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Ecological production of lavenders in Cuenca province (Spain). A study of yield production and quality of the essential oils

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Abstract: Usano-Alemany, J; Herraiz Peñalver, D.; Cuadrado Ortiz, J.; de Benito López, B.; Sánchez Ruiz, O. & Palá-Paúl, J. 2011. Ecological production of lavenders in Cuenca province (Spain). A study of yield production and quality of the essential oils. *Bot. Complut.* 35: 147-152.

In the present paper, we present a description of the ecological agriculture of different lavenders in Cuenca province (Spain). We focused on the important aromatic crops of *Lavandula angustifolia* (lavender) and on three varieties of *Lavandula* × *intermedia* (lavandin) called name abrial, rosso and super. A description of yield production and essential oil qualities obtained in our experimental fields are presented. Lavandin var. super showed the best essential oil quality with good yield production as well. The current market of Fragrant and Medicinal Plants claims raw materials with confirmed quality, with good practices of harvesting, transformation and manufacture by means of ecological production.

Keywords: ecological production, lavandin, lavender, essential oil, linalool, linalyl acetate.

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En este trabajo presentamos una descripción del cultivo ecológico de diferentes lavandas en la provincia de Cuenca (España), concretamente de los cultivos de *Lavandula angustifolia* (lavanda) y de tres variedades de *Lavandula* × *intermedia* denominadas abrial, grosso y super. Se presenta una descripción de los rendimientos de estos cultivos y de las calidades obtenidas de la destilación de sus aceites esenciales. Con la variedad super de lavandin se obtuvieron las mejores producciones y calidades. El mercado actual de plantas aromáticas y medicinales reclama materias primas de calidad contrastada, con trazabilidad óptima de los productos, buenas prácticas de recolección, transformación y manufactura mediante producción ecológica.

Palabras clave: cultivo ecológico, lavandin, lavanda, aceite esencial, linalol, acetato de linalilo.

INTRODUCTION

The genus *Lavandula* L. contains many different species which belong to the *Labiatae* family that geographically grown in Mediterranean countries. There are 5 species of the genus commercially interesting in Spain, with one hybrid within: *Lavandula dentata* L., *L. stoechas* L., *L. latifolia* Medik., *L. angustifolia* Mill. and *L.* × *intermedia* Emeric ex Loisel. (*L. angustifolia* × *L. latifolia*) with the Spanish common names lavanda dentada, cantueso, espliego, lavanda and lavandin, respectively. Spain is an important producer of these different lavenders.

Referencing the document from the Spanish government "Aplicación en España del Chequeo Médico de la PAC" (M.M.A.R. 2009), nowadays it is emerging a scheme with aromatic and medicinal plants crops where those appear as good economical, social and ecological alternative in low productivity areas. Furthermore, the rise of the cultivation of these plants may vary the agricultural offer and create jobs associated to the different farm works. These crops are a remedy against erosion too (Usano-Alemany *et al.* 2008), having been extended as technical forestry in soil conservation and also for fixing the slopes of highways and other roads. Besides aromatic plants are not in competition with sunflower or cereal crops, being those less demanding in the quality of the land. The activity of aromatic culture is complementary to beekeeping, providing support and benefiting in the plantations due to po-

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llination and higher yields of essential oils and more number of fertile seeds obtained. The current market of Fragrant and Medicinal Plants claims raw materials with confirmed quality, with good practices of harvesting, transformation and manufacture by means of ecological production. These species could grow under poor soil conditions and together with its low amount of natural enemies, made them very suitable to the ecological agriculture. According to this, the prices could be more competitive and the culture of theses species could be a real alternative for conventional crops. Furthermore, the increasing rejection about chemical products using in conventional culture and the worry about their negative effects into ecosystems and human health, made necessary to find new alternatives. The ecological agriculture tries to show answer to this worry.

Essential oil or simply essence, are volatile oils of diverse chemical composition, which derive from vegetal materials, giving them their main odours. Because of its delightful odour, lavenders is one of the most useful medicinal plants and has found wide application in perfumes and cosmetics, colognes, skin lotions and other cosmetics (Paúl *et al*. 2004) and in food manufacturing (Kim & Lee 2002). Recently, aromatherapy is becoming increasing popular, and lavender is used as a relaxant. The world demand for lavender essential oils is increasing. It is estimated that over 200.000 ha are being cultivated in Europe and the quality of produced essential oil is important especially for medicinal, pharmaceutical and aromatherapy uses (Hassiotis *et al.* 2010). This quality is determined by the chemical characterization and its biomass yield. The plant genetic information, the phenological state, the growth conditions and culture, together with the conditions of transformation, manipulation and storage, are determinant factors.

A high morphological and chemical diversity in species from *Lamiaceae* family has been described depending on the climatic, geographical, seasonal conditions and genotypic factors by comparing essential oil composition (Ormeño *et al*. 2007, Petropoulos *et al.* 2008). Intraspecific diversity is also observed together with seasonal variation in the essential oil chemical composition (Perry *et al*. 1999, Jordán *et al*. 2006, Muñoz-Bertomeu *et al.* 2007, Herraiz-Peñalver *et al.* 2010). Native wild and cultured aromatic and medicinal plant species of different families are being investigated in Spain by our research group and others. One of our principal researching goals is to know the chemical variation among native populations and finding new agrarian cultures as alternatives knowing the needs of the essential oil and extract industries. *Lavandula angustifolia* L. (lavender) and *Lavandula* x *intermedia* (lavandin) are both within our targets.

The aim of this study was to extend the viability of the ecological agriculture of lavender and the three varieties of lavandin and describe the quality of the essential oils produced growing on edafoclimatic conditions of Cuenca province (Spain).

MATERIAL AND METHODS

Investigation area, crops design and harvesting material. All the experiments have been carried out at the Agrarian Research Centre of "Albadalejito", Cuenca province (Spain). A part of the available field extension of this centre is dedicated to the tillage of different aromatic and medicinal plants. In this study, four plots of 1.5 ha each have been used. In each area, culturing of one of the lavenders has been evaluated. The separation between rows was 1.2 m. All plantations were 5 years old, coming from commercial material and their management was under ecological conditions. Twice a year mechanical weed control of weeds was carried out. No irrigation or fertilization was applied during the growing season. Moreover, no evidence of pathogenic attacks was detected so no means of prophylaxis was needed. Aerial parts were harvested once in the year during flowering (end of July 2009) using mechanical procedures (Fig. 1). In order to dry the green material, it was stored at atmosphere temperature until distillation.

Essential oil extraction and chemical analysis. Isolation of essential oils from dried plant material was achieved by steam distillation using an industrial distiller, stainless steel alembic. The process is done quickly at high pressure and a high temperature. The plants are not directly submerged in boiling water because at high temperatures the most subtle aromas might be altered. The procedure consists of passing water vapour at a low-pressure through a tank containing aromatic plants. The steam captures the essential oil and then travel through a cold-water refrigerated serpentine to condense itself into a liquid. Upon exit, the essential oil is obtained together with the floral water that is in turn separated by their different densities with the help of an "Essencier" or a Florentine vase. Steam distillation of each sample was achieved over 50 minutes.

All the isolated essential oil samples were dried over anhydrous sodium sulphate and stored and stored at 4°C prior to analysis by Gas Chromatography. The analysis of lavender's oil was performed using a Varian 430-GC equipped with a flame ionization detector (FID) and a DB-5MS capillary column (60 m × 0.25 mm, film thickness 0.25 µm). The oven temperature program was as follows: from 4°C to 128°C with a rate of 1.5°C/min, then from 128°C to 170°C with a rate of 2.5°C/min and then from 170°C to 300°C with a rate of 4°C/min holding isothermal for 5min. Detector and inlet temperature were 300°C and 250°C, respectively. Helium was used as carrier gas at constant flow of 1.5 mL/min with a split ratio of 1:200. The injections are 0.4 µL of ether 1:10 dilution of crude essential oils. The identification of the compounds the essential oil samples were done using retention Kováts reten-

Fig. 1– Mechanical harvesting of lavandin and industrial steam distillation.

tion indices based on a comparison of their retention indices relative to (C_8-C_{25}) *n*-alkanes and co-elution with authentic samples of the ten compounds investigated. We focused only in the ten principal compounds generally controlled by industrial perfumers. All quantifications were carried out using a built-in data-handling program provided by the manufacturer of the gas chromatograph (Galaxie Varian GC Control Software, USA). The composition was reported as a relative percentage of the total peak area.

RESULTS AND DISCUSSION

The essential oil quantity measured (% v/w) for all tested crops were 1.1% for lavanda, 1.9% for lavandin var. abrial, 3.1% for lavandin var.super and 3.2% for lavandin var. grosso. Variation in oil content among individuals, plant parts, seasons and sites on *Labiatae* species is well reported (Perry *et al*. 1999, Santos-Gomes 2001). Moreover, oil yields are dependent on the amount of leaf and/or flower harvested. Yield productions of 3.3% with conventional management reported by Muñoz (1987) are close to ours. This fact, coupled with lower production costs under ecological management make this highly recommended.

Table 1 lists percentage of the 10 compounds generally controlled by industrial perfumers. Among the 10 components investigated, there are two monoterpenes, one sesquiterpene and seven oxygenated derivatives. Upon examination of the essential oil profiles of each culture, the following patterns can be discerned: among the monoterpenes, β-(*Z*)-ocimene and limonene ranges are established 0.13% in lavandín var. abrial, 13.23% in lavanda, 0.55% in lavandin var.super and 14.07% in lavandín var. abrial. β-Cariophyllene with and minimum value of 1.76% in lavandín var. super and maximum value of 6.26% in lavanda, is the only sesquiterpene evaluated. Among the oxygenated compounds, ranges are established as follows: 1,8-cineole (0.87% in lavandín var. abrial-7.80% in lavanda), linalool (28.17% in lavandín var. abrial-33.44% in lavanda), camphor (0.03% in lavandín var. super-11.65% in lavandín var. abrial), borneol (1.84% in lavanda-2.38% in lavandín var. super), terpinen-4-ol (0.03% in lavandín var. super-2.50 in lavanda), α-terpineol (0.03% in lavandin var. abrial-0.034% in lavandin var. grosso) and linalyl acetate (12.30% in lavanda-40.61% in lavandin var. super).

The lavandin derived from hybridization between lavender and *Lavandula latifolia* (espliego), but it gives ol-

Tabla 1
Chemnical composition of lavanda essential oils and the three varieties of lavandin evaluated

Components	K.I.	% Composition			
		Lavanda	Lavandín var. super	Lavandín var. grosso	Lavandín var. abrial
Limonene	1024	5.08	0.55	1.90	14.07
1,8-Cineole	1028	7.80	3.43	6.65	0.87
β-(Z)-Ocimene	1030	13.23	1.76	0.81	0.13
Linalool	1140	**33.44**	**31.71**	**29.86**	**28.17**
Camphor	1145	**4.42**	**0.03**	**6.86**	**11.65**
Borneol	1171	1.84	2.38	1.87	2.27
Terpinen-4-ol	1185	2.50	0.03	1.80	0.20
α-Terpineol	1193	0.16	0.32	0.34	0.03
Linalyl acetate	1270	**12.30**	**40.61**	**31.60**	**26.18**
β-caryophyllene	1414	6.26	1.76	2.33	2.30
Total		87.03	82.58	84.02	85.87

K.I.: Kováts retention indices related to n-alkanes on DB-5 column. Constituents in bold indicates critical components in lavenders oil quality.

factory features closer to lavender. The great difference with espliego is given by the 1,8-cineole content. Our results show that the lavandin var. super essential oil culturing within Cuenca province conditions is produced with excellent quality. A chromatogram of lavandin var. super essential oil from our crops is given in Fig. 2. It was very rich in linalool and linalyl acetate (71.7%) and poor in 1.8-cineole with camphor detected in traces (Table 1). Grosso and abrial varieties showed less quality than super variety specially because the detected camphor which decrease the value of these essences. Comparing quality of our cultivars with others reported, the improvement of linalool and linalyl acetate and the decreasing of 1.8-cineole and camphor resulted to a delightful, sweet but not heavy aromas (Renaud & Charles 2001). Among the main lavandin varieties essential oil can have different olfactive quality due to the soil and industrial procedures (Bombarda *et al.* 2008). Our edafoclimatic conditions seem to promote the super variety with an excellent quality. Linalool is an important element of the floral espetra and this allow the relationship with other floral elements. Linalyl acetate is widespread in nature too. According to Burillo (2003), water stress influences the linalool biosynthesis. The high percentage obtained from linalool could be due to the high water stress occurs during the three months just before harvesting time (Fig. 3). These results are an indi-

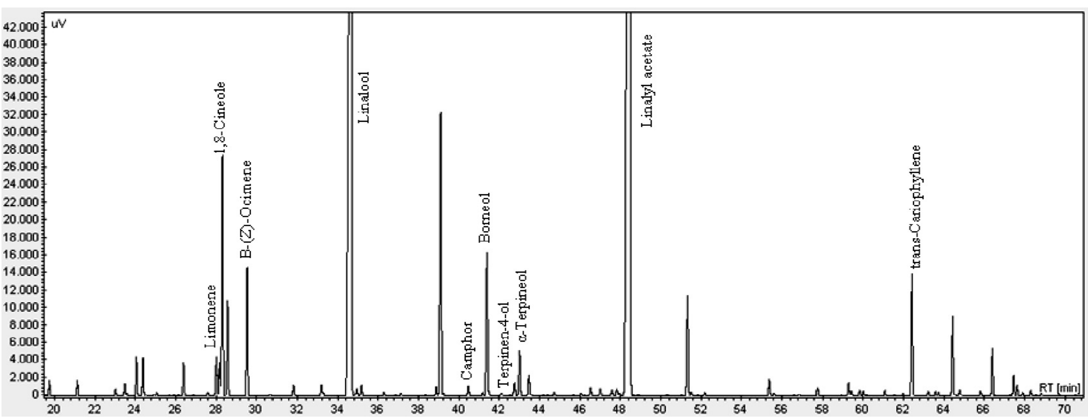

Fig. 2– Chromatogram obtained from lavandin var. super cultured in Cuenca province.

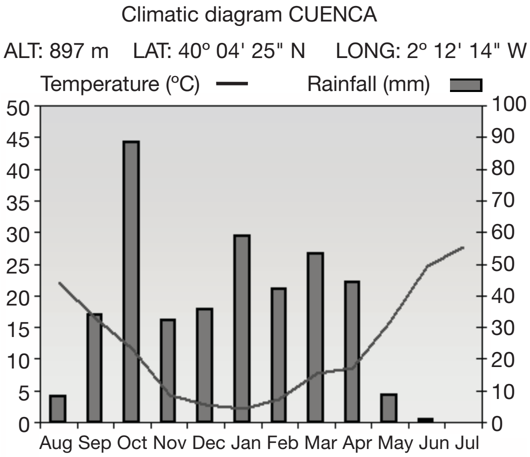

Fig. 3– Climatic diagram obtained from the experimental fields in Cuenca during the evaluated year.

cation and support that in Mediterranean countries with high temperatures and low precipitations are more suitable for development of aromatics.

Lavandin species are considered inferior in quality to lavender and command lower prices. The lavender and hybrid versions have the same components but in different proportions. The criteria for determining the quality are the levels of camphor, linalool and linalyl acetate so resolution of these compounds is critical. For lavender, the camphor needs to be below 0.5% while the linalyl acetate is invariably higher than the linalool in the best quality oils (Warden 2006). The separation and quantification of linalool and linalyl acetate is important in the quality control of many essential oils including oils of sage, bergamot, marjoram and neroli. Dry atmosphere and moderates winds seem to enhance good quality of the essence promoting the evaporation of low molecular weight volatile terpenes commercially undesirable.

Lavandin culturing in Spain comes from French varieties (there are not varieties selected from Spanish lavender or lavandin). The main variety established is super, being the suited to the edafoclimatic conditions although grosso is increasing. The culture of abrial variety is only testimonial. The norms nowadays existed concerning the quality of *Lavandula* sp. essential oils are: Spanish standard UNE 84301:2006 about espliego and International stardards ISO 3515, 3054, 8902 about lavender, lavandin var. abrial and lavandin var. grosso, respectively. No lavandin var. super quality norm is available. That empty quality standard for lavandin var. super did not allow face the excellent quality of the essential oils from lavandin var. super Spanish cultivars. Furthermore, with a standard norm established, production of spanish lavandin would be produced with homogeneous organoleptic characteristic coming from the same homogeneous raw materials. On the other hand, the lack of information about yields and quality of plants along its productive cycle, together with the ignorance of the cultural practices and its incident in the quality, are aspects that limit the consolidation as alternative crops in Spain. It would be important that research centers managed the stock cultures from where multiply material that fulfill composition specifications. Furthermore, because oil content has been shown to be heritable in other species (Franz 1993), it might be possible to develop lavanda and lavandin breeding and cultivation programs in order to obtain higher oil contents under our edafoclimatic conditions.

CONCLUSIONS

The centre of Spain is presented as a favourable area for lavender cultivation. These species are not used at all due to the lack of adapted cultivars or varieties to Spanish conditions together with no norm available for lavandin var. super. Excellent quality of the essential oil obtained from this cultivar is reported in Cuenca province.

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