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Postharvest changes in essential oil content and quality of lavender flowers

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ABSTRACT

The aim of this study was to analyse both the essential oil (EO) content and quality changes of two Czech *Lavandula angustifolia* Mill. varieties, 'Krajová' and 'Beta', in the period between the harvesting and chemical analysis. An eight-year experiment proved that during the long-term storage of dried flowers a gradual reduction in the total content of EO occurs at a rate of about 0.007% per day, which means about 2.56% per year. The content of linalool, terpinen-4-ol, lavandulol, linalyl acetate, α-terpineol, and lavandulyl acetate varied between the varieties. In the case of 'Krajová' the value of the correlation coefficient showed a decreasing tendency of terpinen-4-ol, lavandulol, linalyl acetate, and linalool. In the case of the 'Beta' variety loss rates for linalyl acetate, lavandulyl acetate, and terpinen-4-ol were found. This can be partly explained by disappearance but also by degradation and rearrangement into other compounds, such as linalool, lavandulool, and α-terpineol, whose content increased. The residual moisture of the air-dried plant material and room temperature are sufficient for the changes in such compounds during long-term storage. Only the differences between the varieties that were tested and growing seasons in terms of the EO content and composition were statistically proven, although it can be assumed that the differences in the EO content and composition between determinations would also be statistically significant in longer-term monitoring. No relationship between the initial EO composition and its loss during storage was found.

1. Introduction

All *Lavandula* (*Lamiaceae*) species and hybrids are highly aromatic plants, which produce complex mixtures of EOs from glands on the surface of the flowers and leaves (Lis-Balchin, 2002). These oils – as well as the EOs of many other plant species – have ecological and physiological functions in plant-environment interactions (e.g. pollinator attraction and defence) and in growth and development (e.g. as plant growth regulators) (Lane et al., 2010; Unsicker et al., 2009). Only three *Lavandula* taxa are important in the commercial production of EOs for use in the perfume and cosmetic industries. These are *Lavandula angustifolia*, *Lavandula latifolia*, and *Lavandula hybrida* (*Lavandula latifolia* x *Lavandula angustifolia*), which produce lavender oil, spike lavender oil, and lavandin oil, respectively (Lis-Balchin, 2002; Lubbe and Verpoorte, 2011).

The composition of *L. angustifolia* Mill. EO has been extensively investigated because of its commercial significance in the fragrance industry (soaps, perfumes, skin lotions, and other cosmetics), in aromatherapy (as a relaxant), in pharmaceutical preparations (therapeutic effects as a sedative, spasmolytic, antiviral, and antibacterial agent) and in the food industry (as a natural flavouring for beverages, ice cream, sweets, baked goods, and chewing gum) (Da Porto et al., 2009).

The EO of lavender is a complex mixture that mainly comprises monoterpenes (e.g. linalool, camphor, 1,8-cineole, and borneol) and a few sesquiterpenes (e.g. [*E*]-β-farnesene) as minor oil constituents (Lane et al., 2010). Another characterisation of lavender oil is presented by Da Porto et al. (2009) as a volatile mixture of organic compounds derived from odorous plant material by physical means. The constituents of an EO may be classified into two principal groups: (a) hydrocarbons (terpenes, sesquiterpenes, and diterpenes); (b) oxygenated compounds derived from these hydrocarbons, including alcohols, aldehydes, esters, kethons, phenols, oxides, etc. Linalool and linalool acetate (syn. linalyl acetate) are the most abundant monoterpenes in popular lavender varieties and are considered to be the most desired components of the floral oil, while camphor generally contributes an undesirable odour, diminishing the quality of the oil (Lane et al., 2010).

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The amount and quality of the oil produced from lavender and many other aromatic plants depend on many factors. Commercially grown taxa have been increased by plant breeding compared to wild material and the age and the health status of the plants (Ruminska, 1970), as well as both the soil and climatic conditions during the growing and harvesting of the plants, also play an important role (Karamanos and Sotiropoulou, 2013; Özgüven et al., 2008; Riahi et al., 2015). Other influential factors are the botanical part and stage of development of the plants (Hassiotic et al., 2014), the time of day when the harvesting takes place (Bufalo et al., 2015; Malatova et al., 2011), the number of harvests per year (Zheljazkov et al., 2012), the post-harvest technology, e.g. the drying method (Argyropoulos and Müller, 2014; Pirbalouti et al., 2013; Sárosi et al., 2013; Sefidkon et al., 2006; Szumny et al., 2010), and the method used for the extraction of the oil (Sintim et al., 2015; Stanojević et al., 2014; Tibaldi et al., 2011). Additionally, the effect of storage on the EO quality after its extraction (Turek and Stintzing, 2012), and the analytics used for the identification of the compounds have been documented in several papers (Da Porto et al., 2009; Kiran Babu and Singh, 2010; Najafian, 2014; Périno-Issartier et al., 2013; Rowshan et al., 2013).

However, only a few works (Arabhosseini et al., 2007; Usai et al., 2011) have studied the course of the EO losses and/or there is no data about the changes in the composition of the EOs during the storage of the dry plant material before EO yield analysis. It is important for all the producers, consumers, and other parties concerned with EOs to ensure the effectiveness and quality of EO products. Thus, the objective of this study was to assess the influence of the long-term storage of lavender flowers between the drying and hydrodistillation on the EO content and composition.

2. Material and methods

2.1. Plant material and processing of samples

Cultivars of Czech origin 'Krajová' and 'Beta' of lavender (*L. angustifolia* Mill.) were used as model plants in this study. The field trial was established in the experimental field of the Crop Research Institute in Olomouc in 2002 and this study was started on a well-established six-year-old lavender plantation.

Inflorescences of *L. angustifolila* Mill. were collected in full bloom in 2008–2014 on sunny days. The inflorescences of at least 120 plants were harvested and mixed carefully for each cultivar and each year before drying. The drying was carried out in a field drying chamber with sunlight protection and controlled air flow for about a week. The storage took place in paper bags in a dark room at room temperature. Before the analytical work the flowers were removed from the stems in all cases. The flower samples were not ground because of the superficial position of the unicellular glands containing the EO.

The first samples of lavender flowers for hydrodistillation were taken between 43 (in 2011) and 66 (in 2009) days after harvesting and then almost every week (except the Christmas break) until the plant material ran out. The last samples were analysed between 158 (in 2012) and 310 (in 2008) days after harvesting. An overview of the dates of the harvesting and hydrodistillation is shown in Table 1.

2.2. Extraction procedure of essential oil

Dry lavender flowers (20 g) were submitted to hydrodistillation with a Clevenger-type apparatus. The EO was co-distilled with 500 ml of distilled water for 4 h and collected and stored in glass vials in dark at 4 °C until the GC analysis. Hydrodistillation was performed two times for each sample and the mean values of the extraction yields are reported.

Table 1
Dates of harvesting of plant material and hydrodistillation of EOs in the years evaluated.

	Year	2008	2009	2010	2011	2012	2013	2014
1st analysis	Date of harvesting	30th June	30th June	2nd July	29th June	9th July	2nd July	2nd July
	Date	3rd September	4th September	2nd September	11th August	7th September	15th August	2nd September
	No. of days after harvesting	65	66	62	43	61	44	62
Last analysis	Date	6th May 2009	24th February 2010	27th January 2011	15th December 2011	13th December 2012	20th February 2014	31st March 2015
	No. of days after harvesting	310	239	209	169	158	233	272