Effect of Drying Methods on Essential Oil Yield, Total Phenol Content and Antioxidant Capacity of Peppermint and Dill

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Summary: The present study aimed to estimate the effects of different drying methods on appropriate drying time, essential oil yield, total phenol content and antioxidant capacity of *Anethum graveolens* L. and *Mentha piperita* L. Factorial experiment was conducted in completely randomized design at research field and laboratory of agricultural campus of the University of Guilan during 2011-2012. Treatments were: two levels of plant type (peppermint and dill) and four levels of drying methods (oven drying at 60°C and 75°C, drying at natural shade and drying exposed to sunlight). Results indicated that different drying methods had significant effect on all observed characteristics. In this experiment increasing oven temperature lead to reduction of essential oil yield. Minimum and maximum essential oil were obtained when dill and peppermint were oven dried at 75°C (20.11 ml m⁻²) and dried in shading (28.44 ml m⁻²), respectively. Oven drying at 75°C reduced antioxidant capacity of dill while shade-drying increased antioxidant capacity of peppermint. However drying at 60°C may be an appropriate temperature for drying peppermint and dill plant material, due to a significant reduction of drying time with no adverse effects on the essential oil yields.

Key words: antioxidant capacity, dill, drying, essential oils, *Mentha piperita* L., *Anethum graveolens* L., peppermint, phenols

Introduction

Peppermint (*Mentha piperita* L.) belongs to Lamiaceae family and is a medicinal plant widely used in food, pharmaceutical and health care industries (Miliauskas et al. 2004, Omidbeigi 2009). Its essential oil, well known as peppermint oil, is used both as a medicinal agent and as a flavouring agent in foods and confectionery (Singh et al. 2011, Milovanovic et al. 2009, Miliauskas et al. 2004, Namiki 1990). In Iran, peppermint is a perennial crop established with transplants in the spring and has an average stand life of about six years (Ayyobi et al. 2013). Peppermint is native to temperate region, especially Europe, North America and Africa and it has been cultivated worldwide (Singh et al. 2011). It has been shown that peppermint oil has very strong antioxidant activities (Mimica-Dukic et al. 2003, Singh et al.

2011, Milovanovic et al. 2009, Miliauskas et al. 2004). Natural antioxidants derived from spicy herbs are widely evaluated for their antioxidant properties (Andreja et al. 2000). Chemical compounds with strong antioxidative properties can be classified into two groups: natural and synthetic (Singh et al. 2007). In many cases their primary antioxidant role in suppressing the negative effects of free radicals in the tissues of living organisms, as well as the prevention of some forms of cancer is confirmed (Namiki et al. 1990, Kahl & Kappus 1993). Obviously, for these reasons, scientists are attracted to the opportunity to study a broad population of medicinal herbs and utilize aromatic organic compounds isolated from these plants as a natural source of chemical compounds with strong antioxidant activity (Kulicic et al. 2004).

Dill (*Anethum graveolens* L.) belongs to Apiaceae family (Omidbeigi 2000). It is annual aromatic plant species which possesses several biological properties; it is an appetizer, carminative, diuretic and antispasmodic (GharibNaseri & Haeidari 2006, Taher et al. 2007).

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Drying is one of the most traditional ways for preservation of agricultural products in post-harvest stage facilitating their long-term storage and preventing activities of enzymes, microorganisms and yeast (Ebadi et al. 2010). Different experiments showed the effect of various drying methods on content and composition of essential oil in medicinal plants (Karawya et al. 1980, Raghavan et al. 1997).

Although several drying methods including drying in vacuum, drying in a microwave drier or drying in an inert atmosphere have been used extensively to fulfil the demand for long shelf-life of food products, each drying method has certain limits that can affect the drying rate and the quality of food products in terms of colour, flavour and nutrient retention. In recent years, several studies have been carried out using inert atmosphere, particularly in heat pump dryers. Applications of inert atmosphere are increasing for drying food products in order to yield better quality products. Heat pump drying of food products under inert environment where the drying medium is nitrogen gas or carbon dioxide provides an opportunity to retain quality in terms of colour, flavour and nutrients (Hawlder & Khin 2008). This system enables independent control of the temperature and relative humidity of the drying medium, which is considered essential for heat sensitive food products (Hawlder & Khin 2008). The absence of oxygen from the drying media prevents oxidation of food products during drying and, as such, no browning occurs. However this method is expensive and need special equipment then cheaper methods are more suitable for vegetables such as dill and peppermint.

In an experiment with savory (*Satureja hortensis* L.), among the different drying methods (shading, sunlight and oven drying in 45°C), the highest and lowest essential oil content was obtained with oven drying at 45°C and sun drying, respectively (Sefidkon et al. 2006, Ebadi et al. 2010). In Roman chamomile (*Anthemis nobilis*), the highest essential oil content was obtained with drying of plant material in shade (Omidbeigi et al. 2004).

Since there is limited information regarding essential oil, total phenol content and antioxidant capacity of dill and peppermint under different drying methods this experiment was conducted in order to select the most appropriate drying method with regard to the qualities of those medicinal plants.

Materials and Methods

Plant Materials

In order to evaluate the effect of different drying methods with regard to drying time and temperature, essential oil yield, total phenol content and antioxidant capacity of *Anethum graveolens* L. and *Mentha piperita* L., a factorial experiment was conducted in a completely randomized block design with three treatments in research field and laboratory at the University of Guilan campus, Agriculture Faculty, Rasht, Iran (altitude 7 m below mean sea level, 37°16'N, 51°3'E), during 2011- 2012. Samples from each plant were oven dried at 60 and 75°C and dried under shade and sunlight. On April 15, the rooted cuttings of peppermint were planted in 4 m² plots. On April 23, the seeds of dill were planted. Leak irrigation was used every seven days. The conditions for all plots were identical and after soil analysis and before cultivation, 7 tons of vermicompost was added to the soil and hand weeding was done. Soil type was loam, pH 7.44, containing total N (1%), and total C (1.08%); and there were 4,600 mg kg⁻¹ Ca, 1,700 mg kg⁻¹ P, and 4,000 mg kg⁻¹ K in soil dry matter (DM), with an electrical conductivity (EC) of 0.1 ds cm⁻¹. Peppermint plants were harvested when flowering was about 15%, while the dills were harvested when full bloomed.

Drying of Plant Material

Samples from each plant were oven dried at 60 and 75°C, and dried in shade and sunlight.

Determination of Total Phenol Content and Antioxidant Capacity

Methanol extracts of sample (1 g of sample in 10 ml of methanol) were used for the determination of total phenol content. Total phenolic content was evaluated by colorimetric analyses using Folin-Ciocalteu's phenol reagent (Singleton & Rossi 1965) and it was expressed as mg galic acid equivalent per 100 g of sample. The free radical-scavenging activity against 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical was evaluated with the modified methods of Leong and Shui (2002) and Miliuskas et al. (2004). In the presence of an antioxidant, the purple colour intensity of DPPH solution decays and the changes of absorbance are followed spectrophotometrically at 517 nm.

Table 1. Effect of different drying methods and plant species on essential oil yield, total phenol content and antioxidant capacity (ANOVA test)

Source of variation	df	Mean square			
		Drying time	Essential oil yield	Total phenol	Antioxidant capacity
type of plant (A)	1	24.00 ^{ns}	22.97 [*]	55.61 ^{ns}	3866.64 ^{ns}
drying methods (B)	3	6915.27 ^{ns}	38.72 ^{ns}	5.18 [*]	34.04 [*]
A*B	3	35.77 ^{ns}	11.18 [*]	3.42 [*]	3.31 ^{ns}
Error	16	6.20	5.20	0.6	7.66
C.V. (%)		3.22	9.56	12.98	5.28

ns, *,** non-significant or significant at $P \leq 0.01$ and $P \leq 0.05$, respectively.

Determination of the Essential Oil Content

Chopped stems, leaves and plants were placed in a forced air drying oven at 75°C for 48 hours to determine dry matter. For the evaluation of the amount of essential oil a sample of 100 g of drying matter mixed with 800 ml of water was distilled for 3 hours using a Clevenger apparatus.

Statistical Analysis

Data were subjected to general linear method (GLM) in SAS (ver. 9.1, SAS Institute, Inc., Cary, NC). Means were separated using the Tukey test.

Results and Discussion

Different drying methods significantly influenced drying time, essential oil yield and antioxidant capacity (Table 1). There were significant differences between two plant species regarding total phenol content, antioxidant capacity and essential oil yield (Table 1). Interaction between type of plant and drying methods had significant effect on drying time, total phenol and essential oil yield (Table 1).

Drying time decreased in both plants (peppermint and dill) when oven dried at 75°C. In general, the highest drying time is related to peppermint and shading (125.00 h) while the lowest is related to dill and oven drying at 75°C (45.66 h) (Table 2). The highest antioxidant capacity is related to peppermint and shading (69.40%) while the lowest is related to dill and oven dried at 75°C (54.51%) (Table 2). The highest essential oil yield is related

to peppermint and shading (28.44 ml m²) while the lowest is related to dill and oven dried at 75°C (20.11 ml m²) (Table 2). There were no significant differences in essential oil yield between drying in shade, drying under the sunlight or oven drying at 60°C (Table 2). The highest total phenol content is related to shade-dried peppermint (9.54) while the lowest was related to dill dried under the sunlight (4.38) (Table 2).

Most people used drying methods in order to protect the herbs from bacterial or fungal contamination (Hajimehdipoor et al. 2012). Chemical changes are the most important degradation process in medicinal plants and can be influenced with drying (Fennell et al. 2004). In agricultural crops, it is important to identify appropriate time for drying because excessive decrease of humidity results in decreased quality and quantity of final crops (Hevia et al. 2002).

Previous research indicates that drying methods changed phenolic content of *Azadirachta indica* and *Rosmarinus officinalis*, and that the shade dried leaves contained the higher phenolic contents in comparison to the oven dried leaves (Sejali & Anuar 2011, Khorshidi et al. 2009). Drying methods also showed to affect essential oil content and chemical composition (Ahmadi et al. 2008, Asekun et al. 2006, Asekun et al. 2007, Khorshidi et al. 2009, Okoh et al. 2008, Sefidkon et al. 2006). The results of our investigations and some other studies showed that each plant needs a special drying method to keep the highest content of essential oil yield, antioxidant capacity and the highest total phenolic compounds.

Table 2. Interaction of plant species and drying methods with regards to essential oil yield, total phenol content and antioxidant capacity

Type of plant	Drying method	Means			
		Drying time (h)	Essential oil yield (ml.m2)	Total phenol (mg galic acid per 100 g)	Antioxidant capacity (% of inhibition)
Peppermint	75 °C	47.00 ^d	21.61 ^b	5.65 ^{bc}	62.13 ^{abc}
	60 °C	58.00 ^c	25.78 ^{ab}	6.87 ^{abc}	63.99 ^{abc}
	Sunlight	83.00 ^b	22.40 ^{ab}	8.19 ^{ab}	64.73 ^{ab}
	Shade	125.00 ^a	28.44 ^a	9.54 ^a	69.40 ^a
Dill	75 °C	45.66 ^d	20.11 ^b	4.40 ^c	54.51 ^c
	60 °C	54.33 ^{dc}	23.28 ^{ab}	4.44 ^c	54.72 ^c
	Sunlight	88.00 ^b	22.17 ^{ab}	4.38 ^c	55.26 ^{bc}
	Shade	118.00 ^a	24.85 ^{ab}	4.87 ^c	58.18 ^{bc}

In each column values followed by the same letters do not significantly differ

Conclusions

The plant drying method has very strong effects on essential oil yield, total phenol and antioxidant capacity. The method where plants were oven dried at 60°C was the best for drying peppermint and dill because it preserved total phenol content, essential oil yield and antioxidant capacity and significantly reduced drying time than shading.

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Uticaj metoda sušenja na prinos etarskog ulja, ukupni sadržaj fenola i antioksidativni kapacitet pitome nane i mirođije

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Sažetak: Cilj istraživanja je bila procena uticaja različitih metoda sušenja na vreme sušenja, prinos etarskog ulja, ukupni sadržaj fenola i antioksidativni kapacitet biljaka *Anethum graveolens* L. i *Mentha piperita* L. Faktorijski eksperiment je sproveden u potpuno slučajnom dizajnu na eksperimentalnom polju i laboratoriji poljoprivrednog kampusa Univerziteta u Gilanu, Iran tokom 2011-2012. Tretmani su uključili dva nivoa biljne vrste (pitoma nana i mirođija) i četiri nivoa metoda sušenja (sušenje u sušnici na 60°C i 75°C, sušenje u prirodnoj senci i sušenje na suncu). Rezultati su pokazali da su različite metode sušenja imale značajan uticaj na sve posmatrane osobine. U ovom eksperimentu povećanje temperature u sušnici uzrokovalo je smanjenje prinosa etarskog ulja. Najveći i najmanji prinosi etarskog ulja postignuti su kada su se mirođija i pitoma nana sušile u sušnici na temperaturi od 75°C (20,11 ml m⁻²) i u senci (28,44 ml m⁻²). Sušenje u sušnici na temperaturi od 75°C smanjilo je antioksidativni kapacitet mirođije, dok je sušenje u senci povećalo antioksidativni kapacitet pitome nane. Međutim, sušenje na temperaturi od 60°C bi moglo biti odgovarajuće za sušenje biljnog materijala pitome nane i mirođije zbog značajnog skraćivanja vremena sušenja bez ikakvih negativnih uticaja na prinos etarskog ulja.

Ključne reči: *Anethum graveolens* L., antioksidativni kapacitet, etarsko ulje, fenoli, *Mentha piperita* L., mirođija, pitoma nana, sušenje