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Original Article

Composition of *Lavandula angustifolia* L. cultivated in Transylvania, Romania

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Abstract

An increasing market demand concerning lavender essential oil is reported. Identification and characterization of the main compounds of this oil is needed, in order to identify chemotypes. This information is useful for further uses of the produced oil. Essential oil extracted from two *Lavandula angustifolia* L. varieties, cultivated in different areas of Transylvania, Romania, was analysed from the point of view of qualitative and quantitative composition, using gas-chromatography. Basic statistics was used for calculation of essential oil compounds means and dispersion parameters, while the profile of the essential oil composition was emphasized using Box-Plot diagrams and cluster analysis. Nine compounds, in different amounts were quantified, and two chemotypes, corresponding to 'Mailette' and 'Vera' varieties were established (linalool, and linalyl acetate, respectively). Differences in essential oil composition are recorded in 'Vera' variety corresponding to 'Vera' linalyl acetate chemotype, function of specific condition of lavender cultivation area.

Keywords: chemotype; cluster; distribution; essential oil; lavender; terpene

Introduction

Lavender is a well-known plant, which belongs to the Order Lamiales, Family Laminaceae, Genus *Lavandula*. Our days, there is considered that genus has about 47 species, and since old times it may be encountered worldwide, from Mediterranean areal to Asia and Africa (Cavanagh and Wilkinson, 2002). Among *Lavandula* species, *Lavandula angustifolia* L. is one the most popular in the world. In Romania, it is cultivated since 1950, and in present times, due to the high demands of the market, large areas are occupied by lavender crops.

Due to the composition of the essential oil, lavender has many important benefits for human and animal health, similarly with other biological origin products (Cîmpean *et al.*, 2000a,b,c; Cardia *et al.*, 2018). It is often used in aromatherapy, reduces response to stress in both human and animals (Pourtaraud *et al.*, 2018), and may play the role of food preservation agent (Linck *et al.*, 2010). Literature mentions different constituents as being predominant in *Lavandula angustifolia* L. essential oil (Cardia *et al.*, 2018). They are mainly represented by monoterpenes - camphene, limonene, myrcene, cis- and/or trans-ocimene, α- and β-pinene, monoterpenols - borneol, linalool, terpinen-4-ol, α- and/or γ-terpineol, lavandulol, terpenic esters - lavandulyl acetate, linalyl acetat, sesquiterpenes - caryophyllene and/or its oxide, farnesene, and terpenoids - a terpenic oxide, 1,8-cineole respectively, terpenic ketones, camphor, and 3-octanone (Lesage-Meessen *et al.*, 2015; Tabari *et al.*, 2017). If according to some authors 1,8-cineole, camphor, borneol or α- and β-pinene are the major constituents of *Lavandula angustifolia* L. essential oil (Hajhashemi *et al.*, 2003; Prashar *et al.*, 2004), majority of researches mention that linalool, linalyl acetate, cis/trans β-ocimene or borneol, as main constituents (Kara and Baydar, 2012; Chioca *el al.*, 2013;

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Raina *et al*., 2012; Prusinowska *et al*., 2014; Gassan al-Wassouf, 2018; Santos *et al*., 2018).

Linalool is an aromatic monoterpene, also identified in high amounts in other aromatic herbs (Toncer *et al*., 2017; Ilić *et al*., 2019), and it is considered as having effects in decreasing anxiety (Moss and Oliver, 2012; Chioca *el al*., 2013), but also as anticonvulsant, sedative or antidepressant (Shahabi *et al*., 2014). It is considered as main responsible for *Lavandula angustifolia* L. essential oil anxiolytic effects (Trombeta *et al*., 2005; Kasper *et al*., 2010), by inhibiting serotonin reuptake and increasing the level of serotonin (Cowen *et al*., 2015). It may be used even as alternative to conventional treatments of social stress induced mental disorders, and having sedative effect (Cavanagh and Wilkinson, 2002; Caputo *et al*., 2018). Research concerning other potential actions of linalool on health, also suggests the impact on cardiovascular disease by antihypertensive properties (Umezu *et al*., 2001; Camargo *et al*., 2018; Pereira *et al*., 2018;), protective effects on ulcerative colitis in rats (Smigielski *et al*., 2009), slowing growth rate in bacteria (Petrut *et al*., 2017; Burdon *et al*., 2018), or even anticancer, anti-inflammatory, and anti-hyperlipidemic properties (Peana *et al*., 2014; Shahabi *et al*., 2014; Eide *et al*., 2016). Linalyl acetate is an oxygenated monoterpene (Cavanagh and Wilkinson, 2002), which have a well-known antimicrobial action (Sokovic *et al*., 2010; Peana *et al*., 2014; Shahabi *et al*., 2014). Studies performed by Kim *et al*. (2017) suggest that linalyl acetate may contribute to recovery of cardiovascular changes, and cell damage resulted as consequence of cardiovascular disruption induced by nicotine. Studies performed by Kwoon *et al*. (2018) suggest that it is involved in mechanisms which prevent intestinal hyper motility induced by pathological conditions. It has been shown that it has narcotic actions (Cavanagh and Wilkinson, 2002). Linalool and linalyl acetate are ineffective as repellent agents (Prusinowska *et al*., 2014).

Borneol, also a monoterpene, is well known as having anti-inflammatory, analgesic, sedative, anti-nociceptive, vasorelaxant and antithrombotic effects (Qun-Lin *et al*., 2017). Recent research suggests that it may be considered a promising agent, even further studies are needed, for enhancing the blood-brain barrier permeability, with important consequences on improving in central nervous system drug delivery (Tomescu *et al*., 2015), and, also, having relaxing effect of aortic rings, in rat (Hamidpour *et al*., 2012). Camphor is a ketone, which may be obtained from appropriate overall vegetal sources (Hamidpour *et al*., 2012). It has many pharmaceutical applications, being considered antiseptic, antiinflammatory, antiinfective, topical analgesic, antipruritc, antispasmodic, mild expectorant, rubefacient, cough suppressant, nasal decongestant, and even contraceptive (Wang *et al*., 2018). In rats, it is reported that it decreases the level of follicle-stimulating hormone (FSH), increases the level of luteinizing hormone, but it has no effect on testosterone (Kim *et al*., 2014). 1,8-cineole belongs to the terpenoid family, and it is a lipophilic terpenoid oxide considered to act on receptor sites and enzyme activity, at the neuronal level (Santos and Rao, 2000; Lau *et al*., 2008). According to Umezu *et al*. (2001), and Lau *et al*. (2008), it stimulates activity in mice, and reduces level of anxiety and, according to other research it improves cognitive performance (Moss and Oliver, 2012). It is also considered an inhibitor of acetylcholinesterase (Zuccarini *et al*., 2009; Caldas *et al*., 2015). According to Caldas *et al*. (2015), 1,8-cineole also has gastro protective properties, being involved in antiulcer mechanisms (Nardoni *et al*., 2018). It also acts as acaricidal repellent (Rivas da Silva *et al*., 2012). Another important active principle of the lavender essential oil, pinene, respectively, is a bicyclic monoterpene identified in *Lavandula angustifolia* L. essential oil, has positive enantiomers, α-pinene, and β-pinene, respectively, that have been found to have antimicrobial effects on *Candida albicans, Cryptococcus neoformans*, and *Rhizopus oryzae* (Inouye *et al*., 2001), and gram-positive bacteria (Leite *et al*., 2007; Woelk *et al*., 2010; Woronuk *et al*., 2011).

Due to the continuous increase of *Lavandula angustifolia* L. cultivation areas in Transylvania, Romania, as consequence of market demands, and scarcity of thoroughgoing studies concerning essential oil obtained from this lavender specie, our study focuses on identification and quantification of 9 main components from essential oil (α-pinene, β-pinene, 1,8 cineole, cis-β-ocimene, trans-β-ocimene, linalool, camphor, borneol, linalyl acetate), obtained from four different regions of Transylvanian plane.

Materials and Methods

Plant material

Flowers from two varieties of *Lavandula angustifolia* L., 'Mailette' and 'Vera', respectively, were harvested during the blooming period, in June 2018, from four cultivars founded in 2014.

Sampling area

Lavender samples used in this trial were collected from cultures founded in 4 private farms located in Transylvania: Bonțida (46° 54' 56" N, 23° 48' 30" E), Cluj County - 'Mailette' variety, Sânpaul (46°5 2' 15" N, 23° 25' 09" E), Cluj County - 'Vera' variety, Cămărașu (46° 47' 30" N, 24° 07' 35" E), Cluj County - 'Vera' variety, and 'Fetindia' (47° 08' 28" N, 23° 00' 55" E), Sălaj County - 'Vera' variety.

Distillation

Total volatile oil was obtained by hydro-distillation using Clevenger distillation equipment. Fresh lavender flowers were used as raw material. The drying of the essential oil (distilled material) was performed on anhydrous sodium sulphate. The extracted material was kept at +4 °C

Gas chromatography (GC) - mass spectrometry (MS): The analysis was performed with Shimadzu single quadrupole GCMS-QP2010 equipment. A capillary column SH-Rxi™ - 1MS (Shimadzu), with the mass flow of 1 mL/min, was used, with helium as gas carrier, with pre-rods for minimising the mass filter contamination. The column temperature was between 40 °C - 210 °C, while the ion source temperature was 150 °C, and injector source of 250 °C. In order to identify the main compounds of the lavender essential oil, NIST spectra library was used. The identification and quantification of 9 components of the *Lavandula angustifolia* L. was aimed: α-pinene, β-pinene, 1,8 cineole, cis-β-ocimene, trans-β-ocimene, linalool, camphor, borneol, and linalyl acetate.

Statistical analyses

The implementation of basic statistics, package of IBM SPSS v.20.0 for windows, involves the calculation of means, dispersion parameters, and significance of differences. The descriptive statistics emphasized the means and dispersion parameters of the identified compounds of the studied *Lavandula angustifolia* L. varieties essential oils. The independent group's t-test was applied, in order to compare the means of each lavender essential oil compound, function of variety and cultivation area, and identify the significance of differences between compared means. Box-Plot diagrams were used for emphasizing the distributions of the quantified lavender essential oil compounds, using minimum concentration values, maximum concentration values and quartiles: minimum - first, median, third, and maximum - forth (Nuzzo, 2016). The multivariate analysis package of IBM SPSS v.20.0 for windows, allowed us to run the cluster analysis application, for grouping the 9 quantified components of different lavender varieties essential oil, into distinct, homogenous groups, using Euclidean distances.

Results and Discussion

The content of essential oil from analyzed lavender varieties in main compounds, differ at particular significance thresholds, function of both varieties, and geographical origin (Table 1).

Linalool is the major component (39.05%) of volatile oil resulted from 'Mailette' variety, followed by linalyl acetate (28, 61%), trans-β-ocimene (3.14%), borneol (1.72%) and cis-β-ocimene (1.63%). Differences assured at statistical threshold of 0.01% are reported between the mean linalool, trans-β-ocimene and cis-β-ocimene content, respectively, contents reported in 'Mailette' variety lavender oil, compared to 'Vera' variety lavender oil extracted from flowers harvested from the other three locations. No significant differences are reported between the mean linalyl acetate contents reported in 'Mailette' variety lavender oil, compared to 'Vera' variety lavender oil extracted from flowers harvested from the other three locations (Table 1).

The major component of volatile oil resulted from 'Vera' lavender variety was linalyl acetate (25, 64% - Sânpaul, 26, 18% - Cămărașu, 29, 86% - Fetindia), followed by linalool (22.35% - Sânpaul, 21.38% - Cămărașu, 18.46% - Fetindia). In 'Vera' lavender variety harvested from Sânpaul and Fetindia, the main components following, in terms of share, the linalyl acetate and linalool contents in essential oil, are: trans-β-ocimene (6.70%, and 14.39%, respectively), cis-β-ocimene (6.55%, and 4.75%, respectively), and borneol (2.92%, and 2.78%, respectively). Concerning 'Vera' lavender variety harvested from Cămărașu, the hierarchy of the main components following, in terms of share, the linalyl acetate and linalool contents in essential oil, is: cis-β-ocimene (8.40%), trans-β-ocimene (8.37%), and borneol (2.15%).

These results emphasize that, even though the major components of the volatile oil extracted from the two analyzed lavender varieties harvested from 4 locations are the same, their hierarchy differ function of both, variety and harvesting area.

Table 1. The basic statistics for the main compounds of the lavender oil, function of location of cultivation (%)

Issue		1	2	3	4	5	6	7	8	9
Geographical origin	No. of cases	6	6	6	6	6	6	6	6	6
Bonțida Mailette variety	**X**	**0.13**^{d}	**0.02**^{da}	**0.16**^{d}	**1.63**^{d}	**3.14**^{d}	**39.05**^{d}	**0.21**^{da}	**1.72**^{b}	**28.61**^{a}
	Min.	0.12	0.02	0.15	1.62	3.10	39.00	0.20	1.69	28.40
	Max.	0.14	0.03	0.17	1.65	3.17	39.10	0.22	1.75	28.80
	SD	0.01	0.01	0.01	0.01	0.03	0.04	0.01	0.02	0.16
	CV	5.17	7.42	3.82	0.76	0.83	0.10	3.20	1.26	0.54
Sânpaul Vera variety	**X**	**0.77**^{da}	**0.22**^{da}	**0.74**^{d}	**6.55**^{dc}	**6.70**^{d}	**22.35**^{dab}	**0.31**^{d}	**2.92**^{ba}	**25.64**^{a}
	Min.	0.72	0.21	0.70	6.50	6.60	22.30	0.29	2.85	25.58
	Max.	0.82	0.25	0.80	6.60	7.00	22.41	0.34	2.99	25.72
	SD	0.04	0.02	0.04	0.04	0.15	0.05	0.02	0.05	0.06
	CV	4.60	7.23	4.80	0.58	2.25	0.21	5.77	1.73	0.22
Cămărașu Vera variety	**X**	**0.81**^{da}	**0.20**^{da}	**0.62**^{db}	**8.40**^{dc}	**8.37**^{d}	**21.38**^{dab}	**0.22**^{ad}	**2.15**^{ba}	**26.18**^{a}
	Min.	0.78	0.17	0.59	8.30	8.30	21.30	0.20	2.00	26.10
	Max.	0.83	0.22	0.66	8.50	8.45	21.50	0.24	2.30	26.30
	SD	0.02	0.02	0.02	0.07	0.05	0.07	0.01	0.10	0.07
	CV	2.32	8.90	4.02	0.79	0.65	0.33	6.43	4.73	0.27
Fetindia Vera variety	**X**	**0.34**^{d}	**0.07**^{da}	**0.55**^{db}	**4.75**^{dc}	**14.39**^{d}	**18.46**^{db}	**0.22**^{ad}	**2.78**^{ba}	**29.86**^{a}
	Min.	0.30	0.07	0.50	4.69	14.33	18.40	0.20	2.70	29.80
	Max.	0.37	0.08	0.61	4.82	14.42	18.51	0.24	2.83	29.92
	SD	0.03	0.01	0.04	0.05	0.03	0.05	0.01	0.05	0.05
	CV	7.67	7.58	7.89	1.09	0.23	0.25	6.43	1.70	0.15

Note: X – Mean, SD - Standard deviation, CV - Coefficient of variation, %, 1-α-pinene, 2-β-pinene, 3-1,8 cineole, 4-cis-β-ocimene, 5-trans-β-ocimene, 6-linalool, 7-camphor, 8-borneol, 9-linalyl acetate; a- $p>0.05$; b- $p<0.05$; c-$p<0.01$; d-$p<0.005$

In our trial, linalyl acetate is the main component of the essential oil extracted from *Lavandula angustifolia* L. 'Vera' variety, whatever cultivation area (25.64%-29.86%). Linalool is the main compound (39.05%) of the essential oil of *Lavandula angustifolia* L., 'Mailette' variety, analyzed in our study, and this result is consistent with the findings reported by Lafhal *et al.* (2018), in *Lavandula angustifolia* L. 'Mailette' variety, cultivated in France, where it was identified in amounts of 40.01% (Lafhal *et al.*, 2016). Similar results are reported by Stranev *et al.* (2016), for Bulgarian *Lavandula angustifolia* L. varieties, where linalool was identified in essential oil composition in concentrations ranging from 22.2% to 39.8%. Linalyl acetate occupies the second place in terms of concentrations in essential oil extracted from different Bulgarian *Lavandula angustifolia* L. varieties, the amounts reported, in this case, being within the concentration interval 25.6% - 37.9%, function of cultivation area (Ognyanov, 1984), but the first place (35.8%), in essential oil from Indian varieties (Raina and Negi, 2012). The results we reported for *Lavandula angustifolia* L., 'Vera' variety, are not consistent with those obtained in *Lavandula angustifolia* L. varieties cultivated in Syria, where Al-Wassouf (2018), reports linalool as the main component (34.7%) of the essential oil, in Poland, where Smigielski *et al.* (2009) report a linalool concentration up to 57.5%, in Turkey where Kara and Baydar (2012) report a linalool concentration of 39.3% in 'Vera' variety, and even in Romania where Tomescu *et al.* (2015) report a concentration of 43.3%.

The concentration of the main compounds (linalool, linalyl acetate, ocimene, cineole, camphor) of the essential oil of *Lavandula angustifolia* L., 'Mailette' and 'Vera' varieties, studied in this trial, are similar, in amounts, with those reported by different authors, in the same specie, but in specific pedo-climatic conditions of Bulgaria, Italy, France, and even India (Table 2).

Analysing the Box-Plots of lavender main volatile oil components, 'Vera' variety, function of cultivation location, results similar distribution, by locations, for α-pinene, β-pinene, 1,8 - cineole and cis-β-ocimene. These compounds have the highest share in the essential lavender oil extracted from flowers cultivated in pedo-climatic conditions of Sânpaul, and Cămărașu, Cluj County. Trans-β-ocimene, borneol and linalyl acetate have the same distribution in essential oil, with highest values in oil resulted from lavender flowers cultivated in pedo-climatic conditions of Fetindia, Sălaj County (Fig. 1).

Linalool and camphor have specific distributions, in terms of share from total essential oil, function of harvesting area, with highest values in essential oil extracted from lavender flowers cultivated in pedo-climatic conditions of Sânpaul, Cluj County. Different linalool shares are reported in total essential oil extracted from lavender flowers, emphasizing the following hierarchy: (22.35%) Sânpaul, Cluj County, (21.38%) Cămărașu, Cluj County, and (18.46%) Fetindia, Sălaj County. Identical means of camphor share (0.22%) are reported in total essential oil extracted from lavender flowers cultivated in the pedo-climatic conditions of Cămărașu, Cluj County and Fetindia, Sălaj County (Fig. 1).

According to Box-Plot diagrams (Fig. 1), very similar individual values are recorded for cis-β-ocimene, trans-β-ocimene, and linalool shares in essential oil; in all analyzed varieties from all lavender harvesting locations, with equilibrate distributions. In essential oil extracted from 'Mailette' lavender variety, similar values with equilibrate distributions are also emphasized for α-pinene, β-pinene, and 1,8-cineole. The same characteristics are reported for borneol and linalyl acetate identified in essential oil from 'Vera' variety lavender flowers cultivated in Fetindia, Sălaj County. Values, which differ in a great extent and assimetric distributions are reported in α-pinene, β-pinene, 1,8-cineole, and camphor identified in essential oil from 'Vera' variety lavender flowers cultivated in pedo-climatic conditions of Sânpaul, Cămărașu - Cluj County, and Fetindia - Sălaj County, emphasizing variability within individual essential oil composition of this chemotype.

The cluster analysis emphasizes different patterns concerning the main components of the lavender essential oil, function of both variety, and cultivation area (Fig. 2).

In 'Mailette' variety, cultivated in the pedo-climatic conditions of Bonțida, Cluj-County, the cluster analysis emphasizes two main clusters. The first is a tall cluster, located at linkage distance of 26, with two branches corresponding to the main compounds identified in essential oil, linalool, and linalyl acetate, respectively, while the second cluster is a low one, located at linkage distance of about 3, with many branches, which cannot be clearily differentiated. This emphasize the big differences concerning the amounts of the two identified group of componds, linalool and linalyl acetate on one hand (39.05-28.61%), and the other analyzed compounds (0.02-1.72%) from the essential oil (Fig. 2a). Because small differences in height is emphasized by the dendogram within the second cluster, results that similar concentrations may be reported between their compounds, while the same linkage distance of the both branches of the first cluster suggests very high similarity of concentrations (Fig. 2a, and Table 1).

In 'Vera' variety cultivated in the pedo-climatic conditions of Sânpaul, Cluj-County, the cluster analysis emphasizes several clusters.

Table 2. The main compounds in essential oils of *Lavandula angustifolia* L.

No.	Compound	Experimental Romania	Bulgaria	Italy	France	Poland	India
1	Linalool	18.46-39.5	30.1-33.7	33.3-42.2	9.3-68.8	27.3-34.7	23.6-28.06
2	Linalyl acetate	25.64-29.86	35.2-37.6	37.8-41.2	1.2-59.4	19.7-22.4	47.56
3	Ocimene	1.63-14.39	6.8-7.7	-	0.2-18.1	1.9-2.9	0.70
4	Cineole	0.16-0.74	2.1-3.0	0.02-0.2	0-3.4	0.2-0.5	1.14
5	Camphor	0.21-0.31	< 0.5	0.3-0.6	0-0.5	0.2-0.3	1.40

Source: Ognyanov, 1984; Savelev *et al.*, 2003; Raina *et al.*, 2012; Beale *et al.*, 2017; Al-Wassouf, 2018

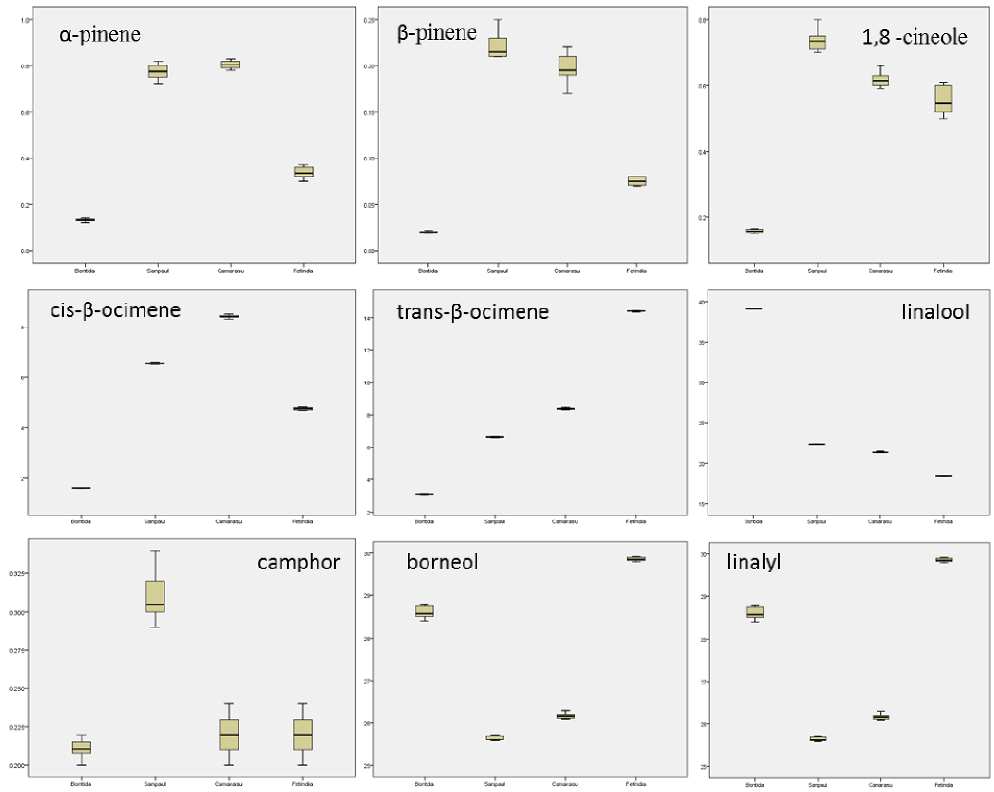

Fig. 1. The box-plots of lavender main volatile oil components function of cultivation location

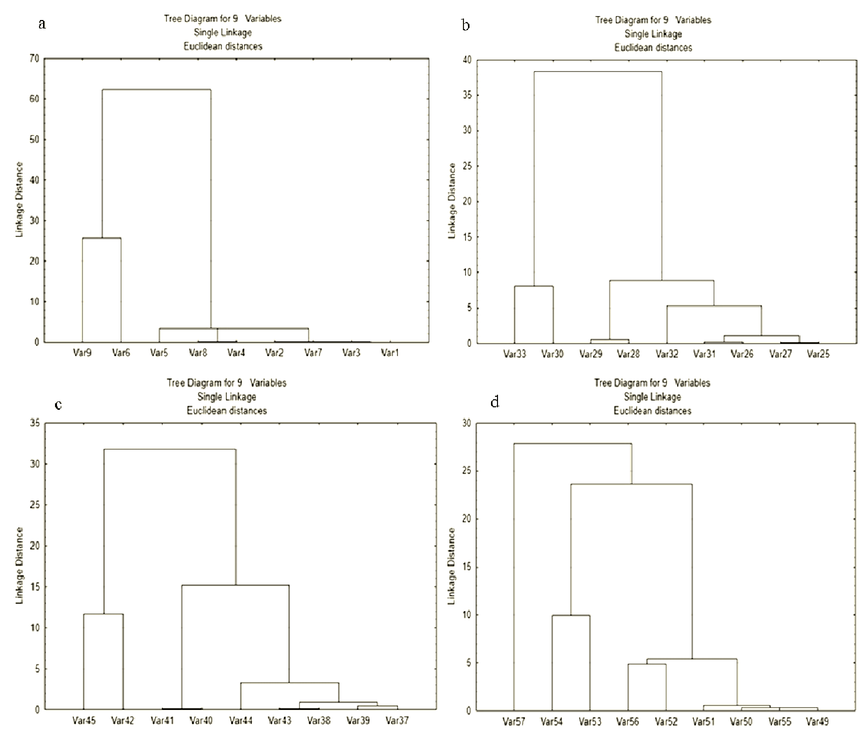

Fig. 2. The cluster analyses for lavender main volatile oil components function of location of cultivation. a: Bonțida- Var 1-α-Pinene, Var 2-β-Pinene, Var 3- 1,8 Cineole, Var 4-cis-β-Ocimene, Var 5-trans-β-Ocimene, Var 6-Linalool, Var 7-Camphor, Var 8-Borneol, Var 9-Linalyl acetate; b: Sânpaul- Var 25-α-Pinene, Var 26-β-Pinene, Var 27-1 ,8 Cineole, Var 28-cis-β-Ocimene, Var 29-trans-β-Ocimene, Var 30-Linalool, Var 31-Camphor, Var 32-Borneol, Var 33-Linalyl acetate; c: Cămărașu- Var 37-α-Pinene, Var 38-β-Pinene, Var 39- 1,8 Cineole, Var 40-cis-β-Ocimene, Var 41-trans-β-Ocimene, Var 42-Linalool, Var 43-Camphor, Var 44-Borneol, Var 45-Linalyl acetate; d: Fetindia- Var 49-α-Pinene, Var 50-β-Pinene, Var 51- 1,8 Cineole, Var 52-cis-β-Ocimene, Var 53-trans-β-Ocimene, Var 54-Linalool, Var 55-Camphor, Var 56-Borneol, Var 57-Linalyl acetate

The first cluster corresponding to linalyl acetate and linalool identified in lavender essential oil, is the tallest cluster of the dendogram, located at linkage distance of 8. The second cluster is subdivided in other clusters, located at lower linkage distance compared to the first one. Thus, the same linkage distance of the both brances of the first cluster confirms the similarity of the linalyl acetate and linalool concentrations in essential oil (22.35%-25.64%). The branched second cluster, emphasizes similar values for cis- and trans-β-ocimene (6.55%-6.70%), α-pinene and 1,8-cineole (0.77%-0.74%), and β-pinene and camphor (0.22-0.31), while camphor (2.92%) is substantially different from the other essential oil compounds within the second cluster (Fig. 2b, and Table 1).

Concerning the essential oil composition of the same variety cultivated in Cămărașu, Cluj County (Fig. 2c), high similarity with the dendrogram resulted for the essential oil composition identified for 'Vera' variety cultivated in Sânpaul, Cluj-County (Fig. 2b), is emphasized. This reflects almost the same structure, in both qualitative and quantitative compounds of the essential oil (Table 2). A different dendrogram structure is reported for the composition of the 'Vera' lavender variety cultivated in Fetindia, Sălaj County (Fig. 2d). This first branch is a singular one located at linkage distance of 28, and emphasizes the difference between the concentration of this compound (29.86%), and the other essential oil compounds (Fig. 2d, and Table 2). The second branch is divided in two main sub-branches. The firs one, corresponding to linalyl acetate and linalool is the tallest of the sub-cluster, and located, in this case, at linkage distance of 10. The second sub-cluster is subdivided in other two major sub-brances. The first one at linkage distance of 5, corresponds to cis-β-ocimene and borneol, which are quantified at the same order of magnitude (4.75%, and 2.78%, respectively), in lavender essential oil. The second sub-branch is located at very low linkage distance, and is is made up of a cluster with three branches emphasizing the similar concentrations of α-pinene, 1,8-cineole, and camphor (0,34%, 0,55%, and 0.22%, respectively), in lavender essential oil (6.55%-6.70%), and a single branch corresponding to β-pinene concentration in essential oil (0.07%), which is substantially different in terms of amounts, compared to other identified compounds (Table 2).

Conclusions

The assessment of the composition of essential oil extracted from two varieties of *Lavandula angustifolia* L. species, 'Mailette', and 'Vera', respectively, cultivated in four areas located in specific pedo-climatic conditions of Transylvania, Romania, emphasizes the main compounds in qualitative and quantitative terms. Two chemotypes were identified, corresponding to 'Mailette' variety linalool, and 'Vera' variety linalyl acetate.

The main compounds identified in essential oil extracted from lavender are the same (linalyl acetate, linalool, α-pinene, β-pinene, 1, 8 cineole, cis-β-ocimene, trans-β-ocimene, camphor, borneol), but differences in their share of total oil content are reported, function of flowers cultivation area. Equilibrate distributions are identified for majority of essential oil analysed compounds, except α-pinene, β-pinene, 1,8-cineole, and camphor identified in essential oil from 'Vera' variety lavender flowers cultivated in pedo-climatic conditions of Sânpaul, Cămărașu - Cluj County, and Fetindia - Sălaj County. The cluster analysis emphasizes similarities in both analyzed chemotypes 'Mailette' and 'Vera', respectively, concerning the main components - linalool and linalyl acetate, while within Vera chemotype differences in amounts of essential oil compounds are identified, function of cultivation area.

Conflicts of interest

The authors declare that there are no conflicts of interest related to this article.

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