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The Effect of Drying Method on the Antioxidant Capacity of *Ocimum basilicum L.* Extracts

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Basil (*Ocimum basilicum L.*) is globally used both as a vegetable and as an herb for medical and therapeutic purposes; hence the need to investigate its phytonutrients. The aim of this study was to evaluate the effects of different drying methods (sun drying, oven drying and microwave drying) on the antioxidant capacity, total phenolics content (TPC) and total flavonoids content (TFC) of basil leaves. The fresh basil leaves had the highest antioxidant capacity, TPC and TFC content on dry weight basis. They exhibited high antioxidant capacity measured by DPPH assay. Drying methods caused a significant decrease in total phenolics, total flavonoids and antioxidant capacity of basil leaves. Drying by sun at 35ºC and oven had the lowest adverse effects on phenolics and flavonoids contents and antioxidant capacities of basil leaves while microwave drying cannot be a competitive process for preserving antioxidants and antioxidant capacity of basil leaves. Therefore, it can be suggested that special care should be taken when processing method is selected for the exploration of basil leaves.

Key words: Basil, Drying method, Phenols, Flavonoids, Antioxidant.

Medicinal plants posses a potential importance in pharmacology and medical science so a potential attention is given to them from ancient decades to now. The medicinal plants have been in therapy for centuries. In the last few years, a high attention was given to the drying methods of the medicinal plants to get herbal products with a quality near that of the fresh product. The herbs quality is contributed by many factors. The color is the most important one. The dried herb final color is the main determent factor for their marketing (Ibrahim *et al*., 2013).

Basil (*Ocimum basilicum L.*) is a member of the Lamiaceae family, is known as aromatic and medicinal plant and is widely cultivated in many countries. In view of its several therapeutic potential and its importance as a basic component of the Mediterranean diet, basil deserves scientific attention (Tarchoune *et al*., 2012). The fresh and dried basil leave is widely in many human daily consuming products as meat flavor, ice creams and vinegars (Musa *et al*., 2005). Basil is an aromatic herb that is used extensively to add a distinctive aroma and flavor to food. Essential oils extracted from fresh leaves and flowers can be used as aroma additives in foods, pharmaceuticals, and cosmetics (Kaurinovic *et al*., 2011). The most sensitive plants for draying methods are the aromatic herbs and spices which showed a sever deterioration. The draying processes usually accompanied with color and texture alteration, reduction in volatiles and flavor as well a reduction in the nutritional value. Peoples usually use the sun-light for draying of vegetables and fruits but it slow increases the contamination and labors consuming

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(Kostaropoulos and Saravacos, 1995). The quality of the dried substances is usually reduces due to high temperature effect (Musa *et al*., 2005). The effect of air, oven drying methods on ash, essential oils and oleoresin of thyme was investigated by Balladin and Headley (1999) who found that the oil percent was low in oven draying the air draying. The same authors in other work mentioned that the rose petals color remained brilliant red with little loss in texture after solar draying. Oven drying produced losses in thyme and sage volatile substances (Venskutonis 1996). The air drying has less effect on verbena than temperature (Belghit and Boutaleb, 1999). Despite of the bad effects of microwave draying, it reduced the drying times by 89–40% Maskan (2001). The effect of hot-air drying red pepper was investigated by Doymaz and Pala (2002). The white mulberry air-drying kinetics was studied by Doymaz (2003) after treatment with ethyl oleate, citric and ascorbic acid solutions.

Major aroma compounds from volatile extracts of basil present anti-oxidative activity. Among the many studies to determine the antioxidant activities of basil, most have focused mainly on the antioxidant activities of crude extracts, using methanol, acetone, or water as a solvent (Kaurinovic *et al*., 2011). There are a scanty works on the drying methods effects on basil antioxidant capacity, TPC and TFC. In this study we tried to contribute the lack of knowledge about the effects of oven, microwave and sun drying on the antioxidants contains of basil herbs.

MATERIALS AND METHODS

Plant

Basil (*O. basilicum L.*) was obtained from the local market in Jeddah, Saudi Arabia. The plant leaves were divided into four parts, 500 g each. The first was used fresh. The other was used for each drying process; every experiment was carried out in triplicate.

Methods of dryness

Three methods were used for draying of plant leaves. Sun-drying, oven draying and microwave draying. In Sun-drying process the leaves were evenly spread on a tray, covered with the cotton sheets and left to dry in the shade place (35°C) for 2 days, until the vegetables were brittle and considered to be dry. In the oven drying process, the plant leaves were kept in oven at temperature of 50 °C for 15h. In the Microwave-drying process, plant leaves were placed in glass plates, which were placed in a microwave oven with power strength of 100 W for 3 min. After draying all leaves samples were ground to get a fine powder using a dry grinder.

Moisture content determination

The Moisture content in fresh and dried leaves was determined by the standard procedures of the AOAC (2000).

Samples extraction

Water and ethanolic extracts were prepared from the fresh and dried herb powder. The plant samples were placed in hot (40 °C) shaking water bath for 24 h 60 rpm. The samples were centrifuged at 1500 rpm for 20 min. The extract was dried by freezing at -50°C for 72 h then evaporated under vacuum. The extract was preserved at -20 °C until be used.

Determination of total phenols

The total phenolic content (TPC) of extracts was measured using the previously reported Folin–Ciocalteu method (Chew *et al*., 2009) the results were expressed as mg of Gallic acid equivalents per gram of extract (mg GAE/g extract).

Determination of Total Flavonoids

The colorimetric method was used for investigation of TFC in the basil extracts using the method of Sakanaka *et al*. (2005). Quercetin was used as slandered. The obtained results were expressed as mg QE/g.

In Vitro Antioxidant Activity Assay

DPPH (1, 1-diphenyl-2 picryl hydrazyl) scavenging activity was determined as previously described by Ibrahim *et al*. (2013). The extract concentrations that were required to scavenge 50% (IC50) of DPPH were determined. Tert-butyl-4-hydroxyanisole (BHA) was used as standard.

Statistical Analysis

The obtained results will be analyzed using SPSS program (SPSS Inc., Chicago, IL, version 20, USA). The data will be presented as mean ± SD. One-way analysis of variance (ANOVA) will be applied for compare the data between the groups. The inter-grouping similarity will be analyzed using Duncan's test.

RESULTS AND DISCUSSION

Moisture content

The fresh basil leaves moisture was 87.2±5.1. The moisture percent was significantly decreased by all the drying methods in comparison with the fresh samples. No statistical difference was revealed between the deferent drying methods (table 1). Musa *et al*. (2005) found that, the moisture contains was 84.67%, 12.37% and 15.33% for fresh basil, oven and microwave dried samples respectively.

Antioxidant capacity

The antioxidant activities of the basil aqueous and ethanolic extracts were investigated. BHA was used as standard. The DPPH is the commune substrates for monitoring of antioxidant activity. DPPH is stabile in the radical form. The DPPH assay is simple. The DPPH assay investigates the ability of extracts to produce electrons. The electrons are used in the reduction of DPPH. The color of DPPH was transferred from purple to yellow from which IC50 values were determined (table 2).

When comparing the basil extract with BHA for neutralizing of DPPH we found that only the H2O extract of fresh leaves had stronger antioxidant properties than BHA. Drying processes resulted in significant reduction in antioxidant capacity in all tested samples. The results revealed that the air-dried aqueous extract showed the highest antioxidant activity compared with the oven-dried and microwave-dried leaves (table 2). The decrease in the antioxidant capacity may refer to the decrease in TPC and TFC contents may be due to the drying process. According to Tomaino *et al*., (2005) microwave drying process would generally result in a depletion of naturally occurring antioxidants in raw grapes. It is necessary to investigate the effects of different method that be used for herbs drying. The best daring method should be known to decrease the harmful effects of draying on the herbs antioxidant capacity. And minimize the deleterious action of the methods on phenolics and flavonoids in herbal plants. There is high difference between the draying methods effects. The highest radical scavenging activity was observed in the aqueous extract of air-dried herb then the oven and the lowest is microwave-dried aqueous extract. Additionally, the same trained was observed in the ethanolic extract. Similarly, Ibrahim *et al*. (2013) proved that the ability of *Streblus asper* dried by oven for scavenging of DPPH was reduced.

Total phenols

The TPC of basil extracts was investigated. The plant phenolics are most important compounds in plants that have

Table 1. Moisture content (%) wet weight basis (wwb) of *O. basilicum L* with different methods of drying

	Draying Method			
	Fresh	Air drying	Oven drying	Microwave drying
Moisture %	87.2±5.1	8.2±1.3***	7.4±1.1***	7.9±1***

Each value represents means (n = 3 ± SE) *** indicate significant differences at P < 0.001 in comparison with the fresh samples.

Table 2. IC50 values (µg/mL) of DPPH radical neutralized with *O. basilicum* leaves aqueous and ethanol extracts of fresh, air, oven and microwave drying methods

Extract solvent	IC50 values (µg/mL)				
	Fresh	Air drying	Oven drying	Microwave drying	BHA
Water extract	12±1.3^{d}	17.1±3.1^{c**}	20.1±3.1^{b**}	25.1±4^{a***}	13.2±2.1
Ethanolic extract	8.1±0.7^{d*}	19.5±1^{c**}	24.3±4^{b**}	29.6±2^{a***}	13.2±2.1

Means (n = 3 ± SE) with different letters in the same row indicate significant differences at P <0.05 between the draying methods as determined by Duncan's multiple range test. Asterix indicate significant differences at ***P < 0.001, **P < 0.01, *P < 0.05 in comparison with BHA standard

antioxidant activity through scavenging of free radicals. It was reported that the basil leaf are rich in phenolic compounds (Wong and Kitts, 2006). Additionally, Phenolic compounds have nutritional values; they prevent lipid peroxidation (Paul Raj *et al*., 2011).

The results revealed that the TPC in fresh basil extracts was ranged from 185±15.1 mgGAE/g extract to 172.3±17.2 mgGAE/g extract in water and ethanolic extract respectively (table 3).The drying method produced a significant alterations in the TPC of the basil extracts. The TPC was highest in the extracts from the air-dried samples and lowest in microwave dried samples. The extraction process aqueous or ethanolic had no effect on the amount of TPC in fresh and dried samples. Drying processes generally resulted in a marked depletion of total phenols of fresh plants especially in case of using microwave drying. Intense and prolonged thermal drying may be responsible for a significant loss of total phenols than none heated samples. Microwave drying resulted in reduction of total phenols by 28% and 18% than did air drying and oven drying. Fresh basil sample lost its phenol content by 46% due to microwave drying, while 43% loss was due to the oven drying and only 24% loss was observed in the air dried sample referred to the fresh one. The recorded decrease may be due to that lots of phenolic substances rapidly decompose when dried at high temperature (Mueller-Harvey, 2001). The obtained data are in accordance with Annamalai *et al*., (2011) who reported that microwave dried sample yielded very poor content of total phenolics when compared to the high values of fresh sample. These findings also are in line with Komes *et al*., (2011) who found that fresh plants were characterized with the highest contents of polpyhenols.

Total Flavonoids Content

The results revealed that amount of Total Flavonoids Content (TFC) in fresh basil extracts was ranged from 19±1.2 mgQE/g extract to 16.3±1 mgQE/g extract in water and ethanolic extract respectively (table 4).The drying method produced an alterations on the concentrations of TFC in basil extracts. The TFC was highest in the extracts from the air-dried samples and lowest in microwave dried samples.

The extraction process aqueous or ethanolic had no effect on the amount of TFC in fresh and dried samples. Drying processes generally resulted in a marked depletion of TFC of fresh plants especially in case of using microwave drying. Intense and prolonged thermal drying may be responsible for a significant loss of TFC than none heated samples. Microwave drying resulted

Table 3. Total phenolic contents of *O. basilicum L* extracts of fresh, air, oven and microwave drying methods

Extract solvent	Total phenolic contents (mg GAE/g extract)			
	Fresh	Air drying	Oven drying	Microwave drying
Water extract	185±15.1^{a}	140±11.3^{b}	123±9.2^{c}	101±13^{d}
Ethanolic extract	172.3±17.2^{a}	146±13.2^{b}	120±10.5^{c}	103±12^{d}

Means (n = 3 ± SE) with different letters in the same row indicate significant differences at P <0.05 between the draying methods as determined by Duncan's multiple range test

Table 4. Total flavonoid contents of *O. basilicum L* extracts of fresh, air, oven and microwave drying methods

Extract solvent	Total flavonoid contents (mg QE/g extract)			
	Fresh	Air drying	Oven drying	Microwave drying
Water extract	19±1.2^{a}	10±2.1^{b}	8.8±0.9^{c}	7.1±0.6^{d}
Ethanolic extract	16.3±1^{a}	10.5±1.4^{b}	7.9±1^{c}	7±0.5^{d}

Means (n = 3 ± SE) with different letters in the same row indicate significant differences at P <0.05 between the draying methods as determined by Duncan's multiple range test. QE, quercetin equivalents

in reduction of TFC by 29% and 20% than did air drying and oven drying. Fresh basil sample lost its phenol content by 63% due to microwave drying, while 54% loss was due to the oven drying and only 48% loss was observed in the air dried sample referred to the fresh one (table 4). Our results are in the same line of a previous work (Kaur and Kapoor, 2002; Ibrahim *et al*., 2013) which demonstrated that high temperature may lose the flavonoids compounds. The Reduction in flavonoid and phenolic contents leads to decrease in antioxidant activity (Tomaino *et al*., 2005). Our work demonstrated that the air-drying is the most valuable method for retaining of the flavonoids and phenolics in basil leaves. On the other hand, Oven drying may decompose the phenolics due to high temperatures (Mueller-Harvey, 2001). Additionally, the results confirm that the air-dried aqueous basil extract was the best source for the antioxidants, phenolics and flavonoids. (Abascal *et al*., 2005). The oven and microwave draying were accompanied with a reduction in TPC and TFC that may be explained by the long drying period, high temperature (Ibrahim *et al*., 2013).

CONCLUSION

The draying methods have deferent deleterious effects on the basil extracts TPC, TFC and antioxidant activity. The air-dried extracts retained the best antioxidant properties and the highest TPC, TFC. The microwave-draying method has the worst effect on antioxidant properties, the amounts of phenolics and flavonoidsin basil leaves.

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