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Full Length Research Paper

Influence of the variety, the crop year and the growing on the fatty acid and tocopherols composition of some Algerian virgin olive oils

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Six local varieties of olives were selected to study their oils and fatty acid composition, with the aim to determine one or several discriminating markers of the botanical origin. The relative percentages of fatty acids were well balanced, conferring to these oils high nutritional quality, characterized by important oleic acid content. The results showed the strongest effect of variety comparing to crop year and region which were less significant. We noticed that 80% of the fatty acids present clear differences between the various varieties population. Samples which present the highest level of oleic acid and mono-unsaturated fatty acids were Grosse du Hamma of first year with respective percentages of 79 and 85% and Azeradj for the same year with 77 and 78% respectively. Whereas, unsaponifiable minor components were present in very small quantities (ppm), but are sufficient to characterize and draw Nutritional and organoleptic olive oil profile. This is perfectly confirmed with principal component analysis results. Azeradj variety, in the four areas presented the highest rates of total tocopherol with averages between 251 and 271 ppm, tocophérol profile shows prevalence of alpha tocopherol (95% of total fraction).

Key words: Olive oil, fatty acids, oleic acid, tocopherols, unsaponifiable.

INTRODUCTION

Algeria has some significant olive resources which up until now are under developed. More than 150 local varieties of olive trees were counted by Chaux (1955). Nowadays, a great number still remains unexploited, in spite of their definite significance. These varieties would hold a great genetic and biochemical variability and would adapt perfectly to their area of origin. Research material points out that fatty acid composition is variable depending on the origin and production area. Moreover, the variability is clearly dependant on genetic factors (cultivar) (Boschelle et al., 1994; Amamou, 1999; Uceda and Hermoso, 2001; Hermoso et al., 2001). These genetic factors constitute an important parameter for the characterization and the definition of olive oil. Moreover, it appears that tocopherols may be biochemical markers and would be a varietal character (Ryan et al., 1998).

The main fatty acid component in olive oil is the monounsaturated fatty acid; oleic acid. This acid represents 65 to 85% of the fatty acids of this oil (Jacotot, 2001; Commission du Codex Alimentarius, 1993; COI, 2003). For this reason, a study of the fatty acid and tocopherol profile is carried out with the objective of this study being the characterization of the different local population varieties of olives. Furthermore, the present work has already been a partial analysis of the fatty acid profile (Douzane et al., 2010).

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MATERIALS AND METHODS

Plant material

The plant material used consists of the following population varieties: Azeradj (Azj), Chemlal (Che), Limli (Lim), Takesrit (Tas), Aghenfas (Agf) and Grosse du Hamma (Grh).

Samples

The olives used in the study were collected regularly from full-grown trees. The picking was done by hand on two trees by population variety during two olive crop years in the central region of the national olive orchard (small and large Kabylia). Some samples were taken from the collection of the ITIFAVF (Technical Iinstitute of Fruit-bearing Arboriculture and Vine) of Takarietz (tak) (Sidi-Aïch), which is situated in the Soummam valley. It is considered as a reference area. Six randomly selected varieties were sampled namely, (Azj), (Che), (Lim), (Tas), (Agf) and (Grh).

Other samples were taken from private olive groves in Chemini (chm), Azzefoun (aze) and in Azazga (aza). Chemini is situated in the Southeast in relation to the main area of the area of Bejaia at an altitude of 700 m. As for the Azzefoun region, it is situated in the north-east of the area of Tizi-ouzou. The village of Mira where the olive grove is found is situated 3 km from the town of Freha on a plain, and 22 km from the sea. The Azazga olive grove is found East of Tizi-Ouzou at the piedmont of Yakouren and South of Azzefoun. The village of Yakouren is located at a high altitude (Figure 1).

The olives were collected from three population varieties cultivated in these zones (Azj), (Che) and (Lim). Each of the said varieties predominates and is a representative of the existing olive grove. We should note that the samples were collected on the same date for all the population varieties at the black stage of maturity. Each sample consists of approximately 6 kg of olives which came exclusively from the four trees and harvested at about six feet off the ground in all their foliage. The fruits are rapidly transported to the laboratory in plastic crates. The oil is extracted from the fruits by the process of centrifugation (3000 tr/min) by means of an Abencor of the Rappanelli type. The extracted oil was conserved at a temperature of 4°C in brown glass bottles filled up to $9/10^{e}$ of their volume whilst waiting to be analyzed.

Methods

The Preliminary analysis of oil samples (Free acidity, peroxide value and UV spectrophotometric indices) were determined according to the European Communities official methods (Réglement CEE, 2568/91, 1991) (Data not shown). All parameters were determined in triplicate for each sample. The composition of the fatty acids was determined by gas chromatography in the form of methyl esters.

Preparation of methyl esters

The fatty acids of the different samples are analysed in the form of fatty acid methyl esters (FAME) which are prepared following the method of the Journal Officiel de la République Française (J.O.R.F, 1985), based on saponification of the glycerides, and then the release and esterification of the fatty acids by methanol-sulphuric acid (49-1 v/v).

Fatty acid methyl esters analysis by gas chromatography (GC)

The samples to be analysed were dissolved in a solvent which has no affinity towards the stationary phase of the column. The Fissons instruments (9000 GC series) chromatograph was used, equipped with a split injector and an FID detector with a DB 23 capillary column (L: 60 m, DI: 0.25 mm; stationary phase: polar (Cyanopropyl at 50%)). Nitrogen was used as a vector gas and the oven temperature maintained at 190°C (isothermal). The temperature of the injector and of the detector is 240°C. The volume of the injection is 0.2 µl (undiluted). Identification of the fatty acids methyl esters was done by measuring the retention time compared with that of pure standards: (C14: 0, C16: 0, C16: 1, C22: 1). In order to simplify the analysis and discussion of the results, only the main fatty acids will be discussed, namely: oleic (18: 1), palmitic (16: 0), palmitoleic (16: 1), stearic (18: 0), and linoleic (18: 2) expressed in percentages of the fatty acid methyl esters.

Extraction and determination of tocopherols

The oil unsaponifiable compounds were extracted according to the IUPAC No 2. 401 (1979) and tocopherols by migration on CCM silica gel 60, 20 × 20 cm (Merck) plates ready-type using a solvent system comprising of chloroform monophase. Tocopherols spots were recovered in hexane and reduced to 1 ml by evaporation under nitrogen. The identification of different forms of tocopherol (α, γ, δ) was performed by HPLC as described by Rougereau et al. (1981) under the following conditions: Device Type SHIMADZU HPLC CBM-10A equipped with a UV-Visible detector, type SHIMADZU. SPD-10A, pump LC-10AD SHIMADZU type and column type WATERS grafted carbon 18 (C_{18}) internal diameter of 4.6 mm, length 150 mm, porosity: 3.5 microns. The separation was performed in isocratic mode at room temperature using methanol-pure water (98 / 2, v / v), at a rate of 2 ml/ min and a pressure of 183 bar. Detection wavelength is 280 and 290 nm. Compounds identification and quantification was performed using the Software SHIMADZU LC-10 class.

Statistical analysis

The data thus obtained was processed statistically by analysis of variance using the Statistica software version 5.1. A principal component analysis (PCA) was used (only the fatty acid composition) so as to be able to compare and classify the results of the different population varieties. We took into consideration the effect of the region, crop year and variety.

RESULTS AND DISCUSSION

Oleic acid and linoleic acid

The results obtained (Table 1) indicated that the population varieties studied are rich (average to high) in oleic acid and produce oils which have high monounsaturated fatty acid content. Figure 2 presents a distribution which follows a normal law. Whatever the population variety considered, the oleic acid content conforms to the standards set by the regulations of IOC (1996) (55 to 83%). Within the Takarietz collection, Grosse du hamma, year 1 was richer in oleic acid (79.06%) and within the four regions it was the Azeradj population from Takareitz that appears with 77.03%. Consequently, the samples from the collection are the ones that present the highest levels of oleic acid (C18: 1) and of monounsaturated acids. Moreover, all the

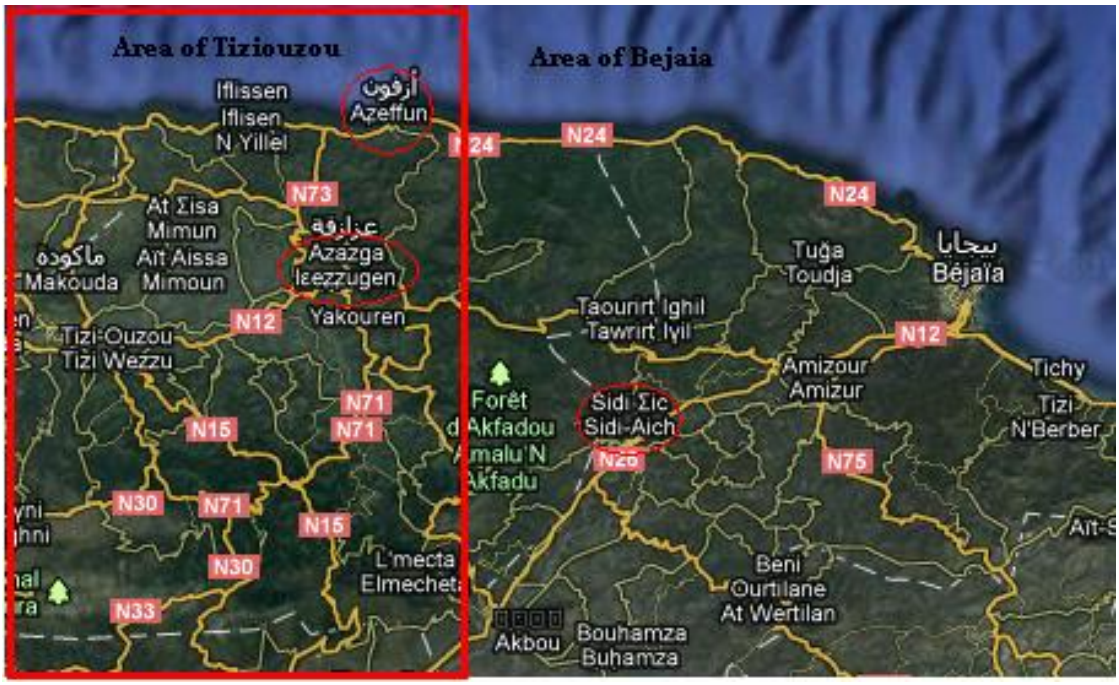

Figure 1. Illustration of the growing area (red circle) by a map.

Table 1. Variations of the fatty acids contents (as a percentage/ total fatty acids) of the oils from Takarietz, (collection) Chemini, Azzefoun and Azazga according to the harvest year.

Takarietz (collection)						
Population variety	**Azeradj**		**Chemlal**		**Limli**	
Crop year	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**
C16: 0	12.83	13.05	16.41	18.81	14.36	18.57
C16: 1	0.97	1.13	1.93	2.29	1.47	2.39
C17: 0	0.23	0.10	0.07	traces	0.05	traces
C17: 1	0.05	0.05	0.08	traces	0.04	traces
C18: 0	1.73	2.30	0.98	2.32	0.72	2.65
C18: 1	77.03	69.50	73.38	63.0	75.0	60.0
C18: 2	6.01	12.00	6.54	10.53	7.08	14.31
C18: 3	0.11	0.65	traces	0.54	0.21	0.65
C20: 0	0.59	0.43	traces	0.40	0.04	0.29
C20: 1	0.18	0.33	traces	0.34	0.50	0.29
C22: 0	-	0.46	1.03	0.89	0.58	0.85

Takarietz (collection)						
Population variety	**Takesrit**		**Aghenfas**		**Grosse du Hamma**	
Crop year	**Year 1**	**Year 2**	**Year 1**	**Year 2**	**Year 1**	**Year 2**
C16: 0	13.85	18.63	11.92	15.80	12.42	15.98
C16: 1	1.5	2.74	0.97	1.64	0.98	1.42
C17: 0	0.04	0.07	0.10	0.11	0.22	0.14
C17: 1	0.04	0.08	0.19	0.21	0.06	0.26
C18: 0	0.98	2.38	1.48	2.22	1.66	2.56
C18: 1	75.0	60.0	78.45	67.00	79.06	70.0
C18: 2	7.0	13.76	2.93	10.60	4.72	6.5
C18: 3	0.50	0.73	traces	0.80	0.124	0.09

Table 1. Contd.

C20: 0	0.30	0.32	0.26	0.35	traces	0.26
C20: 1	0.30	0.23	0.68	0.44	0.41	1.09
C22: 0	0.48	0.71	3.40	0.83	traces	0.60

Chemini

Population variety	Azeradj		Chemlal		Limli	
Crop year	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
C16: 0	11.70	12.51	15.85	18.00	13.19	17.50
C16: 1	1.50	1.40	2.02	2.80	1.69	2.27
C17: 0	0.15	0.12	0.09	0.07	0.05	traces
C17: 1	0.16	0.24	0.17	0.04	0.05	traces
C18: 0	2.43	1.41	1.07	2.40	1.25	3.20
C18: 1	73.98	73.33	73.56	62.30	72.10	60.00
C18: 2	8.83	8.43	6.09	12.40	9.75	14.90
C18: 3	0.24	0.36	0.47	0.38	0.37	0.40
C20: 0	0.53	0.54	-	0.34	0.41	0.75
C20: 1	-	0.30	-	0.33	0.31	traces
C22: 0	0.31	1.15	1.54	0.94	1.44	0.98

Azzefoun

Population variety	Azeradj		Chemlal		Limli	
Crop year	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
C16: 0	15.85	12.00	16.44	12.68	13.30	12.69
C16: 1	1.91	1.03	2.04	1.11	1.66	2.30
C17: 0	0.08	0.10	0.08	0.12	0.07	0.06
C17: 1	0.06	0.08	0.05	0.24	0.08	0.08
C18: 0	1.29	2.00	1.47	2.48	1.27	2.04
C18: 1	66.17	70.05	62.28	69.23	66.29	68.50
C18: 2	13.41	11.90	15.47	11.85	14.43	13.09
C18: 3	0.32	0.38	0.53	0.44	0.34	traces
C20: 0	0.22	0.84	0.35	0.62	0.40	0.55
C20: 1	-	0.33	-	0.41	0.27	traces
C22: 0	0.31	0.44	0.74	0.77	2.04	0.66

Azazga

Population variety	Azeradj		Chemlal		Limli	
Crop year	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
C16: 0	17.54	16.02	17.23	16.40	18.49	16.02
C16: 1	2.18	2.0	2.73	1.90	2.62	2.70
C17: 0	0.04	0.09	0.07	0.10	0.04	0.05
C17: 1	0.04	0.07	0.04	0.09	0.10	0.04
C18: 0	1.09	1.0	0.87	1.25	1.00	2.03
C18: 1	69.60	70.80	68.05	69.60	63.03	66.27
C18: 2	8.72	8.02	7.38	6.75	14.57	12.00
C18: 3	0.19	0.32	0.06	0.45	traces	0.13
C20: 0	0.13	0.55	0.031	0.75	traces	0.26
C20: 1	0.22	0.33	0.20	0.38	0.15	traces
C22: 0	0.61	0.80	3.36	2.15	-	0.50

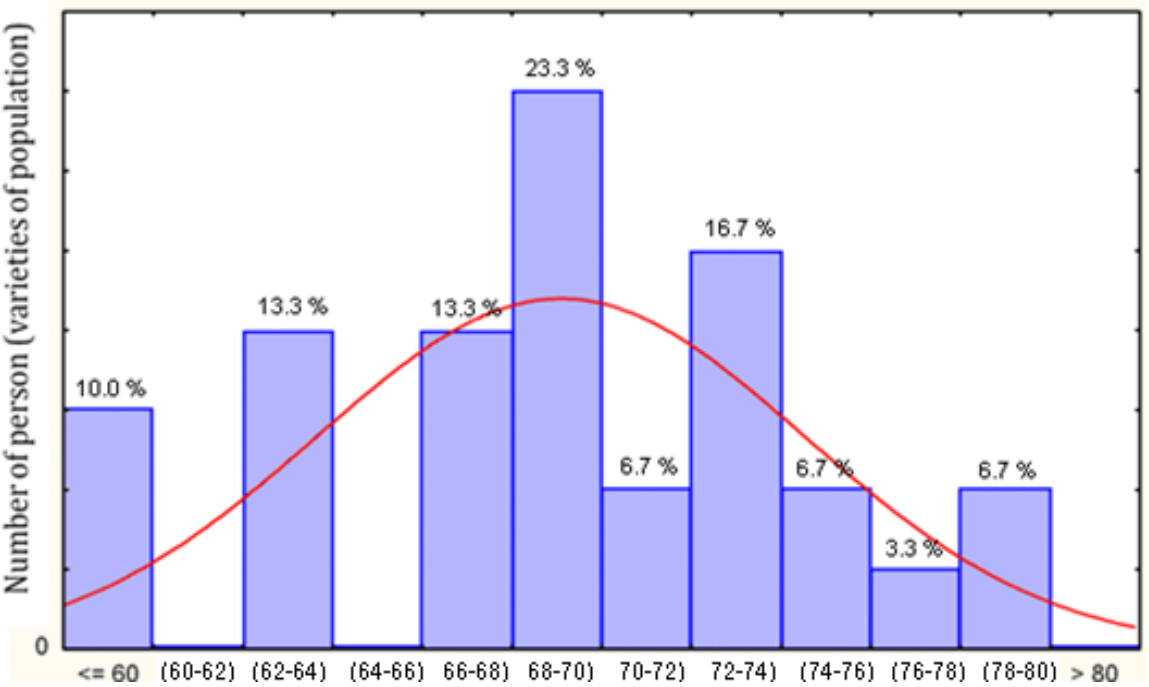

Figure 2. Variation of the oleic acid level (C18:1) according to the individuals in the study.

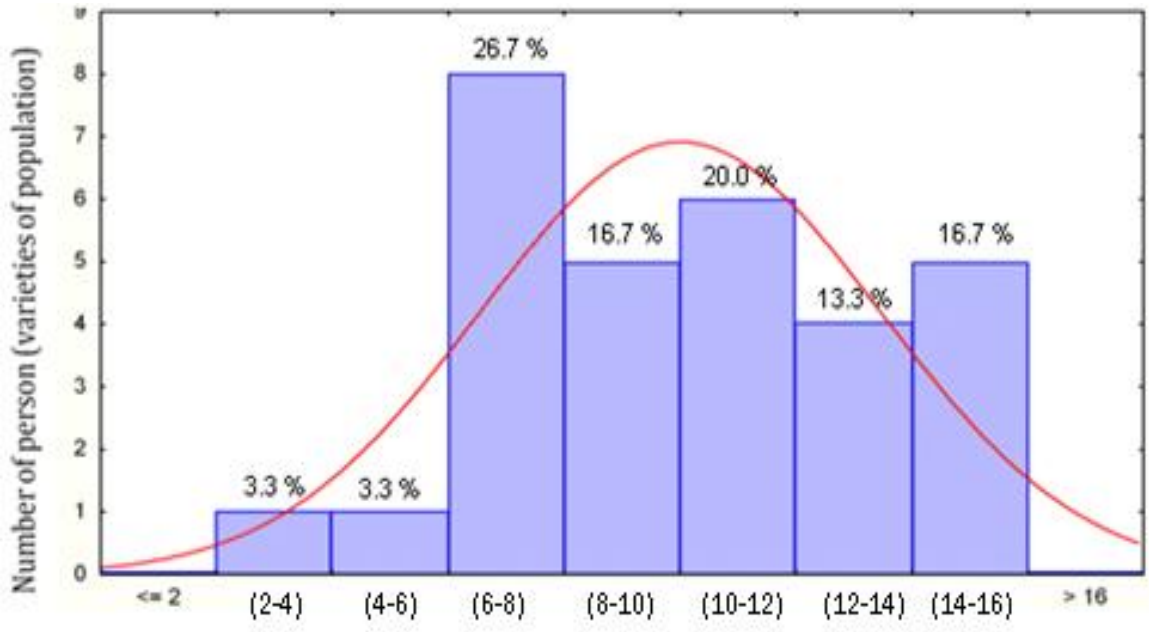

Figure 3. Variation of the linoleic acid level (C18:2) according to the individuals in the study.

specimens of the collection from the first year were characterized by their low linoleic acid content. The same observation could be made for most of the Azazga samples. On the other hand, the other samples during the two crop years were characterized by a level of linoleic acid which was greater than 10%. Only one sample with a limit below that set by the IOC and EEC standards (Réglement CEE, 1991) was shown in the collection (Table 1). For all the other samples, the limits were in perfect harmony with those indicated in the norm (3.5 to 21%). Figure 3 shows that the individuals studied followed a normal law with an asymmetry towards the

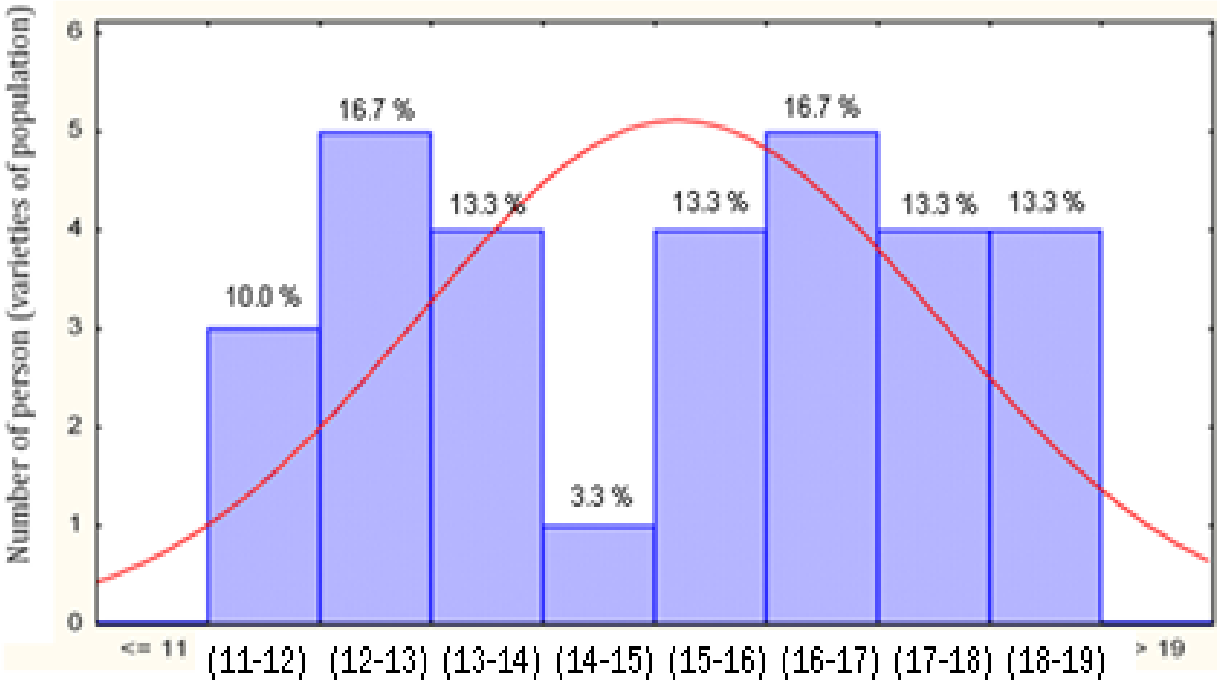

Figure 4. Variation of the palmitic acid level (C16: 0) according to the individuals in the study.

highest contents.

According to the results, the samples of our study could be divided into two groups: one group was characterized by a relatively high oleic acid content (C18: 1) and a relatively low linoleic acid content (C18: 2). The second group was characterized by opposite values. This observation allows one to suppose that the population varieties are situated between the European varieties and those of North Africa. We can conclude that the zone where the orchards were planted does not greatly affect the fatty acid profile. On the other hand, the effect of variety and crop year were evident. In the case of the samples of the collection, the deep effect of the variety and the crop year was noticed once again.

Considering the two crop years separately, the values relative to oleic acid indicated a distinct grouping betweeneach variety which was geographically close, a possible sign of a common parental source.

Palmitic acid and stearic acid

An examination of Table 1 indicates that the values for palmitic acid are in accordance with the IOC and EEC standards for almost the entire total of the populations studied (7.5 to 20%). Figure 4 showed that the distribution of the individuals follows a normal law.

As for stearic acid, an examination of Figure 5 indicates that the distribution of individuals follows a normal law with a slight asymmetry towards the highest contents. All the values are found within the fixed limits of the common regulation for olive oil (0.5 to 5%).

The results of the collection revealed in a general manner a great heterogeneity from one year to the other within the same population variety. For both palmitic acid and stearic acid, the ‘crop year’ effect was highlighted. Moreover, in the four regions, the results showed a substantial difference during the two crop years; the ‘variety’ effect and the ‘region’ effect being the most significant. It must be pointed out that the oils from the Azazga region have great levels of palmitic acid (C16: 0) and low levels of stearic acid (C18: 0). However, the percentages relative to these two fatty acids are relatively average to high.

Furthermore one can point out the great similarity of our results with the data for oil from Tuscany which was obtained from the Frantoio, Moraiolo and Maurino varieties in 1993 (Gigliotti et al., 1993) and 1999 (Sogni, 1999) and oil from the Picual variety in Mengibar, Jaén (Spain) (Beltran et al., 2004). We can conclude that our population varieties can be placed between the Tunisian and Argentinian varieties and the Sicilian variety from Italy with regards to palmitic acid. As for stearic acid, the latter ones can be placed between the Italian and Argentinian varieties.

Gigliotti et al. (1993) pointed out that the high stearic acid content in Greek oils (in the region of 3.20%) as compared to that of Italian, Spanish, Moroccan and Tunisian oils can be used as a distinctive factor of their origin. The use of stearic and palmitic acid in the

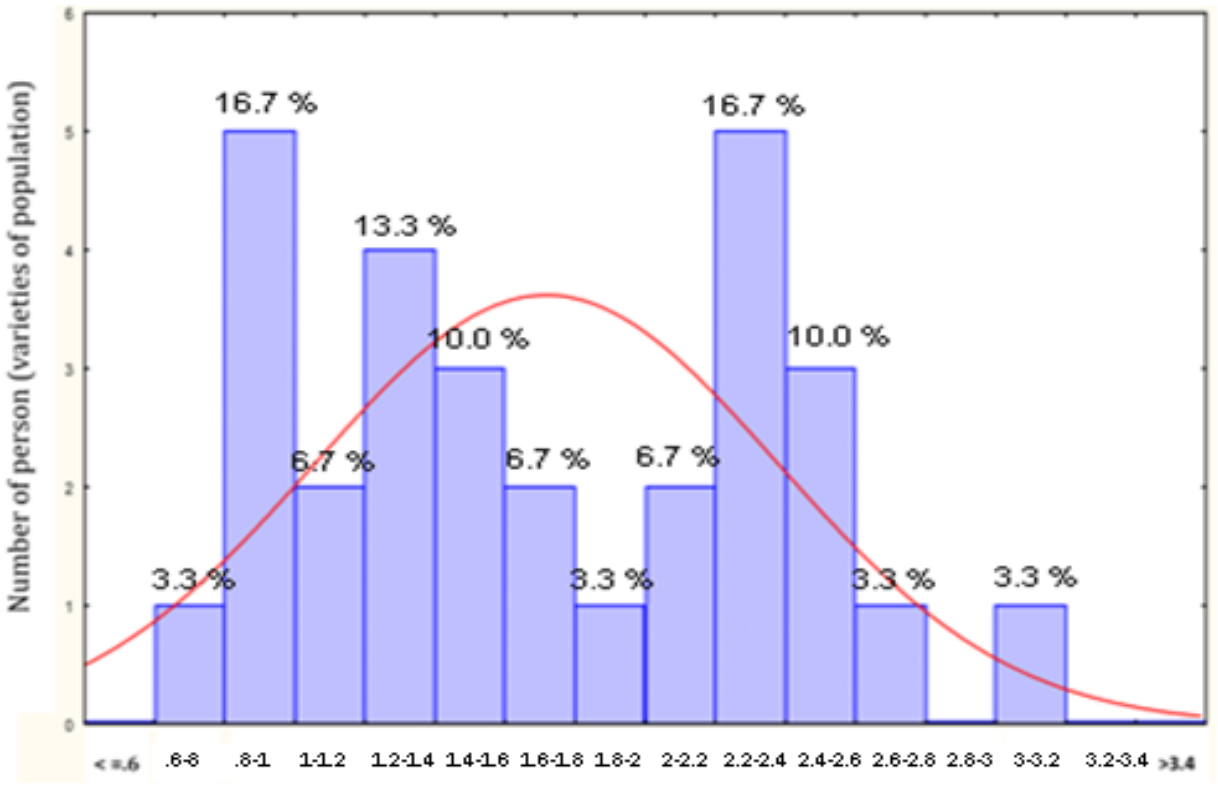

Figure 5. Variation of the stearic acid level (C18: 0) according to the individuals in the study.

determination of the area of origin of olive oil by the writers quoted earlier is confirmed in our study.

Palmitoleic acid

All the values concerning palmitoleic acid are kept with the normal reference range (0.5 to 3.5 %). The distribution of values (Figure 6) follows a normal law and presents a slight asymmetry towards the highest contents. The contents vary moderately according to the regions and the varieties. With regards to the collection from Takarietz, the values are weak during the first crop year and in the four regions. One notes certain uniformity with the relatively important contents for the Azazga region. In fact, the oils of the Azeradj population variety present values which are significantly inferior in this acid with regards to Takarietz and Chemini as compared to the rest of the population varieties. With regards to the collection, one must note the great similarity in the palmitoleic acid levels obtained from Azeradj, Aghenfas and Grosse du Hamma.

Our results are similar to those of Procida and Cichelli (1996), who in their study on the characterization of olive oils produced in Istria, determined the fatty acid profile of several varieties. They observed on the average values of palmitoleic acid (C16: 1) ranging from 0.92 to 2.18% in the Leccino, Buga, Debela, Naska and Slatka varieties. Moreover, our results are similar to those produced by Sogni (1999) in the case of Italian varieties such as Frantoio and Maurino whose values are 0.95 and 2.10%, respectively.

The works by Sarrion-Martinez et al. (1986) and Alessandri (1993), dealing with the models of classification of oils, retained palmitoleic and palmitic acids due to their distinguishing effectiveness in the characterization of the varieties.

Study of saturated and unsaturated fatty acids and the relationship between them

All results obtained so far, brought out the marked effect of the variety. On the other hand, the effect of the crop year and the region were not very significant.

According to Gouveia (1997) the contents of saturated, monounsaturated and polyunsaturated fatty acids, and the relationship between them can contribute to the varietal characterization of olive oils and constitute a method of classification of oils from different farming and varietal origins. Perrin (1992), notes that for the most commonly consumed vegetable oils, olive oil is the one that has the greatest ratio of monounsaturated/ polyunsaturated acids: from 4 to 10% according to the varieties

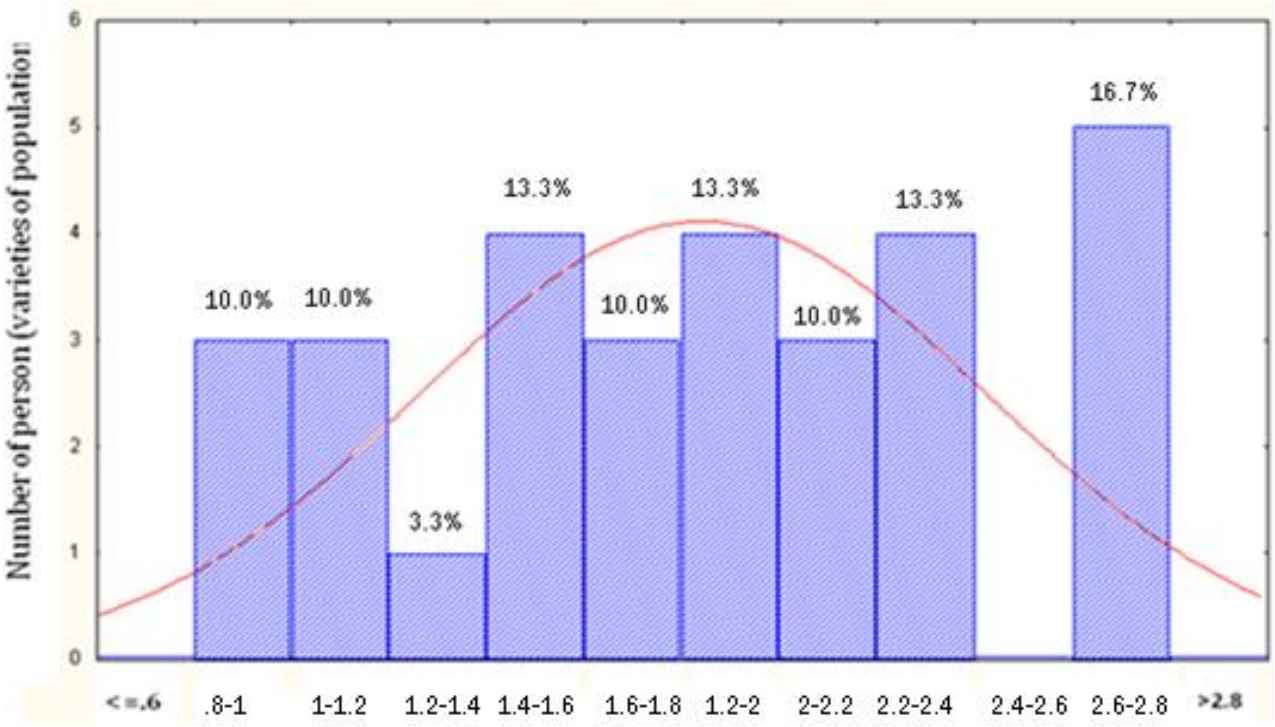

Figure 6. Variation of the palmitoleic acid level (C16: 1) according to the individuals in the study.

varieties and the geographical farming zones and an exception was made for Tunisian olive oils for which this ratio was low (less than 3%). This characteristic gives olive oil a greater stability to oxidation. According to Kiritsakis (1993), an increase in the unsaturated fatty acid content is observed when the temperature of the production zone is low. Since our results show significant values for unsaturated fatty acids (Table 2), this could be linked to the number of freezing days registered during the two crop years (8 days on average) as well as, the low temperatures.

Furthermore, the values obtained pertaining to the unsaturated, saturated and monounsaturated fatty acid contents coincide with those obtained by Sanchez et al. (1999) in Spain, Gouveia (1997) in Portugal, Synouri et al. (1995) in Greece, Rahmani and Saad (1989) in Morocco.

In conclusion, the relative percentages of fatty acids were balanced giving the oils studied a definite nutritional quality. In these oils, the composition is noteworthy due to their richness in oleic acid. According to Bruni et al. (1994), this acid constitutes a presumed genetic mark of the variety. Linoleic acid is less apparent than palmitoleic acid and as such, this compound is considered as a minor. Moreover, with regards to the collection, it must be noted that the Limli and Takesrit samples are identical as far as, the fatty acid profile is concerned (percentage, distribution of saturated, unsaturated, monounsaturated, polyunsaturated and the ratio between them). These results reinforce those of the physico-chemical study on the same samples.

Principal components analysis

The principal components analysis (PCA) accounts for close to 55% of the total variance. The different results pertaining to this fraction are recorded in Table 3 and represented by Figure 7a. In Axis 1 and 35% of variability were essentially accounted for by C18: 1, C18: 2, C16: 1, C16: 0, C17: 0 and to a lesser extent by C20: 1. As regards Axis 2, it absorbs 20% of the variability accounted for especially by C18: 3, C18: 0 and C20: 0.

It should be noted that Axis 1 showed two principal components whereas Axis 2 showed only one. Figure 7b showed that 79% of the individuals display three principal components. These form four groups. The first two showed two components and the last two a single principal component. They contained the following population varieties.

Group I

This group is made up of the following population varieties: Azj/tak/A1; Azj/chm/A2; Agf/tak/A1; Grh/tak/A1 and Grh/tak/A2. These individuals present the highest values of oleic acid (C18: 1) and heptadecanoic acid (C17: 0). They are represented at 80% by the individuals

Table 2. Variations of the AGS/AGI ratio (as a percentage) of the oils from Takarietz (collection), Chemini, Azzefoun and Azazga according to the harvest year.

Takarietz (collection)						
Crop year	**Population variety**	**Unsaturated/ saturated**	**Monounsaturated /saturated**	**Polyunsaturated /saturated**	**Monounsaturated/ unsaturated**	**Monounsaturated /polyunsaturated**
Year 1	Azj	5.484	5.086	0.937	0.927	12.782
	Che	4.43	4.077	0.353	0.92	11.527
	Lim	5.35	4.889	0.46	0.913	10.563
	Tas	5.39	4.90	0.48	0.91	10.24
	Agf	4.849	4.678	0.170	0.964	27.40
	Grh	5.968	5.630	0.338	0.943	16.63
Year 2	Azj	5.119	4.345	0.774	0.935	5.613
	Che	3.42	2.927	0.493	0.855	5.928
	Lim	3.472	2.80	0.669	0.807	4.189
	Tas	3.520	2.86	0.77	0.848	5.61
	Agf	4.178	3.588	0.49	0.855	5.928
	Grh	4.061	3.72	0.669	0.807	4.189
Chemini						
Year 1	Azj	5.735	5.10	0.635	0.889	8.02
	Che	4.30	3.928	0.32	0.925	12.438
	Lim	5.17	4.549	0.62	0.879	7.298
Year 2	Azj	5.417	4.84	0.576	0.893	8.93
	Che	3.589	3.00	0.584	0.837	5.138
	Lim	3.528	2.82	0.708	0.799	3.978
Azzefoun						
Year 1	Azj	4.58	3.817	0.763	0.83	4.999
	Che	4.16	3.34	0.82	0.80	4.068
	Lim	4.884	4.01	0.87	0.82	4.605
Year 2	Azj	5.645	4.79	0.853	0.848	5.61
	Che	5.06	4.305	0.756	0.85	5.69
	Lim	5.46	4.578	0.88	0.838	5.19
Azazga						
Year 1	Azj	4.154	3.70	0.454	0.89	8.14
	Che	3.63	3.289	0.34	0.905	9.548
	Lim	4.12	3.374	0.746	0.819	4.52
Year 2	Azj	4.485	4.015	0.47	0.895	8.54
	Che	3.90	3.536	0.368	0.905	9.596
	Lim	4.339	3.684	0.654	0.819	5.628

from the Takarietz collection.

Group II

It is composed of the following population varieties: Che/tak/A2; Lim/tak/A2; Che/chm/A2; Lim/chm/A2; Che/aze/A1; Lim/tak/A2 and Tas/tak/A2. These individuals present the highest values in C16: 1, C16: 0 and C18: 2 and relatively weak values in C18: 1 and C17: 0. They make up 87% of the second olive crop year and

Table 3. Values of the factorial weight of the fatty acids.

Variable	Axis 1	Axis 2
C16: 0	0.760707*	0.314182
C16: 1	0.824004*	0.406008
C17: 0	-0.748631*	- 0.307894
C17: 1	-0.257125	-0.382530
C18: 0	0.342558	-0.736965*
C18: 1	-0.950421*	0.166045
C18: 2	0.819647*	-0.315570
C18: 3	0.339703	-0.738779*
C20: 0	0.052577	-0.616427
C20: 1	-0.441565	-0.204965
C22: 0	-0.354896	0.342997
Explained variance	3.903851	2.260387
Total proportion	0.354896	0.205490

*P < 0.05.

42% of the Limli population variety. We can say that C18: 1 and C18: 2 marked one group by the region effect, another by the varietal effect and the two groups by the effect of the year.

Group III

This group consists of the following population varieties: Che/tak/A1; Lim/tak/A1; Che/chm/A1; Azj/aza/A1; Che/aza/A1 and Lim/aza/A1. These population varieties present the weakest values in C18: 0, C18: 3 and C20: 0. They were represented at 100% by individuals of the first year and at 50% by the Chemlal population variety.

Group IV

This group is composed of the following population varieties: Azj/tak/A2; Azj/chm/A1; Azj/aze/A2; Che/aze/A2 and Agf/tak/A2. These individuals present the highest values in C18: 0, C18: 3 and C20: 0. The result of the principal components showed that 80% of the population varieties belong to the second olive crop year and 60% were represented by Azeradj.

Finally, the varietal and crop year factors therefore have a homogenous effect on fatty acids. They result in a partial grouping of the cases considered. Nevertheless, all these outcomes cannot allow one to distinguish the population varieties according to the variations of these different fatty acids. According to Kiritsakis (1990) and Boskou (1996), the variations in the fatty acids composition of olive oil depend essentially on the varieties but equally on the climate, the latitude and the level of maturity of the olives at the time of harvesting.

Tocopherols

The levels of total tocopherols measured in oils from all varieties populations were important. Our results are in accordance with previous works reported by Ranalli and Ferante (1996) in Italy on Leccino variety and Rahmani and Saad (1989) on Moroccan Picholine at the beginning and the end of the campaign, and Bruni et al. (1994) on Italian Casativa, Rontondella, Carole and Cassanesse varieties. Furthermore, the data in Table 4 showed the dominance of alpha tocopherol in all studied populations varieties, followed by the gamma and delta tocopherol. Our results agree with those of Speek et al. (1985) and Perrin (1992) on the fact that tocopherols concentration is generally greater than 100 ppm in good quality oils with alpha tocopherol representing about 95% of the total fraction. However, the values of tocopherols revealed groups among the various populations. Azeradj oils presented the highest rates. Intermediate values were observed in Chemlal. Limli presented the lowest values. The results appeared to be related to the factor “variety”, with no impact of “region” and “year”. These results are consistent with those of Ryan et al. (1998) and those of Rahmani (1990). They indicated that tocopherols were influenced by the variety. Thus, the population variety Azeradj in the four regions presented an average for the two campaigns, the respective values of 269.25, 251.43, 245.77 and 271.10 mg/kg. The same tendency was observed for the rest of the population varieties. It suggests that tocopherols may be used to characterize a given variety.

However, the small changes in tocopherols values observed from one season to another (within each population range) could be related to grinding duration in the oil extraction. According to Cortesi et al. (2000), tocopherol content seems to be influenced slightly differently by grinding duration depending on the variety.

We also note that the smaller amounts were found in samples with the highest acidity and peroxide values, especially for the sample Limli / Chm / A2. This confirmed

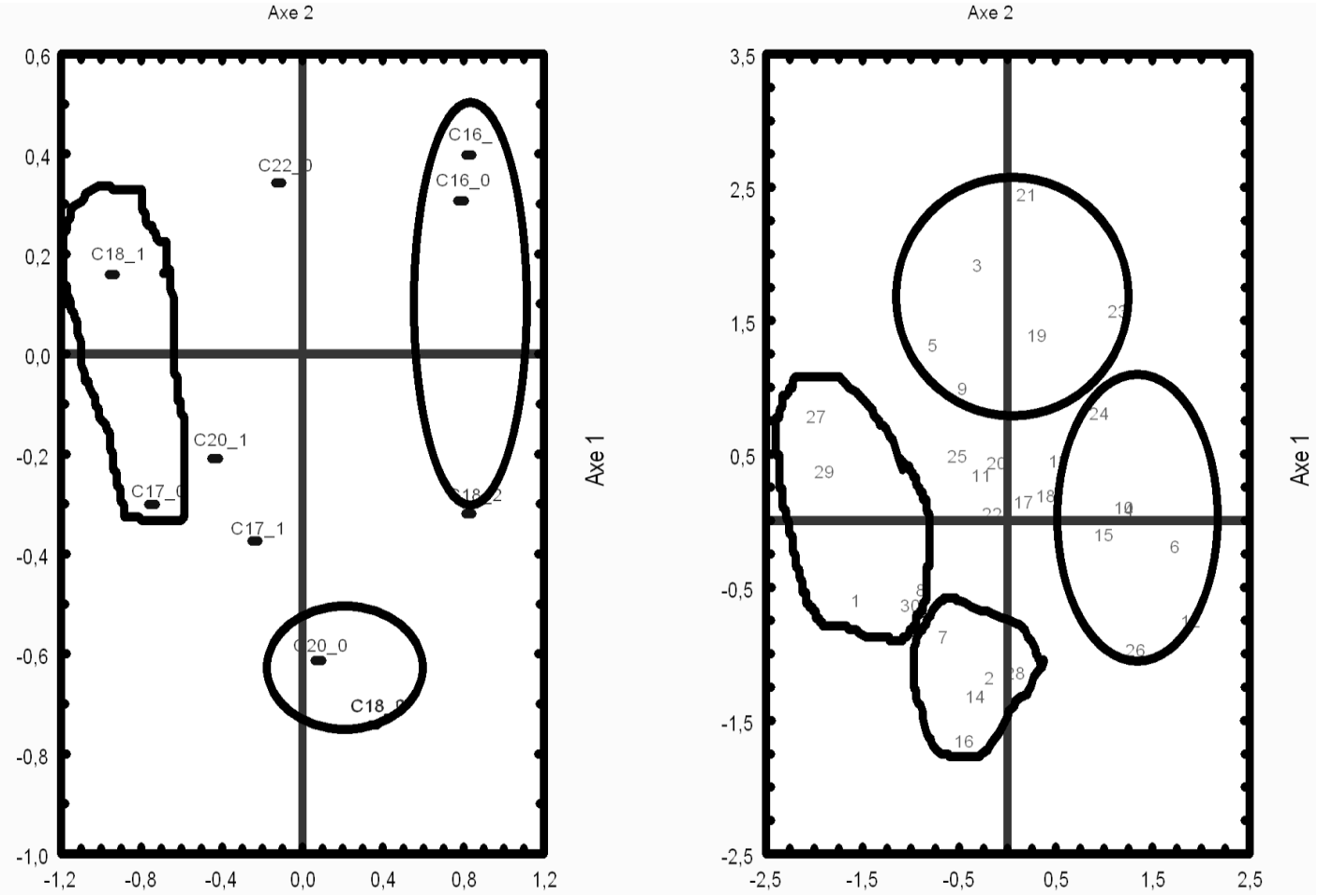

Figure 7. Principal components analysis of the fatty acid profile, b; representation of the individuals according to the different principal components. 1: Azeradj/takarietz/year 1; 2: Azeradj/takarietz/year 2; 3: Chemlal /takarietz/year 1; 4: Chemlal /takarietz/year 2; 5: Limli / takarietz/year 1; 6: Limli / takarietz/year 2; 7: Azeradj/chemini/year 1; 8: Azeradj/chemini/year 2; 9: Chemlal /chemini/year 1; 10: Chemlal /chemini/year 2; 11: Limli / chemini/year 1; 12: Limli / chemini/year 2; 13: Azeradj/azzefoun/year 1; 14: Azeradj/azzefoun/year 2; 15: Chemlal /azzefoun/year 1; 16: Chemlal /azzefoun/year 2; 17: Limli /azzefoun/year 1; 18: Limli /azzefoun/year 2; 19: Azeradj/azazga/year 1; 20: Azeradj/azazga/year 2; 21: Chemlal /azazga/year 1; 22: Chemlal /azazga/year 2; 23: Limli /azazga/year 1; 24: Limli /azazga/year 2; 25: Takesrit /takarietz/year 1; 26: Takesrit /takarietz/year 2; 27: Aghenfas/takarietz/year 1; 28: Aghenfas/takarietz/year 2; 29: Grosse du Hamma /takarietz/year 1; 30 Grosse du Hamma /takarietz/year 2.

Table 4. Change in levels of alpha, gamma and delta tocopherols (mg / kg) oils of different varieties of the study populations.

Variety	Tocopherol			
Takarietz population	**Alpha**	**Gamma**	**Delta**	**Total**
Azeradj 1	280.16	7.01	4.49	291.66
Azeradj 2	243.3	7.33	5.22	246.85
Chemlal 1	189.86	10.3	ND	200.16
Chemlal 2	180.02	7.37	4.73	192.12
Limli 1	175.45	7.21	ND	182.66
Limli 2	169.5	7.19	4.55	181.24

Table 4. Contd.

Variety	Tocopherol			
Takarietz population	**Alpha**	**Alpha**	**Alpha**	**Alpha**
Chemini population				
Azeradj 1	238.92	7.19	5.3	251.41
Azeradj 2	235.39	7.84	8.22	251.45
Chemlal 1	182.5	7.35	5.49	195.34
Chemlal 2	181	6	4.44	191.44
Limli 1	168	7.27	5.99	181.26
Limli 2	166.33	6.69	5.04	178.06
Azzefoune population				
Azeradj 1	246.39	7.8	5.62	259.81
Azeradj 2	220.15	6.79	4.8	231.74
Chemlal 1	186.6	7.59	4.65	198.84
Chemlal 2	185,86	7.47	5.62	198.95
Limli 1	166	5.66	4.81	176.47
Limli 2	168.5	5.2	4	177.7
Azazga population				
Azeradj 1	264.06	9.02	5.87	278.95
Azeradj 2	250.12	8	5.13	263.25
Chemlal 1	184.44	7.2	4.6	196.24
Chemlal 2	180.11	7.23	5.38	192.72
Limli 1	162.3	7.62	ND	169.92
Limli 2	158.6	5.8	4.36	168.76

the results found by Bruni et al. (1994).

Conclusion

Based on the results obtained in our experimental conditions, it is quite clear that fatty acids can characterize a given variety but oleic acid remains the only constant fatty acid vis-à-vis the variation factors in the study for a given population variety. This acid is variable from one population variety to the next. It must be noted that the Limli and Takesrit samples have almost identical average fatty acid values as the physico-chemical results, which leads one to put forward the hypothesis that Limli and Takesrit belong to the same population variety and also like the fatty acid composition, the characterization of varieties of olives can be obtained from the study of different forms of tocopherols contained in the oils.

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