ab}	48.14^{ab}	33.97^{a}	45.98^{a}
Dill (1min)	1636.80^{a}	50.71^{a}	34.6^{a}	48.52^{a}
Dill (2min)	981.75^{b}	33.54^{bc}	30.05^{ab}	36.11^{b}
Dill (3min)	861.63^{b}	21.76^{cd}	20.58^{bc}	11.46^{c}

Means followed by the same letter in each group are not significantly different ($p>0.05$).

Table 3. Effect of microwave heating on the color Indices of parsley and dill leaves

Treatments	Color indices		
	Brightness (L)	Greenness (–a)	Yellowness (+b)
Parsley (0min)	31.95^{a}	-1.35^{ab}	2.73^{a}
Parsley (1min)	28.28^{a}	-1.19^{ab}	2.68^{a}
Parsley (2min)	19.08^{c}	-0.78^{b}	1.98^{b}
Parsley (3min)	22.33^{bc}	-0.90^{b}	1.97^{b}

Dill	**(0 min)**	24.25[bc]	-1.50[a]	2.32[ab]
Dill	**(1min)**	20.99[c]	-1.49 [a]	2.07[ab]
Dill	**(2min)**	21.26[bc]	-1.06[ab]	1.98[b]
Dill	**(3min)**	18.93[bc]	-0.70 [b]	0.63[c]

Means followed by the same letter in each group are not significantly different (p>0.05).

Table 4. Effect of microwave drying on some parameters of parsley and dill leaves

Samples	**Total phenols** (as mg gallic acid/100g)	**Antioxidant activity (%)**	**Chlorophyll (mg/kg)**	**Carotenoids (mg/kg)**
Parsley	1031.39[b]	40.1 [b]	32.47[a]	40.00 [a]
Dried Parsley	900.70 [c]	32.40 [c]	23.94[b]	14.87[b]
Dill	1287.00 [a]	48.14 [a]	33.97 [a]	45.98[a]
Dried Dill	1130.20 [b]	33.27[bc]	20.51 [b]	8.81[b]

Means followed by the same letter in each group are not significantly different (p>0.05).

Table 5. Effect of microwave drying on the color Indices of parsley and dill leaves

Samples	**Color indices**		
	Brightness (L)	Greenness (–a)	Yellowness (+b)
Fresh parsley	41.02[a]	-15.58[a]	28.31[a]
Dried parsley	39.27[a]	-11.38[b]	24.36[b]
Fresh dill	31.39[b]	-11.55[b]	19.61[c]
Dried dill	27.34[b]	-8.93[c]	8.04[d]

Means followed by the same letter in each group are not significantly different (p>0.05).