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Essential oil variation within and among natural populations of *Lavandula latifolia* and its relation to their ecological areas

Jesús Muñoz-Bertomeu, Isabel Arrillaga, Juan Segura*

Departamento de Biología Vegetal (Facultad de Farmacia), Universidad de Valencia, Av. Vicente Andrés Estellés s/n, 46100 Burjasot, Valencia, Spain

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Abstract

Essential oil yield and composition in seven natural populations of *Lavandula latifolia* from the eastern Iberian Peninsula were determined by GC/MS. Twenty-eight constituents were identified, accounting for 92.0–95.4% of the total oils. These oils were dominated by the monoterpene fraction and three of them (linalool, cineole and camphor) constituted 79.5–86.9% of the oil from flowers. Essential oil yield in leaves and flowers varied among and within populations, but hierarchic analyses of variance showed that the proportion of variation attributable to individuals was significantly higher than that attributable to population differences. Principal component and cluster analyses allowed three groups of flower essential oils to be distinguished according to their high, intermediate and low proportion of linalool. These essential oil types are respectively correlated to the Supra-, Meso- and Thermo-Mediterranean bioclimatic belts where the populations are located. A genetic analysis based on those terpenes that showed a trimodal distribution roughly corroborated the relationships between the seven populations obtained from the ordination analyses and emphasizes the distinctiveness of some of the populations.

Keywords: *Lavandula latifolia*; Lamiaceae; Spike lavender; Essential oil yield; Bioclimatic belts; PCA; AHC; Genetic analysis

1. Introduction

Lavandula latifolia Medicus (spike lavender), of the family Lamiaceae, is an aromatic shrub native to the Mediterranean region and cultivated worldwide, which produces the spike lavender oil of commerce. This is the most important of the Spanish essential oils produced commercially (Miralles, 1998). Spike lavender oil has a popular and easily recognisable fragrance, and it is traditionally believed to be antibacterial, antifungal, carminative (smooth muscle relaxing), sedative, antidepressive and effective for burns and insect bites (Font-Quer, 1978). Although these biological activities are still inconclusive and often controversial, there does seem to be clinical data that support these traditional uses of the oil (Cavanagh and Wilkinson, 2002). Today, the pure oil is used in aromatherapy (Buchbauer, 2002), but their primary use, however, is as raw ingredient in industrial perfumes and fragrance materials (Segura and Calvo, 1991). The spike lavender oil composition is determined mainly by the genetic make-up of each cultivar, although monoterpenes

* Corresponding author. Tel.: +34 963544922; fax: +34 963544926.
E-mail address: juan.segura@uv.es (J. Segura).

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are always the major fraction, with three of them (linalool, cineol and camphor) accounting for more than 80% of the total sample (Harborne and Williams, 2002). As in other Lamiaceae, these compounds seem to be synthesized and accumulated in the peltate glandular trichomes found on the aerial parts of the species (Hallahan, 2000).

Due to their economic importance, the composition of the spike lavender oil has been widely studied (for revision see Harborne and Williams, 2002; Lis-Balchin, 2002). These studies demonstrate a high degree of intraspecific differences in the oil due either to genotypic, climatic, geographical and seasonal differences or to the cultural practices used. It can also be due to the method of essential oil extraction and, in the case of commercial oils, to the degree of blending and adulteration. Thus, the selection of suitable *L. latifolia* genotypes for desired phytochemical traits can be achieved relatively easy. To the best of our knowledge, however, little attention has been paid to assay the variability of this trait on a larger scale within and among natural populations of *L. latifolia*. Such information is important for the development of in situ and ex situ conservation programs and for the selection of parental strains in new crosses.

The aim of this study was to estimate essential oil yield and composition in wild-growing plants of *L. latifolia* belonging to seven natural populations from the eastern Iberian Peninsula.

2. Materials and methods

2.1. Populations surveyed and sampling

Leaves and flowers (cymes with 3–5 open flowers) from 72 *L. latifolia* plants were randomly sampled, in July–August 2003, from seven populations located in the Comunidad Valenciana (Spain) that belong to the Thermo-, Meso- or Supra-Mediterranean bioclimatic belts (Table 1). The number of sampled individuals in each population and the geographical distances among the populations are shown in Table 1.

2.2. Analysis of essential oils

Leaves and inflorescences from each of the 72 sampled plants were treated separately for essential oil extraction, and the tissue was manually crushed and mixed to ensure sample uniformity. Air-dried (for 30 days), fully expanded leaves (1.5 g) or flowers (0.5 g) were distilled for 1.5 h in 100 mL of water in a Clevenger-type apparatus, and the distillate analyzed by gas chromatography (with mass spectrometric confirmation of terpene composition) as previously described (Muñoz-Bertomeu et al., 2006). Naphthalene and *n*-tetradecane were added as internal standards to all samples prior to the distillation step.

The products were quantified (mg/g dried tissue) by comparison of detector response with that of the internal standards, assuming equal response factors. Also, percentages of compounds were determined from their peak areas. The relative peak area for individual constituents was determined using the Chrom-Card S/W program (Thermo Finnigan). All analyses were performed at least four times.

2.3. Data analysis

Significance of the variation in essential oil production among populations was determined using analysis of variance (ANOVA) and mean comparisons using Tukey's (1953) procedure were carried out when appropriate. Also, a hierarchic

Table 1
Sampled populations of *L. latifolia* with abbreviations, sample size (SS), bioclimatic belts and ombrotypes (BBO) and geographical location

Populations	SS	BBO	Geographical location		
			Latitude (N)	Longitude (W)	Altitude (m)
Castellón-Morella (CM)	11	Sub-humid Supra-Mediterranean	40°37′55″	0°05′26″	840
Castellón-Foia (CF)	10	Dry Thermo-Mediterranean	40°06′17″	0°12′11″	370
Valencia-Alcublas (VA)	11	Dry Meso-Mediterranean	39°46′55″	0°42′54″	760
Valencia-Aras de los Olmos (VO)	10	Dry Supra-Mediterranean	39°55′00″	1°07′00″	920
Valencia-Villagordo del Cabriel (VC)	10	Dry Meso-Mediterranean	39°32′03″	1°26′53″	860
Valencia-Fuente de la Higuera (VH)	10	Dry Meso-Mediterranean	38°48′36″	0°53′05″	540
Alicante-Puerto de la Carrasqueta (AC)	10	Dry Supra-Mediterranean	38°37′24″	0°29′00″	1020