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Qualitative and quantitative changes in the essential oil of sage (*Salvia hydrangea* DC exBenth.) as affected by different drying methods

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ABSTRACT

Background & Aim: *Salvia hydrangea* is one of the medicinal plants belonging to Lamiaceae family. Medicinal plants can be marketed as fresh or dried products; however aromatic plants are often dried before extraction to reduce moisture content. The aim of this study was to evaluate the impact of different drying methods on qualitative and quantitative changes in essential oil of sage.

Experimental: To determine the effect of drying methods on qualitative and quantitative characteristics of the plant essential oil, samples were dried in sunlight, shade, mechanical oven at 65ºC and then compared with fresh samples. The essential oils of all samples were extracted by hydrodistillation and analyzed using GC and GC–MS.

Results: The results showed that different drying methods had significant effects on essential oil content. According to results fresh herbs had the highest essential oil content followed by shade drying, sun drying and oven drying samples, respectively. Significant changes in chemical compound amount of the essential oils were observed which associated with the drying methods. Significant differences occurred among several constituents in the extracted essential oils, including a-pinene, camphene, phellandrene, 1,8-cineole and bornylacetate.

Recommended applications/industries: Drying of *Salvia hydrangea* aerial parts in the shade is more suitable for obtaining higher amount of oil yield and percentage of a-pinene and 1,8-cineole. Therefore, shade drying could be recommended for extraction of essential oil from this plant on an industrial scale.

1. Introduction

The genus *Salvia* (common name: sage) is the largest and the most important aromatic and medicinal member of the Lamiaceae family and includes about 1000 species of shrubs, herbaceous perennials and annuals (Farimani *et al.*, 2011). Salvia has radiated extensively in three regions of the world: Central and South America, western Asia and eastern Asia (Alziar, 1988–1993).

The pharmacological effects of *Salvia* essential oils are based on the presence of more than 100 active elements which can be categorized into Monoterpene

hydrocarbons, Oxygenated monoterpenes, Sesquiterpene hydrocarbons, Diterpenes, isoprenoid compounds and Oxygenated sesquiterpenes. Salvia species are also rich sources of polyphenolic flavonoids and phenolic acids. The major components contain 1,8-cineole, camphor, borneol, β-pinene, α- pinene, camphene and α-thujene and each of them has their own outstanding medicinal effects (Zhiming *et al.*, 2013).

Medicinal plants can be marketed as fresh or dried products, according to their use, howere aromatic plants are often dried before extraction to reduce moisture content. Fresh herbs (especially Lamiaceae) usually contain 75–80% water, and these water levels need to be lowered to less than 15% for preservation (Ghasemi Pirbalouti *et al.*, 2013a; Diaz-Maroto, *et al.*, 2002). Dehydration of herbs can be performed using different methods. The aim of this study was to evaluate the effect of various drying conditions (sun, shade and oven at 65ºC) on essential oil content and oil composition in *S. hydrangea*.

2. Materials and Methods

2.1. Plant materials

The arial parts of sage (*S. hydrangea*) were collected from Tang-e-sayad (Shahrekord), Southwest Iran (3563716 N and 0510449E) about 2430m above sea level. The plants were identified by taxonomic references (Rechinger, 1969) and specimens that have been placed in the Herbarium of the Research Center of Medicinal Plants, Shahrekord Branch, I.A.U., Iran (Voucher specimen no. 2316). The collected samples were randomly divided into four batches containing four sets of 300 g. One set was used for analysis of the fresh tissue and the remaining batches were dried using one of the following methods: air drying in shade at ambient temperature (20 ± 5 ºC); air drying in full sunlight at ambient temperatures (20–37°C); oven drying in hot air at 65 °C. All drying methods were replicated three times, the final moisture content of dried samples was determined after drying at 72 h in a lab oven at 75 °C. Dried (100 g) and fresh plant (200 g) materials were subjected to hydrodistillation (1000 ml distillated water) for 3 h using a Clevenger- type apparatus. Oil samples were kept in amber glass vials at 4 °C until analysis.

2.2. Gas chromatography/mass spectrometry (GC–MS) analysis

GC analysis was done on an Agilent Technologies 7890 gas chromatograph equipped with Flame Ionization Detector (FID) and a HP-5MS 5% capillary column (30 m × 0.25 mm, 0.25 µm film thicknesses). Oven temperature was kept at 60 ºC for 4 min initially, and then raised at the rate of 4 ºC/min to 280 ºC. Injector and detector temperatures were set at 290 ºC and 300 ºC, respectively. Helium was used as carrier gas at a flow rate of 2 ml/min, and 0.1 µl samples were injected manually in the split mode(1:40). Peak areas were used for quantifying the constituent percentage in total oil. The gas chromatograph was coupled to an Agilent 5975 C (Agilent Technologies, Palo Alto, CA, USA) mass selective detector (MSD) and quadrupole EI mass analyzer (Agilent Technologies, Palo Alto, CA, USA). Operating parameters for the EI-MS were: ionization voltage, 70 eV and ion source temperature, 250 ºC. Retention indices were calculated for all components using a homologous series of n-alkanes (C5–C24) injected in conditions equal to the oil samples. Identification of oil components was accomplished based on comparison of retention times with those of authentic standards, and by comparison of their mass spectral fragmentation patterns (WILLEY/ChemStation data system) (Adams, 2007). Area percent was obtained electronically from the GC–FID responses without the use of an internal standard or correction factors.

2.3. Statistical analyses

The data was statistically analyzed using one-way ANOVA by SPSS (19.0), and comparison of the means of main constituents for essential oils was evaluated by Duncan's multiple range test at $p < 0.05$ level. Analytical data for hierarchical cluster analysis were treated by means of the SPSS statistical software.

3. Results and discussion

3.1. Effect of drying methods on the essential oil yield

All essential oils extracted from the aerial parts of *S. hydrangea* dried under different conditions produced a clear, yellow liquid. An analysis of variance indicated that the drying method had a significant effect on oil yield. In accordance with our results, there are similar reports from other researchers about other medicinal

plants (GhasemipirbaloutI *et al.*, 2013 a, b; Ahmadi *et al.*, 2008). Fresh herbs had the highest essential oil contents (0.40ml/100g) followed by shade drying (0.20ml/100g), sun drying (0.15ml/100g) and oven drying (0.025ml/100g) respectively (Fig. 1). In total, the results showed that drying methods brought about significant losses of the essential oil content compared with fresh state and dried samples in shade had the higher essential oil as compared to samples that dried in sun and oven. In agreement with our results, the oil content of shade-dried *Roman chamomile* flowers was found to be larger (1.9% w/w) than there of sun-dried (0.4%) and oven-dried at 40ºC (0.9%) (Omidbaigi *et al*, 2004).

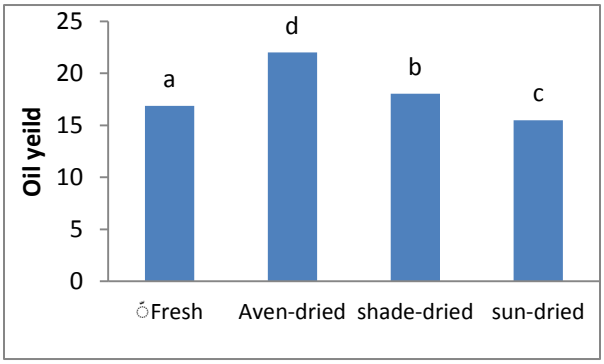

Fig. 1. Comparison of essential oil yield of fresh sample and dry samples of the drying methods. (Significant different at $p < 0.05$ have been indicated with different letters.).

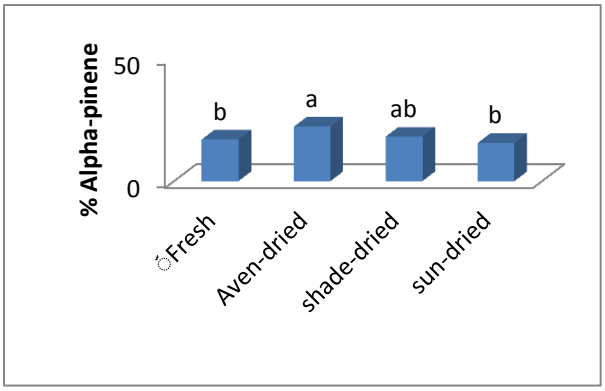

Fig. 2. Comparison of Alpha-pinene of fresh sample and dry samples of the drying methods. (Significant different at $p < 0.05$ have been indicated with different letters.)

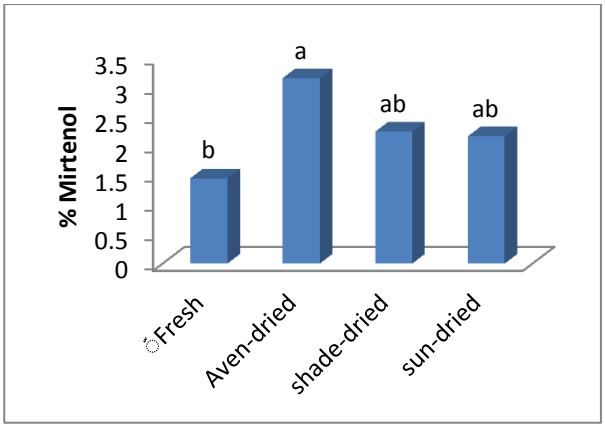

Fig 3. Comparison of Mirtenol of fresh sample and dry samples of the drying methods. (Significant different at $p < 0.05$ have been indicated with different letters.)

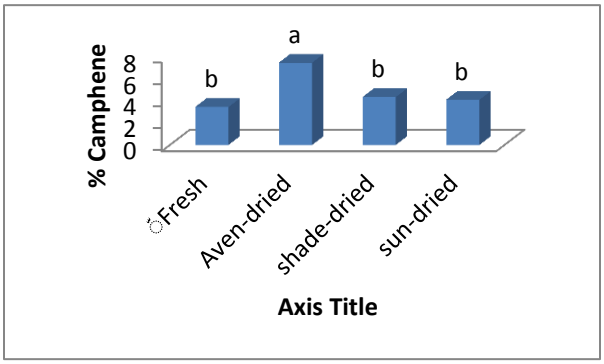

Fig. 4. Comparison of Camphene fresh sample and dry samples of the drying methods. (Significant different at $p < 0.05$ have been indicated with different letters.)

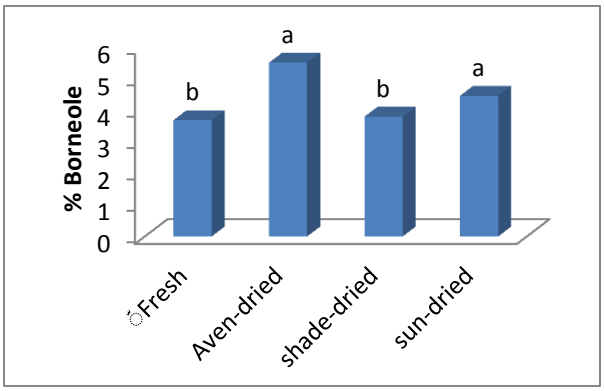

Fig. 5. Comparison of Borneole of fresh sample and dry samples of the drying methods. (Significant different at $p < 0.05$ have been indicated with different letters.).

Increasing in drying temperature significantly decreased the essential oil content, indicating that the biological structure of the oil glands of sage was collapsed, resulting in a loss of essential oils. In anatomical studies of fresh and dried leaves of spearmint (*Menthaspicata*), Diaz-Maroto *et al.* (2003) observed that epithelial cells in the dried samples can collapse and split open. A decrease in essential oil content with higher drying temperatures has been also reported by Venskutonis (1997) in thyme (*Thymusvulgaris*) when they were oven-dried at 60 ºC.

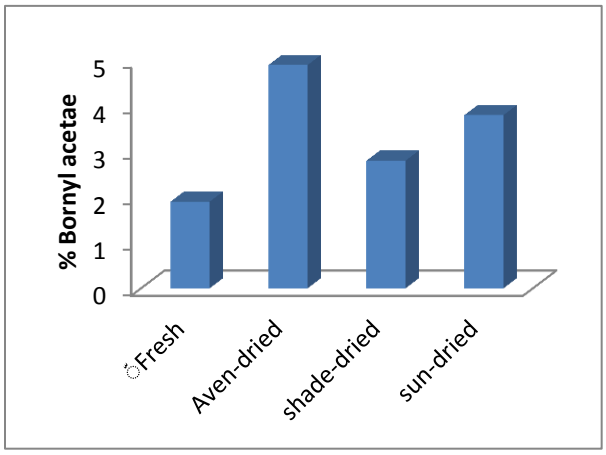

Fig. 6. Comparison Bornyl acetae of fresh sample and dry samples of the drying methods. (Significant different at $p < 0.05$ have been indicated with different letters.).

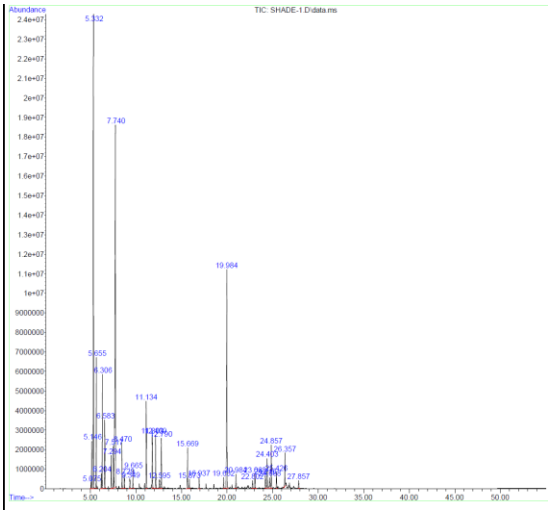

Fig. 7. Example of the chromatograms found in Shade-dried *S. hydrangea* samples.

3.1. Effect of drying methods on the essential oil composition

In general 33 components were identified in the essential oil of dried and fresh samples represented 86–96% of the oils. GC-Ms results showed that different drying methods had no effect on the main components of the oil but had a significant effect on their percentage. This result was in agreement with results of some studies on other essential oil-bearing plants (Omidbaigi *et al.*, 2004). In fresh aerial parts, the major components of the oil were 1,8-cineole (18.22%), α-pinene (15.58%), trans-caryophyllene (12.97%), camphore (5.34%) and camphene (4.60%). The main components of the oil of shade-dried aerial parts were α-pinene (18.4%), 1,8- cineole (18.08%), trans-caryophyllene (17.38%) and camphene (4.30%). The major components of the oil of sun-dried aerial parts were α-pinene (22.02%), 1,8-cineole (15.52%), trans-caryophyllene (10.13%), camphene (7.04%) and borneol (5.50%). The main components of the oil of oven-dried aerial parts were trans-caryophyllene (19.05%), α-pinene (16.88%), 1,8-cineole (11.38%), β-pinene (4.28%), borneol (3.68%) and camphore (3.51%). Therefore, the drying method caused some variation of the relative proportions of the components (Fig. 2-6).

Some studies (Hamrouni-Sellami *et al.*, 2011; Rahimmalek and Goli, 2013) showed presence of some components in essential oil of dried samples which were not present in essential oil of the fresh samples. Yuan and Zhezhi (2007) reported that different drying methods caused some variation of the relative proportions of the components in *Glechoma longituba* and the higher amount of germacrene D (19.0%) was obtained by shade-drying method. In the *Mentha longifolia* L. only oven drying caused significant losses of the major compounds (menthone, pulegone and 1,8-cineole) in essential oil when compared to the fresh samples (Asekun*et al.*, 2007). These variations in oil constituents can be related to formation of new compounds by oxidation, glycoside hydrolysis, esterification, and/or other processes (Diaz-Maroto*et al.*, 2004). Results of the present study showed that 1,8-Cineole was decreased in higher temperatures. Among medicinal and aromatic plants, the extensive decrease

in the majority of essential oil constituents of dried samples at higher temperatures were reported in sage and thyme (Venskutonis, 1997) and basil (Yousif *et al.*, 1999). At high temperatures, the biological structure of the oil glands of medicinal and aromatic plants can be affected and subsequently the epithelial cells in the dried samples especially some sensible plants can collapse (Venskutonis, 1997). In the present study, trans-caryophyllene content increased at higher temperatures and oven drying at 65 °C led to higher amounts of trans-caryophyllene content in comparison to other drying methods. In other studies, thymol and β-caryophyllene contents increased at higher temperatures in essential oil of *Thymus vulgaris* L. and *Thymus daenensis* Celak. under different drying methods (Venskutonis, 1997; Rahimmalek and Goli, 2013).

Generally results showed that oven drying method had no effect on trans-caryophyllen, myrtenol, borneol, camphor, β-pinene, β-phellandrene and alpha-thujene compared to fresh sample. Sangwan *et al.* (2012) reported a non-significant difference ($p < 0.05$) in β-carotene, polyphenol and ascorbic acid contents of ginger powder prepared using different drying methods. Moreover, different drying methods do not influenced pyrethrins content of pyrethrum plants under customary drying conditions (Morris *et al.*, 2006). Overall, the results obtained from the present experiment and also reports of other researchers showed that there was a contradictory viewpoint on the effects of different drying methods on the essential oil profile of different plants.

4. Conclusion

Drying methods have a great importance in preparation of plants to extraction of essential oil and can affect the quantity and quality of essential oil. Higher drying temperature significantly reduced the essential oil obtained from aerial parts of *S. hydrangea*, especially when dried at 65°C. Thirty three components were identified in the essential oil of *S. hydrangea* which main constituents were α-pinene, 1,8- cineole and trans-caryophyllene. Significant differences were observed in the some volatile constituents as affected by drying methods. Finally, concerning the volatile oil content, it could be concluded that shade drying method is suitable for highest essential oil quantity and durability.

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