Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.jfda-online.com

Original Article

By-product of *Lavandula latifolia* essential oil distillation as source of antioxidants

Inés Méndez-Tovar [a,d,*], Baudilio Herrero [b], Silvia Pérez-Magariño [a,e], José Alberto Pereira [c], M. Carmen Asensio-S.-Manzanera [a,f]

[a] Instituto Tecnológico Agrario de Castilla y León (ITACyL), Carretera Burgos km 119, 47071 Valladolid, Spain
[b] Departamento de Ciencias Agroforestales, ETS de Ingenierías Agrarias, Universidad de Valladolid, Avenida de Madrid, 57, 34004 Palencia, Spain
[c] Mountain Research Centre (CIMO), School of Agriculture, Polytechnic Institute of Bragança, Campus de Santa Apolónia, Apartado 1172, 5301-855 Bragança, Portugal
[d] Unidad de Cultivos Leñosos y Hortícolas, Instituto Tecnológico Agrario de Castilla y León (ITACyL), Carretera de Burgos km 119, 47071, Valladolid, Spain
[e] Estación Enológica, Instituto Tecnológico Agrario de Castilla y León (ITACyL), Carretera de Burgos km 119, 47071, Valladolid, Spain
[f] Unidad de Cultivos Herbáceos, Instituto Tecnológico Agrario de Castilla y León (ITACyL), Carretera de Burgos km 119, 47071, Valladolid, Spain

ARTICLE INFO

Article history:
Received 19 May 2014
Received in revised form
9 July 2014
Accepted 10 July 2014
Available online 24 August 2014

Keywords:
antioxidant activity
by-product
interpopulation variability
spike lavender
total phenolic content

ABSTRACT

The objective of this work was to evaluate the antioxidant properties of *Lavandula latifolia* waste obtained after essential oil distillation. Samples of 12 wild populations of the *Lavandula* genus collected between 2009 and 2010 were hydrodistilled and their by-products were analyzed using the Folin–Ciocalteu, free radical scavenging activity (2,2-diphenyl-1-picrylhydrazyl), and the ferric reducing antioxidant power (FRAP) methods. Rosmarinic acid, apigenin, and luteolin contents were analyzed by high-performance liquid chromatography–diode array detection. The mean of total phenolic content ranged from 1.89 ± 0.09 mg gallic acid equivalents/g dry weight to 3.54 ± 0.22 mg gallic acid equivalents/g dry weight. The average value of the half maximal effective concentration (EC_{50}) for scavenging activity ranged from 5.09 ± 0.17 mg/mL to 14.30 ± 1.90 mg/mL and the variability of the EC_{50} in FRAP ranged from 3.72 ± 0.12 mg/mL to 18.55 ± 0.77 mg/mL. Annual variation was found among this samples and the environmental conditions of 2009 were found to be more favorable. The plants collected from Sedano showed the highest antioxidant power. Our results show that rosmarinic acid and apigenin in *L. latifolia* contributed to the antioxidant properties of the waste. In conclusion, the by-product of the distillation industry could be valorizing as a source of natural antioxidants.

* Corresponding author. Unidad de Cultivos Leñosos y Hortícolas, Instituto Tecnológico Agrario de Castilla y León (ITACyL), Carretera Burgos km 119, 47071 Valladolid, Spain.
E-mail address: mentovin@itacyl.es (I. Méndez-Tovar).
http://dx.doi.org/10.1016/j.jfda.2014.07.003

1. Introduction

The genus *Lavandula* is a member of the Lamiaceae (Labiatae) family, which includes 39 species. This genus has a wide distribution from the Macaronesic region to all the Mediterranean regions and is scattered throughout the Northern parts of Africa, the Arabian Peninsula, and South Asia reaching India [1]. In particular, spike lavender (*Lavandula latifolia* Medik.) is a shrub that measures between 50 cm and 70 cm (height) and blossoms in mid-July [2]. *Lavandula latifolia* prefers limestone rocks or dry pastures on sunny hillsides and requires a basic alluvial substratum (between 20 m and 2050 m). The species is commonly found in the Iberian Peninsula, France, Italy, and former Yugoslavia [1].

Since ancient times, various species of the *Lavandula* genus have been used for medicinal and ornamental purposes. They are also used as a flavoring agent. In addition, they are used as a condiment and as a disinfectant, due to their antiseptic properties. The essential oil from the plants of this genus is extracted and used in perfumes. Additionally, in recent years, the potential of *Lavandula* oil as a bactericidal, bacteriostatic, and as an antifungal agent has been studied, with study results supporting its bactericidal and antifungal properties [3].

Lavandula × *intermedia* Emeric ex Loiseleur, *L. angustifolia* Mill., and *L. latifolia* Medik. are the most widely used species of this genus [1]. Nowadays, the plants of this genus are especially used for medicinal purposes; in addition, the flower spikes are distilled to obtain essential oils, which are widely used in the perfume industry. The genus possesses anti-inflammatory [4], antispasmodic, anticonvulsant [5], and sedative properties. In addition, it is also known to improve the quality of sleep and reduce anxiety and stress [6,7].

In the perfume industry, essential oil is extracted from the flowers of the plant spike lavender. This process of extraction generates large amounts of residue, with 50–100 tons of wastes generated every year [8]. This large volume of by-product generated during distillation is of growing concern. In some industries, the biomass is used for generating energy or for preparing compost [9]. However, this recycling system has the following disadvantages: recycling the by-product to energy requires a huge investment, and recycling to composting is not always satisfactory due to the antigerminative properties of some aromatic plants [10], which may also be transferred by the plant residue. The aerial parts of the plants of the genus *Lavandula* also have the ability to act as a natural antioxidant [11], acting as a free radical scavenger with a diverse content of polyphenols [12]. Torras-Claveria et al [13] identified the phenolic content of lavandin waste (*Lavandula* × *intermedia* Emeric ex Loiseleur) obtained after the distillation of essential oils. Rosmarinic acid was identified as the main compound in these wastes; in addition, important flavones (apigenin, luteolin, and chrysoeriol) were also identified. This indicates that other similar residues from the plants of this genus may also contain polyphenols, which can be used for various purposes.

The value of *L. latifolia* by-product can be increased by using it as a source of natural antioxidants. These natural antioxidants could be extracted for animal feed or as a natural food preservation agent in the food industry. Previous studies have reported the toxicity of food preservatives such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) in animals [14,15]. Although recent studies by the European Food Safety Authority [16,17] reported that the acceptable daily intake of BHA and BHT is not generally exceeded in food products, the safety of these authorized and widely used additives is still controversial. At present, intake of antioxidants and identifying new sources of natural antioxidants are a priority. As a result, many studies evaluating the antioxidant content of plants have been carried out in recent years [12,13,18].

In order to exploit spike lavender as a source of natural antioxidants, it is essential to understand the variability in the antioxidant content of different wild populations of *L. latifolia*, so as to select those with a high content of antioxidants. The objective of this work was to study the variability of the antioxidant capacity and content of polyphenols among different populations of the genus and seasons in the aerial parts of the plant and in the hydrodistilled residue. In this way, it would be possible to revalue the waste of the distilling industry, thereby reducing production costs and preserving the environment. Antioxidants and phenols are influenced by climatic conditions [19], and therefore the populations were studied for a period of 2 years.

Table 1 – Geographical coordinates of collected populations of *Lavandula latifolia*.

Populations	Province	Locality	Latitude (N)	Longitude (W)	Altitude (m)
LL-01	Soria	Dévanos	41°54′06″	1°55′01″	968
LL-02	Soria	Velamazán	41°29′05″	2°47′22″	936
LL-03	Segovia	Moral de Hornuez	41°27′15″	3°37′56″	1133
LL-04	Segovia	Fuentidueña	41°26′41″	3°57′38″	844
LL-05	Burgos	Sedano	42°41′18″	3°44′13″	750
LL-06	Burgos	Santibáñez del Val	41°58′38″	3°29′08″	953
LL-07	Burgos	Gumiel de Izán	41°46′23″	3°40′40″	899
LL-08	Valladolid	Quintanilla de Onésimo	41°37′14″	4°20′09″	879
LL-09	Palencia	Aguilar de Campoo	42°45′33″	4°13′50″	913
LL-10	Soria	Tejado	41°33′40″	2°13′26″	1066
LL-11	Palencia	Cevico Navero	41°52′21″	4°11′36″	916
LL-12	Palencia	Reinoso de Cerrato	41°56′57″	4°22′28″	876