

Original Research Paper

Morphometric and Phytochemical Characterization of the Mastic Tree (*Pistacia lentiscus* L.) in Western Algeria.

Henaoui Z.B.¹, Derrar Y.K.¹, Selka S.¹, Seladji M.², Taibi W.¹, Gaouar S.B.S.¹

¹Laboratory of Applied Genetics in Agronomy, Ecology, and Public Health (GenApAgiE), Department of Biology, University of Tlemcen, Algeria.

²Laboratory of Natural products (LAPRONA), Department of Biology, University of Tlemcen, Algeria.

*Corresponding Authors : Henaoui Z.B, GENAPAGIE, Tlemcen, Algeria : Email : Bouchrahenaoui06@gmail.com
Derrar Y.K, GENAPAGIE, Tlemcen, Algeria : Email : derrar-fz@yahoo.fr

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Abstract:

The *Pistacia lentiscus*, belonging to the family Anacardiaceae, has been known since antiquity for its medicinal properties, but little attention has been paid to its morphology and phenotype. Therefore, the main objective of this study is to characterize the species, a shrub of the Anacardiaceae family widely used in medicinal industries and natural treatments. We conducted a morphometric and phytochemical analysis in different regions of four wilayas in western Algeria (Tlemcen, Sidi Bel Abbès, Oran, Mascara), followed by a statistical study aimed at evaluating the diversity of the quantitative and qualitative characteristics examined. The results of the statistical analyses, including ANOVA, hierarchical ascending classification, principal component analysis, the Chi-squared test, as well as the Shannon and Weaver diversity index, revealed significant phenotypic and phytochemical diversity.

Keywords: *Pistacia lentiscus* L, morphometric, phytochemical, western Algeria.

المخلص

شجرة الضر، التي تنتمي إلى عائلة الأنكاردية، معروفة منذ العصور القديمة بخصائصها الطبية، ولكن لم يتم إيلاء الكثير من الاهتمام لعلم الشكل والظواهر الخاصة بها. لذلك، الهدف الرئيسي من هذه الدراسة هو وصف نوع بيسناتاكيا لونتيسكرو هو شجيرة من عائلة الأنكاردية تُستخدم على نطاق واسع في الصناعات الطبية والعلاجات الطبيعية. قمنا بإجراء تحليل مورفومتري وفيتوكيميائي في مناطق مختلفة من أربع ولايات في غرب الجزائر (تلمسان، سيدي بلعباس، وهران، معسكر)، تلا ذلك دراسة إحصائية تهدف إلى تقييم تنوع الخصائص الكمية والنوعية التي تم فحصها. أظهرت نتائج التحليلات الإحصائية، بما في ذلك تحليل التباين التصنيف الهرمي التصاعدي، تحليل المكونات الرئيسية، اختبار كاي-2، بالإضافة إلى مؤشر تنوع شانون وويفر، تنوعاً كبيراً في الظواهر الفينوتيبية والفيتوكيميائية.

الكلمات المفتاحية : شجرة الضر، مورفومتر، كيميائي، غرب الجزائر

Introduction

The use of medicinal plants, primarily rooted in rural areas through ancestral knowledge, has significantly expanded in recent years with the growing commercialization of these plants and the opening of specialized outlets (Beldi *et al.*, 2021). In Algeria, their usage is ancient and is now attracting renewed interest (Boutabia *et al.*, 2011; Lazli *et al.*, 2019). Among the thousands of species in the Algerian flora, the mastic tree (*Pistacia lentiscus* L.) is known by different names depending on the region, such as "Dro" in the western part of the country (Cheraft, 2011).

The mastic tree belongs to the Anacardiaceae family of the *Pistacia* genus; it is a shrub or small tree generally reaching between 1 and 5 meters in height, typical of Mediterranean ecosystems. It has a dense, bushy structure with often twisted branches, giving it a compact form resistant to dry winds and arid conditions (Quézel et Médail, 2003).

Pistacia lentiscus is a wild plant that grows in scrublands and maquis on various types of soil, particularly in the subhumid and semi-arid areas of Algeria (Smail-Saadoun, 2002), found both on the

coast (Saidi, 2008) and in interior regions (Belhadj, 2000). Known since antiquity for its medicinal properties (Boughrara-Merzougui, 2015), the mastic tree is distinguished by its richness in chemical components, particularly tannins, flavonoids, and essential oils, which give it a characteristic aromatic smell. It is widely used in traditional Arab and European medicine (Hamlat et Hassani, 2008; Bensalem, 2015; Boughrara-Merzougui, 2015), particularly its oil, reputed for treating stomach ulcers, bronchitis, wound healing, and

contributing to improving rural incomes (Mezni *et al.*, 2012).

Scientifically, the genetics of the mastic tree are studied to understand its genetic diversity and morphological characteristics in Mediterranean regions (Al-Saghir, 2012).

This species is also an important producer of oleoresin, a valuable resource both economically and pharmaceutically (Saidi, 2008).

In this study, we focus on characterizing this relatively unknown oil by analyzing the morphometric parameters of *pistacia lentiscus* and the phytochemical composition of samples collected from various regions across the wilayas of Tlemcen, Sidi Bel Abbès, Mascara, and Oran.

Materials and Methods

Study area

The study examined 100 mastic tree shrubs from 10 distinct regions in four western Algeria provinces (Table 01) (Tlemcen, Sidi Bel Abbès, Oran, and Mascara) (Figure 01). The collection was made in 2023-2024.



Figure 1. Location of the different sampling sites in four provinces (wilayas) of western Algeria: Tlemcen, Sidi Bel Abbès, Oran, Mascara.

Table 1. The geographical location of the sampling sites.

Province	Region	Geographical location	Agroecological zones
Tlemcen	L'ourit	(35°52'46"N 1°15'57"W) 738.1m	Plaines sub-littorales
	Ouled sida li belhadj	(34°48'44"N 1°11'07"W) 962.43m	Plaines sub-littorales
	Ziatin	(35°07'19"N 1°45'17"W) 263.38m	Littorale
	Ouchba	(34°54'05"N 1°13'18"W) 779.93m	Plaines sub-littorales
Sidi Bel Abbès	Benitala	(35°15'13"N 0°11'44"W) 530.62m	Steppes
	Telmouni	(35°06'01"N 0°29'50"W) 653.84m	Steppes
Oran	Foret de canastel	(35°45'47"N 0°33'04"W) 224.75m	Littorale
	Foret des lions	(35°45'30"N 0°29'49"W) 277.49m	Littorale
Mascara	Djebailia	(35°17'46"N 0°07'55"W) 400.79m	Steppes
	El gaada	(35°25'08"N 0°18'15"W) 528.83m	Steppes

Plant materials

In our study, 100 shrubs of (*Pistacia lentiscus* L.) were examined each represented by 5 leaves and 5 fruits (a total of 500 leaves and 500 fruits) (UPOV, 2021).

Character observation

Seven quantitative variables were considered for the leaves and fruits, as indicated in Table 2.

Phytochemical study

The leaves of the mastic tree (*Pistacia lentiscus*) were air-dried, protected from light, at room temperature (25°C) for 10 ± 2 days. Once dried, the plant material was ground using a chopper, then stored in airtight sealed paper envelopes.

Table 2. Measured quantitative traits. (UPOV, 2021).

N°	Traits	Code	Unit
01	Leaf width	Larf	cm
02	Leaf length	Longf	cm
03	Number of leaflets	Nf	
04	Petiole length	Longp	cm
05	Rachis length	Longr	cm
06	Fruit weight	Pf	g
07	Fruit diameter	Df	mm

Extraction Method

Essential oils were obtained using the hydrodistillation method with a Clevenger-type apparatus; 100 g of the dried plant material were placed in a 1000 ml flask, followed by the addition of 500 ml of distilled water. The mixture was brought to a boil using a heating mantle. The vapors carrying the essential oil passed through the condenser, where condensation occurred. The hydrodistillation lasts for 3 hours, and the amount of essential oil obtained is weighed to calculate the yield (Boukhatem *et al.*, 2010).

The phenotypic study of leaves and fruits focused on six qualitative variables, as shown in Table 3.

Table 3. Measured qualitative traits (UPOV, 2021).

N°	Traits	Code	Modalities
01	Leaf color	Clrf	Dark green , medium green , light green
02	Terminal leaflet	Ft	Present , absent
03	Leaflet apex	Af	Acute , rounded , obcordate
04	Leaflet base	Bf	Acute , rounded
05	Fruit color	Cf	Black , dark red
06	Fruit shape	Ff	Rounded , oval

The preservation of essential oils requires certain necessary precautions. For this reason, the essential oils are stored in shaded, airtight glass tubes wrapped in aluminum foil to prevent oxidation and kept at 4°C to avoid polymerization (Gardeli *et al.*, 2008).

Yield calculation

According to the AFNOR standard (1986), the essential oil yield (RHE), expressed as a percentage (%), is defined as the ratio between the mass of essential oil (MEH) in grams (g) and the mass of fresh plant material (MF) in grams (g). The following equation is used to calculate it:

$$RHE = \frac{MEH}{MF} \times 100$$

RHE: Essential oil yield in %;

MEH: Mass of essential oil in grams;

MF: Mass of fresh plant material in grams.

Data Analysis

Each trait was categorized into specific class states. The six qualitative and seven quantitative traits, along with the phytochemical characteristics, were classified according to the characteristic numbers defined by UPOV (Union for the Protection of New Plant Varieties). Statistical analyses were performed using SPSS V21: Descriptive analyses, One-Way ANOVA, Chi-square test, Principal Component Analysis (PCA), Multiple correspondence analysis (MCA), Hierarchical clustering analysis (CAH).

Results and Dissolutions*Descriptive analyses*

The results of the descriptive analysis related to quantitative and phytochemical traits: the arithmetic mean,

standard deviation, minimum and maximum values are represented by agro-ecological zones in Table 4.

For leaf-related variables, the leaf width reached a maximum of 5 cm (in steppes and sub-littoral plains) and a maximum length of 8 cm (in steppes). In coastal areas, it was observed that leaf dimensions were smaller than in other zones. Generally, morphological traits related to vegetative structures were the most variable. In fact, leaf length shows significant variation. According to Bouta (2021), smaller leaves tend to be more abundant in high plateaus and other cold places.

In steppes and coastal areas the number of leaflets reaches a maximum of 10 and 8 leaflets in sub-littoral plains; according to Guelilia and Siyahia (2019) the number of leaflets per leaf varies from 7 to 14 (in Tegdempt, Tiaret, and Zemmoura, Relizane), with an average of 9.08 leaflets per leaf. The petiole length is set at 1 cm across all three zones; according to Guelilia and Siyahia (2019) the average value for this parameter across all populations is 13.01 mm. This value ranges from a minimum of 7.56 mm in Faidja (Tiaret) to a maximum of 19.76 mm in Zemmoura (Relizane).

The rachis length reaches a maximum of 6 cm in steppes and a minimum of 3 cm in both steppes and coastal areas; according to Guelilia and Siyahia (2019) the average rachis length is 46.05 mm, with a minimum recorded in the Faidja population (Tiaret) at 29.10 mm and a maximum of 68.58 mm in Zemmoura (Relizane).

Regarding fruit-related variables, the fruit weight reaches a maximum of 0.08 g (in steppes and sub-littoral plains), whereas in coastal areas, the average fruit weight is 0.0633 g. Fruit weight is an important hereditary quantitative factor that determines yield and fruit quality (Crisosto et al., 2004).

Oil yield averages 0.1093% in sub-littoral plains and 0.09025% in steppes, while in coastal areas, the average is 0.0800%. These results may be explained by environmental differences from one wilaya to another. The IC50 (median inhibitory concentrations) reach a maximum of 8.035 mg/ml (in sub-littoral plains), which can be attributed to variability in the chemical composition of essential oils from these wilayas and their different origins. These findings, which differ depending on the zones under study, demonstrate how the climate affects the production of leaves, fruits, and oil.

Table 4. Results of the descriptive statistics for quantitative data.

Aro- ecological zones	Characters	N	Min	Max	Mean	Sd
Sub-littoral plains		3	4,00	5,00	5,01	0,00
	larf	3	5,00	7,00	6,00	0,00
	longf	3	7,00	8,00	7,00	0,00
	nff longpf longrf	3	1,04	1,00	1,00	0,00
	pf	3	3,00	4,00	4,00	0,00
	df	3	0,06	0,08	0,07	0,01
	Rendement IC50	3	4,00	5,04	4,00	0,04
	Nvalide (listwise)	3	0,00	0,00	0,00	0,04
		3	7,00	8,03	7,00	0,00
Steppes	larf	4	4,00	5,00	5,00	0,00
	longf	4	5,00	8,00	7,00	1,00
	nff	4	7,00	10,0	8,00	1,00
	longpf	4	1,00	1,00	1,00	0,00
	longrf	4	4,00	6,00	5,00	0,00
	pf	4	0,05	0,08	0,06	0,01
	df	4	4,00	5,03	4,00	0,05
	Rendement	4	0,06	0,00	0,09	0,02
	IC50	4	4,00	8,00	6,00	1,00
	Nvalide (listwise)	4				
Littoral	larf	3	3,00	4,00	4,05	0,00
	longf	3	5,00	7,00	6,00	0,00
	nff	3	8,00	10,0	9,00	1,00
	longpf	3	1,05	1,00	1,00	0,00
	longrf	3	3,00	5,00	4,00	0,00
	pf	3	0,06	0,07	0,06	0,00
	df	3	5,02	5,00	5,06	0,05
	Rendement	3	0,02	0,00	0,06	0,04

IC50	3	4,00	8,00	6,00	1,00
Nvalide (listwise)	3				

One-Way ANOVA

The analysis of variance for quantitative traits by region and agro-ecological zones, presented in Table 5, reveals highly significant results (p -value < 0.05) for the following traits: larf, longf, nff, longpf, pf, df and IC50. This indicates that these traits are discriminating based on regions and agro-ecological zones, suggesting the probable existence of genes that control leaf size and fruit weight. This diversity is linked to climatic and geographical variations that influence the different characteristics of the trees, a finding that has also been confirmed by descriptive analysis.

Table 5. Analysis of variance by region and agro-ecological zones (One-Way ANOVA).

According to the regions						
		Sum of squares	Ddl	Mean of squares	F	<i>p</i> -value
Larf	Inter-groupe	1,000	3	,000	2,000	,000
	Intra-groups	1,000	6	,000		
	Total	3,000	9			
Longf	Inter-groups	4,000	3	1,000	2,071	,000
	Intra-groups	4,093	6	,000		
	Total	8,000	9			
Nff	Inter-groups	14,000	3	4,000	19,000	,002
	Intra-groups	1,000	6	,000		
	Total	16,000	9			
Longpf	Inter-groups	,000	3	,043	,000	,000
	Intra-groups	,000	6	,068		
	Total	,000	9			
Longrf	Inter-groups	3,000	3	1,000	4,000	,055
	Intra-groups	1,000	6	,000		
	Total	5,000	9			
Pf	Inter-groups	,000	3	,000	1,000	,000
	Intra-groups	,000	6	,000		
	Total	,001	9			
Df	Inter-groups	,018	3	,006	2,000	,000
	Intra-groups	,016	6	,003		
	Total	,034	9			
According agro-ecological zones						
		Sum of squares	Ddl	Mean of squares	F	<i>p</i> -value
larf	Inter-groups	2,000	2	1,000	6,000	,022
	Intra-groups	1,000	7	,000		
	Total	3,000	9			
longf	Inter-groups	,000	2	,000	,000	,000
	Intra-groups	7,000	7	1,077		
	Total	8,000	9			
nff	Inter-groups	6,017	2	3,008	2,088	,000
	Intra-groups	10,083	7	1,000		
	Total	16,000	9			
	Inter-groups	,000	2	,074	1,000	,000

longpf	Intra-groups	,000	7	,055		
	Total	,000	9			
longrf	Inter-groups	1,000	2	,000	1,000	,000
	Intra-groups	4,000	7	,000		
	Total	5,000	9			
Pf	Inter-groups	,000	2	,000	,000	,000
	Intra-groups	,001	7	,000		
	Total	,001	9			
Df	Inter-groups	,016	2	,008	2,000	,000
	Intra-groups	,019	7	,003		
	Total	,034	9			
Rendement	Inter-groups	,010	2	,005	3,000	,073
	Intra-groups	,009	7	,001		
	Total	,019	9			
IC50	Inter-groups	1,000	2	,000	,000	,000
	Intra-groups	14,063	7	2,009		
	Total	15,000	9			

Chi-square test and correlations for qualitative variables

The Chi-square test evaluated the relationship between the qualitative traits studied represented in Table 6 , showing a significant association ($p < 0.05$) between fruit shape and color, leaflet apex, terminal leaflet, leaf color, and regions. Depending on eco-physiological processes involving chlorophyll pigments, especially those involving water availability, leaf color can change; because oxidation of pigments and a pale green tint of the foliage might result from water stress (Belhadj et al., 2008).

The statistical analysis' findings suggest that there are very significant regional variations in a number of fruit traits, including form, color, leaflet apex, and terminal leaflet, with a Pearson chi-square significance level of 0.000.

With a Pearson chi-square significance level of 0.000, the leaf color displayed highly significant findings across regions.

Table 6. Statistical values of the Chi-square test.

Characters		Value	Ddl	p-value
ff (Shape of the leaf)	Pearson's chi-squared test Likelihood	10,000a	9	,000
	ratio	6,000	9	,000
	Linear-by-linear association Number of valid observations	10,000	1	,000
		10		
cf (Color of the fruit)	Pearson's chi-squared test Likelihood	10,000a	9	,000
	ratio	6,000	9	,000
	Linear-by-linear association Number of valid observations	1,000	1	,000
		10		
Aff (Apex of the leaflet)	Pearson's chi-squared test Likelihood	20,000a	18	,000
	ratio	16,036	18	,000
	Linear-by-linear association Number of valid observations	2,000	1	,000
		10		
ftf (terminal leaflet)	Pearson's chi-squared test Likelihood	10,000a	9	,000
	ratio	12,000	9	,000
	Linear-by-linear association Number of valid observations	,000	1	,000
		10		
Clrf (The color of the leaf)	Pearson's chi-squared test Likelihood	20,000a	18	,000
	ratio	18,000	18	,000
	Linear-by-linear association Number of valid observations	,060	1	,000
		10		

Principal Component Analysis (PCA)

The principal component analysis (PCA) of quantitative variables (figure 2) was performed to obtain a clearer visualization of the data. The results show that the first two axes (PC 1 and PC 2) explain 44% and

27% of the total variance, respectively, accounting for 71% overall. This analysis highlights a strong positive correlation between the number of leaflets (nff) and fruit weight (pf), as well as a positive correlation between the length of the rachis (lonrf) and leaf length (longf), and between petiole length (longpf) and yield. For example, in the regions of Benitala and Telmouni (Sidi Bel Abbès), an increased number of leaflets per leaf is associated with a higher fruit weight, and a longer leaf is linked to a longer rachis. Conversely, a negative correlation was observed between leaf width (larf) and fruit diameter (df) in the Canastel forest in Oran, where a larger fruit diameter is associated with a reduced leaf width.

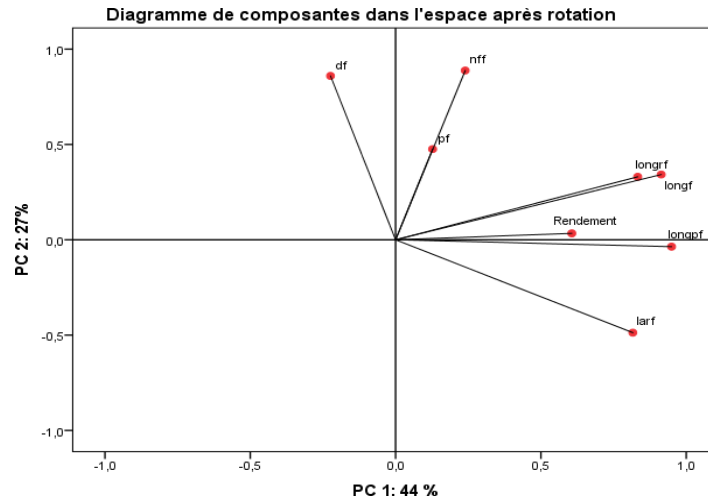


Figure 2. Graphical representation of variables through principal component analysis.

Multiple correspondence analysis (MCA)

Multiple Correspondence Analysis (MCA) was conducted to evaluate the variance explained by different qualitative traits, revealing that the leaf color and the apex of the leaflet are strongly correlated with the region, as illustrated in Figure 3. The characteristics of the leaves, particularly their color, serve as indicators of the palatability of forage shrubs (Chriyaa, 2009), influenced by ecophysiological factors (Belhadj *et al.*, 2007). These results highlight the most discriminating variables for the characterization of the lentisk pistachio, supporting the results of the coefficient of contingency and the chi-square tests.

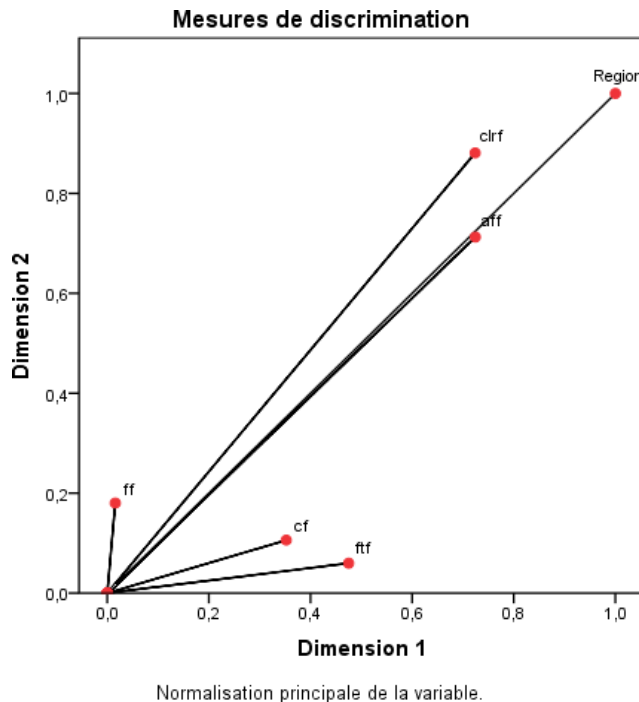


Figure 3. Graphical representation of the variables through Multiple Correspondence Analysis.

Principal component analysis (PCA)

The Principal Component Analysis (PCA) provided a clear visualization of the data (figure 4), with the first

two axes explaining 78.84% of the total variance. The variables "leaf length" and "rachis length" are strongly correlated, as are the "number of leaflets" and "fruit weight." However, there is a negative correlation between "leaf width" and "fruit diameter."

The Graphical representation of individuals using Principal Component Analysis represented in figure 5: indicated the individuals from Telmouniet Benitala, Foret de Canastel, and Ouchba-El Ourit are grouped based on the variables longf, df, and larf, respectively

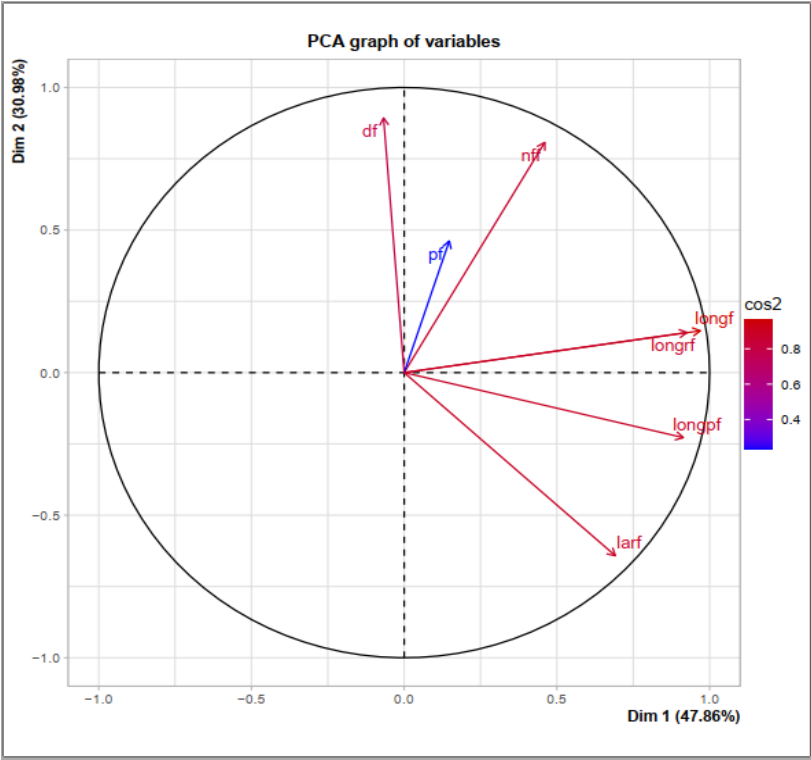


Figure 4. Graphical representation of quantitative variables using Principal Component Analysis (PCA).

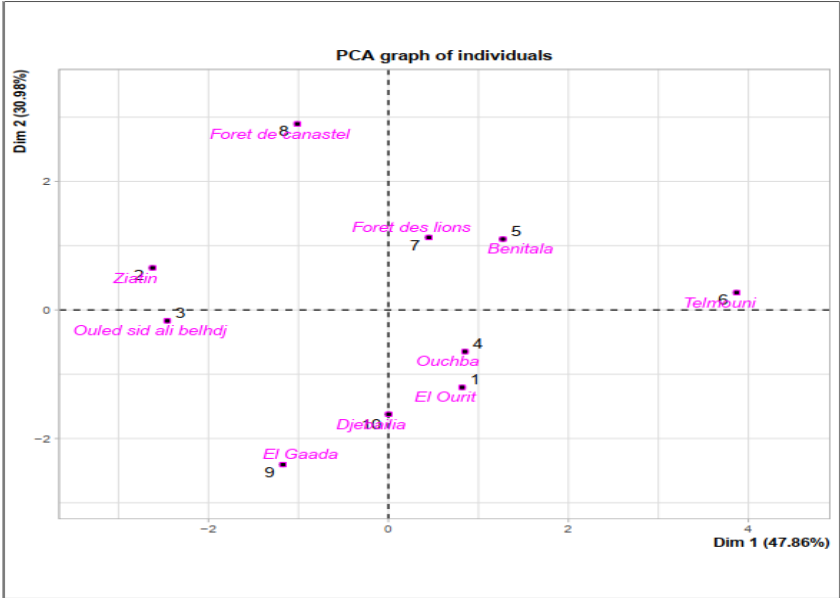


Figure 5. Graphical representation of individuals using Principal Component Analysis (PCA).

Hierarchical clustering analysis (CAH)

Hierarchical clustering uses the aggregation method based on Euclidean distance. The dendrogram (Figure 6) reveals 3 mains classes.

- **Class 1:** Includes Ziatin, OuledsidAli belhadj, and Forêt de Canastel, characterized

by low values for the variables longpf, larf, and longrf (from the most extreme to the least extreme).

- **Class 2:** Includes Ouchba, Forêt des Lions, and Djebailia, characterized by variable values close to the average.
- **Class 3:** Includes Tlemouni, characterized by high values for the variables longrf and longf (from the most extreme to the least extreme).

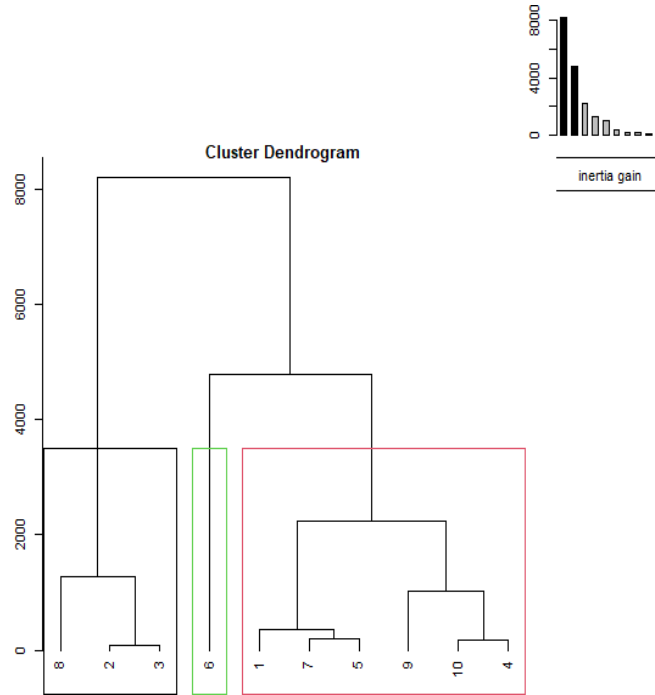


Figure 6. Hierarchical tree based on quantitative variables.

The Shannon and Weaver Diversity Index

The average relative diversity index (H' mean) in Table 7 of the studied cultivars of *Pistacia lentiscus* is about 0.50, indicating an average morphological diversity among the samples in this collection.

Table 7. Relative diversity index of quantitative and qualitative traits of *Pistacia lentiscus*.

H Totale	Clrf	ftf	aff	bff	cf	Ff	larf	Longf	Nff	Longpf	Longrf	Pf	Df	Mean (region)
El Ourit (Tlemcen)	0	0	0.62	0	0	0.72	0.84	0.43	0.78	0.92	0.98	0.92	0.23	0.50
Ziatin (Tlemcen)	0.82	0.88	0.63	0	0	0	0.57	0.84	0.74	0.23	0.46	0.99	0.44	0.51
OuledsidaliBelhadj (Tlemcen)	0	0.72	0.94	0	0.88	0.47	0.75	0.74	0.92	0.23	0.23	0.58	0.58	0.54
Ouchba (Tlemcen)	0.56	0.47	0.46	0	0.47	0.97	0.23	0.84	0.92	0.58	0.76	0.84	0.76	0.60
Benitala (Sidi Bel Abbès)	0.56	0	0	0	0.72	0.97	0.98	0.74	0.44	0.88	0.68	0.79	0.74	0.58
Tlemouni (Sidi Bel Abbès)	0.56	0.47	0	0	0.88	0	0.45	0	0.23	0.46	0	0.78	0.58	0.34
Foret des lions (Oran)	0.63	0.99	0.56	0	0.47	0.47	0.92	0.68	0.23	0.92	0.44	0.48	0.58	0.57
Foret de canastel (Oran)	0.62	0.88	0.59	0	0	0.88	0.45	0.49	0.88	0.68	0.58	0.76	0.44	0.56
El Gaada (Mascara)	0.62	0	0.56	0	0.88	0	0.74	0.57	0.74	0.46	0.5	0	0.5	0.43
Djebailia (Mascara)	0.56	0	0	0	0	0.72	0.43	0.34	0.88	0.48	0.58	0.76	0.23	0.38
Mean (CARACTERES)	0.49	0.44	0.44	0	0.43	0.52	0.64	0.57	0.68	0.58	0.52	0.69	0.51	0.50

Qualitative traits

The diversity index for qualitative traits is 0.39, ranging from 0.18 in the Djebailia region (Mascara province) to 0.45 in the Forest of Lions (Oran province). For the trait "leaflet base," the index is $H' = 0.00$, while for the leaflet shape, it is $H' = 0.52$. For polymorphic traits, $H' = 0.94$ is observed for the "leaflet apex" in the

Ouledsid Ali Belhadj region (Tlemcen province), $H' = 0.97$ for leaf shape in the Ouchba region (Tlemcen province), and $H' = 0.99$ for the terminal leaflet in the Forest of Lions (Oran province). For qualitative traits, the indices are $H' = 0.49$ for leaf color, $H' = 0.44$ for terminal leaflet and leaflet apex, $H' = 0.00$ for leaflet base, $H' = 0.43$ for fruit color, and $H' = 0.52$ for fruit shape.

The values are obtained as indicators of average diversity ($H' \leq 0.40$) for ten accessions (El Ourit, Ziatin, Ouledsid Ali Belhadj, Ouchba, Benitala, Tlemouni, Forest of Lions, Forest of Canastel, El Gaada, Djebailia). Table 8 summarizes the averages of the various qualitative traits studied in the genotypes of *Pistacia lentiscus*.

Table 8. Relative diversity index of qualitative trait of *Pistacia lentiscus* L.

H (QUALITATIF)	Clrf	Ftf	Aff	Bff	Cf	Ff	Mean (région)
El Ourit (Tlemcen)	0	0	0,62	0	0	0,72	0,19
Ziatin (Tlemcen)	0,82	0,88	0,63	0	0	0	0,33
OuledsidaliBelhdj (Tlemcen)	0	0,72	0,94	0	0,88	0,47	0,43
Ouchba (Tlemcen)	0,56	0,47	0,46	0	0,47	0,97	0,42
Benitala (Sidi Bel Abbès)	0,56	0	0	0	0,72	0,97	0,32
Tlemouni (Sidi Bel Abbès)	0,56	0,47	0	0	0,88	0	0,27
Foret des lions (Oran)	0,63	0,99	0,56	0	0,47	0,47	0,45
Foret de canastel (Oran)	0,62	0,88	0,59	0	0	0,88	0,42
El Gaada (Mascara)	0,62	0	0,56	0	0,88	0	0,29
Djebailia (Mascara)	0,56	0	0	0	0	0,72	0,18
Mean (CARACTERES)	0,49	0,44	0,44	0,00	0,43	0,52	0,39

Quantitative traits

For the quantitative traits, the relative diversity index (H' mean) is 0.60, ranging from 0.23 in the regions of El Ourit (Tlemcen province) and Djebailia (Mascara province) to 0.76 in the Ouchba region (Tlemcen province). For the "fruit diameter" trait, the index is $H' = 0.50$, while for the fruit weight, it is $H' = 0.69$. The most diverse traits include leaf width and petiole length, with an index of $H' = 0.92$ in the Forest of Lions (Oran province), as well as the number of leaves in the Ouledsid Ali Belhadj region (Tlemcen province), petiole length, and fruit weight in the El Ourit region (Tlemcen province). The index of $H' = 0.98$ for leaf width is observed in the Benitala region (Sidi Bel Abbès province), and the fruit weight in the Ziatin region (Tlemcen province) is represented by $H' = 0.99$. The average values for the following traits are: leaf width 0.64, leaf length 0.57, number of leaflets 0.68, petiole length 0.58, rachis length 0.52, fruit weight 0.69, and fruit diameter 0.50.

Table 9 summarizes the averages of the various qualitative traits studied in the genotypes of *Pistacia lentiscus*.

Table 9. Relative diversity index of quantitative traits of *Pistacia lentiscus* L.

H (QUANTITATIVE)	larf	longf	Nff	longpf	Longrf	Pf	Df	Mean (région)
El Ourit (Tlemcen)	0,84	0,43	0,78	0,92	0,98	0,92	0,23	0,73
Ziatin (Tlemcen)	0,57	0,84	0,74	0,23	0,46	0,99	0,44	0,61
OuledsidaliBelhdj (Tlemcen)	0,75	0,74	0,92	0,23	0,23	0,58	0,58	0,58
Ouchba (Tlemcen)	0,23	0,84	0,92	0,58	0,76	0,84	0,76	0,70
Benitala (Sidi Bel Abbès)	0,98	0,74	0,44	0,88	0,68	0,79	0,74	0,75
Tlemouni (Sidi Bel Abbès)	0,45	0	0,23	0,46	0	0,78	0,58	0,36
Foret des lions (Oran)	0,92	0,68	0,23	0,92	0,44	0,48	0,58	0,61
Foret de canastel (Oran)	0,45	0,49	0,88	0,68	0,58	0,76	0,44	0,61
El Gaada (Mascara)	0,74	0,57	0,74	0,46	0,5	0	0,5	0,50
Djebailia (Mascara)	0,43	0,34	0,88	0,48	0,58	0,76	0,23	0,53
Mean (CARACTERES)	0,64	0,57	0,68	0,58	0,52	0,69	0,51	0,60

This diversity may be due to several factors such as the geographical location of the study sites and the pedoclimatic diversity.

Organoleptic characteristics of Pistacia lentiscus essential oil

The sensory and organoleptic properties allow for the authentication and quality control of essential oils, which are extracted by hydrodistillation using a Clevenger apparatus. Tables 10 and 11 compare the properties of our essential oil to those from other studies on *Pistacia lentiscus*.

Table 10. Organoleptic characteristics of *Pistacia lentiscus* L. essential oil.

Properties	Our study	AFNOR
Aspect	Liquid, clear, and mobile	Liquid, clear, and mobile
Color	Very pale yellow	Pale yellow
Odor	Characteristic	Characteristic

Oil yield

The average essential oil yield from the aerial parts of *Pistacia lentiscus*, extracted by hydrodistillation, was calculated based on the mass of the plant material. The results are summarized in the table below.

Table 11. Essential oil yield of *Pistacia lentiscus* L.

Studied parameters	Yield (%)	Smaili, (2022) Tissemsilt	Amhamdi et al., (2009) Maroc	Hamiani et al., (2016) Oran, Algérie	Benhamou et Atik-Bekkara, (2009) Tlemcen, Algérie
Tlemcen					
Ourit	0.139 ± 0,006				
Ouled Sid Ali Belhadj	0.1005 ± 0,0145				Ain Fezza : 0.05
Ouchba	0.180 ± 0,000	0.39%	0.14 %	1.26%	Oum El Alou : 0.07
Ziatin					
	0.0177 ± 0,000				
		0.39%	0.14 %	1.26%	Ain Fezza : 0.05 Oum El Alou : 0.07
HE Sidi Bel Abbès					
Beni Tala	0.126 ± 0,026				
Telmoni	0.100 ± 0,000				
Mascara					
El Gaada	0.065 ± 0,000				
Djebailia	0.070 ± 0,000				
Oran					
Forêt des lions	0.06 ± 0,0100				
Forêt des Canastel	0.100 ± 0,000				

Table 11 shows that the essential oil yield of *Pistacia lentiscus* ranges from 0.0177% to 0.180%. Yields in Tlemcen are higher (0.139% at Ourit, 0.1005% at Ouled Sid Ali Belhadj, 0.180% at Ouchba, and 0.177% at Ziatin) than those of Benhamou and Atik-Bekkara (2009) in Ain Fezza (0.05%) and Oum El Alou (0.07%), likely due to different harvesting periods. In Sidi Bel Abbès, yields are 0.126% at Beni Tala and 0.100% at Telouni, comparable to Amhamdi et al. (2009) in eastern Morocco (0.14%).

In Mascara, yields are 0.065% at El Gaada and 0.070% at Djebailia, similar to Oran (0.06% in the Forest of Lions and 0.100% in the Forest of Canastel) but lower than Hamiani et al. (2016) who reported 1.26% in Oran, potentially due to different harvesting seasons. Overall, yields in western Algeria are lower than those reported by Smaili (2022) in Tissemsilt (0.39%) in eastern Algeria, possibly due to environmental differences related to the distance between sites.

The results from Table 12 indicate that the radical scavenging ability of the studied essential oils from pistachio is ranked as follows: HE El Gaada (IC₅₀ = 4.56181 mg/ml), HE Forest of Lions (IC₅₀ = 4.8805 mg/ml), HE Beni Tala (IC₅₀ = 6.84818 mg/ml), HE Ourit (IC₅₀ = 7.70531 mg/ml), HE Forest of Canastel (IC₅₀ = 7.25 mg/ml), HE Ouled Sid Ali Belhadj (IC₅₀ = 7.70531 mg/ml), HE Telmouni (IC₅₀ = 7.76781 mg/ml), HE Ouchba (IC₅₀ = 8.03562 mg/ml), HE Djebailia (IC₅₀ = 8.16068 mg/ml), and HE Ziatin (IC₅₀ = 8.20531 mg/ml).

Table 12. The median inhibitory concentration of *Pistacia lentiscus* essential

Regions	IC ₅₀ (mg/ml)
Tlemcen	
Ourit	7,1425
Ziatin	8,20531
Ouled Sidi Ali Belhadj	7,70531
Ouchba	8,03562
Sidi Bel Abbès	
Benitala	6,84818
Telmouni	7,76781
Mascara	
El Gaada	4,56181
Djebailia	8,16068
Oran	
Forêt des Lions	4,8805
Forêt de Canastel	7,25
Contrôle positif	
Acide ascorbique	0,12

The essential oil from the El Gaada region in the Mascara wilaya shows the best ability to scavenge the DPPH free radical among the studied samples of the same species (*Pistacia lentiscus*).

The results obtained are lower than those of Souilah et al. (2022), who demonstrated a good radical scavenging activity (IC₅₀ = 10.5 µg/ml) for the essential oil of pistachio lentisk from the El Kala region in eastern Algeria. Other studies on the leaves of pistachio lentisk from Tunisia revealed IC₅₀ values ranging between 60 and 100.8 µg/ml. These variations may be due to the diversity of the chemical composition of essential oils based on their origin. In contrast, our results surpass those of Gourine et al. (2010), who reported low antioxidant activity for the essential oils of *P. atlantica* leaves in Algeria, with IC₅₀ values of 17.22 mg/ml in Laghouat and 18.95 mg/ml in Hassi R'mel, a difference attributed to regional environmental and chemical variations.

Conclusion

Algeria, thanks to its pedoclimatic diversity, has a notable wealth of phylogenetic resources. The mastic tree (*Pistacia lentiscus* L.), a plant with multiple medicinal and ecological properties, is widely distributed across the country. This study characterized the species in four wilayas of Western Algeria through morphometric and phytochemical analyses, revealing significant variability between populations. A positive correlation was observed between certain morphological traits and essential oil yield, particularly in Tlemcen and Sidi Bel Abbès, based on tests such as PCA, CAH, ANOVA, and Chi-square.

El Gaada essential oil has the highest antioxidant activity, which suggests that it may help treat bronchitis, gastric ulcers, and wound healing. Additionally, it increases the income of rural households. It is advised that more research be done to confirm these results and broaden the sampling areas.

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