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COMPARATIVE ESSENTIAL OIL COMPOSITION OF LEAVES OF *PISTACIA LENTISCUS* L. FROM DIFFERENT REGIONS OF NORD EASTERN ALGERIA

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Abstract

Essential oils obtained by hydrodistillation from leaves of *Pistacia lentiscus* L. from four regions of Nord-Est Algeria (Bejaia, Jijel, Skikda and El-Taref) were analysed by GC and GC-MS. A total of 132 compounds accounting for 69,41-99,97% of the total EO were identified. Two main essential oil profiles have been distinguished according the rate of monoterpene/sesquiterpene. The samples collected from Bejaia and Skikda respectively was found to be rich in monoterpene hydrocarbons (35-56,39%), whereas sesquiterpene hydrocarbons was found to be rich in the samples collected from Jijel and El-Taref respectively (44- 53,19%). The results clearly indicate the appearance of four chemotypes which are currently described. The first contains high proportions of α-pinene (12.12) in Bejaia oil. The second contains a high proportions of caryophyllene (20.87%) and α-pinene (17,83%) in Jijel oil. The third contains a high proportion of D-limonene in Skikda oil (31.42%). The last revealed that β-cubebene (18.92%) and caryophyllene (17.58%) were the main constituents of El-Taref oil, this particular composition is reported for the first time in the *P. lentiscus* species. A comparison with oils from *P. lentiscus* of diverse regions of Algeria and other countries of mediterranean region reported in literature shows both quantitative and qualitative differences.

Keywords: *Pistacia lentiscus* L.; Nord Eastern Algeria; α-pinene; D-limonene; caryophyllene; β-cubebene; chemotype.

ÉTUDE COMPARATIVE DE LA COMPOSITION CHIMIQUE DES HUILES ESSENTIELLES DES FEUILLES DE *PISTACIA LENTISCUS* L. DE DIFFERENTES RÉGIONS DU NORD EST DE L'ALGÉRIE

Résumé

Les huiles essentielles obtenues par hydrodistillation des feuilles de *Pistacia lentiscus* L. de quatre régions du Nord-Est de l'Algérie (Bejaia, Jijel, Skikda et El-Taref) ont été analysées par GC et GC-MS. Un total de 132 composés représentant 69,41 à 99,97% des HEs ont été identifiés. Deux principaux profils d'huiles essentielles ont été distingués selon le taux de monoterpène/sesquiterpène. Les échantillons prélevés respectivement à Bejaia et Skikda se sont avérés riches en monoterpenes hydrocarbonés (35-56,39%), tandis que les sesquiterpéniques hydrocarbonés se sont révélés riches dans les échantillons prélevés respectivement à Jijel et El-Taref (44-53,19 %). Les résultats indiquent clairement l'apparition de quatre chémotypes actuellement décrits. Le premier contient des proportions élevées en α-pinène (12.12) dans l'huile de Bejaia. Le second contient une forte proportion de caryophyllène (20,87%) et d'α-pinène (17,83%) dans l'huile de Jijel. Le troisième contient une forte proportion en D-limonène dans l'huile de Skikda (31,42%). Le dernier a révélé que le β-cubebène (18,92%) et le caryophyllène (17,58%) étaient les principaux constituants de l'huile d'El-Taref, cette composition particulière est signalée pour la première fois chez l'espèce P. lentiscus. Une comparaison avec les huiles de *P. lentiscus* de diverses régions d'Algérie et d'autres pays de la région méditerranéenne rapportées dans la littérature montre des différences à la fois quantitatives et qualitatives.
Mots clés : *Pistacia lentiscus* L.; Nord-Est Algerien; α-pinene; D-limonene; caryophyllene; β-cubebene ; chémotype.

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INTRODUCTION

Pistacia lentiscus L., Darou in local Arabic *or* T'ru, is an evergreen shrub of the family Anarcadiaceae characteristic of Mediterranean countries [1]. It is associated with the olive tree in the Western Mediterranean and with the carob tree in the East [2]. It is very abandoned in North Africa and is one of the constant elements of forests and maquis [3]. In Algeria, *P. lentiscus* has a large geographical distribution and grows spontaneously in diverse habitats throughout the arid to the humid bioclimatic zones and distributed all along the coast. It is associated with species such as *Quercus suber* L., *Olea europea* L., *Ceratonia siliqua* L., *Myrtus communis* L., *Juniperus phoenicea* L., *Arbutus unedo* L., *Erica arborea* L., *Phillyrea angustifolia* L.,…*etc.* depending on the bioclimatic zone, the type of soil and the altitude [4-6]. This dioecious species can not usually exceed 1.5 to 2 m although it can sometimes reach 5 to 6 m in height. Leaves are evergreen paripinnate with four to ten pairs of leaflets. The flowers are small racemes in the axils of the leaves, apetalous and unisexual. The fruit is a globose drupe, first red then black at maturity [4, 7].

In therapeutic applications, this plant and its preparations have been used traditionally for their antiacetylcholinesterase, antiatherogenic, antiinflammatory anti-ulcer, hypotensive, hypoglycemic, anticancer, antimutagenic, cytoprotective and diuretique effect. It was even used as appetizer, astringent, expectorant and cicatrisant agent and treat eczema, diarrhoea and throat infections [8-11]. It also served to purify water and increase the time of conservation of diverse aliments [12-14].

Different plant extracts are obtained from *P. lentiscus* and are extensively used in folk medicine. The three main products are the resin trunk exudates (mastic gum), the cold pressed oil extracted from the berries, and the essential oil from the leaves, stem, flowers and fruits.

The oleoresin has been reported to possess anticancer [15-18], antiulcer [19-20] and antibacterial activity [21-22]. As well as, the oil extracted from fruits, containing a considerable amount of unsaturated fatty acids, omega-3 and phytosterols [23], is traditionally used to treat scabies, rheumatism, diarrhea, wounds, burns, respiratory problems such as: sore throat, bronchitis, allergies, and asthma. Other less common uses of this oil include the treatment of arthralgia, haemorrhoids, jaundice and gastrointestinal disorders [24-25]. It is used in several industrial applications such as perfumery, food and pharmaceutical and it has been reevaluated recently as a flavouring in alcoholic beverages and chewing gum [26-28].

On the other hand, the essential oil extracted from aerial parts of *P. lentiscus* possesses appreciable biological and pharmacological properties including antifungal [29-31], antibacterial and antimicrobial [32-44], insecticidal [45-48], herbicidal [49], antiproliferative [50-51] and antioxidant [52-57] depending on the chemical composition.

Indeed, essential oils called volatile or ethereal oils are a variable mixture of several chemical compound mainly terpenes (monoterpenes, sesquiterpenes) and a variety of a low molecular weight aliphatic hydrocarbons, ethers, acetates, ketones, alcohols, aldehydes, phenols, acids acyclic esters, or lactones [58-59]. These are very interesting natural plant products and have various biological properties which result from a complex interaction between the main and the minor ones which produce both synergistic and antagonistic responses [60].

The chemical composition of the *P. lentiscus* essential oil collected from different parts of plant (leaves, twigs, branches, flowers, fruits and resin) and of diverse regions of Algeria and several countries of mediterranean region (Spain, Greece, France, Italy, Turkey, Morocco and Tunisia) were previously studied. Different compositions were established (Table 1) and the most oils have a high content of Monoterpenes (α-pinene, β-pinene, limonene, β-myrcene, p-cymène, sabinene, α-phellandrene, β-phellandrene, α-terpinene, γ-terpinene, terpinen-4-ol, α-terpineol) and Sesquiterpenes (caryophyllene, D-germacrene, δ-cadinene, γ-cadinene, α-cadinol, caryophyllene oxide). The percentages of these compounds are quite variable depending on the geographic origin of samples.

However, up to now, no studies have been found in the literature concerning the chemical composition of leaf essential oil from the Eastern Algeria of the same plant, specially Skikda and El-Taref. This paper presents an investigation of the Algerian *P. lentiscus* oil composition collected from four populations growing wild in different regions of Nord Eastern Algeria (Bejaia, Jijel, Skikda and El-Taref) and to highlight a possible variability in the chemical composition of these oils.

This study fits into the more global context of enhancing the biodiversity of Algerian aromatic plants for their medicinal and nutritional properties.The results of this study were compared with some oils which come from different regions of Algeria and other countries of the Mediterranean region.

Table 1. Major constituents of *P. lentiscus* L. essential oils obtained by hydrodistillation of different origins.

Origin, plant material and sample period		Chemotype and Major compounds (>5%)	major terpenoîds	references
Spain (Sevilla /Coria del Rio) Fresh leaves, fruiting (October)		β-myrcene (19,25%), α-pinene (11,20%), β-caryophyllene (8,60%), terpinen-4-ol (8,41%), α-terpineol (6,68%) and D-germacrene (6,35%).	MH (50,3%)	[32]
Greece (Chios Island)		myrcene (20,58%), D-germacrene (13,30%), E-caryophyllene (8,33%), α-cadinol (7,33%) and δ-cadinene (7%).	SH (40,37%)	[33]
France (Corsica) Fresh leaves and twigs (March-October)	group I	terpinen-4-ol (25,6%), α-pinene (16%) and α-terpineol (3,5%)	-	[34]
	group II	α-pinene (31,9%), terpinen-4-ol (9%) and limonene (5%)	-	
	group III	limonene (47%), terpinen-4-ol (11.2%) and α-pinene (5,2%)	-	
	group IV	myrcene (76,9%), D-germacrene (2,1%), α-pinene (2,0%)	-	
Spain (Jaén) Air-dried aerial parts, Fruiting (October)		α-pinene (13%), β-caryophyllene (6,9 %) and limonene/β-phellandrene (5,4%).	MH (33,4%)	[26]
Italy (Sardinia/ Costa Rey) Air-dried leaves, full blossom		β-pinene (18,71%), β-caryophyllene (13,22%), β-phellandrene (12,63%), camphene (8,69%) and δ-cadinene (5,09%).	MH (50,14%)	[35]
Turkey (Fethiye) leaves (July)		terpinen-4-ol (29,9%), α-terpineol (11,6%), limonene (10,6%) and (*Z*)-3-Hex-1-enyl benzoate (6,7%).	OM (51,6%)	[29]
Morocco Air dried aerial parts Monthly sampling, (December-june)	Mehdia	terpinen-4-ol (14.5–19.3%), caryophyllene oxide (6.5–10.3%) and limonene (6.7–8.1%)	MH (26,8-41,2%)	[36]
	Chaouen	terpinen-4-ol (32,7-43,8%), α-pinene (7,1-13,5%), bornyl acetate (6,8-10,3%), β-caryophyllene (4,3-5,2%) and sabinene (4,2-5,4%).	OM (39,5-55,0%)	
	Oulmes	α-pinene (16,5-38,5%), β-myrcene (10,2-11,5%) and limonene (6,8-9,8%).	MH (41,9-75,8 %)	
Italy (Tuscany) Leaves, fruiting (Seasonal sampling: Winter, spring, summer, autumn over 2 years)		α-pinene (16,1-25,3%), D-germacrene (9,6-14,3%), terpinen-4-ol (7,6-12,7%), β-caryophyllene (5,2-8,7%), β-myrcene (4,6-8,3%), β-pinene (4,2-6,8%), δ-cadinene (2,7-5,2%) and β-phellandrene (2,4-5%).	MH (56,9-64,4%)	[69]
Turkey (Çeşme-Ardiç) leaves (February)		terpinen-4-ol (29,2%) and *p*-cymene (7,1%).	OM (36,0 %)	[72]
Tunisia (Zaghouan) Fresh leaves		α-pinene (16,8%), 4-terpineol (11,9%), β-phellandrene (8,9%), sabinene (5,7%) and γ-terpinene (5,5%).	MH (59,5 %)	[67]
Algeria (Algiers citys) leaves	Baïnem	terpinen-4-ol (17,3%), D-germacrene (15,8%), α-terpineol (10,4%) and β-caryophyllene (5%).	OM (30,9%)	[70]
	Taref	terpinen-4-ol (34,7%), α-terpineol (11%) and D-germacrene (8,4%)	OM (50,2%)	
Algeria Air dried aerial parts (June)	Algiers	longifolene (12,8%), γ-cadinene (6,2%) and trans-β-terpineol (5%).	SH (35,5%)	[61]
	Tizi-Ozou	longifolene (16,4%), Trans-β-terpineol (15,6%), terpinen-4-ol (7%) and γ-muurolene (5,7%).	SH (36,0%)	
	Oran	α-pinene (19%), trans-β terpineol (13,1%), sabinene (12,6%), β-pinene (6,5%), (*E*)-β-ocimene (5,5%) and longifolene (5,2 %).	MH (56,3%)	
Italy (Sardinia) Fresh aerial parts, full flowering.	Torre delle Stele	α-pinene (20,40%), β-myrcene (18,29%), p-cymene (14,79%), terpinen-4-ol (14,17%).	MH (70,01%)	[31]
	Orroli	β-myrcene (19,36%), α-pinene (19,15%), terpinen-4-ol (15,07%) and p-cymene (9,92%).	MH (68,54%)	
	Villaputzu	Terpinen-4-ol (19,74%), α-pinene (14,81%), p-cymene (14,79%), β-myrcene (10,84%), γ-terpinene (6,56%) and α-terpinene (5,12%).	MH (57,24%)	
	Oristano	α-pinene (21,55%), terpinen-4-ol (19,84%), p-cymene (14,79%), α-phellandrene (10,84%), β-phellandrene (5,39%) and γ-terpinene (5,15%).	MH (67,42%)	
	Alghero	Terpinen-4-ol (28,29%), α-pinene (22,59%), *p*-cymene (16,22%) and sabinene (8,13%).	MH (58,88%)	
Italy (Sicily) Leaves, vegetative stage (January–April)		D-germacrene (18,61%), β-caryophyllene (14,68%), δ-cadinene (11,13%), epi-α-muurolol (5,79%) and α-cadinol (5,36%).	SH (67,08 %)	[27]
Algeria (different localities) Air dried leaves for 2-3 days (September-november)	Tipaza citys	α-pinene (20,2%), limonene (18,4%), β-pinene (10,54%) and sabinene (5%).	MH (67,66%)	[62]
	Algiers	α-pinene (25,93%), limonene (14,37%) and β-pinene (8,13%).	MH (72,63%)	
	Tizi-Ouzou (Tigzirt)	α-pinene (25,5%), myrcene (12,2%), sabinene (10%) and terpinen-4-ol (5,15%).	MH (71,95%)	
	Bouira	α-pinene (20%), α-phellandrene (14,1%), camphene (5,7%), limonene (5,3%) and D-germacrene (5,3%).	MH (67.0%)	
	Blida (Chrea)	myrcene (33,1%), α-pinene (17,9%), β-pinene (8,9%) and D-germacrene (6,2%).	MH (74.4%)	

	Medea (Berrouaghia)	α-pinene (22,7%), limonene (13,8%), sabinene (8,7%), terpinen-4-ol (7,1%) and β-pinene (6,6%).	MH (76.1%)	
	Bejaia	Limonene (9,8%), *p*-cymene (7,7%), sabinene (7,1%), caryophyllene oxide (7%) and terpinen-4-ol (6,3%).	MH (34.5%) SH (20,1%)	
	Jijel	β-caryophyllene (13,1%), D-germacrene (10,2%), myrcene (8,4%) and δ-cadinene (5,4%).	SH (45.4%) MH (21,1%)	
	Annaba	α-pinene (28%), sabinene (7,7%), β-pinene (6,5%) and D-germacrene (6,3%).	MH (70.7%)	
	Djelfa	β-caryophyllene (19,3%) and δ-cadinene (5,7%).	SH (43.9%)	
Greece (Zakynthos) Air dried leaves (February- May- August)	Before flowering	α-pinene (17,1%), limonene (13,9%), terpinen-4-ol (10,6%) and p-cymene (7,5%).	MH (54,2%)	[54]
	flowering	α-pinene (24,9%), limonene (17,8%), β-pinene (6,9%) and terpinen-4-ol (6,8%).	MH (68,3%)	
	fruiting	D-germacrene (13,5%), terpinen-4-ol (10%), α-pinene (9,4%), limonene (9%) and sabinene (6,7%).	MH (45%)	
Morocco (Tafoghalt) Leaves (February)		β-myrcene (39,2%), limonene (10,3%) and β-gurgujene (7,8%).	MH (57,9%)	[65]
Tunisia (Jebel Mansour) Air dried leaves one week, flowering stage (May)		limonene (19,11%) and α-pinene (9,48%).	MH (45,06%)	[46]
Tunisia (Siliana) Air dried leaves one week, flowering stage (May)		Terpinen-4-ol (23,32%), β-caryophyllene (22,62%) and α-terpineol (7,22%).	OM (39.88%)	[47]
Morocco (Fez city/ sekoura region) air dried Leaves for 25 days (May)		α-pinene (24,25%), β-pinene (12,58%), limonene (7,56%) and terpinen-4-ol (6,98%).	MH (55,76%)	[38]
France (St Rémy de Provence,) biological cultive		β-myrcene (15,18%), 1.8-cineole (15,02%), terpinen-4-ol (6,41%), α-pinene (5,54%) and β-pinene (5,1%).	MH (40,21%) OM (33,42%)	[39]
Algeria (Three sites located at different Altitudes) Air dried leaves, fructification stage	Low altitude	δ-cadinene (10,9%), cubebol (10,5%) and β-bisabolene (7,7%).	-	[6]
	Mid altitude	β-caryophyllene (11,5%), δ-cadinene (8,6%) and caryophyllene oxide (6,8%).	-	
	High altitude	β-caryophyllene (12%), δ-cadinene (9,3%) and α-pinene (6,3%).	-	
Tunisia (Korbous) Fresh leaves (October)		α-pinene (20,6%), limonene (15,3%), β-pinene (9,6%), D-germacrene (8,4%) and terpinen-4-ol (8,2%).	MH (63,9%)	[49]
Morocco (Taounate) Air dried leaves		myrcene (25,3%), limonene (15,7%) and terpinen-4-ol (9,2%).	MH (57,6 %)	[42]
Algeria (Boumerdes) Fresh leaves (Mars-Avril)		spathulenol (13,35%), undecanone (5,58%) and β-cubebene (5,54%).	SO (17,47%)	[55]
Morocco (Taounate) Fresh leaves, flowering stage (May)		tricyclene (7,71%), terpinen-4-ol (7,44%), sabinene (6,96%), β-caryophyllene (6,62%), caryophyllene oxide (6,05%) and *p*-cymene (5,04%).	MH (33,52%)	[66]
Spain (Valencia) Air dried leaves for 20 days, fructification stage	Segart (Siliceous soil)	D-germacrene (17,5%), β -caryophyllene (12,8%), myrcene (11%), muurolol-epi-α (9,1%) and terpinen-4-ol (6,7%).	SH (39,9%)	[68]
	Xeraco (Calcicolous soil)	α-pinene (19%), β- caryophyllene (11,1%), D-germacrene (10,8%), Limonene (8,5%), δ-3-carene (7,2%), β-pinene (6,4%), sabinene (6,1%) and terpinen -4-ol (5,1%).	MH (57,5%)	
Algeria /Bouira (Bouderbala) Air-dried (leaves for a week flowering stage		α-pinene (15,47 %), limonene (14,7 %), β-myrcene (9,93 %), β-pinene (7,31 %), β-caryophyllene (5,03%).	MH (65,61%)	[43]
Tunisia Leaves air dried for two weeks, fruiting stage	Upper semi-arid	α-pinene (12,44%), D-germacrene (9,63%), limonene (9,3%), β-caryophyllene (7,33%), δ-cadinene (6,83%), terpinen-4-ol (6,03%) and sabinene (5,2%).	MH (50,09%)	[57]
	Sub-humid	D-germacrene (14,65%), β-caryophyllene (9,3%), α-pinene (8,25%), limonene (7,18%) and δ-cadinene (6,07%).	SH (48,23%)	
	Lower humid	D-germacrene (13,57%), δ-cadinene (9,5%), β-caryophyllene (8,7%), limonene (8,2%) and α-pinene (6,27%).	SH (46,33%)	
Algeria (localities in eastern) Aerial parts air dried, flowering stage	Constantine	α-pinene (20,08%), α-phellandrene (14,71%), sabinene (7,74%), D-germacrene (7,34%), (E)-caryophyllene (6,6%) and limonene (5,62%).	MH (64,74%)	[63]
	Derguina	myrcene (71,96%) and (E)-caryophyllene (9,51%).	MH (75,92%)	
	Ait Idriss	α-pinene (28,91%), sabinene (11,75%), β-pinene (9,94%) and terpinen-4-ol (8,4%).	MH (78,14%)	
	Ain Smara	myrcene (64,03%) and D-germacrene (7,4%)	MH (67,89%)	
	Ait Anane	α-pinene (34,35%), α- phellandrene (6,77%), D-germacrene (6,49%) and terpinen-4-ol (5,01%).	MH (72,03%)	
	Merouaha	myrcene (73,78%).	MH (78,42%)	
	Bouakrez	α-pinene (23,38%), β-pinene (14,88%), D-germacrene (6,02%) and (E)- caryophyllene (5,9%).	MH (61,88%)	
	Souk Lethnine	limonene (50,81%), α-pinene (14,09%), β-pinene (7,7%), myrcene (5,7%) and D-germacrene (5,05%).	MH (84,32%)	

	Kherrata	α-pinene (33,59%), β-pinene (21,18%), myrcene (12,21%) and D-germacrene (7,28%).	MH (78,12%)	
	Amoucha	α-pinene (27,7%), D-germacrene (14,31%), sabinene (13,75%), terpinen-4-ol (11,73%).	MH (57,75%)	
Algeria (Oran) Air-dried aerial parts (leaves and flowers), flowering (June)		terpinene-4-ol (41,24%), β-caryophyllene (12,62%), myrcene (10,5%), α–pinene (9,48%), limonene (9,11%), p-cymene (8,67%) and α-terpineol (7,31%).	OM (51,45%)	[71]
Algeria (Mostaganem) Fresh aerial parts (leaves and twigs) (Mars)		α-pinene (42,13%), sabinene (6,46%), terpinen-4-ol (6,22%) and γ-terpinene (6,21%).	MH (72.43%)	[64]
Algeria Leaves air dried (Before flowering)	**Bejaia**	α-pinene (12,12%), caryophyllene (8,63%), L-terpinen-4-ol (7,13%), β-phellandrene (6,88%) and γ-cadinene (6,74%).	MH (35%)	**Present study**
	Jijel	caryophyllene (20,87%), α-pinene (17,83%), β-cubebene (7,72%) and β-pinene (7,29%).	SH (44,44%) MH (33,62%)	
	Skikda	D-limonene (31,42%), γ-cadinene (7,22%), caryophyllene (7,05%) and α-pinene (6,77%).	MH (56,39%)	
	El-Taref	β-cubebene (18,92%), caryophyllene (17,58%), β-cadinene (7,5%), D-limonene (6,23%) and β-myrcene (5,5%).	SH (53,15%)	

MATERIALS AND METHODS

1. *Plant Material*

The leaves of *P. lentiscus* were collected early in the morning, during the vegetative stage of the plant, between March and April from four regions of North East of Algeria (Bejaia, Jijel, Skikda and El-Taref) (Figure1). The samples were dried in the shade away from light at room temperature.

Meteorological data of the study area were obtained from the local meteorology stations and EMBERGER's formula was applied. Full details are provided in Table 2, they include the yearly precipitation (average of yearly precipitation) (P), the mean minimum temperature for the coldest month (average of minimal temperature for the coldest month of the year) (m), the mean maximum temperature for the hottest month (average of maximal temperature for the warmest month of the year) (M), the drought duration in months of Bagnouls and Gaussen, the Emberger's pluviothermic quotient (Emberger's coefficient) (Q_2). The study area is classified into humid and sub-humid bioclimatic zones. For each site the altitude (Alt) was also provided.

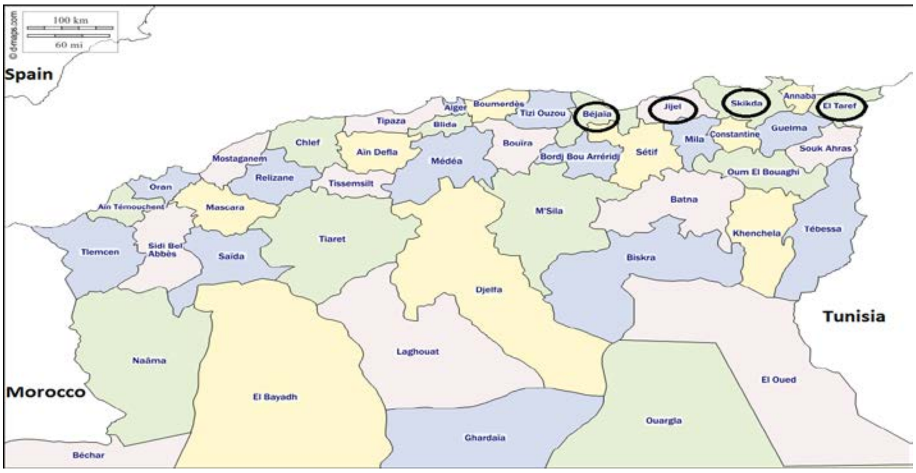

Figure 1. The locations of *P. lentiscus* populations sampled (www.google.com).

Table 2. Main ecological traits of the investigated *Pistacia lentiscus* populations

Regions	T (°C)	m (°C)	M (°C)	P (mm)	Drought duration	H (%)	Q_2	Bioclimate	Alt (m)
Béjaia **(Souk El-Tenine)**	18,01	7,40	30,10	738,25	4	76,00	111,55	sub-humid	400
Jijel **(El-Chahena)**	18,39	9,00	28,60	986,00	3,5	75,05	172,55	humid	430
Skikda **(Sidi Mezghiche)**	19,12	12,50	26,60	677,90	4	76,07	164,91	sub-humid	248
El Taref **(Bougous)**	17,58	6,20	27,90	882,73	3,5	76,13	139,53	humid	260

2. Essential oil extraction and analysis

Essential oils were obtained as follows: 100 g of leaves of each species were subjected to hydrodistillation in a Clevenger apparatus for 2 h with 1000 ml of deionised water. The resulting essential oils were stored with anhydrous sodium sulfate in dark vials at 4°C until used.

The composition of the oil was analysed by GC and GC/MS. The essential oil analysis was performed using Schimadzu GCMSQP2010 model gas chromatograph coupled to a quadruple mass spectrometer type EI model 70 eV equipped with a polar capillary column SE 30. Temperature programme, from 55°C (3 min) to 120 °C (5 min) at 4°C/min and maintained at 180°C (6min) at 8°C/min; injection temperature, 250°C; injection volume, 1,0 µl; inlet pressure, 24,4 kPa; carrier gas, He; linear velocity ($\bar{u}$), 35 cm/s; injection mode, split (20:0). The temperatures of the source and the interface were set to 200°C and 250°C, respectively. The constituents were identified by the NIST library 05.

RESULTS AND DISCUSSION

The constituents of the essential oils of *P. lentiscus* for different regions of North East of Algeria identified by GC–GC/MS, their Chemical formula and area percentages, represented in order of their appearances, are summarized in Table 3.

Table 3. Chemical composition of leaf essential oils from four Algerian *P. lentiscus*.

N°	Compound Name	Rt	Chemical formula	Area (%)			
				Bejaia	Jijel	Skikda	El-Taref
1	Unknown	3.050	/	-	0,59	-	-
2	1,3-dioxane-4,6-dione,2,2-dimethyl-	3.090	$C_6H_8O_4$	-	-	-	1,31
3	δ3-p-Menthene	4.235	$C_{10}H_{18}$	-	0,17	-	-
4	Tricyclene	4.239	$C_{10}H_{16}$	0,47	-	0,22	-
5	α-Pinene	4.505	$C_{10}H_{16}$	12,12	17,83	6,77	1,8
6	Camphene	4.769	$C_{10}H_{16}$	2,30	0,97	1,10	-
7	β- Thujene	5.366	$C_{10}H_{16}$	-	0,23	-	-
8	β-Pinene	5.442	$C_{10}H_{16}$	1,89	7,29	3,21	1,72
9	β-Myrcene	5.931	$C_{10}H_{16}$	0,70	0,25	2,33	5,50
10	4-Hexen-1-ol, acetate, (Z)-	6.139	$C_8H_{14}O_2$	-	0,20	-	-
11	α-Thujene	6.173	$C_{10}H_{16}$	0,46	0,21	0,08	0,20
12	α-Phellandrene	6.209	$C_{10}H_{16}$	-	-	0,60	-
13	cis-p-Mentha-2,4(8)-diene	6.572	$C_{10}H_{16}$	-	0,16	-	0,48
14	α-Terpinene	6.588	$C_{10}H_{16}$	-	-	1,98	-
15	o-Cymene	6.655	$C_{10}H_{14}$	0,30	0,56	-	-
16	p-Methylvalerophenone	6.664	$C_{12}H_{16}O$	-	-	-	0,17
17	β-Phellandrene	6.848	$C_{10}H_{16}$	6,88	1,93	3,06	0,28
18	cis-4-Thujanol	6.862	$C_{10}H_{18}O$	-	-	-	2,04
19	D-limonene	6.970	$C_{10}H_{16}$	2,04	2,97	31,42	6,23
20	Trans-β-Ocimene	7.288	$C_{10}H_{16}$	-	-	0,44	-
21	Methacrylic anhydride	7.383	$C_8H_{10}O_3$	0,04	-	-	-
22	cis-β-Ocimene	7.587	$C_{10}H_{16}$	0.22	0,15	1,26	-
23	1-Butanol,3-methyl-, carbonate (2 :1)	7.698	$C_{11}H_{22}O_3$	0,11	-	-	-
24	γ-Terpinene	7.826	$C_{10}H_{16}$	3,89	0,42	2,79	1,55
25	(+)-4-Carene	8.738	$C_{10}H_{16}$	2,40	0,48	1,13	0,75
26	2-Carene	8.742	$C_{10}H_{16}$	1,33	-	-	-
27	Nonanal	9.037	$C_9H_{18}O$	0,18	-	-	-
28	Linalol	9.075	$C_{10}H_{18}O$	-	0,23	0,21	-
29	Hexyl octyl ether	9.307	$C_{14}H_{30}O$	-	0,30	-	-
30	Butanoic acid, 3-methyl-, 3-methylbuthyl ester	9.333	$C_{10}H_{20}O_2$	0,18	-	0,10	-
31	Trans-Pinocarveol	10.066	$C_{10}H_{16}O$	-	-	0,09	-
32	cis-4-Thujanol	10.297	$C_{10}H_{18}O$	0,06	-	0,19	-
33	Camphene hydrate	10.303	$C_{10}H_{18}O$	0,09	-	-	-
34	1-(3h-imidazol-4-yl)-ethanone	10.954	$C_5H_6N_2O$	-	0,12	-	-
35	2-oxatricyclo[3.3.1.1(3,7)]decane, 1-methyl-	10.955	$C_{10}H_{16}O$	-	-	0,12	-
36	Cyclopentanecarboxylic acid, 2-methyl-3-methylene-, methyl ester	10.959	$C_9H_{14}O_2$	0,06	-	-	-
37	Ether,p-menth-6-en-2-yl methyl	11.308	$C_{11}H_{20}O$	0,05	-	0,29	-
38	Terpinen-4-ol	11.397	$C_{10}H_{18}O$	-	0,66	-	-
39	L-terpinen-4-ol	11.422	$C_{10}H_{18}O$	7,13	-	4,23	0,78
40	α-terpineole	11.813	$C_{10}H_{18}O$	1,51	3,13	1,62	-
41	Cyclohexanone,4-(1,1-dimethylpropyl)-	11.934	$C_{11}H_{20}O$	0,15	-	-	-
42	1H-Inden-1-one, octahydro-7-a-hydroxy-	11.943	/	-	-	0,15	
43	Unknown	12.100	/	0,07	-	-	-

44	*Pulegone*	*13.53*	$C_{10}H_{16}O$	-	*0,21*	-	*0,52*
45	*Diaminopyridine*	*13.558*	$C_{5}H_{7}N_{3}$	-	-		*0,17*
46	*Isopentyl hexanoate*	*14.153*	$C_{11}H_{22}O_{2}$	*0,14*	-	*0,11*	*0,17*
47	*Trans-4-t-Pentyl Cyclohexanol*	*14.242*	$C_{11}H_{22}O_{2}$	-	-	*0,10*	-
48	*Isopentyl hexanoate*	*14.258*	$C_{11}H_{22}O_{2}$	*0,07*	-	-	-
49	*δ-Decalactone*	*14.264*	$C_{10}H_{18}O_{2}$	-	-	-	*0,14*
50	*2(1H)-Naphthalenone,3,4,4a,5,6,7-hexahydro-1,1,4a-trimethyl-*	*14.867*	$C_{13}H_{20}O$	*0,08*	-	*0,12*	-
51	*Bornyl acetate*	*15.030*	$C_{12}H_{20}O_{2}$	*3,50*	*0,93*	*1,38*	*1,81*
52	*2-Undecanone*	*15.437*	$C_{11}H_{22}O$	*0,53*	*0,76*	*0,37*	-
53	*2-Decanone*	*15.474*	$C_{10}H_{20}O$	-	-	-	*0,90*
54	*δ-EIemene*	*17.108*	$C_{15}H_{24}$	*0,23*	-	-	
55	*2,7-Dimethyl-2,6-octadien-4-ol*	*17.139*	$C_{10}H_{18}O$	-	-	-	*0,13*
56	*α-Terpineol acetate*	*17.154*	$C_{12}H_{20}O_{2}$	-	*0,35*	-	-
57	*Longipinene*	*17.403*	$C_{15}H_{24}$	-	-	*0,10*	
58	*α-cubebene*	*17.523*	$C_{15}H_{24}$	-	-	*0,08*	*2,48*
59	*1,2-Bis(2-hydroxypropyl)hydrazine*	*18.033*	$C_{6}H_{16}N_{2}O_{2}$	-	-	-	*0,28*
60	*Copaene*	*18.281*	$C_{15}H_{24}$	*0,13*	-	*0,75*	
61	*trans-Geranyl acetate*	*18.293*	$C_{12}H_{20}O_{2}$	-	*2,61*	-	-
62	*β-Bourbonene*	*18.466*	$C_{15}H_{24}$	*0,04*	-	-	
63	*Unknown*	*18.508*	/	-	-	-	*0,19*
64	*Methyleugenol*	*18.542*	$C_{11}H_{14}O_{2}$	-	*0,57*	-	-
65	*β-Elemene*	*18.753*	$C_{15}H_{24}$	*0,29*	*0,60*	*0,31*	*0,66*
66	*Caryophyllene*	*19.492*	$C_{15}H_{24}$	*8,63*	*20,87*	*7,05*	*17,58*
67	*Aziridine, 2,3-dimethyl-1-(1-methylethyl)-,cis-*	*19.575*	$C_{7}H_{15}N$	-	-	-	*0,17*
68	*Isoamyl benzoate*	*19.650*	$C_{12}H_{16}O_{2}$	*0,19*	*0,23*	*0,18*	*0,73*
69	*D-Germacrene*	*19.815*	$C_{15}H_{24}$	*0,07*	*0,21*	-	-
70	*Unknown*	*19.850*	/	-	-	-	*0,40*
71	*γ- Elemene*	*20.048*	$C_{15}H_{24}$	-	*0,16*	-	-
72	*Geranyl acetone*	*20.415*	$C_{13}H_{22}O$	*0,18*	-	-	-
73	*2-Phenylacetamide, N-(1-phenyl-2-propyl)-*	*20.475*	$C_{17}H_{19}NO$	-	-	-	*0,31*
74	*(+)-Epi-bicyclosesquiphellandrene*	*20.483*	$C_{15}H_{24}$	-	*0,51*	*0,64*	*1,25*
75	*α- Caryophyllene*	*20.578*	$C_{15}H_{24}$	*1,00*	*3,12*	*1,49*	*3,35*
76	*Alloaromadedrene*	*20.825*	$C_{15}H_{24}$	-	*0,36*	*0,32*	-
77	*1,4-Methanocycloocta[d]pyridazine, 1,4,4a,5,6, 9,10,10a- octahydo-11,11-dimethyl-,(1α,4α,1aα ,10aα)]-*	*20.839*	$C_{17}H_{21}NO$	-	-	-	*0,42*
78	*Bicyclo[4.4.0]dec-1-ene, 2-isopropyl-5-methyl-9-methylene*	*21.429*	$C_{15}H_{24}$	-	*0,33*	-	-
79	*β-Cubebene*	*21.605*	$C_{15}H_{24}$	-	*7,72*	*0,11*	*18,92*
80	*β-Selinene (β-Eudesmene)*	*21.791*	$C_{15}H_{24}$	-	*0,38*	*0,18*	-
81	*γ-Gurjunene*	*22.235*	$C_{15}H_{24}$	-	*0,90*	-	-
82	*β-Germacrene*	*22.258*	$C_{15}H_{24}$	*0,20*	-	*0,89*	-
83	*Artemesia triene*	*22.262*	$C_{10}H_{16}$	-	-	-	*0,76*
84	*Butanimidamide*	*22.392*	$C_{4}H_{10}N_{2}$	-	*0,14*		
85	*α.-Muurolene*	*22.578*	$C_{15}H_{24}$	*0,14*	*1,33*	*1.12*	*1,41*
86	*1-Alanine, N-(2- fluorobenzoyl)-, tatradecyl ester*	*22.735*	$C_{26}H_{41}ClFNO$	-	*0,16*	-	-
87	*δ-Cadinene*	*22.849*	$C_{15}H_{24}$	-	-	*0,11*	-
88	*γ-Cadinene*	*23.026*	$C_{15}H_{24}$	*6,74*	*0,51*	*7,22*	-
89	*Adamantane, 1-(2-bromoethenyl)-*	*23.056*	$C_{12}H_{19}Br$	-	-	-	*0,30*
90	*(-)-Calamenene*	*23.233*	$C_{15}H_{22}$	-	*0,88*	-	-
91	*α-Farnesene*	*23.292*	$C_{15}H_{24}$	-	-	*0,47*	-
92	*β-Cadinene*	*23.607*	$C_{15}H_{24}$	*0,68*	*4,66*	*4,55*	*7,5*
93	*Cadinadiene-1,4*	*23.982*	$C_{15}H_{24}$	-	-	*0,26*	-
94	*α-Calacorene*	*24.108*	$C_{15}H_{20}$	-	-	*0,08*	-
95	*Bicyclo[4.1.0]-3-heptene,2-isopropenyl-5-isopropyl-7,7-dimethyl-*	*24.200*	$C_{15}H_{24}$	-	*0,16*	-	-
96	*Benzoic acid, 3-methyl-2-trimethylsilyloxy-,trimethylsilyl ester*	*25.202*	$C_{14}H_{24}O_{3}Si_{2}$	*0,09*	-	-	-
97	*γ –Elemene*	*24.898*	$C_{15}H_{24}$	*0,07*	*0,76*	-	-
89	*Cycloheptasiloxane tetradecamethyl-*	*25.204*	$C_{14}H_{42}O_{7}Si_{7}$	-	*0,42*	-	-
90	*3-butoxy-1 1 1 7 7 7-hexamethyl-3 5 5-tris(trimethylsiloxy)tetrasiloxane*	*25.223*	$C_{19}H_{54}O_{7}Si_{7}$		-	-	*0,64*
100	*Allo Pregnane-3 beta,7 alpha,11 alpha-triol-20-one*	*25.501*	$C_{21}H_{32}O_{2}$	-	*0,33*	-	-
101	*Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-*	*25.589*	$C_{15}H_{24}$	*0,09*	-	-	-
102	*Caryophyllene oxide*	*25.604*	$C_{15}H_{24}O$	-	*2,12*	*0,57*	*0,64*
103	*(-)-Globulol*	*25.832*	$C_{15}H_{26}O$	-	-	*0,25*	-

104	1-Cycloheptene, 1,4-dimethyl-3-(2-methyl-1-propene-1-yl)-4-vinyl-	26.066	$C_{15}H_{24}$	-	-	0,25	-
105	Ethyl iso-allocholate	26.159	$C_{26}H_{44}O_5$	-	-	0,27	-
106	3-cyclohexene-1-carboxaldehyde 3 4-dimethyl-	26.472	$C_9H_{14}O$	-	0,29		-
107	Spatulenol	26.728	$C_{15}H_{24}O$	-	-	0,57	-
108	Humulane-1,6-dien-3-ol	26.885	$C_{15}H_{26}O$	-	-	0,16	-
109	4'-Ethoxy-2'-hydroxyoctadecanophenone	27.044	$C_{26}H_{44}O_3$	-	0,20	-	-
110	α-Cedrene	27.292	$C_{15}H_{24}$	0,09	0,98	-	-
111	Di-epi-alpha-cedrene-(1)-	27.310	$C_{15}H_{24}$	-	-	0,97	-
112	Unknown	27.503	/	-	0,16	-	-
113	Undecane,3,8-dimethyl-	27.518	$C_{13}H_{28}$	-	-	-	0,50
114	δ-Cadinol	27.739	$C_{15}H_{26}O$	0,6	2,36	1,07	1,40
115	tau-Cadinol	27.749	$C_{15}H_{26}O$	-	-	0,30	2,05
116	Benzylamine, .alpha.-carboxy-n-heptyl-	27.792	$C_{13}H_{28}$	-	0,44	-	-
117	Seychellene	27.850	$C_{15}H_{24}$	0,10	-	-	-
118	Unknown	27.852	/	-	0,13	-	-
119	2H-Pyran-2ol,tetrahydro-	27.942	$C_5H_{10}O_2$	-	-	-	2,10
120	α-Cadinol	27.937	$C_{15}H_{26}O$	0,45	1,18	3,35	-
121	Unknown	28.142	/	-	-	-	0,16
122	Thujopsene	28.334	$C_{15}H_{24}$	-	-	0,08	-
123	Unknown	28.421	/	-	-	0,08	-
124	1,5,9,11-Tridecatetraene, 12-methyl-(E,E)-	28.592	$C_{14}H_{22}$	-	0,43	-	-
125	7R,8R-8-Hydroxy-4-isopropylidene-7-methyl bicyclo[5.3.1]undec-1-ene	28.595	$C_{15}H_{24}O$	-	-	0,18	-
126	α-Bisabolol	28.809	$C_{15}H_{26}O$	-	0,59	0,41	0,33
127	Dimethylundecane	29.839	$C_{13}H_{28}$	-	0,19	-	-
128	3-Ethoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane;	29.923	$C_{17}H_{50}O_7Si_7$	0.07	0,48	-	-
129	Cyclohexane, (1,2,2-trimethylbutyl)-	30.050	$C_{13}H_{26}$	-	0,19	-	-
130	Urea, 1-methylcyclopropyl-	30.317	$C_5H_{10}N_2O$	-	0,11	-	-
131	Sulfurous acid, 2ethylhexyl isohexyl ester	31.642	$C_{14}H_{30}O_3S$	0,05	-	-	-
132	Undecane,3,8-dimethyl-	31.644	$C_{13}H_{28}$	-	-	-	0,44
133	Diisobutyl phthalate	31.924	$C_{16}H_{22}O_4$	0,07	0,22	-	1,06
134	2-Pantadecanone,6,10,14-trimethyl-	32.072	$C_{18}H_{36}O$	-	-	0,07	-
135	1,1,1,3,5,7,9,11,11,11-decamethyl-5-(trimethylsiloxy)tetrasiloxane	32.793	$C_{12}H_{36}O_4Si_5$	0,12	0,36	-	1,95
136	Nonane,3,7-dimethyl-	33.464	$C_{11}H_{24}$	-	-	-	0,19
137	Hexadecanoic acid, methyl ester	33.629	$C_{17}H_{34}O_2$	0,12	0,33	-	1,68
138	3-isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane	36.507	$C_{18}H_{52}O_7Si_7$	0,09	0,28	-	2,23
139	1,1,1,3,5,5,7,7,7-Nonamethyl-3-(trimethylsiloxy)tetrasiloxane	36.527	$C_{12}H_{36}O_4Si_5$	-	-	-	1,28
140	Unknown	37.515	/	30,52	-	-	-
Monoterpenes				43,97%	37,85%	62,95%	23,78%
monoterpene hydrocarbons				35%	33,62%	56,39%	19,27%
oxygenated monoterpenes				8,97%	4,23%	6,56%	4,51%
Sesquiterpenes				19,55%	50,69%	33,98%	57,57%
sesquiterpene hydrocarbons				18,5%	44,44%	27,12%	53,15%
oxygenated sesquiterpenes				1,05%	6,25%	6,86%	4,42%
Others				5,89%	10,64%	3,04%	17,91%
Total identified				69,41%	99,12%	99,97%	99,26%

- : not detected

A total of one hundred and thirty two compounds, representing on average 91,94% of the total oils, were identified. Fifty five, Sixty six, Sixty-one and Forty-nine compounds accounting for 69,41%, 99,12%, 99,97% and 99,26% of the total essential oils were identified in Bejaia, Jijel, Skikda and El-Taref respectively. At the species level (average over the 4 populations), the essential oils was characterized by its richness in monoterpene hydrocarbons (36,07%) and sesquiterpene hydrocarbons (35,80%). The minor volatile fractions were represented by the oxygenated monoterpenes (6,07%) and sesquiterpenes (4,65%).

Two main essential oil profiles have been distinguished according the rate of monoterpene/sesquiterpene composition in leaf samples. The samples collected from Bejaia and Skikda respectively was found to be rich in monoterpene hydrocarbons (35-56,39%), whereas sesquiterpene hydrocarbons was found to be rich in the samples collected from Jijel and El-Taref respectively (44- 53,19%). These different profiles agree with those referred in the literature. Indeed, data from other Algerian locations [43, 61-64], Morocco [36, 65, 38, 42, 66], Tunisia [67, 46, 49, 57], Spain [32, 26, 68], Italy [35, 69, 31] are quite similar to those that were found in Bejaia and Skikda regions.

On the contrary, profiles as those reported by Dob et *al.* [61] in Algiers (Algeria), Mecherara-Idjeri et *al.* [62] in Jijel and Djelfa (Algeria), Lo Presti et *al.* [27] in Sicily (Italy), Llorens-Molina et *al.* [68] in Spain and Magiatis et *al.* [33] in Chios Island (Greece) show a clear predominance of sesquiterpenes hydrocarbons over monoterpenes hydrocarbons, being closer to Jijel and El-Taref regions. Other profiles were also reported: to oxygenated monoterpenes from Algeria [70-71], Tunisia [47] and Turkey [29, 72]. Algerian oil contained a profiles to oxygenated sesquiterpenes from Boumerdes [55].

The obtained results from this study were revealed some qualitative and quantitative differences between the compositions of the four oils reported from a region to another (Table 3). The major oil components of *P. lentiscus* from Bejaia were α-pinene (12,12%) followed by caryophyllene (8,63%), L-terpinen-4-ol (7,13%), β-phellandrene (6,88%) and γ-cadinene (6,74%), while caryophyllene (20,87%) and α-pinene (17,83%) followed by β-cubebene (7,72%) and β-pinene (7,29%) were the main constituents of Jijel oil. D-limonene (31,42%), caryophyllene (7,05%), γ-cadinene (7,22%), α-pinene (6,77%), were the main constituents of Skikda oil. For P. lentiscus oil from El-Taref, β-cubebene (18,92%) and caryophyllene (17,58%) followed by β-Cadinene (7,5%), D-limonene (6,23%), β-Myrcene (5,5%), were the major components.

Our results are comparable with some studies and differ from others. All the samples from different Mediterranean areas were characterized by the occurrence of one of the following monoterpenes as major components (α-pinene, β-pinene, limonene, β-myrcene, p-cymène, sabinene, α-phellandrene, β-phellandrene, α-terpinene, γ-terpinene, terpinen-4-ol, α-terpineol).

α-pinene (12,12%), which is the major compounds of Bejaia essential oil, has also the abundant compound in the samples from differents localities in central Algeria (Agiers, Tizi Ouzou, Medea, Tipaza and Bouira) (15,47-25,93%) [43, 62], Estern Algeria (Annaba, Constantine, Setif and Bejaia) (14,09-73,78%) [62-63], Western Algeria (Oran and Mostagamem) (19-42,13%) [61, 64], Morocco (Oulmes and Fez city) (16,5-38,5%) [36,38], Tunisia (Karbous and Zaghouan) (16,8-20,6%) [49, 67], Spain (Jaén and Xeraco) (13-19%) [26,68], Greece (Zakynthos) (17,1-24,9%) [54], Italy (Sardinia /Torre delle Stele, Oristano and Tuscany) (16,1-25,3%) [31, 69] and France (Corsica) (31,9%) [34].

Moreover, D-limonene (31,42%) was the major compound of Skikda essential oil. This compound was also abundant in the samples from France (Corsica) (47%) [34], Tunisia (Jebel Mansour) (19,11%) [46] and Algeria (Bejaia) (9,8-50,81%) [62-63].

The chemotype to myrcene is reported in Algeria (Blida/Chrea, Ain Smara, Derguina, Merouaha) (33,10-73,78%) [62-63], Spain (Sevilla) (19,25%) [32], France (Corsica, St Rémy de Provence) (15,18-76,9%) [34, 39], Italy (Orroli) (19,36%) [31], Greece (Chios Island) (20,58%) [33] and Morocco (Taounate and Tafoghalt) (25,3-39,2%) [42, 65]. On the other hand, the chemotype to terpinen-4-ol was identified in Algeria (Algiers and Oran) (17,3-41,24%) [70, 71], France (Corsica) (25,6%) [34], Morocco (Chaouen and Mehdia) (14.5-43,8%) [36], Tunisia (Siliana) (23,32%) [47], Turkey (Fethiye and Çeşme-Ardiç) (29,2-29,9%) [29, 72] and Italy (19,74-28,29%) [31]. Marocan oil contained a chemotype to tricyclene (7,71%) [66] and Italian oil contained a chemotype to β-pinene (18,71%) [35].

Unlike the other samples dominated by sesquiterpenes characterized by β-caryophyllene, D-germacrene, longifolene, spatulenol and δ-cadinene. In this study caryophyllene (20,87%) was the major compound of Jijel essential oil. This compound was also abundant in the samples from different regions in Algeria (Jijel, Djelfa, High and Mid altitude) (11,5-19,3%) [6, 62].

On the other hand, the chemotype to D-germacrene was identified in Tunis (11,9%) [57], Spain (Segart Valencia) in siliceous soil (17,5%) [68] and Italy (Sicily) (18,61%) [27].

Other chemotypes were also reported in Algeria: to longifolene from Algiers (12,8%), Tizi-Ozou (16,4%) and Oran (19%) [61]; spatulenol from Boumerdes (13,35%) [55] and δ-cadinene from Algerian sites located at Low altitude [6].

Finally, β-cubebene, which is the major component found in our investigation (oil of El-Taref), was previously reported in verry low proportions in Turkey [72], Morocco (Mehdia) [36], Algeria [6] , Spain [26] and Greece [54, 33].

Concerning the constitution of the various majority compounds, our results are not in agreement with those from all previous studies performed on Algerian *P. lentiscus* essential oil.

Benyoussef et *al.* [70] studied the chemical composition of the essential oils obtained from the leaves of *P. lentiscus* from Algiers city. The authors identified 64 components and reported that the oxygenated monoterpenes fraction was dominant in the oil (30,9-50,2%). The terpinen-4-ol (17,3-34,7%), D-germacrene (8,4-15,8%), α-terpineol (10,4-11%), β-caryophyllene (2,7-5%) were the main components.

Furthermore, Dob et *al.* [61] identified 65, 69 and 71 components accounting for 85.1%, 85.4% and 95.9% of total oils, respectively in aerial parts of *P. lentiscus* from Algiers, Tizi-Ouzou and Oran and reported that the sesquiterpenes hydrocarbons fraction was dominant in the oil from Algiers (35,5%) with longifolene (12,8%), γ-cadinene (6,2%), *Trans*-β-terpineol (5.0%) as the major components. Oxygenated monoterpenes fraction was dominant in the oil of Tizi-Ozou (36%), longifolene (16,4%), *Trans*-β-terpineol (15,6%), terpinen-4-ol (7,0%), γ-muurolene (5,7%) were the main components. From Oran, monoterpenes hydrocarbons fraction was dominant (56,3%), α-pinene (19.0 %), *Trans*-β terpineol (13,1%), sabinene (12,6%), β-pinene (6,5%), (*E*)-β-ocimene (5,5%), longifolene (5,2%) were the major components.

Arab et *al.* [55] studied the chemical composition of the oils obtained from the aerial parts of *P. lentiscus* from Boumerdes. Spathulenol (13,35%), undecanone (5,58%), β-cubebene (5,54%), limonene (4,76%), α-cadinol (4,11%) were the main components.

The chemical composition of 17 samples of leaf oil from *Pistacia lentiscus* L. growing wild in Algeria was investigated and more than 60 compounds were identified. α-Pinene (20-34,2%), myrcene (23-33,1%) or limonene (25,5-43,8%) were the major components [61]. α-pinene, β-pinene, β-myrcene, limonene, and β-caryophyllene were found to be the abundant terpenic fraction of *P. lentiscus* collected from Bouira and different localities in eastern of Algeria [43; 63].

However, the chemical variability of *P. lentiscus* essential oil obtained from samples harvested at Bejaia region was reported as limonene (50,81%), α-pinene (14,09%), β-pinene (7,7%), myrcene (5,7%) and D-germacrene (5,05%) were the major constituents [63]. However, the oils obtained from leaves of Pistacia lentiscus collected by Mecherara-Idjeri et *al.* [62] displayed a different profile since it consisted mainly of limonene (9,8%), *p*-cymene (7,7%), sabinene (7,1%), caryophyllene oxide (7,0%) and terpinen-4-ol (6,3%). In our samples from Bejaia, limonene, myrcene and D-germacrene, were present in low proportions, sabinene and caryophyllene oxide were not detected.

Similarly, comparing our results with those reported by Mecherara-Idjeri et *al.* [62], the major compound in Jijel oil were β-caryophyllene (13.1%), D-germacrene (10.2%), myrcene (8.4%) and δ-cadinene (5.4%), α-Cadinol (3,6%), α-pinene (3,5%). In our samples from Jijel, D-germacrene and myrcene were present in low proportions, δ-cadinene were not detected.

In other countries of Mediterranean region, several investigations [34, 38, 49, 54) showed that α-Pinene, β-Pinene, limonene and terpinen-4-ol were found to be the abundant terpenic fraction of *P. lentiscus* collected from France, Morocco, Tunisia and Greece.

α-Pinene, β-myrcene, and terpinen-4-ol were found to be the main compounds of *P. lentiscus* originated from Italy, Spain, Morocco, France and Algeria [31, 32, 36, 39, 62].

The composition of Bejaia and Jijel oils, which are characterized by α-pinene and caryophyllene is close to the spain oil sample [26, 68]. Moreover, sample of Skikda contained limonene, β-caryophyllene and α-pinene as main components, like the Marocan oil sample [36]. Finally, the composition of sample of El-Taref is original.

The chemical variation between samples occurs mainly according to their geographic appurtenances. However, a considerable variation among samples collected (harvested) from the same locations was also detected in Algeria [6, 61-63, 70], Morocco [36], Tunisia [57], France (Corsica) [34], Italy (Sardinia) [31], and Spain (Valencia) [68].

Hence, this study has allowed us to highlight the presence of four chemotypes. The populations of Bejaia contain the chemotype to α-pinene (12.12%) and jijel contain the chemotype to caryophyllene/α-pinene with the high proportions of and caryophyllene (20.87%) and α-pinene (17.83%) respectively. The chemotype to limonene and β-cubebene/caryophyllene characterizes populations of Skikda and El-taref respectively. It appears that P. lentiscus from El-teref (Algeria) belongs to the β-cuebene/caryophyllene chemotype, which could be new chemotype that have not yet been reported in the literature.

Therefore, the differences we have found between our and other authors results may be explained by the influence of geography, climatic factors (precipitation, temperature, Emberger's coefficient, …), altitude, substrate type, edaphic soil conditions, plant organ, growth stage, the collection period, the drying time, extraction technique, and the genetic characteristics of each plant.

CONCLUSION

The chemical composition of the essential oils of *Pistacia lentiscus* growing wild in Nord estern Algéria was investigated. The data obtained in this study showed a remarkable quantitative and qualitative variations of constituents in the oils. This variety of composition is only the reflection of the molecular biodiversity found in this plant. To our knowledge, β-cubebene has never been reported as a major constituent of *P. lentiscus*. The sample from El-Taref represents a new chemotic typical of the extreme North-East of Algeria and whose biological properties are being studied.

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