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RESEARCH ARTICLE

Essential oil composition of berries and leaves of *Juniperus oxycedrus* ssp. *oxycedrus* L. from two typical substrates of Valencia (Spain)

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Abstract

Essential oil (EO) of berries and leaves of *Juniperus oxycedrus* ssp. *oxycedrus* L. is characterized by the predominance of hydrocarbon monoterpenes and α-pinene as the major compound. Nevertheless, a noticeable variability is found with respect to other compounds belonging to hydrocarbon monoterpenic and sesquiterpenic fractions. Insofar as this species grows in many type of substrates and no clear relationships can be found between EO composition and geographical origin, the hypothetical influence of soils may be considered. For this reason, a first approach to this matter is carried out in this study by comparing EO composition of berries and leaves coming from two typical substrates of Eastern Iberian Peninsula.

In general, the berries EO composition shows the typical profile reported in the literature: α-pinene (55.7-65.0 %) and myrcene (16.6-22.6 %) were the main compounds in berries, whereas the hydrocarbon monoterpenic fraction in leaves exhibited a wider range of secondary compounds accounting for 1-5 % such as β-pinene, δ-3-carene, *p*-cymene, limonene, β-phellandrene and terpinolene. Noticeable amounts of germacrene-D were also found in this fraction.

Regarding substrate, statistically significant differences were observed concerning all the fractions and major compounds for EO berries composition. Hydrocarbon monoterpenes were significantly higher in siliceous location (95.4 %) against calcicolous one (78.4 %); conversely, the rest of fractions reached significant lower amounts. No significant differences were found for leaves in any fraction or major compound. These results lead to consider extending this study by comparison of individuals coming from a wider range of soil types, analyzing their main physicochemical parameters.

Keywords: *Juniperus oxycedrus*, soil, berries, leaves

Introduction

Juniperus oxycedrus ssp. *oxycedrus* L. (Cupressaceae) is a common heliophilic and xerophilic shrub growing in scrublands of Mediterranean countries. Despite its adaptability to many sorts of substrates, it shows preference for calcareous soils (Valentini, Bellomaria, Maggi & Manzi, 2003). As described by Derwich & Chabir (2011), the essential oil of J. *oxycedrus* from different plant organs has a wide range of uses in food, cosmetics and pharmaceutical industries as well. Likewise, many studies concerning its biological activity (antioxidant, antimicrobial, antifungal, etc.) have also been reported (Angioni et al., 2003; Loizzo, 2007; Derwich & Chabir, 2011).

With regard to EO chemical profile, both leaves and berries have been characterized by the great predominance of hydrocarbon monoterpenic fraction with α-pinene as the major component. Nevertheless, some differences could be noted when comparing sample origins, plant organs or harvest dates. Berries' oil showed more homogeneous monoterpenic profiles, in which α-pinene was the main compound followed by myrcene in samples from Croatia (Milos & Radonic, 1999–subspecies not identified-), Sardinia (Italy) (Angioni et al. 2003); Corsica (France) (Boti, Bighelli, Cavaleiro, Salgueiro &

Casanova, 2006) and Baskinta (Lebanon) (Loizzo et al., 2007). Conversely, myrcene was the dominant component in samples from Abruzzo (Italy) (Valentini et al. 2003) and Kosovo (Hajdariet al., 2014). Germacrene D has been reported in moderate amounts in some of the above mentioned studies (Angioni et al., 2003; Boti et al., 2006, mainly). Indeed, as referred by Boti et al. (2006), two groups according to their relative amounts of α-pinene, myrcene and germacrene D could be distinguished. Otherwise, this compound was scarcely found in the rest of reported data.

Regarding seasonal variations, no great differences were found between ripe and unripe berries (Milos & Radonic, 1999; Angioni et al., 2003). Unlike these results, noticeable changes affecting mainly α-pinene and germacrene D were reported by Salido et al. (2002) comparing unripe and ripe berries in *Juniperus oxycedrus* ssp. *badia*.

EO from leaves exhibited a higher variability according to geographical origin and harvest date. As in berries, monoterpenic hydrocarbon was the major fraction and, generally, α-pinene the main compound (Derwich & Chabir, 2011). Nevertheless, other compounds reached noticeable rates (10-30 %), such as limonene in Northern Greece (Adams, Altarejos, Fernández & Camacho, 1999) and Abruzzo (Italy) (Valentini et al., 2003) and carene (δ-2 and δ-3 isomers) in samples from Southern Greece (Adams et al., 1999) and Sardinia (Italy) (Angioni et al., 2003). Moreover, as referred by Boti et al. (2006) two statistically consistent patterns defined by α-pinene and α-pinene/δ-3-carene could be distinguished in samples from Corsica (France).

In general, as reported in the above mentioned researches, *J. oxycedrus* L. ssp. *oxycedrus* shows a more heterogeneous profile of this fraction in such a way that hydrocarbon monoterpenes such as β-pinene, sabinene, myrcene, α and β-phellandrene, α and γ-terpinene and *p*-cymene reach rates comprised between 1 and 10 %.

Oxygen containing monoterpene are reported in moderate amounts (7.2-12.6 %) in leaf samples from Spain (Adams, 1998), Northern Greece (Adams et al., 1999), Abruzzo (Italy) (Valentini et al., 2003) Corsica (Boti et al., 2006) and Morocco (Derwich & Chabir, 2011). Other components such as α-terpineol, terpinen-4-ol, myrtenal, myrtenol, verbenol, pinocarvone, 1,8-cineole, α-campholenal, (*E*)-pinocarveol, (*E*)-sabinol, bornyl acetate and β-thujone represented a 1-5 % in the above mentioned studies.

Sesquiterpenic fraction accounting for a 1-10 % was found in leaf samples from North Greece (Adams et al., 1999), Abruzzo (Italy) (Valentini et al., 2003), Taferdoust (Morocco) (Derwich & Chabir, 2011) and Northern Tunisia (Medini et al., 2010). The hydrocarbon components: cadinene isomers, germacrene D and β-caryophyllene were found relatively abundant (5-11 %) whereas the oxygenated ones reached a particularly high amount in samples from North Tunisia (Medini et al., 2010) as it is also reported by Valentini et al. (2003) in those collected in Abruzzo (Italy).

Finally, diterpenes (manoyl oxide and epi-manoyl oxide) were also found in moderate amounts (5.00-7.25 %) in leaf samples from North Tunisia (Medini et al., 2010) and Spain (Adams, 1998).

There are only a few studies about *J. oxycedrus* reported in Spain. Apart from those conducted by Teresa, Barrero, Caballero & San Feliciano (1978) and Guerra, López & García (1987) (Cited by Boti et al., 2006), only the data from Adams (1998) were referred to *oxycedrus* subspecies. Several more recent reports are devoted to *badia* (Salido et al., 2002; Alonso et al., 2003) and *macrocarpa* subspecies (Velasco-Negueruela, Pérez-Alonso, Palá-Paul, Iñigo & López, 2005).

Significant seasonal and environmental variations on EO yield and composition were reported in a study conducted in four locations in Tunisia concerning *J. oxycedrus* (Medini et al., 2010) –subspecies not specified-. Concretely, the three coastal locations (littoral dunes) show marked different with respect to continental and calcareous one. On the other hand, as supported by Hajdari et al. (2014), although climatic conditions may have a partial influence on the identified chemodiversity, other environmental factors can exert a significant impact, given that no clear correlations have been found according the geographical origin. Consequently, the suitability of conducting researches devoted to study the environmental factors affecting EO composition should be considered. This way, the aim of this work is to carry out a first approach to chemical profile differences in EO of leaves and berries due to soil characteristics. For this purpose, two representative sampling areas with predominance of calcicolous and siliceous materials and similar climatic characteristics were selected in Eastern Spain, also aimed to extend the scarce data available about this EO coming from this region.

Materials and Methods

Plant material

Three samples of leaves and ripe berries were gathered coming from ten individuals randomly selected within a 10 ha land (approximately) in two different locations 30 km apart. Both sampling zones (Segart and Lliria in Valencia, Spain) were Southeast-oriented and their climatic and geological features are detailed in table 1. According their thermicity indexes, both locations have a transitional termomediterranean to mesomediterranean climate, according Rivas-Martinez (2008) classification.

Leaves and berries were collected in such a way that they were uniformly distributed over each one of individuals. After removing yellowish and damaged material, each whole sample was dried at room temperature for 20 days before essential oil extraction. Voucher specimens were placed in the Herbarium of Mediterranean Agroforestry Institute at the Universitat Politècnica de València (Spain) (VALA 9572-9573)

Table 1. Climatic and geological features of sampling areas

Location	**Altitude (m a.s.l.)**	**Average yearly precipitation**[a]	**Average yearly temperature**[a]	**Thermicity Index**[b]	**Coordinates (centre of sampling zone)**	**Geological features**[c]
Segart	300 m	469 mm	15,8 ºC	341	39º 40’ 57’’ N; 0º 22´38 ’’ W	Silicious[d] (argillites, sandstone)
Lliria	194 m	422 mm	16,4 ºC	360	39°37'39.8"N; 0°40'53.0"W	Carbonated muds[e]

[a]Meteorological data from the nearest climatic station, [b]Thermicity index calculated as described by Martinez (1983), [c]Source:**terrasit**.gva.es/,[d]http://info.igme.es/cartografia/datos/magna50/pdfs/d6_pdf/Magna50_668.pdf,http://info.igme.es/cartografia/datos/magna50/pdfs/d6_pdf/Magna50_695.pdf

Essential oil extraction

Plant material (leaves or berries) coming from each location was repeatedly mixed by hand to homogenize it. Then, three portions of 50 g were subjected to hydrodistillation for 2.5 h in a Clevenger type apparatus (berries were previously crushed with a domestic grinder). The essential oil was swept away with 2 mL of dichloromethane anhydrous, ≥99.8%, containing 40-150 ppm amylene as stabilizer (Sigma-Aldrich, Madrid, Spain). After separating the aqueous phase, the essential oil extract was dried over anhydrous sodium sulphate. The solvent was removed at room temperature under reduced pressure on a rotary evaporator. A solution containing 10 μL EO/1 mL of dichloromethane was kept in the dark at -18ºC in sealed vials until analysis.

GC Analysis

The analysis of samples was carried out by GC and GC/MS with a Clarus 500 GC (Perkin-Elmer Inc., Wellesley, PA, USA) chromatograph equipped with a capillary column ZB-5 (30 m x 0.25 mm i.d. x 0.25 mm film thickness; Phenomenex Inc., Torrance, CA, USA). The injection volume was 1 μL. The GC oven temperature was programmed from 50ºC to 250ºC at a rate of 3ºC/min. Helium was the carrier gas (1.2 mL/min). The quantitative analysis was performed using a FID detector set at 250ºC. The percentage composition of the essential oil was computed from GC peak areas without correction factors by means of the software Total Chrom 6.2 (Perkin-Elmer Inc.).

Analysis by GC-MS was carried out using a Clarus 500 GC-MS apparatus (Perkin-Elmer Inc.) which Ionization source temperature was set at 200˚C and 70 eV electron impact mode was employed. MS spectra were obtained by means of total ion scan (TIC) mode (mass range m/z 45-500 uma). The total ion chromatograms and mass spectra were processed with the software Turbomass 5.4 (Perkin-Elmer Inc.).

Retention indices were determined by injection of C8–C25 n-alkanes standard (Supelco®) under the same conditions. The essential oil components were identified by comparison of their mass spectra with those of computer library NIST MS Search 2.0 and available data in the literature. The identification of the following compounds was confirmed by comparison of their experimental RI with those of authentic reference standards (Sigma-Aldrich®): α-pinene, β-pinene, camphene, myrcene, camphor, terpinolene, borneol, terpinen-4-ol, bornyl acetate and linalool.

Statistical analysis

The statistical analysis was carried out by means of analysis of variance (ANOVA) using Statgraphics 5.1. software. As the raw data were expressed as % peak areas, they were subjected to arcsin [square root (%/100)] transformation and previous homocedasticity test. Then, Tukey's HSD multiple-range test at $P<0.05$ was used to consider significant differences in average values of the components among the locations.

Results and Discussion

Yield

Yield and detailed composition (components by elution order and main fractions) are listed in table 2. These values are the means and standard deviations of three replications of samples (berries and leaves) coming from the siliceous location (Segart) and the calcicolous one (Lliria).

Yield values for berries (1.2 – 0.8 %) were quite similar to those reported in the literature. Accordingly, for example, Hajdari et al. (2014) reports values from 0.4 to 1.8 % in samples from Kosovo. However, the yield from leaves was lower (0.2 % for both locations) and were very similar to those reported by Medini et al. (2010) (0.15-0.21 %) in the same time of year.

Table 2. Yield and chemical composition of essential oil of berries and leaves from siliceous and calcicolous locations.

			BERRIES	**LEAVES**		
			Siliceous	**Calcicolous**	**Siliceous**	**Calcicolous**
yield % (V/m)[1]			0.8 ± 0.03	1.2 ± 0.25	0.2 ± 0.08	0.2 ± 0.02
Compounds[2]	**RI**[3]	**Identification**[4]				
tricyclene	926	MS, RI	0.3 ± 0.01	0.2 ± 0.03	0.1 ± 0.12	-[5]
α-thujene	930	MS, RI	0.1 ± 0.01	-	-	-
α -pinene	942	MS, RI, St	**65.0 ± 0.67^{a}[6]**	**55.7 ± 3.25^{b}**	**53.2 ± 15.92^{a}**	**42.0 ± 6.71^{a}**
camphene	954	MS, RI, St	0.6 ± 0.02	0.3 ± 0.01	0.3 ± 0.27	0.3 ± 0.14
thuja-2,4(10)-diene	957	MS, RI	0.3 ± 0.01	0.2 ± 0.01	0.1 ± 0.12	0.1 ± 0.10
sabinene	975	MS, RI	0.2 ± 0.00	0.1 ± 0.02	0.3 ± 0.24	0.5 ± 0.14
β-pinene	980	MS, RI, St	2.2 ± 0.07	1.6 ± 0.04	2.0 ± 0.63	2.2 ± 0.55
myrcene	993	MS, RI, St	**22.6 ± 0.21^{a}**	**16.6 ± 1.11^{b}**	**3.4 ± 0.49^{a}**	**4.4 ± 0.47^{a}**
δ-3-carene	1031	MS, RI	0.1 ± 0.00	tr[7]	**3.6 ± 1.43^{a}**	**6.0 ± 0.38^{b}**
α-terpinene	1018	MS, RI, St	0.0 ± 0.00	-	tr	0.1 ± 0.07
p-cymene	1027	MS, RI, St	0.0 ± 0.01	-	2.8 ± 0.35	5.3 ± 0.43
limonene	1032	MS, RI, St.	0.3 ± 0.01	0.4 ± 0.08	3.1 ± 0.30	4.6 ± 0.47
β-phellandrene	1032	MS, RI	3.3 ± 0.06	3.1 ± 0.25	1.8 ± 0.35	3.2 ± 0.42
γ-terpinene	1061	MS, RI, St	0.1 ± 0.01	-	0.1 ± 0.13	0.4 ± 0.05
terpinolene	1085	MS, RI, St	0.3 ± 0.02	0.1 ± 0.04	1.5 ± 0.57	2.2 ± 0.43
perillene	1097	MS, RI	0.1 ± 0.01	-	-	-
menthatriene <1,3,8-*p*->	1100	MS, RI	-	tr	-	-
Monoterpenes			**95.4 ± 0.92^{a}**	**78.4 ± 3.03^{b}**	**72.5 ± 20.98^{a}**	**71.4 ± 10.36^{a}**
linalool	1097	MS, RI, St	0.0 ± 0.00	-	1.2 ± 0.82	0.3 ± 0.05
fenchol	1119	MS, RI	tr	tr	-	-
α -campholenal	1128	MS, RI	0.4 ± 0.03	0.5 ± 0.08	0.4 ± 0.13	0.4 ± 0.17
(*E*)-pinocarveol	1142	MS, RI	0.5 ± 0.07	1.2 ± 0.18	0.4 ± 0.14	0.6 ± 0.22
camphor	1147	MS, RI, St	0.1 ± 0.02	-	tr	0.1 ± 0.14
pinene oxide-β	1159	MS, RI	0.1 ± 0.02	0.2 ± 0.03	0.0 ± 0.07	0.1 ± 0.09
pinocarvone	1163	MS, RI	0.0 ± 0.01	-	0.0 ± 0.03	0.1 ± 0.09
mentha-1,5-dien-8-ol	1173	MS, RI	0.0 ± 0.03	-	-	-
terpinen-4-ol	1180	MS, RI, St	0.0 ± 0.01	0.5 ± 0.05	0.4 ± 0.21	0.5 ± 0.42
p-cymen-8-ol	1187	MS, RI	tr	0.3 ± 0.04	0.4 ± 0.02	0.6 ± 0.06
α -terpineol	1194	MS, RI	0.1 ± 0.01	0.6 ± 0.15	-	-
verbenone	1204	MS, RI	0.0 ± 0.01	tr	1.5 ± 0.42	0.9 ± 0.17
(*E*)-carveol	1219	MS, RI	0.0 ± 0.02	0.4 ± 0.13	tr	0.1 ± 0.11
isobornyl *n*-butanoate	1464	MS, RI	-	-	-	-
oxygenated monoterpenes			**1.3 ± 0.17^{a}**	**3.6 ± 0.60^{b}**	**4.4 ± 1.96^{a}**	**3.5 ± 1.52^{a}**
α-cubebene	1346	MS, RI	0.3 ± 0.03	1.9 ± 0.19	tr	0.1 ± 0.13
α-copaene	1373	MS, RI	0.0 ± 0.01	-	-	-
β-cubebene	1385	MS, RI	0.1 ± 0.02	0.6 ± 0.06	0.6 ± 0.27	0.7 ± 0.23
β-caryophyllene	1414	MS, RI	0.4 ± 0.05	0.7 ± 0.03	1.7 ± 0.56	1.3 ± 0.44
α -(*E*)-bergamotene	1431	MS, RI	tr	-	-	-
α -humulene	1451	MS, RI	0.3 ± 0.05	1.0 ± 0.02	1.1 ± 0.60	1.1 ± 0.38
γ-muurolene	1473	MS, RI	tr	0.1 ± 0.00	0.9 ± 0.46	1.2 ± 0.47
germacrene D	1478	MS, RI	**0.3 ± 0.07^{a}**	**1.3 ± 0.08^{b}**	**8.2 ± 5.20^{a}**	**7.0 ± 3.00^{a}**

α– amorphene	1488	MS, RI	0.9 ± 0.18	2.6 ± 0.65	0.3 ± 0.34	0.6 ± 0.25
α– muurolene	1495	MS, RI	0.1 ± 0.02	0.2 ± 0.02	0.4 ± 0.20	0.6 ± 0.22
farnesene (*E,E*-α)	1506	MS, RI	0.1 ± 0.04	0.7 ± 0.06	-	-
γ-cadinene	1509	MS, RI	0.4 ± 0.19	2.6 ± 0.41	2.5 ± 1.49	3.0 ± 0.96
δ-cadinene	1515	MS, RI	0.2 ± 0.09	1.1 ± 0.03	1.0 ± 0.63	1.2 ± 0.46
α -cadinene	1533	MS, RI	-	0.2 ± 0.03	-	0.2 ± 0.02
Sesquiterpenes			**3.1 ± 0.77**^{a}	**12.9 ± 0.13**^{b}	**16.8 ± 9.83**^{a}	**16.9 ± 6.55**^{a}
(*E*)-nerolidol	1561	MS, RI	-	0.8 ± 0.19	0.5 ± 0.45	0.7 ± 0.08
caryophyllene oxide	1577	MS, RI	-	0.9 ± 0.65	1.7 ± 1.65	1.6 ± 0.18
salvial-4(14)-en-1-one	1587	MS, RI	-	0.4 ± 0.11	0.4 ± 0.30	0.5 ± 0.07
humulene epoxide II	1603	MS, RI	-	0.3 ± 0.08	0.2 ± 0.26	0.4 ± 0.03
α-muurolol	1611	MS, RI	-	0.6 ± 0.26	0.3 ± 0.51	0.6 ± 0.07
τ-cadinol	1638	MS, RI	-	-	-	0.1 ± 0.11
α-cadinol	1651	MS, RI	-	0.3 ± 0.13	0.4 ± 0.47	0.3 ± 0.20
eudesma-4(15),7-dien-1-β-ol	1685	MS, RI	-	0.3 ± 0.16	-	-
Oxygenated sesquiterpenes			**-**	**3.4 ± 1.62**	3.2 ± 3.12	3.6 ± 0.68
Manoyl oxide	1990	MS, RI	-	0.8 ± 0.45	0.8 ± 1.06	2.0 ± 0.27
Diterpenoids			-	0.8 ± 0.45	0.8 ± 1.06	2.0 ± 0.27
3-hexen-1-ol	859	MS, RI	-	-	tr	-
Other			-	-	tr	-
Total identified			**99,8**	**99,1**	**97,7**	**97,4**

1) EO yield expressed as % of V(mL) of essential oil/m(g) air room dried leaves or berries; 2) Elution order as determined on ZB-5 column; 3) Retention indices as determined on ZB-5 column using homologous series of n-alkanes; 4) Methods of identification: MS, by comparison of the mass spectrum with those of the computer mass libraries; RI, by comparison of RI with those from the literature; St, by injection of an authentic sample; 5) -: not detected; 6) Values within a row for each compound having different letters are significantly different from each other according Tukey's HSD test ($P<0.05$); 7) tr: traces (<0.1%).

Berry oil composition

Monoterpenic hydrocarbons (α-pinene -65.0 and 55.7 %- and myrcene-22.6-16.6 %- as major compounds) was the predominant fraction (95.4-78.4 %) for the siliceous and calcicolous locations, respectively (table 2). Other monoterpenic hydrocarbons also reached noticeable amounts, such as β-pinene (2.2-1.6 %) and β–phellandrene (3.3-3.1 %). With respect to sesquiterpenic fraction, hydrocarbons (α-cubebene, α-amorphene, γ- and δ-cadinene as main components) were also the most abundant compounds: 3.9-12.9 % in siliceous and calcicolous locations, respectively. Concerning the main compounds, these results are similar to those reported by Milos & Raonic (1999), Angioni et al. (2003), Loizzo et al. (2007). Nevertheless, it is noticeable the occurrence of high amounts of limonene instead myrcene as reported by Salido et al. (2002) in samples from Spain. Oxygenated monoterpenes and sesquiterpenes reached small quantities (3.6-1.6 %), respectively, in the calcicolous location, whereas they were hardly detected (0-1.3 %) in the siliceous one (table 2). It is worth to mention the occurrence of the diterpene manoyl oxide, also referred in small quantities in some previous works (Milos & Radonic, 1999; Valentini et al., 2003; Boti et al., 2006; Loizzo et al., 2007). If the sesquiterpenic fraction is considered as a whole, the most similar composition to those ones have been reported by Angioni et al. (2003) and Boti (2006) with samples from Sardinia (Italy)), and Corsica (France), respectively.

Comparing both locations, the proportion of monoterpenic hydrocarbon fraction and each of its major components were significantly higher for the siliceous location ($P<0.05$). Conversely, the rest of groups of components showed significantly higher amounts for the calcicolous location.

Leaf oil composition

Monoterpenic hydrocarbon fraction was also found predominant in essential oil composition of leaves both for siliceous and calcicolous locations 72.5-71.4 %. α-Pinene was also the main component accounting for 53.2-42.0 %. Nevertheless, unlike it happens in berries oil, the rest of components show a more equilibrated distribution in such a way that some compounds reach moderate amounts: limonene (3.1-4.6 %), δ-3-carene (3.6-6.0 %), *p*-cymene (2.8-5.3 %), β-pinene (2.0-2.2 %), β-phellandrene (3.3-3.1 %) and terpinolene (1.5-2.2 %). This fact agrees with data from literature in which the leaf profiles are quite more complex than those reported for berries. Moreover, limonene has been found as predominant monoterpenic hydrocarbon in samples from Abruzzo (Italy) (Valentini et al., 2003) and Northern Greece (Adams et al. 1999). δ-3-carene reached also a noticeable proportion (13.7-22.82 %) in samples from Southern Greece (Adams et al., 1999) and Sardinia (Italy) (Angioni et al., 2003).

As a whole, the most similar data to those reported in the present study were referred by Boti et al. (2006) –Corsica (France)- and Derwich & Chabir (2011) –Taferdoust (Morocco)-. Sesquiterpenic hydrocarbon fraction accounted for a 16.8-16.9 % for the siliceous and calcicolous locations, respectively. Germacrene-D was the main component (8.2-7.0 %) and other ones such as γ-cadinene, δ-cadinene, α-humulene and γ-muurolene showed a range of 1-3 %. Regarding oxygen containing sesquiterpenes, the observed range (3.2-3.6 %) agrees with is the one reported in the literature, except for those coming from Abruzzo (Italy) (Valentini et al., 2003) and Northern Tunisia (winter harvest) (Medini et al., 2010). In general, according the whole sesquiterpenic fraction, samples from Northern Greece (13.7 %) (Adams et al., 1999), Abruzzo (Italy) (24.7 %) and Tunisia (Medini et al., 2010).

If the sesquiterpenic fraction is taken as a whole, the samples from this study can be considered rich in these compounds (20.0-20.5 %) if comparing with those reported in Morocco (10.10 %) (Derwich & Chabir, 2011), Northern Greece (13.7 %) (Adams et al., 1999), Abruzzo (24.7%) (Valentini et al., 2003) and, mainly, Northern Tunisia (7.66 – 30.69 % -winter harvest-)(Medini et al. 2010). With respect to diterpenes, small amounts of manoyl oxide (0.8-2 %) were detected. From the comparative point of view, any relevant component (except for δ-3 carene) or fraction showed statistically significant differences (P<0.05).

In summary, data obtained in the present study show typical essential oil profiles both for berries and leaves of *J. oxycedrus*, ssp. *oxycedrus* L., which can be related to other ones reported from different countries. These results go in the line of supporting the independence of *J. oxycedrus* essential oil composition from geographical origin. Otherwise, significant and general differences have been noted for berry oil according type of substrate. This fact leads to consider the suitability of further investigations in order to find possible correlations between essential oil composition and specific physicochemical soil parameters.

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