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Original Article

Morpho-Genetic Variability in Phytochemical Composition and Essential Oils of Three Common *Lavandula* Species Cultivated in Van, Türkiye

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ABSTRACT

Background: *Lavandula* sp. is a valuable plant species as ornamental plant with beautiful inflorescence and aromatic plant with high yield of essential oil. Lavender is mostly produced in Europe, the Middle East, Asia, Northern Africa, France and Bulgaria. Most varieties of lavender are known for their sedative properties and have historically been used to treat diabetes, depression and headaches. Chemical composition and the existence of phenolic compounds may be related to these biological properties. **Aim:** This study aims to compare morpho-genetic variability in total phenolics, flavonoids, antioxidants and essential oils of three *Lavandula* species cultivated under identical conditions. As a result of the study, total ash, dry matter, phenolic profile and mineral content of both leaf and inflorescence is clarified. **Results:** Both inflorescence and leaves *L. intermedia* has highest flavonoid content value (8.76 and 11.26 mg QE/100 g) for the study. Total antioxidant activity ranged for inflorescence 83.92 to 167.94 μmol TE/g and 75.64 to 135.48 μmol TE/g for leaves. Total phenolic content value (198.29 and 208.92 mg GAE/g) for both inflorescence and leaves obtained from *L. dentata*. Essential oil yield (v/w) of *L. angustifolia* found 7.31%, *L. intermedia* 4.92% and *L. dentata* 3.92%. Linalool were the predominant essential oil constituents in both *L. angustifolia* (50.04%) and *L. intermedia* (48.69%), whereas 1,8-cineole were (82.66%) major constituents in *L. dentata*. **Conclusion:** *L. angustifolia* were more productive in terms of essential oil content and also mineral content for some elements except heavy metals. For phenolic compound, while *L. dentata* shows higher results with total flavonoid and phenolic content, *L. intermedia* shows greater total antioxidant activity.

Keywords: Antioxidant Activity, Essential Oils, *Lavandula*, Mineral Content, Phytochemicals.

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INTRODUCTION

Although aromatic and medicinal plants have been used for centuries, some have only recently gained international recognition as economical crops for valuable essential oils.[1] Within the Lamiaceae family; the genus *Lavandula* comprises approximately 40 species, numerous hybrids and nearly 400 registered cultivars. The aromatic foliage and flowers of the Lavender genus are composed of small evergreen bushes. Lavender (*Lavandula angustifolia* Mill.), lavandin (*Lavandula intermedia* Emeric ex Loisel., which is a cross between *L. angustifolia* and *L. latifolia*), spike lavender (*Lavandula latifolia* Medik.), *Lavandula stoechas* and *Lavandula dentata* are Mediterranean-originated perennial and most widely cultivated species that are grown all over the world as ornamental and medicinal plants.[2-4]

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Lavender is mostly produced in Europe, the Middle East, Asia, Northern Africa, France and Bulgaria. Although these countries produce the majority of the lavender in the globe, other countries that produce lavender in varying quantities include Spain, Romania, Russia, Italy, Yugoslavia, Morocco, Hungary, Ukraine and Türkiye.[5] Bulgaria is the main producer of lavender, followed by France; France is the main producer essential oil of lavandin, followed by Spain.[6]

Most varieties of lavender are known for their sedative properties and have historically been used to treat diabetes, depression and headaches. Chemical composition and the existence of phenolic compounds may be related to these biological properties. Currently, the antibacterial, antifungal, carminative, antidepressant and anti-inflammatory qualities of lavender's essential oils are used.[7] 1 L of lavender oil is derived from about 120-150 kg of lavender inflorescence, depending on the climatic conditions.[8] Every year, around thousand tons of lavandin essential oil (*L. intermedia*) are produced globally, although only 200 tons of lavender essential oil (*L. angustifolia* Mill.) and 200 tons of spike lavender essential oil (*L. latifolia* Medik.) are produced.[9] According to ISO 3515:2002 and ISO 8902:2009 standards, linalyl acetate (25-45%), linalool (25-38%) and camphor (0.5-1.0%) are present in lavender essential oil, while linalyl acetate (28-38%), linalool (24-35%) and camphor (6-7%) are present in lavandin essential oil.[10] Lavender essential oil has applications in many part of industries, because of its greater linalool and linalyl acetate content, whereas essential oil of lavandin is frequently utilized in industrial and residential cleaning goods, hygiene and detergents thanks to higher camphor levels.[9]

This research aimed to investigate the morpho-genetic impact on macro-micronutrient, phenolic, flavonoid content, antioxidant activities and essential oil profile of three common commercial *Lavandula* species. The chosen species *L. angustifolia, L. intermedia* and *L. dentata* are among the most commercially significant due to their wide cultivation, diverse essential oil compositions and potential applications in pharmaceutical, cosmetic and food industries.

MATERIALS AND METHODS

Plant materials

The study materials consist of *Lavandula* species cultivated in the Medicinal and Aromatic Plants Garden of Van Yuzuncu Yil University, Faculty of Agriculture, Department of Field Crops. This garden is located in 1680 m altitude (38º33'46.21" N, 43º17'51.29" E). The study materials consist of three *Lavandula* species. These are *Lavandula angustifolia* Mill., *Lavandula intermedia* Emeric ex Loisel. and *Lavandula dentata* L. Samples were taken 3 years after planting, first week of August. Shade drying was used to minimize degradation of thermosensitive compounds, preserving the phenolic and essential oil content. The dried samples were then cut into smaller pieces and grounded into moderately coarse powder.

Determination of ash, dry matter, heavy metal and nutrient contents

The nutritious values such as total ash, dry matter and minerals (macro elements, K, Ca and Mg; micro elements, Fe, Zn, Cu and Mn) and some heavy metals (As, Cd, Co, Ni, Cr and Pb) were measured in plant both leaves and flower parts. Dry matter was determined by drying the samples at 105ºC for 24 hr in oven. For the total ash (inorganic matter) determination, an Electrical Muffle furnace set at 550ºC was used. The mineral constituents of the plant samples were investigated as follows: at first, the dried samples were ashed in a furnace with hydrochloric acid and nitric acid (AR) (AOAC 2000). Then, distilled water (50 mL) was added to samples in a volumetric flask. All assays were performed triplicate, and the standard materials were being utilized for chemical analyses. Atomic Absorption Spectrometry (AAS) was used to determine K, Ca, Mg, Fe contents. ICP-OES (Inductively coupled plasma-Optical emission spectrometer) was also used to determine other micro elements and heavy metals (Mn, Zn, Cu, Ni, As, Cd, Co, Cr and Pb).

Total antioxidant, total phenolic and total flavonoids contents

Total phenolic compounds content was measured according to method.[11] The antioxidant activity was also determined based on the Antioxidant Power (FRAP) (Iron (III) antioxidant power reduction) method[12] followed by readings the absorbance at 593 nm and antioxidant activity values were recorded as Trolox Equivalent (TE)/mg. The total flavonoids content was determinated with some modifications according to the method.[13] The total amount of flavonoids was measured at 415 nm and calculated in mg Quercetin Equivalent (QE) 100 g^{-1} DM by using the calibration curve using standard quercetin.

Isolation of the Essential Oils

The essential oils were isolated from air-dried plant materials by hydrodistillation for 3 hr, using a clevenger-type apparatus. The oils obtained were dried over anhydrous sodium sulphate and stored at +4ºC in the dark.

GC-MS Analysis

The essential oil composition was analyzed by gas chromatography (Agilent 5975C) coupled to flame ionization detector and mass spectrometry (Agilent 5975C) using capillary column (HP Innowax Capillary; 60.0 m×0.25 mM×0.25 µM). Essential oils were diluted 1:50 ratio with hexane. GC-MS/FID analysis was carried out at split mode of 50:1. Injection volume and temperature were adjusted as 1 µL and 250ºC, respectively. Helium (99.9%) was the carrier gas at a constant flow rate of 1 mL/min. The oven temperature was set as follows: 60ºC for 10 min, increased at 20ºC/min to 250ºC and held at 250ºC for 8 min. MS spectra were monitored between 35 and 450 amu and the ionization mode used was electronic impact at 70 eV.

Identification of Compounds

The relative percentage of the components was calculated from GC-FID peak areas and components were identified by Wiley 7n, Nist 05 and Flavour and Fragrance Natural and Synthetic Compounds (ver. 1.3) Libraries.

RESULTS AND DISCUSSION

In this study, the total ash varied from 7.01% to7.84% for inflorescence and 5.53% to 10.14% for leaves (Table 1). For inflorescence results are pretty close to each other. Previous study inflorescence ash determined as 9.2% for *L. officinalis*[14] and 7.49% for *L. angustifolia.*[15] Our finding on total ash content pretty similar to previous study. Dry matter, for inflorescence and leaves between 87.86% to 92.25% and 84.86% to 93.82%, respectively. Previous study reveals that, for *L. angustifolia* dry matter 93.20% as it similar to our results.[15]

Total flavonoid content of the species for inflorescence varied between 6.64 to 8.76 mg QE/100 g and for leaves between 7.72 to 11.26 mg QE/100 g. Both inflorescence and leaves *L. intermedia* has highest flavonoid content value for the study. İn a previous study, 30 different *L. intermedia* populations flavonoid content researched, and they found that between 28.19 to 71.62 mg QE/100 g.[16] The values we obtained may be lower than the results of previous studies, but considering that flavonoid content is affected by many factors such as environmental conditions, our results are acceptable. Total antioxidant activity for inflorescence between 83.92 to 167.94 µmol TE/g and for leaves between 75.64 to 135.48 µmol TE/g. *L. angustifolia* and *L. intermedia* cultivars antioxidant capacity and found between 79.21-203.06 µmol TE/g in a previous study.[17] Our findings are parallel to previous studies results. Total phenolic content of *Lavandula* species inflorescence and leaves varied 191.73 to 208.5 mg GAE/g, 110.48 to 208.92 mg GAE/g, respectively. The highest phenolic content value for study is obtained from leaves of the *L. dentata* and it is noteworthy that the antioxidant activity, total flavonoid and phenolic content of the leaves of *L. dentata* unlike the other species is higher than inflorescence (Table 1). In previous research *L. angustifolia* phenolic content found between 208.7 to 289.8 mg GAE/100 g,[18] *L. intermedia* phenolic content found between 31.45-105.39 mg GAE/100 g.[16] When the results of previous studies were examined, they were similar to the results we obtained as a result of the study.

Macro and micronutrient results shows that highest concentrations of Calcium (Ca), Magnesium (Mg), Potassium (K), Iron (Fe) and Manganese (Mn) have been found in *L. angustifolia*. Moreover, while lowest concentrations of Ca, Mg, K and Fe were observed in *L. dentata*, highest concentrations of Zinc (Zn) and Copper (Cu) observed in same species (Table 2). In a study *L. angustifolia* concentrations reported as Calcium 10500 mg kg^{-1} (10.5 g kg^{-1}), Magnesium 2192 mg kg^{-1} (2.19 g kg^{-1}), Potassium 11991 mg kg^{-1} (11.9 g kg^{-1}).[15] Micronutrients of *L. angustifolia* and *L. intermedia* both leaves and inflorescence studied, *L. angustifolia* leaves and inflorescence concentration of Fe 353.2 mg kg^{-1}, 230.9 mg kg^{-1}, concentration of Mn 38.9 mg kg^{-1}, 9.85 mg kg^{-1}, concentration of Zn 45.7 mg kg^{-1}, 68.0 mg kg^{-1}, concentration of Cu 2.38 mg kg^{-1}, 3.96 mg kg^{-1}, respectively.[19] Same studies result about *L. intermedia* leaves and inflorescence concentration of Fe 350.5 mg kg^{-1}, 186.8 mg kg^{-1}, concentration of Mn 37.7 mg kg^{-1}, 10.8 mg kg^{-1}, concentration of Zn 48.5 mg kg^{-1}, 49.5 mg kg^{-1}, concentration of Cu 3.19 mg kg^{-1}, 4.88 mg kg^{-1}, respectively. Mineral concentration of plant affected many environmental factors, such as soil properties, climatic condition, altitude etc., some of our findings are higher, some of them are lower than previous study but all of the findings from the study were consistent with the relevant literature.

In *Lavandula* species the concentration of heavy metals were as follows; Nickel (Ni) concentration 0.75 mg kg^{-1} to 1.50 mg kg^{-1}, Arsenic (As) concentration 0.53 mg kg^{-1} to 3.61 mg kg^{-1}, Cadmium (Cd) concentration 0.03 mg kg^{-1} to 0.04 mg kg^{-1} and Cobalt (Co) concentration 0.02 mg $kg^{-1}$to 0.38 mg kg^{-1}, Chromium (Cr) concentration 0.26 mg kg^{-1} to 4.21 mg $kg^{-1}$and Lead (Pb) 0.87 mg kg^{-1} to 2.21 mg kg^{-1} (Table 2). While in inflorescence of three *Lavandula* species heavy metal of cadmium not detected, three heavy metals (Ni, Cd, Co) not detected in leaves of *L. intermedia*. Concentration of heavy metals in *L. angustifolia* reported as follows; lead concentration 0.11 mg kg^{-1}, copper 0.41 mg kg^{-1} and Cadmium 0.019 mg kg^{-1}.[20] Another study also reported that concentration of heavy metals in *L. angustifolia* as cadmium and lead 6.15 mg kg^{-1} and 68.04 mg kg^{-1}, respectively.[21] Heavy metals content in plant depends on their ecological condition, especially contaminated soil and water by heavy metals. Previous study and our results showing difference, but also previous study does not seem consistent each other. The reason for this is thought to be that these values are highly affected by environmental conditions.

As can be seen in Table 3, the ratio of essential oil (%v/w) was 7.31% for *L. angustifolia*, 4.92% for *L. intermedia* and 3.92% for *L. dentata*. Essential oil yields obtained in our study were generally

Table 1: Total ash, Dry matter, Total flavonoids, Total Antioxidant activity and Total phenolic content of *Lavandula* species.

	Lavandula angustifolia		***Lavandula intermedia***		***Lavandula dentata***	
	Inflorescence	**Leaf**	**Inflorescence**	**Leaf**	**Inflorescence**	**Leaf**
	Mean±S.d.	**Mean±S.d.**	**Mean±S.d.**	**Mean±S.d.**	**Mean±S.d.**	**Mean±S.d.**
Total Ash (%)	7.83 ±0.55	8.92±0.42	7.01±0.33	5.53 ± 0.57	7.55±0.46	10.14±0.66
Dry matter (%)	87.85±0.60	84.86±0.50	91.89±0.48	93.81±0.46	92.25±0.40	90.90±0.48
Total flavonoids (mg QE/100 g)	8.16±1.38	7.72±2.10	8.76±0.64	11.26±1.66	6.64±0.59	8.80±0.94
Total antioxidant Activity (µmol TE/g)	83.92±0.82	75.64±5.47	167.94±9.99	92.82±12.19	111.73±8.75	135.48±0.59
Total phenolic (mg GAE/g)	208.5±17.81	110.48± 11.09	191.73±3.91	153.92±2.43	198.29±12.97	208.92±11.09

S.D. represents Standard Deviation for three replications (*n*=3).

higher results with literature data, for all species. The essential oil yield of *L. angustifolia* shows higher results compared to previous reports[22,23] but also lower than the previous results (10.27%).[24] On the other hand, essential oil yields cultivated in same plot of *L. angustifolia* and *L. intermedia*; reported that the oil yield (%v/w) 1.13% and 2.75%,[25] 3.3% and 0.9%,[26] 3.1-3.6% (v/w) and 4.4-8.1% (v/w),[27] respectively. *L. intermedia* EO ratio found in a study 7.95% in condition of Konya/Türkiye.[28] The essential oil yield of *L. dentata* was also higher in comparison with previous reports of 2.0% (w/w),[29] 0.70% (w/w)[30] and 1.41%.[31,32] The lower essential oil yields in *L. dentata* may be attributed to its genetic characteristics and higher sensitivity to environmental factors, such as temperature and soil conditions, compared to *L. angustifolia*. Essential oil yield is affected by many factors, such as genotype, environmental conditions, harvest and extraction method. The differences between our result and previous studies could be explained by these factors.

Linalool were the predominant essential oil constituents in both *L. angustifolia* (50.04%) and *L. intermedia* (48.69%), whereas 1,8-cineole were (82.66%) major constituents in *L. dentata* (Table 3). 1,8-cineole and camphor were the major essential oil constituents in all species with different rates (Figure 1). The high linalool content in *L. angustifolia* and *L. intermedia* makes them suitable for pharmaceutical and cosmetic applications, while the phenolic richness of *L. dentata* highlights its potential for

Table 2: Macro, micro elements and heavy metal content of *Lavandula* species.

	Lavandula angustifolia		*Lavandula intermedia*		*Lavandula dentata*	
	Inflorescence	Leaf	Inflorescence	Leaf	Inflorescence	Leaf
Elements	Mean±S.d.	Mean±S.d.	Mean±S.d.	Mean±S.d.	Mean±S.d.	Mean±S.d.
Mg (g kg^{-1})	7.37±1.25	6.01±0.14	4.47±0.66	4.07±0.10	3.81±0.07	4.16±2.34
K (g kg^{-1})	21.26±0.52	18.86±10.92	20.78±4.57	38.81±0.14	18.62±1.12	5.42±1.82
Ca (g kg^{-1})	19.18±2.85	32.87±15.35	10.81±1.70	14.95±0.73	14.77±0.30	7.86±2.69
Fe (mg kg^{-1})	515.36±42.68	871.18±103.23	713.64±37.02	467.62±21.54	399.16±22.80	268.78±46.44
Mn (mg kg^{-1})	38.86±0.48	72.32±12.78	18.01±2.43	25.63±0.20	41.62±2.08	66.04±12.11
Zn (mg kg^{-1})	21.80±1.89	26.06±5.73	32.21±1.95	27.88±2.01	40.03±2.93	29.16±4.94
Cu (mg kg^{-1})	6.34±0.44	6.31±0.81	10.31±2.13	10.29±0.05	13.46±0.68	10.06±1.52
Ni (mg kg^{-1})	nd	1.50±0.54	0.83±0.53	nd	0.75±0.45	nd
As (mg kg^{-1})	1.56±0.07	3.61±2.60	0.84±0.43	0.84±0.14	0.64±0.23	0.53±0.24
Cd (mg kg^{-1})	nd	0.04±0.02	nd	nd	nd	0.03±0.01
Co (mg kg^{-1})	0.17±0.01	0.38±0.02	0.10±0.05	nd	0.18±0.01	0.02±0.01
Cr (mg kg^{-1})	1.63±0.12	4.21±0.81	1.14±0.53	1.77±0.05	1.98±0.06	0.26±0.05
Pb (mg kg^{-1})	1.50±0.23	0.94±0.13	0.87±0.35	2.21±1.37	2.12±0.40	2.06±0.90

S.D.: Standard Deviation for three replications (*n*=3), nd: Not Detected.

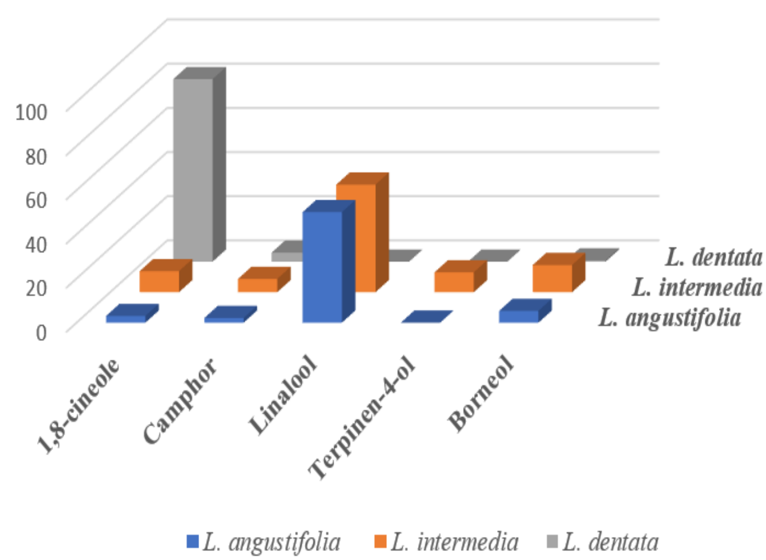

Figure 1: Major compounds of essential oil of *Lavandula* species.

Table 3: Essential oil compounds and ratio of *Lavandula* species.

RI	RT	Compound	*Lavandula angustifolia*	*Lavandula intermedia*	*Lavandula dentata*
1010	10.809	α-pinene	-	0.42	1.13
1051	12.410	Camphene	-	0.38	-
1102	14.262	β-pinene	-	-	1.97
1148	16.420	Myrcene	0.79	0.58	-
1185	18.050	Limonene	0.51	1.38	1.13
1196	18.527	1.8-cineole	3.04	9.51	82.66
1236	20.253	β-ocimene	1.82	2	-
1243	20.555	3-octanone	0.84	-	-
1257	21.180	Hexyl acetate	0.71	-	-
1333	24.284	Hexanol	-	0.42	-
1360	25.354	1-octen-3-ol acetate	0.26	-	-
1397	26.799	Hexyl butyrate	0.77	0.76	-
1410	27.238	Hexyl-2-methyl butyrate	-	0.37	-
1427	27.829	Trans-linalool oxide	0.75	1.56	-
1455	28.828	Cis-linalool oxide	0.57	0.77	-
1519	30.864	Camphor	2.11	5.99	4.07
1523	31.170	Linalool	50.04	48.69	-
1536	31.539	Linalyl acetate	20.75	2.63	-
1567	32.545	Pinocarvone	-	-	0.84
1585	33.113	Lavandulyl acetate	2.71	-	-
1586	33.160	Terpinen-4-ol	-	8.97	-
1597	33.385	Terpinen-4-ol	-	-	0.88
1629	34.449	Myrtenal	-	-	0.78
1643	34.870	Trans-β-farnesene	-	0.67	-
1646	34.959	Trans-pinocarveol	-		0.89
1651	35.131	Lavandulol	-	1.03	-
1661	35.418	δ-terpineol	-	-	1.48
1668	35.621	Trans-verbenol	-	-	0.5
1678	35.910	Cryptone	-	-	0.76
1678	35.941	α-terpineol	3.24	0.64	0.97
1682	36.038	Borneol	5.34	12.29	0.6
1702	36.639	Neryl acetate	0.77	-	-
1732	37.479	Geranyl acetate	1.37	-	-
1773	38.630	Nerol	0.69	-	-
1783	38.897	Cuminal	-	-	0.63
1817	39.836	Geraniol	1.85	-	-
1980	44.095	Caryophyllene oxide	0.43	-	0.72
2192	49.070	α-bisabolol	0.66	0.94	-
Essential oil ratio (%):			7.31	4.92	3.92

functional food industries. While linalyl acetate (20.75%), lavandulyl acetate (2.71%), α-terpineol (3.24%) and borneol (5.34%) were other major components for *L. angustifolia*, terpinen-4-ol (8.97%) and borneol (12.29%) were major component for *L. intermedia*. İn a previous study, major constituent for both *L. intermedia* and *L. angustifolia* as Lavandulyl acetate (8.26%-5.90%), Linalyl acetate (34.22%-21.05%), α-Terpineol (4.30%-3.97%), Linalool (21.77%-29.56%) and 1,8-Cineole(2.77%-9.10%)[27], in another research 1,8 Cineole (2.92%-8.44%), Linalool (53.97%-57.10%), Terpinen-4-ol (3.70%-2.33%) and Linalyl acetate (11.56-9.83%) reported.[26] For *L. dentata* our results were not accordance with previous research for major constituents but those research also not showing accordance with each other. Previous report about major constituents of *L. dentata*, Eucalyptol (46.3%), camphor (15.0%), Fenchone (15.8%), β-pinene (5.3%), α-pinene (3.7%),[33] in another study α-pinene (4.05%), Sabinene (13.89%), 1,8-cineole (41.28%), Myrtenal (5.11%), Borneol (2.88%), Linalool (2.76%),[34] in different study β-Eudesmol (21.17%), Myrtenol (13.02%), Sabinol (11.02%), β-Selinene (5.00%) and p-Mentha-1,8-dien-4-ol (5.73%).[35] This may be explained by the fact that *L. dentata* species are more affected by environmental conditions than other species.

CONCLUSION

Lavandula sp. is a valuable plant species as an ornamental plant with beautiful inflorescence and aromatic plant with high yield of essential oil. This comparative study revealed morpho-genetic variability of three common cultivated lavender species under the same conditions. *L. angustifolia* were more productive in terms of essential oil content and also mineral content for some elements except heavy metals. For phenolic compound, while *L. dentata* shows higher results with total flavonoid and phenolic content, *L. intermedia* shows greater total antioxidant activity. It's noteworthy that *L. angustifolia* and *L. intermedia* major compounds in essential oil has similarities and predominant compound for both species Linalool about 50%. *L. dentata*'s predominant compound is 1,8-cineole about 80%. Those plant species could have potential in the food, cosmetics and pharmaceutical industries as well as ornamental sectors. This study highlights the variability in phytochemical content and essential oil composition among *L. angustifolia, L. intermedia* and *L. dentata*. The high linalool content in *L. angustifolia* and *L. intermedia* underscores their potential for pharmaceutical and cosmetic applications. In contrast, the phenolic and antioxidant richness of *L. dentata* offers promising opportunities in the functional food industry. These findings provide valuable insights for optimizing the industrial use of *Lavandula* species cultivated under varying conditions.

ABBREVIATIONS

SD: Standard Deviation; **GAE:** Gallic Acid Equivalent; **QE:** Quarcetin Equivalent; **TE:** Trolox Equivalent; **RT:** Retention time; **RI:** Retention index.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

SUMMARY

Lavandula species (Lavender, lavandin, spike lavender) are Mediterranean-originated perennial and most widely cultivated species that are grown all over the world as ornamental and medicinal plants.

The samples investigated from different organs (leaf and inflorescence) of three common *Lavandula* species were used to monitor phenolic and mineral content.

Under the same cultivation conditions *L. angustifolia* were more productive in terms of essential oil content and mineral content. For phenolic compound, while *L. dentata* shows higher results with total flavonoid and phenolic content, *L. intermedia* shows greater total antioxidant activity.

1,8-cineole and camphor were the major essential oil constituents in all species with different rates.

Linalool were the predominant essential oil constituents in both *L. angustifolia* (50.04%) and *L. intermedia* (48.69%), whereas 1,8-cineole were (82.66%) major constituents in *L. dentata*.

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