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Extraction of essential oils from *Mentha piperita* using advanced techniques: Microwave versus ohmic assisted hydrodistillation

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ABSTRACT

Ohmic and microwave assisted hydrodistillation (OAHD and MAHD, respectively) are advanced hydrodistillation (HD) techniques utilizing ohmic and microwave heating processes for extraction of essential oils. OAHD and MAHD of essential oils from the aerial parts of peppermint were studied and the results were compared with those of the traditional HD. The results showed that OAHD and MAHD methods require less than half an hour for extraction process while HD require about 1 h. Scanning electron microscopy of mint leaves undergone OAHD and MAHD provided evidences as to a sudden rupture of essential oil glands. GC–MS analysis did not indicate any noticeable changes in the compounds of the essential oils obtained by novel studied methods in comparison with HD. The results introduced OAHD as the greenest technique in terms of energy consumption. MAHD was superior in terms of rate of essential oils accumulation and also extraction duration parameter.

1. Introduction

Mentha piperita L. (common known as peppermint), a perennial aromatic/medicinal plant belonging to the family Lamiaceae, is a hybrid of *M. spicata* L. and *M. aquatic* (Gulluce et al., 2007). This plant was cultivated by the ancient Egyptians and documented in the Icelandic pharmacopoeia of the thirteenth century. It is widely grown in temperate areas of the world, particularly in Europe, North America and North Africa. However, nowadays peppermint is cultivated in other regions of the world including Middle East (Briggs, 1993; Gulluce et al., 2007).

The essential oil of peppermint is commercially used in different industries including food, beverages, pharmaceutical,

Abbreviations: OAHD, ohmic assisted hydrodistillation; MAHD, microwave assisted hydrodistillation; HD, hydrodistillation; SHD, salted hydrodistillation; NHD, normal hydrodistillation; GC–MS, gas chromatography–mass spectrometry; SEM, scanning electron microscopy.

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cosmetics, health and tobacco. The major consumer of mint essential oil is tobacco industry (by consumption of more than one third of the total mint essential oil) followed by pharmaceutical and confectionary industries. Usually the main components of peppermint oil include menthol, menthone and menthofuran. The main substance that gives the mint its characteristic aromas and flavors is menthol. This compound is used as a raw material in toothpaste, chewing tobacco, confectionary, mouth fresheners, analgesic balms, cough drops, perfumes, chewing gums, candies and tobacco industry (Carmines, 2002). The peppermint oil is reported to have anti-oxidant and antibacterial activities (Singh et al., 2011) and is one of the most important constituents of some over-the-counter remedies in Europe for irritable bowel syndrome (Pittler and Ernst, 1998).

Essential oils can be isolated from aromatic plants using a number of extraction techniques. Among them, hydrodistillation (HD) has been the most common approach to extract the essential oils from the medicinal plants (Stahl-Biskup and Sáez, 2002) and known as the traditional method of essential oils extraction. However, in order to reduce the extraction time and possibly improve the extraction yield, to enhance the quality of the extracts and also to reduce the operation costs, new approaches such as microwave-assisted extraction (MAE), pressurized solvent extraction, supercritical fluid extraction, and ultrasound-assisted extraction have also been sought (Kaufmann and Christen, 2002; Wang and Weller, 2006).

Among novel extraction methods, employing ultrasound or microwave heating as assisting techniques are widely studied. In employing ultrasound for plant extraction the collapse of cavitation bubbles and formation of microjets will lead to better cell disruption and consequently result in increased mass transfer, lower extraction temperatures and faster extraction rates (Toma et al., 2001; Mason et al., 2011). The acceleration of extraction rates under microwaves assisted extraction could be due to a synergistic combination of the mass and heat acting in the same direction and also due to fast internal heating which depends on the microwave power and the dielectric loss factor of the material (Chemat et al., 2009; Mason et al., 2011).

Some recently-published studies have successfully utilized a microwave oven for the extraction of active components from aromatic plants (Lucchesi et al., 2004; Stashenko et al., 2004; Wang et al., 2006). Lucchesi et al. (2004) reported a solvent-less microwave method for the extraction of essential oils from three medicinal herbs (basil, garden mint, and thyme). The amount of essential oils obtained in half an hour with this method was comparable, both from qualitative and quantitative points of view, to those obtained after more than 4 h by HD. In an attempt to take advantage of microwave heating with the conventional HD, microwave-assisted hydrodistillation (MAHD) was then developed and used for the extraction of essential oils from *Xylopia aromatica* (Stashenko et al., 2004). MAHD was also reported for the extraction of essential oils from *Cuminum cyminum* L. and *Zanthoxylum bungeanum* Maxim (Wang et al., 2006) and also for *Thymus vulgaris* L. (Golmakani and Rezaei, 2008b) and *Zataria multiflora* Boiss (Golmakani and Rezaei, 2008a).

OAHD has been recently proposed for extraction of essential oils from aromatic plants. This emerging technology uses ohmic heating to generate heat inside the materials rapidly depending on the electrical conductivity of materials. As a result, greater and faster disruption of cells and also higher heating rate can decrease the required process time. This method was first reported by Gavahian et al. (2011) for extraction of essential oils from *Z. multiflora* (Shirazi thyme) as a faster and more environmentally friendly method than conventional HD. This method was also used for extraction of essential oils from *T. vulgaris* L. and the results showed that this method consumed less energy, had shorter extraction time (about 25 min vs. about 1 h for HD) and yielded approximately same amount of essential oils (Gavahian et al., 2012). Similar results were reported by Gavahian et al. (2013), for extraction from *Myrtle communis*. Hamzah et al. (2011) also used OAHD for extraction of essential oil from four different aromatic herbs including *Cymbopogon atratus* (Lemon grass), *Cymbopogon nardus* (Citronella grass), *Backhousia Citriodora* (Lemon myrtle) and *Syzygium aromaticum* (clove) and reported that in most cases, OAHD required less energy and yielded more essential oils than HD.

Usually emerging technologies have a high degree of uncertainty and complexity, and these make their industrialization difficult. Industries have to decide which emerging technology is more suitable to be used as a substitution of traditional methods. Comparing novel technologies which can have the same application and new advantages will facilitate industrial decision. Both OAHD and MAHD are new proposed technologies to industry with some similar advantages including reducing process time.

However, to the best of authors' knowledge no work has been published on comparison of MAHD and OAHD of mint species or any other aromatic herbs. Therefore, the objectives of this study were to investigate the advantages of MAHD and OAHD for the extraction of essential oils from dried *M. piperita* (peppermint) aerial parts. An attempt has also been made to compare extraction time, extraction yield/efficiency and aromatic composition of the extracts of MAHD and OAHD with those of HD (as the reference method of extraction).

2. Materials and methods

2.1. *Plant materials*

Fresh aerial parts of peppermint when the plant has enough foliage (before flowering stage) were collected from an indigenous crop in Noor-Abad (Mamasani, southern Iran), in July 2013.

The identity of the genus Mentha was certified by plant taxonomy experts from Biology Department of the Shiraz University, Shiraz, Iran. The herbs were then dried in a dark room under ambient conditions (30–40 °C) for four days on a large screened tray, packed in high density poly ethylene (HDPE) bags, put in a cardboard box and kept in a dark and cool place for further experiments. The moisture content of the plants was measured in triplicate using a laboratory oven by drying until constant weight and was about $12.4 \pm 0.2\%$.

2.2. *OAHD*

OAHD was performed using an ohmic distillator device with platinum electrodes as designed and developed by Farahnaky et al. (2010), in the Department of Food Science and Technology of Shiraz University, Shiraz, Iran. Processing parameters (e.g. processing time, temperature and power consumption), were precisely monitored using a software developed and coupled with a Wattmeter to record the input power of ohmic apparatus to double check the data given by the software. OAHD was performed at 220 V, 50 Hz and variable current values depending on the process time.