Note

Use of Microwave-assisted Hydrodistillation to Extract the Essential Oils from *Satureja hortensis* and *Satureja montana*

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Microwave-assisted hydrodistillation (MAHD) has recently been attended for the extraction of essential oils from medicinal plants/herbs. In this study, MAHD was investigated for the extraction of essential oils from two genotypes of savory (*Satureja hortensis*, so-called summer savory, and *Satureja montana*, so-called winter savory). Three levels of microwave power (220, 440 and 660 W) were selected for the extraction. MAHD resulted in a shorter extraction time compared to that in HD. Total extraction times at 660 W microwave power was 180 min for *S. hortensis* and 90 min for *S. montana*. The extraction yield obtained by MAHD was almost equal to that obtained by HD (3.1%, w/w, for *S. hortensis* and 0.7% for *S. Montana*). Extraction was more efficient at higher power levels.

Keywords: essential oils, microwave-assisted hydrodistillation, *Satureja hortensis*, *Satureja montana*, savory

Introduction

The use of herbs and plants in food industry has a long history. The diversity among the components of the plants has resulted in their use in many applications including in flavors and fragrances as well as in medicine. Essential oils are among the secondary metabolites produced within the various organs of medicinal herbs/plants. They are complex mixtures of volatile compounds such as terpenes (mostly monoterpenes and sesquiterpenes), phenolics and alcohols (Lucchesi *et al.*, 2004). The conventional method for the extraction of essential oils is hydrodistillation (HD), in which the essential oils are evaporated by heating a mixture of water and plant materials followed by the liquefaction of the vapors in a condenser. However, this method suffers from several disadvantages including losses in the volatile compounds, long extraction time and degradation of some components through thermal and/or hydrolytic effects (Khajeh *et al.*, 2004; Lucchesi *et al.*, 2004). Because of these shortcomings, newer approaches such as microwave-assisted extraction (MAE,) with or without the use of a solvent, have been developed. MAE, for example, has been applied for the

extraction of cocaine and benzoylecgonine from coca leaves by using both polar and nonpolar solvents (Brachet *et al.*, 2002). MAE has also been investigated for the extraction of essential oils from several herbs including artemisia (Hao *et al.*, 2002), caraway seeds (Chemat *et al.*, 2005), orange peel (Ferhat *et al.*, 2006), lavender (Chemat *et al.*, 2006), and cardamom (Lucchesi *et al.*, 2007). Another extraction method in this area is microwave assisted hydrodistillation (MAHD,) which is an advanced hydrodistillation method based on the use of a microwave oven. This technique has recently been investigated in the extraction of volatile secondary metabolites from *Lippia Alba* (Stashenko *et al.*, 2004a) and *Xylopi aromatic* (Stashenko *et al.*, 2004b). The efficiency of MAHD is strongly dependent on the dielectric constant of water and the matrix (Brachet *et al.*, 2002). MAHD causes the rapid delivery of energy to the total volume of solvent/sample leading to a rapid rise in the temperature. Heat is originated through the molecular motions within the polar components or ionic species (Brachet *et al.*, 2002). That is, the rise in temperature within the plant cells is similar to that occurring outside the cells. Once the pressure within the glands reaches above certain level, the external cell walls break apart and as a consequence the essential oils are released to the environment (Chemat *et al.*, 2005). From this

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point on, the essential oils are carried away by water vapor, liquefied in the condenser on the top of the main apparatus and collected in the receiving flask (Chemat *et al.*, 2006). Because of different densities and also due to their immiscibilities, water and essential oils are separated from each other and the excess water is refluxed to the extraction vessel (Chemat *et al.*, 2006).

Savory, from the Labiatae family, is among the medicinal plants having relatively higher level of essential oils when compared to other herbs. Carvacrol, γ -terpinene, p -cymene and thymol are among the most important bioactive components present in the essential oils of savory (Sefidkon *et al.*, 2006). While having strong flavors, these components also possess certain levels of antimicrobial and medicinal properties. Extraction of essential oils from savory has been reported using HD (Sefidkon and Jamzad, 2005; Sefidkon *et al.*, 2006) and supercritical fluid extraction (Esquivel *et al.*, 1999). However, no studies have been reported in the literature to apply MAHD for the extraction of essential oils from savory. Therefore, the objectives of this study were to extract the essential oils from two genotypes of savory, *Satureja hortensis* (summer savory) and *Satureja montana* (winter savory) using MAHD and to compare the yields and the extraction kinetics in this method with those of HD.

Materials and Methods

Plant materials *S. hortensis* was provided from the farms of Industrial Center for Plant Pesticides and Fertilizers (Karaj, Iran). *S. montana* was harvested from Maraghe, Azarbayejan, Iran. Both plants were cleaned and dried in a dark room at 25°C. The initial moisture contents of *S. hortensis* and *S. montana* at the time of extraction were 8.6 and 9.0% (w/w), respectively.

Hydrodistillation A “water to plant” ratio of 20:1 (w/w) was considered for HD. Sixty g *S. montana* was mixed with 1.2 L of distilled water and extraction was performed using a Clevenger-type apparatus for a total length of 4 h, after which no more essential oils were extracted. The essential oils were collected, dried over anhydrous sodium sulphate and stored at 4°C until used. For *S. hortensis*, 30 g plant materials were mixed with 600 mL of distilled water and extraction was performed in a similar approach as the one explained for *S. montana*. For each plant, extraction was repeated 3 times.

Microwave-assisted hydrodistillation MAHD was performed at atmospheric pressure with a microwave frequency of 2450 MHz using a household microwave oven (Panasonic Corp., Japan, model NN-S674 MF) with a maximum output power of 1100 W and inner dimensions of 22.5 cm $\times$ 37.5 cm $\times$ 38.6 cm equipped with a flask and a condenser.

Water/plant ratio of 20:1 (w/w) was also considered with MAHD and 60 g of *S. montana* and 30 g of *S. hortensis* were extracted using three different power levels of 220, 440 and 660 W. The essential oils were collected, dried over anhydrous sodium sulphate and then stored at 4°C until used. Extraction was performed 3 times for each plant.

Results and Discussion

Effect of extraction time Times needed to reach the extraction temperature (so-called induction times) are shown on Figure 1a for *S. hortensis* and Figure 1b for *S. montana*. For both methods, the extraction started at the boiling point of water at the ambient conditions. For MAHD (at 660 W), the extraction started much earlier than that in HD. With HD, induction time was 14 min for *S. hortensis* and 30 min for *S. montana*. However, with MAHD at 660 W, the induction time was 6 min for *S. hortensis* and 12 min for *S. Montana*. Such results can be attributed to the more powerful effect of microwaves on water, a solvent with a high dielectric constant. However, once the microwave power was reduced to 220 W, the induction time with MAHD was longer than that in HD (Figs. 1a and 1b). This is related to the low density of

Fig. 1. Effect of microwave (MW) power on the starting time of extraction in *S. hortensis* (a) and *S. montana* (b). Hydrodistillation (HD) was used as a reference method (n=3).

Fig. 2. Effect of microwave (MW) power on the extraction time of essential oils from *S. hortensis* and *S. montana*. Hydrodistillation (HD) was used as a reference method (n=3).

waves at this power level.

Total times needed to fully recover the essential oils from the two plants at different power levels are shown on Figure 2. MAHD needed shorter times than HD. Such effect is clearer when microwave power is increased to higher levels. Total extraction time needed for HD was 240 min for *S. hortensis* and 180 min for *S. montana*. These results are in agreement with those of Ferhat *et al.* (2006) and Chemat *et al.* (2006) in the extraction of essential oils from orange peels and lavender, respectively. It can also be concluded that by increasing microwave power from 220 to 660 W, the induction time for evaporation and total time for the extraction decrease (Figs. 1 and 2). According to Chen and Spiro (1995) and Lucchesi *et al.* (2007), at higher power levels, the microwaves (i.e., the radiations) can be absorbed by water more intensively and as a result the disruption rate of cellular texture and release of essential oils also increase. Using scanning electron microscopy, Chen and Spiro (1995) and Lucchesi *et al.* (2007) also reported that cells undergone MAE resulted in faster rupture than those undergone the conventional extraction. When studying two genotypes of thyme using MAHD, Golmakani and Rezaei (2008a,b) reported that chemical compositions of the oils extracted with MAHD were similar to those obtained by the conventional HD method.

Extraction yield The changes in the extraction yield of essential oils by HD and MAHD are shown on Figures 3a (*S. hortensis*) and 3b (*S. montana*). In both cases, the extraction yield increased with time. When considering the extraction patterns of each plant separately, both MAHD and HD resulted in similar yields after the extraction was over. Total yield of extraction was 3.12% (w/w) for *S. hortensis* and 0.7% (w/w) for *S. montana*. In the extraction of essential oils from *Origanum glandulosum*, Bendahou *et al.* (2008)

Fig. 3. Extraction yield of essential oils from *S. hortensis* (a) and *S. montana* (b) by Hydrodistillation (HD) and microwave-assisted hydrodistillation (MAHD) (n=3).

reported that the extraction yield by HD was greater than that by MAE. This can be related to the differences in the properties of the solvents used in MAE and that of water, which is used in HD. Bendahou *et al.* (2008) used hexane as solvent, which has lower solvent power compared to water used in HD. According to Figures 3a and 3b, at a given time, in the early stages of extraction, extraction yield was greater with MAHD than with HD. For example, the extraction yield for *S. hortensis* at 50 min was 1.67% (w/w) with HD and 2.00, 2.37 and 2.48%, with MAHD at 220, 440 and 660 W, respectively. This is in agreement with the findings of Lucchesi *et al.* (2004) and Chemat *et al.* (2006) that MAE of essential oils from cumin, star anise and lavender needed shorter times than did HD. Indeed, water with a high dielectric constant absorb the radiation from the microwaves resulting in a rise in the temperature more rapidly than that in HD. Higher temperature causes an easier degradation of plant cells and consequently a shorter extraction time can be achieved (Käufmann *et al.*, 2001). This effect is more evident at higher power levels.

Conclusions

Extraction with MAHD was more efficient than that by the conventional HD using a Clevenger-type apparatus. However, both HD and MAHD resulted in similar amounts of extracts if enough time were allowed with HD. Therefore, in order to reduce the extraction time MAHD can be used for the extraction of metabolites from the herbs instead of conventional HD. There is a need to investigate the effect of microwave radiation on the structure of the components of essential oils especially those responsible for the flavor and fragrance from the plants.

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