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Caractérisation physico-chimique de quelques huiles d'olive algériennesproduites par différents processus

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RESUME

L'Algérie est l'un des plus grands producteurs d'huile d'olive dans le monde, mais sa qualité reste à discuter. Cette huile a le potentiel pour être une bonne huile, mais il ya un manque de connaissances des agriculteurs et le manque de moyens pour d'autres agriculteurs. Dans cette thèse, il a été étudié qualitativement trois échantillons de l'huile d'olive algérienne avec trois différents procédés de transformation. Ces huiles ont été évaluées en fonction des règlements C.E. (Communauté Européenne) et du C.O.I. (Conseil Oléicole International). En outre, ils ont été comparés à certains produits de différentes régions du sud de l'Italie. Les résultats ont montré que l'huile d'olive algérienne extraite avec le système moderne et suivant les bonnes conditions de récolte et d'extraction, était la meilleure et a présenté de bonnes caractéristiques comparables à certaines huiles italiennes.

Mots clés *: huile d'olive, la qualité, Algérie*

SUMMARY

Algeria is one of the biggest producers of olive oil in the world, but its quality remains to be discussed. This oil has the potential to be good oil but there is lack of farmers' knowledge and lack of means for other farmers. In this thesis, it was studied qualitatively three samples of Algerian olive oil with three different transformation processes. Those oils were evaluated according to E.C. and I.O.C. regulations. In addition, they were compared with some products from different regions of Southern Italy. The results showed that the Algerian oil extracted with modern system and followed right conditions of harvest and extraction was the best one and it had good characteristics comparable to some Italians oils.

Key words : *olive oil, quality, Algeria*

الملخص

list of abbreviations

- **Cr**: crusher
- **cv**.: cultivar
- **E.C.**: European Community
- **ECe**: Electric Conductivity
- **ET:** evapotranspiration
- **F.A.M.Es**: Fatty Acid Methyl Esters
- **FID**: Flame Ionization Detector
- **GC**: Gas Chromatography
- **H.P.L.C.:** High Performance Liquid Chromatography
- **I.D**: internal diameter
- **I.O.C.:** International Olive Council
- **I.T.A.F.** : Institut Technique de l'Arboriculture Fruitière et de la Vigne
- **Kc**: crop coefficient
- **M.U.F.As**: monounsaturated fatty acids
- **P.U.F.As**: polyunsaturated fatty acids
- **PV**: peroxide value
- **PXA**: Pulsed Xenon Arc
- **S.F.As**: saturated fatty acids
- ***U.F.As*** *: unsaturated fatty acids*

INTRODUCTION

There is in the world a demand for food quality. Algeria is traditionally a country with olive growing vocation. In the last decade, the Algerian olive growers have understood the necessity to produce olive oil with the better quality standard. However, it is necessary to intervene in production, transformation and storage levels, to reach the quality standard. For this motif, it is fundamentally important to know the quality of Algerian olive oil.

Olive oil is obtained solely from the fruit of the olive tree (*Olea europaea* L.); excluding oils obtained using solvents or re-esterification processes and any mixture with oils of other kinds. Virgin olive oils are the oils obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions, particularly thermal ones, that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decantation, centrifugation and filtration (International Olive Council (I.O.C.), 2006).

In Algeria, the area covered by olive trees, in 2006, was 263,352 ha with a production of 196,258 tons (17.8 L of oil/quintal of olives). According to International Olive Oil Council (I.O.C.) data (2009), the Algerian production of olive oil, in 2008, was 240,000 tons, while the Italian production was 510,000 tons and the European Community production was 2,118,700 tons of oil.

The oliviculture is concentrated mainly in the center of the country, the "Kabylie" with 58.4% of the total oliviculture area (153,708 ha). The oliviculture in Algeria deals with different social, economic and cultural obstacles.The oldness of the extraction system and the smallness of the factories lead to a long time wasted from the harvest to the oil extraction, which means that the chemical and organoleptic qualities of the oil are affected and, variables depending on a work conditions (time, type of extraction system, cleanness of material, and oil conservation).

The aim of this work is to make qualitative study of three Algerian samples of olive oil extracted with different systems, also comparing them with the Italian ones. The results were evaluated by both I.O.C and E.C. regulations.

I.BIBLIOGRAPHIC SYNTHESIS

I.1. Repartition of oliviculture in the world

Over 750 million olive trees are cultivated worldwide, 95% of which are in the Mediterranean region. Oliviculture has been moving westward over the last three millennia, and today Spain is the world's largest producer of olives (36%) followed by Italy (25%)and Greece (18%), and world production had crossed 2,118,700 tons in 2008, of which Spain contributed 40% to 45% (IOC, 2009). Most of global production comes from Southern Europe , North Africa and the Near East . Of the European production, more than 90% comes from Croatia , Greece , Italy , Portugal and Spain (IOC, 2009).

According to International Olive Oil Council (I.O.C.) data, the Algerian production of olive oil, in 2008, was 240,000 tons, while the Italian production was 510,000 tons and the European Community production was 2,118,700 tons of oil. According to the same council and in the same year, the consumption of olive oil is higher in the European community with 1865,9000 tons where Italy is the highest consumer with 705,000 tons following by Spain with 546,3000 tons after that Greece with 264,000 tons. In Algeria, the consumption of olive oil was 25,000 tons in 2008 (IOC, 2009).

The olive has also been planted in other regions such as Chile , Australia , and California ; but the primary production is almost entirely around the Mediterranean.

I.2. Olive tree

The Olive, *Olea europaea*, is a species of a small tree in the family Oleaceae , native to the coastal areas of the eastern Mediterranean Basin (the adjoining coastal areas of southeastern Europe, western Asia and northern Africa) as well as northern Iran at the south end of the Caspian Sea . Its fruit, also called the olive , is of major agricultural importance in the Mediterranean region as the source of olive oil . The tree and its fruit give its name to the plant family, which also includes species such as lilacs , jasmine , Forsythia and the true ash trees (Fraxinus). The word derives from Latin "oliva" which in turn comes from the Greek (*elaia*). The word 'oil' in multiple languages ultimately derives from the name of this tree and its fruit (Giorgini, 1979; Alfei *et al.,* 2003).

The olive tree is an evergreen tree or shrub native to the Mediterranean , Asia and Africa . It is short and squat, and rarely exceeds 8–15 meters in height. The silvery green leaves are oblong in shape, measuring 4–10 centimeters long and 1–3 centimeters wide. The trunk is typically gnarled and twisted (Giorgini, 1979; Alfei *et al.,* 2003).

The small white flowers , with ten-cleft calyx and corolla , two stamens and bifid stigma , are borne generally on the last year's wood, in racemes springing from the axils of the leaves (Giorgini, 1979; Alfei *et al.,* 2003).

The fruit is a small drupe 1–2.5 centimeters long, thinner-fleshed and smaller in wild plants than in orchard cultivars. Olives are harvested in the green to purple stage. Canned

black olives may contain chemicals (usually ferrous sulfate) that turn them black artificially (Giorgini, 1979; Alfei et al., 2003).

There are thousands of cultivars of the olive. In Italy alone at least three hundred cultivars have been enumerated, but only a few are grown to a large extent. The Iberian olives are usually cured and eaten, often after being pitted, stuffed and packed in brine, in jars or tins. Some also pickle olives at home.

Since many cultivars are self sterile or nearly so, they are generally planted in pairs with a single primary cultivar and a secondary cultivar selected for its ability to fertilize the primary one. In recent times, efforts have been directed at producing hybrid cultivars with qualities such as resistance to disease, quick growth and larger or more consistent crops (Alfei *et al.,* 2003).

A fungus , Cycloconium oleaginum , can infect the trees for several successive seasons, causing great damage to plantations. A species of bacterium , Pseudomonas savastanoi pv. *oleae*,induces tumor growth in the shoots. Certain lepidopterous caterpillars feed on the leaves and flowers. More serious damage is caused by olive-fly attacks to the fruit (Janse, 1982).

A pest which spreads through olive trees is the black scale bug, a small black scale insect that resembles a small black spot. They attach themselves firmly to olive trees and reduce the quality of the fruit; their main predators are wasps . The curculio beetle eats the edges of leaves, leaving sawtooth damage (Burr, 1999).

Rabbits eat the bark of olive trees and can do considerable damage, especially to young trees. If the bark is removed around the entire circumference of a tree it is likely to die (Alfei *et al.,* 2003).

In France and north-central Italy, olives suffer occasionally from frost . Gales and long-continued rains during the gathering season also cause damage (Alfei *et al.,* 2003).

Considerable research supports the health-giving benefits of consuming olives, olive leaf and olive oil. Olive leaves are used in medicinal teas. The health benefits of olive oil consumption are mainly due to the high content of its phenolic compounds. These benefits can be the reduced risk of cancer in different sites such as breast (Moreno *et al.,* 1994; Trichopoulou *et al*., 1995; La Vecchia *et al.,* 1995), prostate (Hodge *et al.,* 2004), lung (Fortes *et al.*, 2003), larynx (Bosetti *et al.,* 2002a), ovary (Bosetti *et al.,* 2002b) and colon (Stoneham *et al.,* 2002).

Also, the olive oil supplements for animals can prevent the development of azoxymethane-induced aberrant crypt foci and colon carcinomas (Bartoli *et al.,* 2000), reduce the incidence of dimethylbenz (α) anthracene-induced mammary tumor in rats (Solanas *et al.*, 2002). Furthermore, spontaneous liver tumorigenesis in mice can be restrained by olive oil (Thuy and Takeuchi, 2000) and skin carcinogenesis is diminished when the olive oil is applied before and after exposure of mice to ultraviolet light (Budiyanto et al., 2000).

Phenolic compounds may be beneficial also in the struggle against diseases related to excessive oxygen radical formation exceeding the antioxidant defense capacity of the human body (Morello *et al.,* 2004).

Olives are now being looked atfor use as a renewable energy source, using waste produced from the olive plants as an energy source that produces 2.5 times the energy generated by burning the same amount of wood. The same reference claims that the smoke

released has no negative impact on neighbors or the environment, and the ash left in the stove can be used for fertilizing gardens and plants (faqs, 2009).

I.3. The crop conditions

The crop is indigenous to the Mediterranean region with a mild, rainy winter and a hot, dry summer. A dormancy period of about two months with average temperatures lower than 10° C is conducive to flower bud differentiation. Some cultivars are adapted to areas with higher winter temperatures but reduced flowering is noted under these conditions. During the dormancy period, the tree tolerates short periods of frost of -6° C, but during the bearing period frost causes damage to the fruits which are then only suitable for oil production. High temperatures and dry winds cause poor fruit setting and excessive drop of young fruits with remaining fruits shriveling on the tree. A long sunny, warm summer results in a high oil content of the fruit. High humidity at flowering causes flower drop and infestation of sooty mould (FAO, 2010).

The crop produces acceptable yields on poor soil as long as it is deep, well-aerated and free from waterlogging. Under waterlogged conditions damage through lack of oxygen and fungal diseases increases sharply. The fertilizer requirements are 200 to 250 kg/ha N, 55 to 70 kg/ha P and 160 to 210 kg/ha K. Nitrogen is applied prior to or during the flowering and fruit formation period (FAO, 2010).

The olive tree is moderately tolerant to soil salinity provided ECe does not exceed 8 dS/m (25°C), but ECe of 4.5 dS/m (25°C) or less is preferred (FAO, 2010).

Olive trees are commonly grown without irrigation in areas with an annual rainfall of 400 to 600 mm but are even found in areas with about 200 mm rainfall. For high yields, 600 to 800 mm are required. The crop coefficient (kc) relating maximum evapotranspiration (ETm) to reference evapotranspiration (ETo) is between 0.4 and 0.6 (FAO, 2010).

After 3 to 4 years the tree forms a fascilar root system which continues to grow with age. In heavy textured and poorly aerated soils, roots are concentrated near the soil surface but are found at a greater depth in light textured soils. Lateral roots can be up to 12 m long. The tree thus explores a large volume of soil for nutrients and water. Generally, water uptake occurs over the first 1.2 to 1.7 m of soil depth. Under conditions when maximum evapotranspiration (ETm) is 5 to 6 mm/day, the rate of soil water uptake by the crop starts to reduce when some 60 to 70 percent of the total available soil water has been depleted (FAO, 2010).

With winter rain of about 500 mm, irrigation is applied during and after stone hardening. Under conditions of little winter rain, irrigation is applied during bud differentiation (early spring), prior to flowering (early summer) and during yield formation and particularly during stone hardening. Irrigation is also applied at two to three weeks before flowering; when the fruit reaches one third its full size; and when the fruit reaches almost full size (FAO, 2010).

For oil production, irrigation supply must be discontinued early enough to give a dry period during ripening. This will have little effect on the oil content but will reduce the water content of the fruit. Irrigation is applied by different surface methods, but when limited water is available, localized irrigation is preferred (FAO, 2010).

The fruits of irrigated trees reach high oil content later in the season than those of rainfed trees. Also, for irrigated trees the change of fruit color from green to black is more gradual. Oil content as percentage of fresh fruit weight tends to be higher for rainfed than for irrigated trees but little difference is noted with oil content expressed as percentage of dry matter (FAO, 2010).

Time of picking depends on the use of the harvested product. Varieties with fruits of a high flesh/pit ratio and uniform shape are used for table olive production. In the northern hemisphere, green table olives are harvested from mid-September onward with end of harvest being determined when the fruit color changes to green-yellow. Black table olives are harvested in December. Olives for oil are harvested from mid-December until March with oil content independent of the time of harvest. Maximum oil content and weight are reached six to eight months after flowering. Olive fruits can be harvested long before they fall naturally (FAO, 2010).

Yields vary from year to year and from tree to tree. Good commercial yields under irrigation are 50 to 65 kg/tree of fruit with a possible maximum of 100 kg/tree of fruit. Oil content of the fresh fruit ranges from 20 to 25 percent. The water utilization efficiency for harvested yield (Ey) for fresh olives containing about 30 percent moisture is 1.5 to 2.0 kg/ m^3 (FAO, 2010).

II.4. Olive oil

Olive oil is obtained solely from the fruit of the olive tree (*Olea europaea* L.); excluding oils obtained using solvents or re-esterification processes and any mixture with oils of other kinds. Virgin olive oils are the oils obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions, particularly thermal ones, that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decantation, centrifugation and filtration (International Olive Council (I.O.C.), 2006).

I.3.1. Different categories of olive oil

(International Olive Council (I.O.C.), 2006).

I.3.1.1. Virgin olive oils

are the oils obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions, particularly thermal conditions, that do not lead to alterations in the oil, and which have not undergone any treatment other than washing, decantation, centrifugation and filtration. Virgin olive oils fit for consumption as they are include:

- **Extra virgin olive oil**: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 0.8 gram**s** per 100 grams, and the other characteristics of which correspond to those fixed for this category in this standard.
- **Virgin olive oil**: virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 2 grams per 100 grams and the other characteristics of which correspond to those fixed for this category in this standard.
- **Ordinary virgin olive oil:** virgin olive oil which has a free acidity, expressed as oleic acid, of not more than 3.3 grams per 100 grams and the other characteristics of which correspond to those fixed for this category in this standard.

I.3.1.2. Virgin olive oil

not fit for consumption as it is, designated lampante virgin olive oil, is virgin olive oil which has a free acidity, expressed as oleic acid, of more than 3.3 grams per 100 grams and/or the organoleptic characteristics and other characteristics of which correspond to those fixed for this category in this standard. It is intended for refining or for technical use.

I.3.1.3. Refined olive

oil is the olive oil obtained from virgin olive oils by refining methods which do not lead to alterations in the initial glyceridic structure. It has a free acidity, expressed as oleic acid, of not more than 0.3 grams per 100 grams and its other characteristics correspond to those fixed for this category in this standard.

I.3.1.4. Olive oil

is the oil consisting of a blend of refined olive oil and virgin olive oils fit for consumption as they are. It has a free acidity, expressed as oleic acid, of not more than 1 gram per 100 grams and its other characteristics correspond to those fixed for this category in this standard.

I.4. Process of extraction of olive oil

Virgin olive oil is extracted in olive oil mills with pressure, centrifugation and percolation systems by using different apparatus driven by physical forces which, when correctly exerted on olive paste, enable the separation of the different phases of olives, liquid and solid (Di Giovacchino *et al.*, 2002).

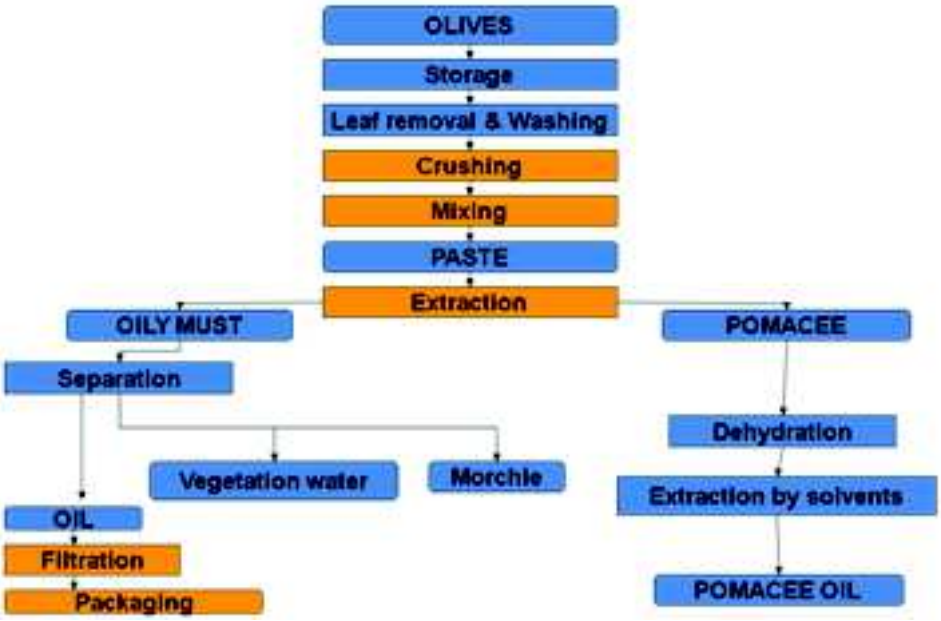

***Figure1**: From the olives to the consumer*

Applying pressure is the oldest and still wide-spread system used to extract virgin olive oil. It is based on the principle that when the olive paste will release the oily must (olive oil + vegetable water) if it is pressed under the right conditions. The oily must can be separated

from the solid phase (pomace) with the help of the drainage effect of the mats and stone fragments (Di Giovacchino *et al.*, 2002).

Centrifugation process is a relatively new process for separation of oil from olive paste. It is based on the differences in density of the olive paste constituents (olive oil, water and insoluble solids). Separation is accomplished through a horizontal centrifuge (decanter). After crushing and mixing, the olive oil is either completely free or in the form of small droplets inside microgels, or emulsified in the aqueous phase. Free olive oil is separated by the centrifuge, while the oil locked in the microgels is released by adding water (Kapellakis *et al.*, 2008).

I.5. Factors which influence olive oil quality

Virgin olive oil quality depends on different factors such as olive cultivar, olive tree cultivation, the pedoclimatic conditions of cultivation, as well as the pruning, fertilization and irrigation of olive trees and, the operations of olive picking and time, storage and processing (Tura *et al.*, 2007).

The antioxidative stability profile is firstly influenced by the cultivar (tocopherols) and then by the environment (polyphenols). The fatty acids are affected by both of two factors (Tura *et al.*, 2007).

Leaf removal and olive washing are important operations for the mechanical safety of the olive extracting equipment which operates at high speed and for the organoleptic quality of olive oil. The leaves mixed with olives may increase, in fact, the organoleptic attributes of 'fresh-cut' grass or 'green', especially if metallic crushers are used to prepare olive paste (Di Giovacchino *et al.*, 2002).

In oil extracted from green olives, there is a higher content of β-carotene and phenolic compounds, and to a lesser extent of α-tocopherol, as opposed to ripe olives (Gimeno *et al.,* 2002).

Olive crushing has an important influence on organoleptic and nutritional qualities of virgin olive oil. When mill stones are used, the obtained oils have a lower intensity of bitterness and pungency because this crushing method helps to produce oil with a lower content of phenolic substances. When metallic crushers are used oils have, due to the violent action, a higher content of phenolic compounds and are more bitter and pungent (Di Giovacchino *et al.*, 2002).

Table I: case study. Differences among oils obtained by mean of stone mill (Crusher A) and others obtained by mean of metal hammer crusher with a rotating grating (Crusher B)

Variety	Crusher	Panel test	Acidity (%)	Peroxide (meq/kg)	K_{232}	K_{270}
Leccino	A	6.7	0.6	12.0	1.41	0.096
	B	7.3	0.4	8.6	1.38	0.097
Dritta	A	8.3	0.3	11.6	1.45	0.105
	B	7.6	0.4	10.1	1.34	0.085
Carolea	A	7.7	0.8	13.5	1.36	0.086
	B	7.8	0.4	12.5	1.38	0.068

(Ranalli & Giansante, 1994).

Olive paste malaxation influences the oil yields and also the antioxidant content of oil. With prolonged malaxation oil yields, generally, increase while the phenol content of oils decreases (Di Giovacchino *et al.*, 2002). Low temperatures are always recommended for the malaxation step, whereas times ranging between 30 and 45 minutes, seem to satisfy a good yield and oil quality, because compounds responsible for attractive perceptions, such as esters, are still present at high level, and concentrations of those giving unpleasant sensations such as trans-2-hexen-1-ol and hexan-1-ol are rather low. In addition, the amount of secoiridoid compounds is great enough to ensure a suitable shelf-life of the oil (Angerosa *et al.*, 2001).

Through all these different aspects to have a good olive oil quality, Algeria is one from the producer of olive oil which has different issues to cope with.

I.6. Oliviculture in Algeria

Oliviculture in Algeria has an important and an ancestral place. In 2006, the area covered by olive trees was 263,352 ha (29,995,980 trees) corresponding to 32.5% of total tree growing area except vineyard (810,193 ha) (Algerian Ministry of Agriculture and Rural Development, 2006).

However, the olive oil production is concentrated mainly in the center of the country, “the Kabylie” with 58.4% of the total oliviculture area (153,708 ha) (Algerian Ministry of Agriculture and Rural Development, 2006).

I.6.1. Description of the Kabylie Region

Kabylie is a mountainous coastal region in northern Algeria (Figure 2), between Algiers and Skikda (the east of Algeria). It has two capitals: Tizi-Ouzou (north west) and Béjaia (south east). It comprises: the Great Kabylie (Grande Kabylie) or Djurdjura Mountains bounded on the west by the Isser River and on the southeast by the Wadi Soummam; the Little Kabylie (Petite Kabylie, or Kabylie des Babors) around the Gulf of Béjaïa; and the Collo Kabylie (Kabylie de Collo) forming the hinterland of Cape Bougaroun. The Kabylie is joined to the Tell Atlas on the west by the Bou Zegza Mountains.

The altitude in the Kabylie is from 0 to more than 1,200 m, the average is about 500 m. The littoral and the maritime Kabylie have a Mediterranean climate, with the average temperature of 15°C in winter and 35°C in summer. In the highland region, the climate is severe, with negative temperatures and an abundant snow in the winter and a hot and dry summer, in particular in the south where the rain is less. However, in the highest parts of the region, the summer temperature is moderated by the altitude. In the plateaux and the interior valleys, the winter is more or less similar to the one of the Highland region, but the temperatures in summer are very high, like in Medjana, Akbou.

The Kabylie benefits from an abundant rain. In the Great Kabylie, the interior regions are more watered. In Larbâa Nath Irathen, city of Tizi Ouzou province, the rain is 1,059 mm per year against 833 mm per year in Tizi Ouzou). The crest line which crosses the region joining the Atlas of Blida, the Djurdjura, Babors, the massif of collo, separates a North part

more rainy (more than 800 mm rain per year) of the South part less rainy (between 600 to 800 mm rain per year).

***Figure 2**: The Kabylie. Algeria is white colour and the Kabylie is red colour*

I.7. Varieties cultivated in Algeria

There are many cultivated and described varieties of olive trees in Algeria; 36 varieties are homologated by I.T.A.F. (Institut Technique de l'Arboriculture Fruitière et de la Vigne) (I.T.A.F., 2006). I.T.A.F. is a national Technical Institute of tree and wine growing created in 1987, the headquarters is situated in Algiers but it has 10 demonstration farms in different regions of Algeria. The most important varieties are**:**

- " ***Chemlal*** ": in the Kabylie region, it occupies 40% of the national area for oliviculture, cultivated for olive oil extraction.
- " ***Sigoise*** ": in the west of Algeria, it occupies 25% of the national area for oliviculture, it has double destination (olive oil and table olives).
- " ***Azeradj*** ": in the Kabylie region (the east center), it occupies 10% of the national area for oliviculture, often associated with ***"Chemlal"*** for pollination. It has double destination (olive oil and table olives).

The production of olive oil, in 2006, was 196,258 tons (17.8 L of oil/quintal of olives) (Algerian Ministry of Agriculture and Rural Development, 2006). The oliviculture in Algeria deals with different social, economic and cultural obstacles.The oldness of the extraction system and the smallness of the factories lead to a long time wasted from the harvest to the oil extraction, which means that the chemical and organoleptic qualities of the oil are affected and, variables depending on a work conditions (time, type of extraction system, cleanness of material, and oil conservation).

Three extraction systems of olive oil are used but with different and distinctive percentages, the mainly used, with more than 58.52 %, is the traditional one, just 20.59 % are modern system ones and 21.21 % are systems by pressure (Algerian Ministry of Agriculture and Rural Development, 2006).

In some farms like “Ifri Olive” (one of the most important firm of olive oil industry and deals with foreign markets (Europe, USA, Australia,…) which are aware of all defects of Algerian olive oil, are willing to improve their situation with better knowledge about olive oil quality.

II.MATERIAL AND METHODS

II.1. Materials

The material that we used for our study was three samples of Algerian olive oil extracted with three different processes: old traditional system (sample A), traditional system with pressure (sample B) and modern and continuous system (sample C).

Sample A: The olive oil of the sample A was a mixture of varieties but "Chemlal" variety was dominant. It was extracted in Ighil Ali (situated at 80 km south east of Béjaïa province) (Figure 3) with a traditional process, rotating stone mill cared with a mule using oil diaphragms called '*boxades'* for putting paste from the rotating wheels were functioning as filters, a method is well spread in Algeria. The oil had a smoke smell because they burned the tool used for the oil extraction, to have more oil. When the olives were collected in January, they were ripe and black colored, exposed to sun, scatted in the land, until the olives were well dried, this is for an economic reason, to decrease the weight of olives so the extraction cost will be less expensive.

Sample B: The oil was a mixture of three varieties (Chemlal, Azeradj and Bouichret). It was extracted with pressure system (RAPANELLI) using the oil diaphragms which were placed one over the other in the bottom side of the press. The factory where we got the oil was in Aghbalou (situated at 60 km east of Bouira province). The oil was without a characteristic smell. The olives were ripe and black colored. They were collected in the same period like the sample A, in January and they underwent the same process of drying.

Sample C: It is fromIfri farm in Ighzer Amokrane (Béjaïa province). The oil was from one variety '*Chemlal*'. It was extracted with a modern system (continuous system, ALFA LAVAL and PIERALISI) with metal crusher and centrifugation of the olive paste. The oil was with fruity smell. The olives were collected in November, when the olives were not completely ripe (between green and black), and directly transformed to oil.

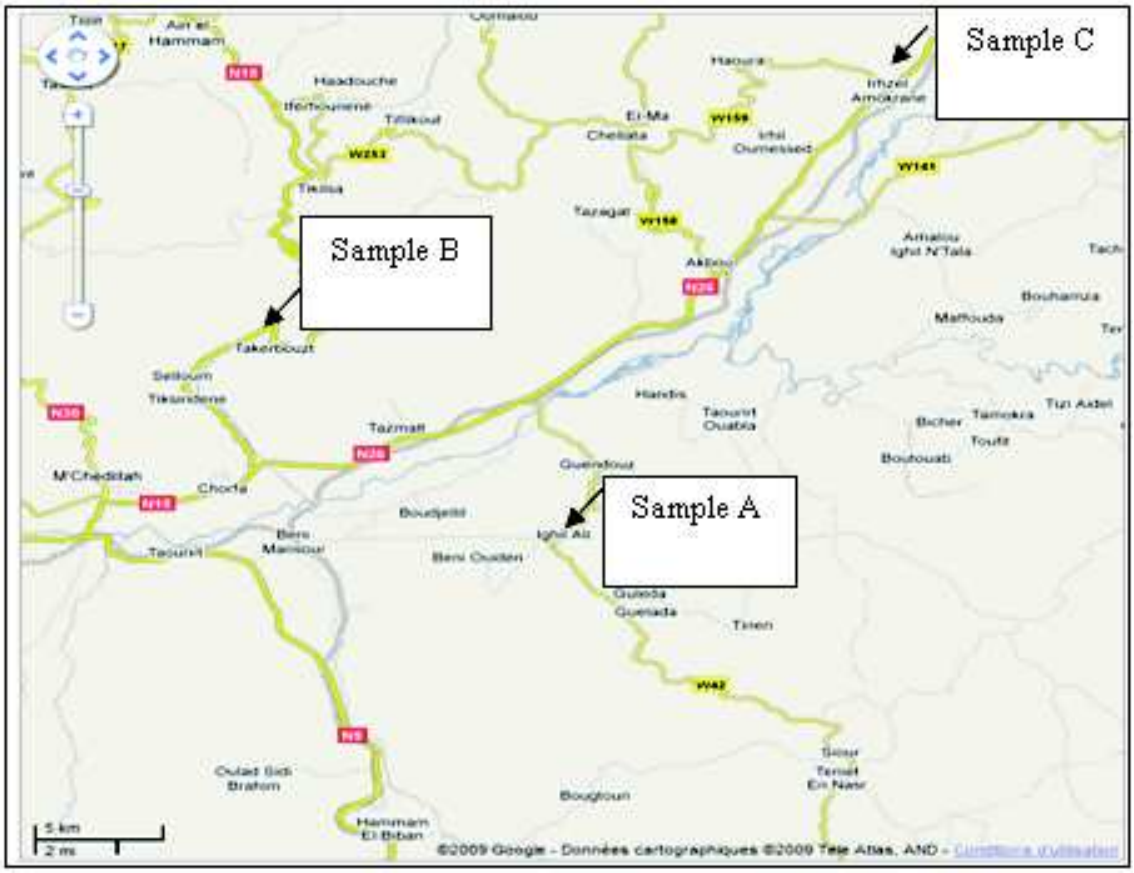

Figure 3: *Origins of the three samples*

The samples (A, B and C) obtained in Algeria, were compared with some olive oils coming from different parts of the Southern Italy.

Sample D: it isderivedfrom “Ottobratica”; an autochthonous variety cultivated in Gioia Tauro, in the western side of Reggio Calabria Province, Southern Italy. Its name “Ottobratica” means that the olive fruits are ripe in October. The oil was extracted with a traditional discontinuous system with a stone mill crusher and pressure of the olive paste (Giuffrè, 2006a).

Sample E: it is a sample constituted of a mix of different varieties(Ottobratica, Sinopolese, Rotondella and Leccino), cultivated in Montebello Jonico, a hilly area of the Eastern side of Reggio Calabria Province (Giuffrè, 2006b).

Sample F: it is derived from “Tonda Iblea” cultivar, cultivated in Gioia Tauro, in the western side of Reggio Calabria Province, Southern Italy. It is an allochthonous variety of the Calabria region, since it is coming from Sicily. The oil was extracted with a traditional discontinuous system with a grindstone mill and pressure of the olive paste (Giuffrè, 2005).

Sample G: it is an average of 65 samples of olive oil derived from “Peranzana” variety, which is a variety from Apulia and cultivated in Foggia Province. A part of the oils were extracted by stone mill crusher and centrifugation of olive paste. And the other part, were extracted by metal crusher and subsequent centrifugation of the olive paste (Giuffrè, 2002a, Giuffrè, 2003).

Sample H: it is an average of 17 samples of olive oils derived from a mix of different varieties (Ogliarola, Frantoio, Leccino and Ravece). The samples were coming from Campania Region, in Avellino Province (Giuffrè, 2002b).

II.2. Reagents

All the chemicals (analytical, H.P.L.C., GC and spectrophotometer grade) were purchased from VWR International – Merck (Darmstadt, Germany).

II.3. Methods

The methods used are those described by the European Community Regulation **(Consleg, 2003).** First of all, the samples were filtered, to decrease the moisture and impurities. Then, they were stored in dark glass bottles (50 mL), until analysis.

II.3.1. Free Fatty acids

Principle:

A sample is dissolved in a mixture of solvents and the free fatty acids present titrated using an ethanolic solution of potassium hydroxide.

Procedure:

After weighting the samples (2 g precisely weighted), we dissolved them in 50 mL of a neutralized mixture of diethyl ether and ethanol 95% (1:1, v/v).

We titrated with 0.1 mol/L solution of potassium hydroxide until the indicator changed the color (pink).

The acidity is expressed as a percentage of oleic acid in 100 g of oil:

$$Acidity = V \times c \times \frac{M}{1000} \times \frac{100}{m} = \frac{V \times c \times M}{10 \times m}$$

Where:

V = Volume of titrated potassium hydroxide solution (mL)

c = the concentration of the titrated solution of potassium hydroxide used (moles/L)

M = the molar weight of the acid used to express the result (282 g/mole)

m = the weight of the sample (g)

II.3.2. Peroxide value

Principle:

The treatment of the test portion, in solution in acetic acid and chloroform, by a solution of potassium iodide. Titration of the liberated iodine with standardized sodium thiosulfate solution.

Procedure:

- We weighted the samples in a glass scoop (1g). Then, we added 10 mL of chloroform, 15 mL of acetic acid and after 1 mL of a saturated potassium iodide solution. We inserted the stopper quickly.
- We shook for one minute and left for exactly five minutes away from the light at a temperature from 15 to 25°C.
- We added 75 mL of distilled water. We titrated the liberated iodine with the sodium thiosulphate solution.
- The peroxide value (PV) is expressed in milliequivalents of active oxygen per kilogram of olive oil.

$$PV = \frac{V \times T \times 1000}{m}$$

Where:

V = the volume of the standardized sodium thiosulphate solution (mL)

T = the exact molarity of sodium thiosulphate solution (0.01 mol/L)

m= the weight of the test portion (g)

II.3.3. Rancimat test

The test was performed by a Metrohm Rancimat 679 model, with six reaction vessels. It consists on the acceleration of the oxidation of the oil with giving high flow of air and high temperatures. Three reaction vessels were activated number 1, 4 and 6 respectively for the samples A, B and C. Three grams of olive oil from each sample were weighted into the reaction vessels and the analysis was conducted at the following parameters:

- Temperature 120°C
- Air flow rate: 10 liters of air per hour
- 60 mL of distilled water into the measuring vessel
- Speed chart of the paper: 1 cm per hour

II.3.4. Color

The measurement was performed by a Chroma meter CR-300 instrument (the Konica Minolta series), which is a compact tristimulus color analyzer for measuring reflective colors of surfaces, by the method L.a.b. A Pulsed Xenon Arc (PXA) lamp inside a mixing chamber provides diffuse, uniform lighting over the 8 mm diameter specimen area. Only the light reflected perpendicular to the specimen surface is collected by the optical-fiber cable for color analysis. The theory of the colorimeter is based on the principle of additive synthesis trichrome.

II.3.5. Fatty acids

We used the method A from the European Community Regulation, the trans-esterification with cold methanolic solution of potassium hydroxide. The fatty acids were observed as their methyl esters (Fatty Acid Methyl Esters, F.A.M.Es).

Principle:

Methyl esters are formed by trans-esterification with methanolic potassium hydroxide as an intermediate stage before saponification takes place.

Procedure:

- In 5 mL screw-top test tube, we weighted approximately 0.1 g of the oil sample.
- We added 2 mL of heptane, and shook.
- We added 0.2 mL of 2 N methanolic potassium hydroxide solution, put on the cap fitted with a PTFE joint.
- We tightened the cap, and shook vigorously for 30 seconds.
- We left to stratify until the upper solution becomes clear.
- We decanted the upper layer containing the methyl esters.
- We injected into the Gas Chromatograph

Gas Chromatograph characteristics

- PERKIN ELMER, Model 8600;
- Detector FID (Flame Ionization Detector) at 250°C;
- Split splitless injection at 250°C;
- Capillary column SUPELCOWAX th – 10; 30 M of length x 0.32 mm of internal diameter, 0.5 µm film thickness;
- Oven temperature 145°C 235°C (17 minutes);
- Carrier gas: Helium 12 PSIG;
- Auxiliary gases: air (150 Kpa) and H_2 (100 Kpa).

II.3.6. Total polyphenols

The total polyphenols were extracted according to Folin Ciocalteu's method

Procedure:

- We weighted 2 g from the oil sample.
- We added 2 mL of methanol and H_2O for extraction of total polyphenols (we made three extractions in order to extract all the phenols).

- We mixed in Vortex apparatus for 2 minutes.
- We centrifuged for 3000 turns per minutes, for 3 minutes.
- The extract was removed and collected, and the *n*-hexane layer was subjected to another extraction. We repeated the same operation twice, and we mixed all the three extracts.
- We added to the mixture of extracts, 1 mL of *n*-hexane to delete the oil which remained.
- Then, we put again in vortex apparatus for 2 minutes.
- Centrifugation (3000 turns per minutes for 3 minutes).
- We took out the upper layer which contained the oil, we saved the layer down, for which we added distilled water till 25 mL.
- We took 10 mL of the last solution; we added 50 mL of distilled water, 5 mL of Folin Ciocalteu's reagent (yellow green color), and 20 mL of Na_2CO_3. Finally, we completed with distilled water to 100 mL.
- The blank was prepared with 5 mL of reagent, 20 mL of Na_2CO_3 and completed with water.
- We put the samples in the dark overnight at ambient temperature.
- We read in spectrophotometer apparatus for the wavelength 725 nm.
- The total phenolic content was expressed as gallic acid equivalence (ppm), as follows:

$$Xppm = \frac{Cx \times 10 \times 25}{weight\ (g)}$$

Where:

C_x the concentration of the sample

$$Cx = \frac{ABS - b}{slope}$$

ABS: the absorbance at 725 nm

II.3.7. Spectrophotometry characteristics Principle

The fat in question is dissolved in the required solvent and the extinction of the solution is then determined at the specified wavelengths with reference to pure solvent. Specific extinctions are calculated from the spectrophotometer readings.

Procedure:

- We weighted 0.25 g of the sample, prepared into a 25 ml graduated flask, we made up to the mark with the solvent specified and homogenized (Isooctane).

- We filled a cuvette with the solution obtained and we measured the extinctions at appropriate wavelengths (232, 266, 270 and 274 nm).
- We recorded the specific extinctions (extinction coefficients) at the various wavelengths calculated as follows:

$$K\lambda = \frac{E\lambda}{c \times s}$$

Where:

K_λ = specific extinction at wavelength λ

E_λ = extinction measured at wavelength λ

c = concentration of the solution in g/100 ml

s = thickness of the cuvette in cm

$$\Delta K = Km - \left[{}^{[K(m-4)+K(m+4)]}/_{2} \right]$$

Where:

K_m = specific extinction at wavelength m

II.3.8. Polyphenolic analysis by H.P.L.C.

The phenolic compounds composition was determined by High Performance Liquid Chromatography (H.P.L.C.), according to the method described by Pirisi *et al*. (2000) as following:

- 2 g of olive oil were weighted from each sample in a centrifuge tube;
- We added 200 µl of internal standard (Gallic acid: 10 mmoles with 0.0122 g/25 mL) and, 2 mL of methanol/water (80:20, v/v);
- The mixture was stirred in Vortex apparatus for 2 minutes;
- Centrifugation at 4000 rpm for 3 minutes;
- The methanol layer was separated and the extraction repeated twice;
- After collecting the three extracts, we evaporated to dryness under vacuum in Rotavapor instrument in low temperature (less than 35°C);
- The residue was dissolved into 1 mL of Methanol/water (1/1, v/v);
- Then, we filtered it with a filter of syringe ;

- We analyzed in H.P.L.C. instrument.
- The concentration in ppm of the phenolic compound is calculated as following:

$$\frac{Ps}{Px} = K\ \frac{As}{Ax} \rightarrow Px = \frac{Ax}{As} \times \frac{Ps}{K}$$

$$P'x(ppm) = \frac{Px \times 1000}{The\ weight\ of\ the\ sample}$$

Where:

P_s= the concentration of the internal standard, the Gallic acid, 0.0976 mg/200µl

P_x= the concentration of the phenolic compound (mg/µl)

K = the response factor, different for each phenolic compounds

A_s= the area of the internal standard observed in the graph obtained from the H.P.L.C.

A_x= the area of the phenolic compound

P'_x =the concentration in ppm of the phenolic compound

H.P.L.C. instrument characteristics (Figure 4)

- Knauer HPLC system (Asi Advanced Scientific Instruments, Berlin, Germany);
- A Smartline pump 1000 and a H.P.L.C. column Polymer Laboratories C18 (4,6mm I.D. x 250 mm, particle size 5 µm), protected with a precolumn (4,6 mm I.D., analytical particle size 5 µm.);
- An UV detector Waters and a Rheodyne injection valve (20 µL loop);
- Mobile phase utilised, consisted of a mixture water/acetic acid (98:2, v/v, solvent A), methanol and acetonitrile (50:50, v/v, solvent B);
- The elution gradient was from 95% (A) – 5% (B) to 70% (A) – 30% (B) in 25 min, to 60% (A) – 40% (B) in 10 min, to 52% (A) - 48% (B) in 5 min, to 30% (A) – 70% (B) in 10 min, followed by 100% (B) in 5 min, to 95% (A) – 5% (B) in 5 min.
- The chromatograms were recorded at 280 nm using gallic acid as internal standard and identified by comparison with relative retention times of pure compounds.

Figure 4: *H.P.L.C. instrument.*

II.4. Statistical analysis:

the results of the three Algerian samples are expressed as the mean of three values ±deviation standard.

III.RESULTS AND DISCUSSION

III.1. Chemical and physical characteristics of different olive oils

The chemical and physical characteristics of the olive oils are shown in the table II. With regards of Algerian olive oil, as expected, the sample C has better characteristics than the two other samples. The olives were collected in the right moment, when they were not completely ripe, in order to preserve the quality of the oil. Then, the oil was extracted from olives within 24 hours from the harvest. Finally, modern machinery was used in appropriate working conditions (temperature < 27°C) and well maintained (cleanness), while with the two other samples where the olives were exposed to the sun which decreased the phenol content and increased the value of peroxides.

Samples Parameters	A	B	C	D (1)	E (2)	F (3)	G (4)	H (5)
Acidity (As oleic acid %)	2.23±0.03	1.41±0.03	0.42±0.01	0.36	1.25	0.37	0.41	0.78
Peroxide value (meq O_2/kg)	10.00±1.00	8.00±0.87	7.00±1.00	7.29	12.29	5.19	12.85	18.76
Induction time (h)	3.68±0.01	5.03±0.02	7.32±0.04	8.24	5.28	8.90	7.68	5.48
K_{232}nm	3.683±0.004	2.415±0.002	2.260±0.021	1.455	1.851	1.556	1.866	2.276
K_{266}nm	0.263±0.001	0.199±0.002	0.179±0.004	0.109	0.219	0.102	0.157	0.115
K_{270}nm	0.248±0.001	0.191±0.002	0.177±0.001	0.109	0.131	0.101	0.148	0.108
K_{274}nm	0.218±0.001	0.175±0.002	0.168±0.002	0.109	0.122	0.097	0.144	0.101
ΔK	0.0075±0.0001	0.004±0.002	0.0035±0.0002	-0.0004	0.003	0.0013	- 0.0027	0.000
K_{232}nm/ K_{270}nm	14.85±0.07	12.64±0.029	12.77±0.026	13.69	14.13	15.41	12.61	21.07
Total polyphenols (ppm)	27±1.15	54±2.00	144±3.61	215	85	184	98	110
Color	L: 30.32±0.02 a: -0.31±0.01 b: 6.67±0.05	L: 29.97±0.025 a: -0.75±0.031 b: 7.01±0.021	L: 30.20±0.36 a: -1.04±-0.02 b: 7.20±0.33	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _

Table II. *Chemical and physical characteristics of different olive oils.*

(1): Giuffrè, 2006a.

(2): Giuffrè, 2006b.

(3): Giuffrè, 2005.

(4): Giuffrè, 2002a.

(5): Giuffrè, 2002b

According to European Regulation No 1513/2001 (E.C., 2001) and I.O.C. Regulation (I.O.C., 2006), concerning the acidity, the oil of sample C is considered as an extra virgin olive oil (maximum 0.8%). The oil of the sample B is considered as a virgin olive oil (maximum 2.0%). The oil of the sample A is considered as lampante virgin olive oil according to European Regulation (E.C., 2001), exceeding the 2.0% of free acidity, and ordinary virgin olive oil according to I.O.C. Regulation (I.O.C, 2006), as the value doesn't exceed the 3.3% of free acidity. Comparing with Italian olive oils, the oil of sample C can be similar with the oils of the western side of Reggio Calabria Province (cv. Ottobratica (sample D) and cv.Tonda

Iblea (sample F)), Apulia (cv. Peranzana, sample G) and Campania (sample H). The oil of the sample B is almost similar to the oil of Montebello Jonico (sample E), in the eastern side of Reggio Calabria Province (Table II). The figure 5 shows the classification of the different compared samples for acidity values, we can see that the highest value is observed in the sample A following by the sample B, those two values are higher because of the extraction system which is used and the exposition of the olives to the light which influence negatively on the acidity percentage.

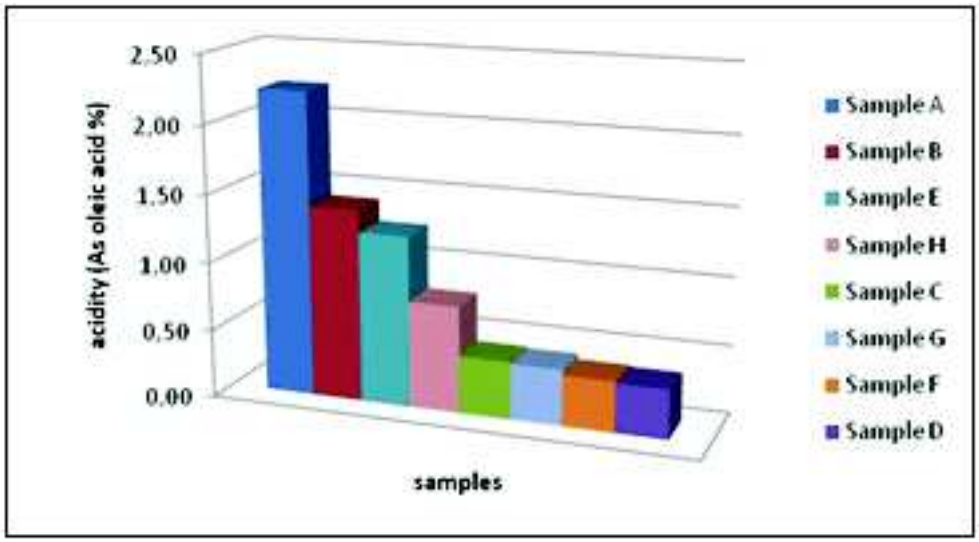

***Figure 5**: histogram of acidity values of the different samples.*

The peroxide value of the Algerian olive oil is well correlated with the induction time (R^2=0.964) (Figure 6). Those observed values are more than acceptable, according to European Regulation (E.C., 2001) and I.O.C. Regulation (I.O.C, 2006) (≤ 20 meq O_2/kg). The oil of the sample C has the lowest value of Peroxide as it is shown in figure 7, better than oil produced in Reggio Calabria (sample D, cv. Ottobratica), Montebello Jonico (sample E), Apulia (sample G) and Campania (sample H).

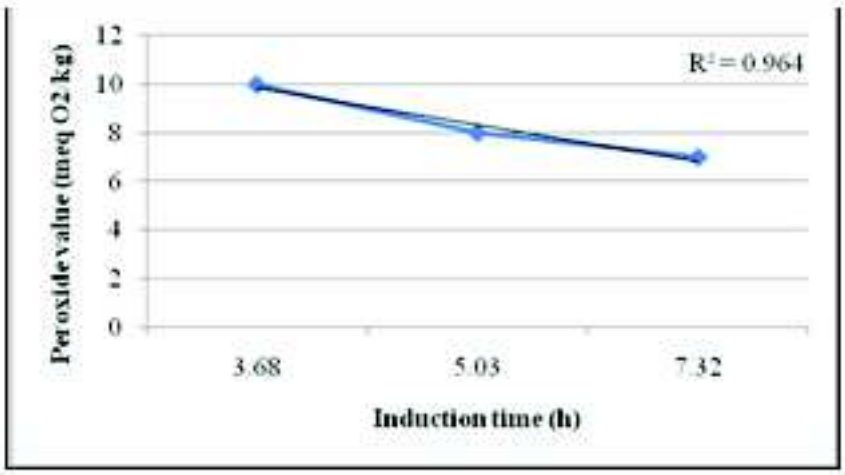

***Figure 6** : Correlation between peroxide value and induction time.*

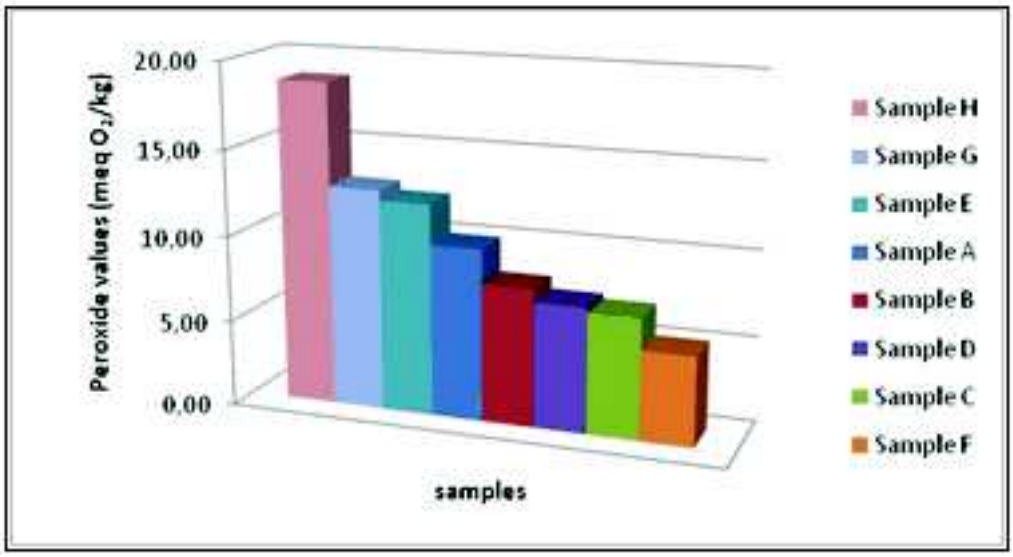

***Figure 7**: histogram of Peroxide values of the different samples.*

Figure 8 shows the Rancimat test. The results expressed in hours define the resistance of oils to oxidation. As reported in table I, the highest value of the induction time of Algerian olive oils, was observed in sample C, confirming the high correlation with the peroxide value (Figure 6). If compared to Italian samples, the induction time of sample C is less than the ones of Reggio Calabria (sample D, cv. Ottobratica and sample F, cv. Tonda Iblea) and Apulia (sample G).

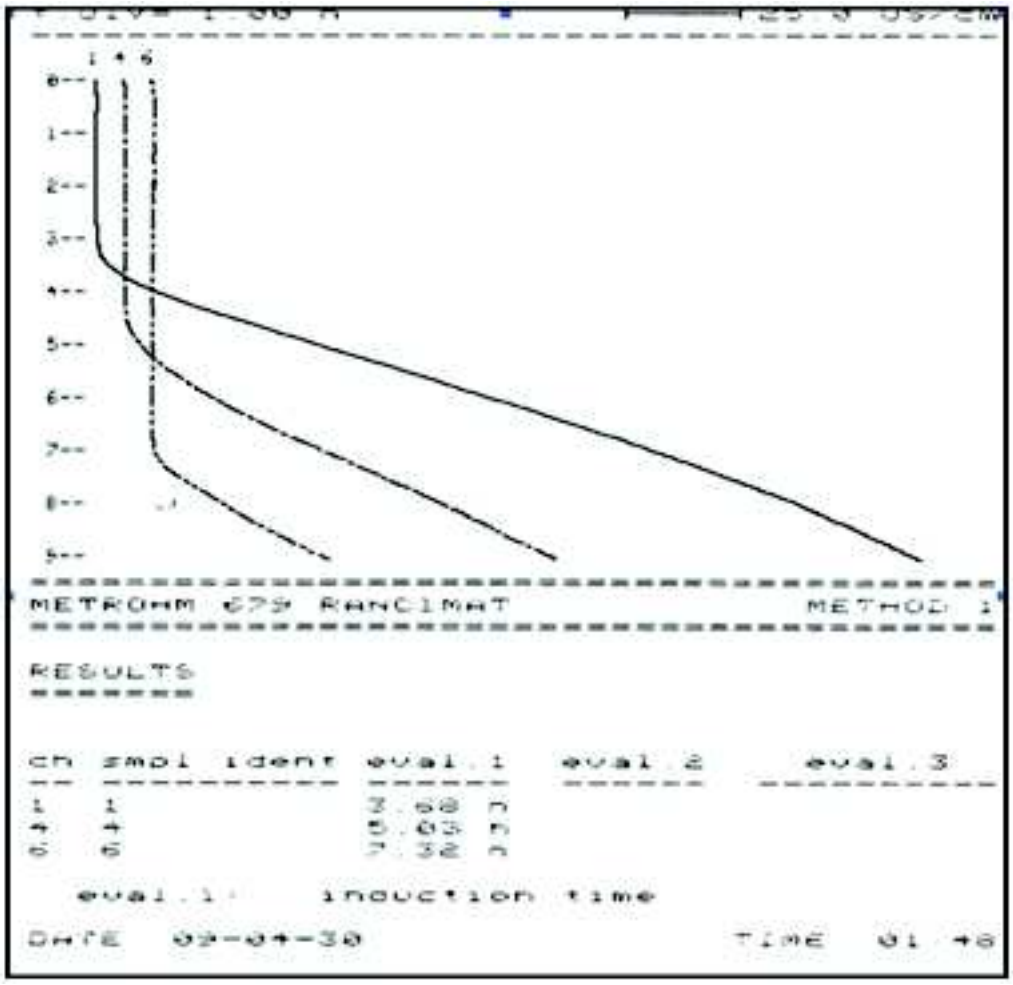

***Figure 8**: Rancimat profile.*

For the spectrophotometry characteristics, the sample B and C show values of K_{232} and K_{270} acceptable by European Regulation (E.C., 2001) and I.O.C. Regulation (I.O.C, 2006) (respectively ≤ 2.50 and ≤ 0.22). The sample A has the highest value of K_{232} and both parameters (K_{232} and K_{270}) describe the sample A as a "lampante olive oil". Comparing to the Italian samples, the value of K_{232} is the highest for Algerian samples.

According to our experience, concerning the total phenols in the ambit of olive oil, we can claim that a good extra virgin olive oil has to contain more than 300 ppm of those compounds. However, the values of the sample A and B are very low compared with the oil of the sample C (figure 9) where the value is higher than the total polyphenols of Apulia (sample G) and Campania (sample H), but lesser than the values of Calabria. Morello *et al.,* (2004) showed that during storage of the olive oil, phenolic compounds undergo qualitative and quantitative modifications due to decomposition and oxidation reactions. Scientifically, it is proved that 12 to 18 months is the maximum storage period from bottling to consumption. We can see in the figure 9 that Italian samples had better values of total phenols but the sample C had a good value comparing with the two other Algerian samples where values are the lowest, because of the extraction and storage conditions which are the worst.

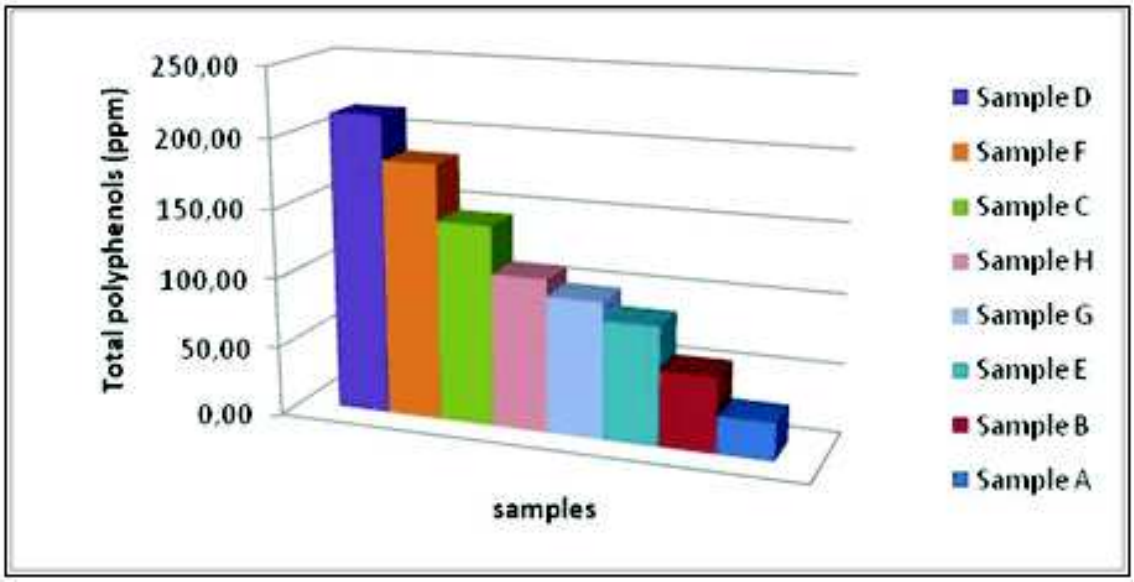

***Figure 9**: histogram of total polyphenols values of the different samples.*

Color analysis showed "L" values closed between 30.32 and 29.97. The "- a" values, describing the greenness of the oils, were -0.31, -0.75 and -1.04 respectively for samples A, B and C; this means that the sample C was greener than the two other Algerian samples. The "+ b" value, describing the yellowness of the oils, were 6.67, 7.01 and 7.20 respectively for samples A, B and C; this means that the sample C is yellower than the two other Algerian olive oils.

III.2. Fatty acid composition

Table III and the figure 10 depict the fatty acid composition of the Algerian olive oils, also compared with some Italian olive oils. The percentage of the fatty acids observed in the three Algerian oils can be well accepted by the European Regulation (E.C., 2001) and I.O.C. Regulation (I.O.C., 2006), except in the sample C where the value of the arachidic acid whose value is higher than the limit accepted by the two regulations (≤ 0.6%). The sum of saturated fatty acids (S.F.As) is highest in the sample C while it is the lowest for the unsaturated fatty acids (U.F.As), if compared with the Italian olive oils and with the two other Algerian olive oils.

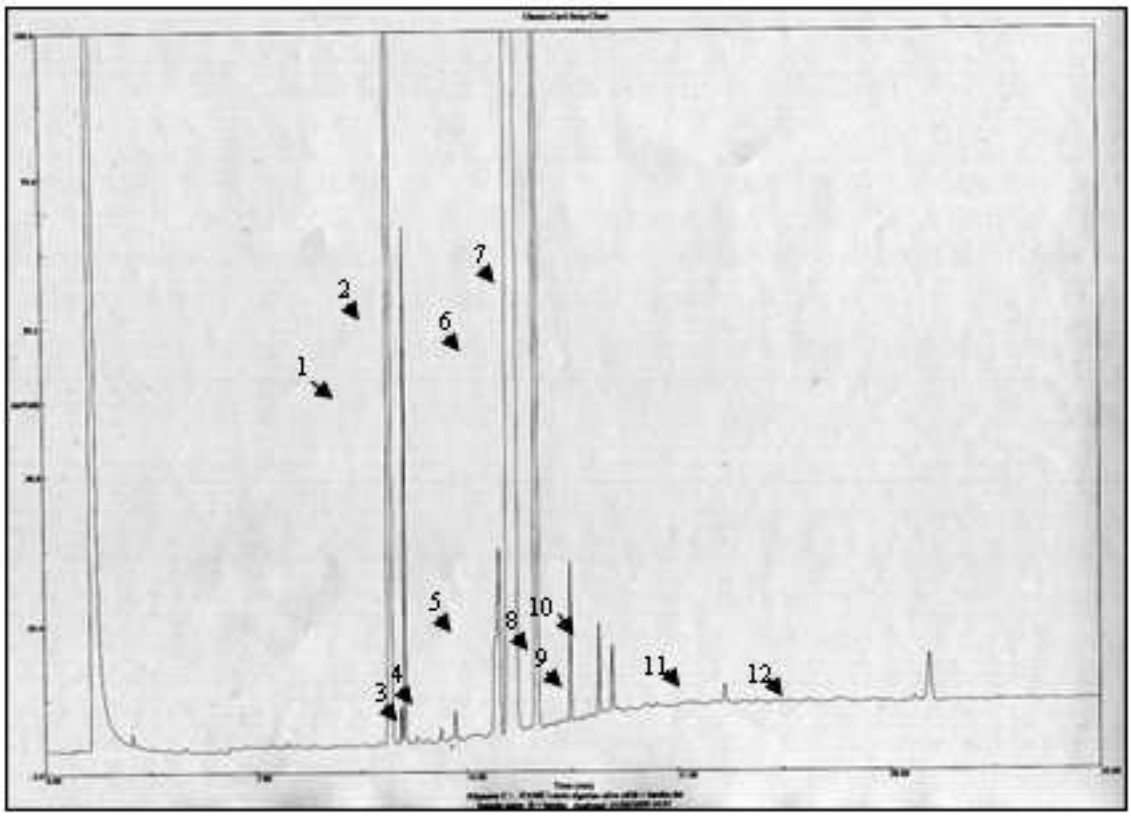

Figure 10: *Fatty Acid Methyl Esters gas chromatographic profile of Algerian olive oils.*

1. Palmitic. 2. Palmitoleic. 3. Margaric.

4.Margaroleic. 5. Stearic. 6. Oleic. 7. Linoleic. 8. Arachidic. 9. Linolenic. 10. Gadoleic. 11. Behenic. 12. Lignoceric

Fatty acids	Sample A	Sample B	Sample C	Sample D (1)	Sample E (2)	Sample F (3)	Sample G (4)	Sample H (5)
C14:0 (%)	_	_	_	0.01	_	0.03	_	_
C16:0 (%)	15.00±0.87	14.15±0.14	18.59±0.04	15.33	11.43	16.60	14.45	11.84
C16:1(%)	2.24±0.07	1.88±0.02	2.82±0.06	1.79	0.90	2.27	0.99	0.81
C17:0 (%)	0.03±0.02	0.06±0.01	0.03±0.004	0.17	0.18	0.05	0.07	0.08
C17:1 (%)	0.17±0.04	0.11±0.06	0.16±0.07	0.25	0.22	0.09	0.10	0.11
C18:0 (%)	1.93±0.01	2.07±0.07	1.84±0.03	1.87	2.52	1.55	2.27	2.92
C18:1 (%)	64.09±0.12	67.48±0.04	61.41±0.10	69.23	75.77	66.59	71.16	75.05
C18:2 (%)	15.39±0.07	12.93±0.07	13.63±0.06	9.84	7.60	11.47	9.47	7.71
C20:0 (%)	0.52±0.08	0.57±0.04	0.73±0.04	0.38	0.55	0.24	0.34	0.40
C18:3 (%)	0.30±0.12	0.35±0.05	0.37±0.06	0.63	0.39	0.85	0.70	0.62
C20:1 (%)	0.21±0.04	0.26±0.06	0.27±0.06	0.30	0.28	0.18	0.30	0.24
C22:0 (%)	0.08±0.03	0.11±0.04	0.11±0.06	0.13	0.12	0.05	0.11	0.14
C 24:0 (%)	0.04±0.01	0.03±0.01	0.04±0.02	0.07	0.04	0.03	0.04	0.08
Σ SFA	17.60±0.88	16.99±0.18	21.34±0.02	17.96	14.84	18.55	17.28	15.46
Σ UFA	82.40±0.25	83.01±0.21	78.66±0.21	82.04	85.16	81.45	82.72	84.54
Σ MUFAs	66.71±0.13	69.73±0.18	64.66±0.16	71.57	77.17	69.13	72.55	76.21
Σ PUFAs	15.69±0.13	13.28±0.12	14.00±0.11	10.47	7.99	12.32	10.17	8.33
UFA/SFA	4.68±0.22	4.89±0.05	3.69±0.01	4.58	5.83	4.39	4.81	5.47
C 18:1/C18 :2	4.16±0.01	5.22±0.03	4.51±0.03	7.08	10.00	5.81	7.56	9.78
C 18:1+C18 :2	79.48±0.18	80.41±0.09	75.04±0.04	79.07	83.37	78.06	80.63	82.76
MUFA/SFA	3.79±0.18	4.10±0.04	3.03±0.01	3.99	5.20	3.73	4.19	4.93
MUFA/PUFA	4.25±0.03	5.25±0.05	4.62±0.04	6.87	9.50	5.61	7.13	9.31
C 18:1/C16:0	4.27±0.23	4.77±0.05	3.30±0.01	4.52	6.66	4.01	4.92	6.35
C16 :0/ C18 :2	0.97±0.05	1.09±0.02	1.36±0.01	1.57	1.51	1.45	1.53	1.55

Table III. *Fatty acid composition of the three Algerian olive oils compared with the Italian olive oil.*

(1): **Giuffrè**, 2006a.

(2): **Giuffrè,** 2006b.

(3): **Giuffrè,** 2005.

(4): **Giuffrè**, 2003.

(5):**Giuffrè**, 2002b

Compared with the samples A and B and with Italian olive oils, the sample C has the lowest value of oleic acid (C18:1) (61.42%). The ratio oleic acid/linoleic acid (C18:1/C18:2) is lower in the sample A (4.16) than in the two other samples and the Italian olive oils. Among Algerian olive oils, the sample C shows the lowest ratio oleic acid/palmitic acid (C18:1/C16:0) (3.30) and in the same time, the highest ratio of palmitic acid/linoleic acid (C16:0/C18:2) (1.36). Also, compared to the Italian olive oils, the two ratios are the lowest in the sample C.

Regarding the fatty acid contents, a negative aspect of the studied olive oils is that the percentage of polyunsaturated fatty acids (P.U.F.As) is higher than the one of the Italian olive oils considered in this work. Reciprocally, in Algerian olive oils, the sum of monounsaturated fatty acids (M.U.F.As) is generally lower than the sum in Italian olive oils, except for the sample B, where the M.U.F.As' content is approximately similar to the sample F.

III.3. Polyphenols composition

Concerning the total phenols in the ambit of olive oil, we can claim that a good extra virgin olive oil has to contain more than 300 ppm of those compounds calculated as colorimetric data (Tura *et al.,*2007; Caponio *et al.,* 1999). However, the values of the sample A and B are very low compared with the oil of the sample C where the value is higher than the total phenols of Apulia (sample G) and Campania (sample H), but less than the values of Calabria.

Table IV shows the quantitative composition (ppm) of the simple and complex phenols determined by H.P.L.C. analysis of the studied olive oils. This table considers the presence of 11 phenolic compounds.

Polyphenols (ppm)	**Sample A**	**Sample B**	**Sample C**
1- Phenolic acids			
p-Coumaric acid	6.35±0.06	4.88±0.01	1.59±0.04
o-Coumaric acid	0.14±0.02	0.30±0.08	0.21±0.04
Cinnamic acid	_	_	3.04±0.06
2- Phenolic alcohols			
Hydroxytyrosol	0.55±0.01	1.96±0.05	2.47±0.06
Tyrosol	1.67±0.05	4.31±0.06	10.56±0.06
3- Lignans			
Pinoresinol	13.40±0.07	10.30±0.09	45.82±0.03
1-Acetoxypinoresinol	7.95±0.11	7.43±0.05	20.45±0.05
4- Secoiridoids			
Dialdehydic form of decarboxymethyl oleuropein aglycon	_	0.14±0.05	3.52±0.01
Dialdehydic form of decarboxymethyl ligstroside aglycon	1.33±0.06	1.26±0.05	1.57±0.03
Dialdehydic form of oleuropein aglycon	0.85±0.07	0.76±0.06	2.89±0.08
Dialdehydic form of ligstroside aglycon	1.78±0.06	0.74±0.01	3.53±0.01

***Table IV**. Polyphenols composition*

The main simple phenols found in the Algerian olive oils were hydroxytyrosol and tyrosol (figure 11). Tyrosol concentration was higher than hydroxytyrosol. Brenes *et al.* (2001) demonstrate that the main changes in the phenolic compounds present in virgin olive oil were associated to hydrolysis of the secoiridoid aglycons. like oleuropein and ligstroside aglycons. These compounds participate in the bitter taste and stability of the oil. The figure 11 shows that for the three samples, the content of tyrosol is higher for the three samples, highest for the sample A. These reactions were influenced by the acidity of the oil and the filtration step. According to Di Benedetto *et al.* (2007), Hydroxytyrosol was found as quickly inside the cells as it disappeared, probably because it was metabolized or released. Tyrosol, indeed, accumulated intracellularly with time, and in so doing, it was likely to reach useful concentrations to exert its protective effects in the long term. However, it is again noteworthy that the concentrations at which they exerted the protective effects were very different: hydroxytyrosol acted at concentrations about a thousand times lower than tyrosol.

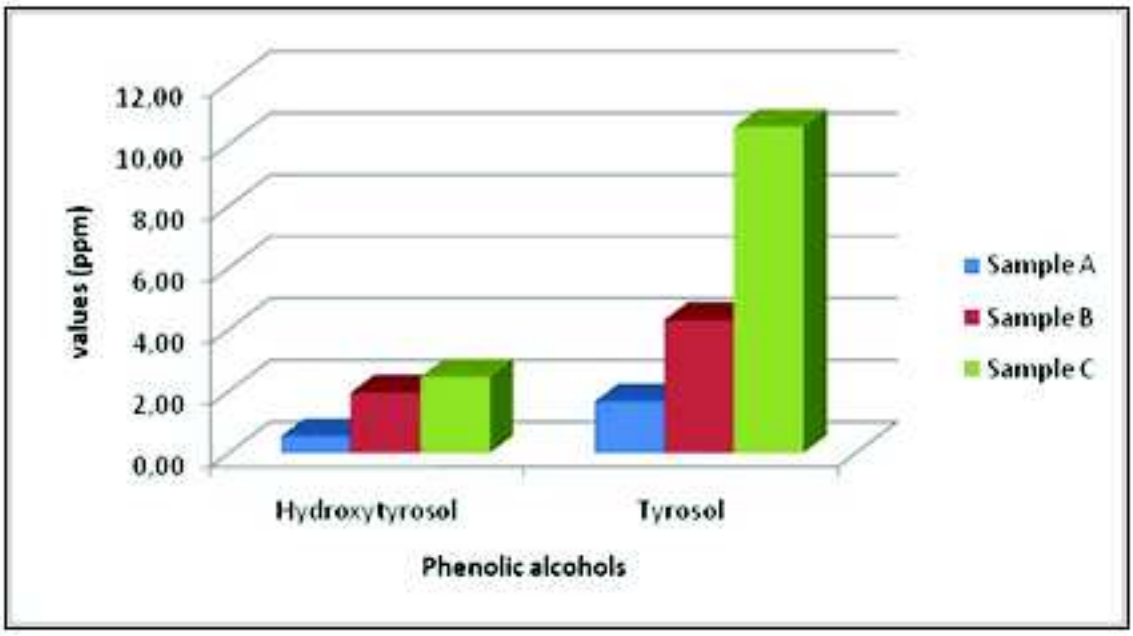

***Figure 11**: histogram of phenolic alcohols values of the Algerian samples.*

The quantified aglycon derivatives were the dialdehydic form of the decarboxymethyl oleuropein aglycon, the dialdehydic form of the decarboxymethyl ligstroside aglycon, the dialdehydic form of the oleuropein aglycon, the dialdehydic form of the ligstroside aglycon and the dialdehydic form of the oleuropein aglycon (figure 12). During extraction processing the concentration of cited compounds can be influenced by oxidation reactions and partition between colloidal and liquid phases.

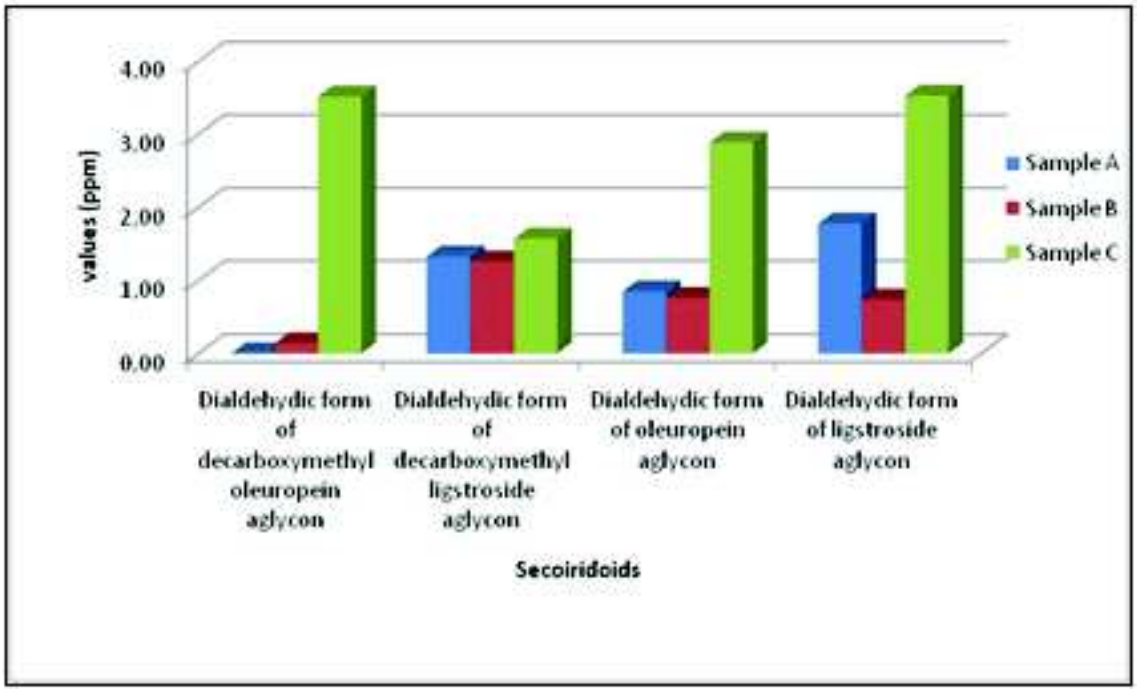

***Figure 12**: histogram of secoiridoids values of the Algerian samples.*

Rovellini and Cortesi (2002) and Bonoli *et al*. (2004) demonstrated that the dialdehydic form of decarboxymethyl oleuropein aglycon and the dialdehydic form of decarboxymethyl ligustroside aglycon show decreasing trends through the ripening. This is confirmed by our results (figure 12) which revealed that the maximum values of the two compounds, 3.52 ppm for the dialdehydic form of decarboxymethyl oleuropein aglycon and 1.57 ppm for the dialdehydic form of decarboxymethyl ligustroside aglycon, are observed in the sample C, derived from olives collected in November, while, in the sample A and B derived from olives collected in January, the content of these two compounds was lower than the one of sample C.

The *p*-coumaric, *o*-coumaric and cinnamic acids were the revealed phenolic acids (figure 13). Other researchers (Caponio *et al.*, 1999; Montedoro, 1992; Tsimidou *et al.*, 1992a; Tsimidou *et al.*,1992b) reported that among this fraction the most represented was the *p*-coumaric acid and it is in accordance with our Algerian olive oils, where it was found 6.35 ppm (sample A), 4.88 ppm (sample B) and 1.59 ppm (sample C), while the *o*-coumaric content is always lower than 0.50 ppm. Cinnamic acid was present just in the sample C (3.04 ppm)

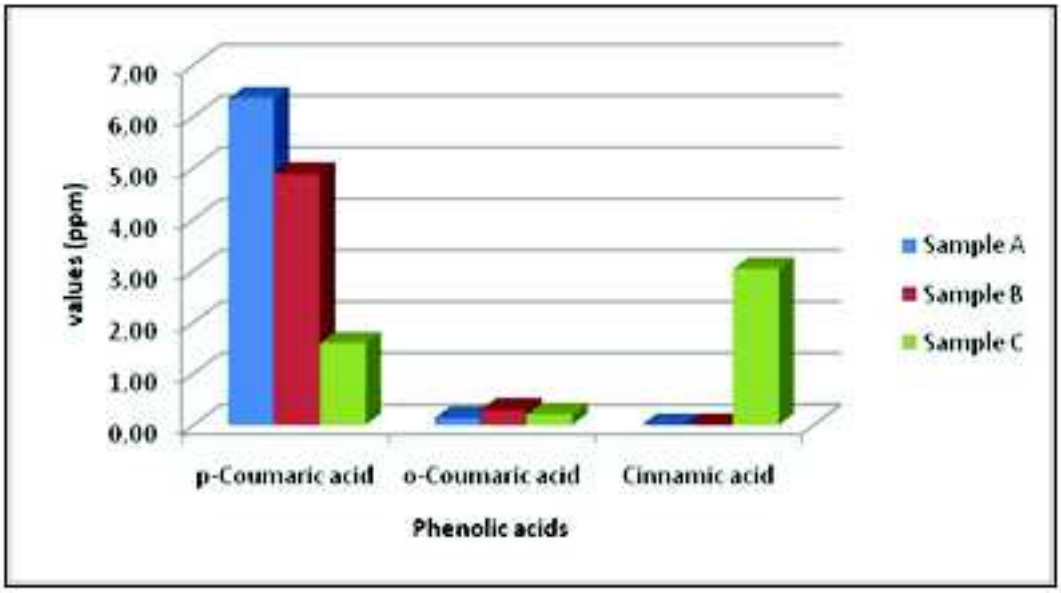

***Figure 13**: histogram of phenolic acids values of the Algerian samples.*

The phenol analysis shows the high level of lignan compounds (figure 14) as 1-acetoxypinoresinol and pinoresinol of the fraction extracted from Algerian olive oil. Pinoresinol is almost two times higher than 1-acetoxypinoresinol. As reported in literature, these compounds are mainly present in the olive endocarp and practically absent in the pulp and leaves. Their quantification in olive oil is probably due to a hard mechanical effect in the drupes during the extraction process (Owen *et al.*, 2000). So the concentration was due to plant characteristics but is also related to the fruit size and pulp/stone ratio.

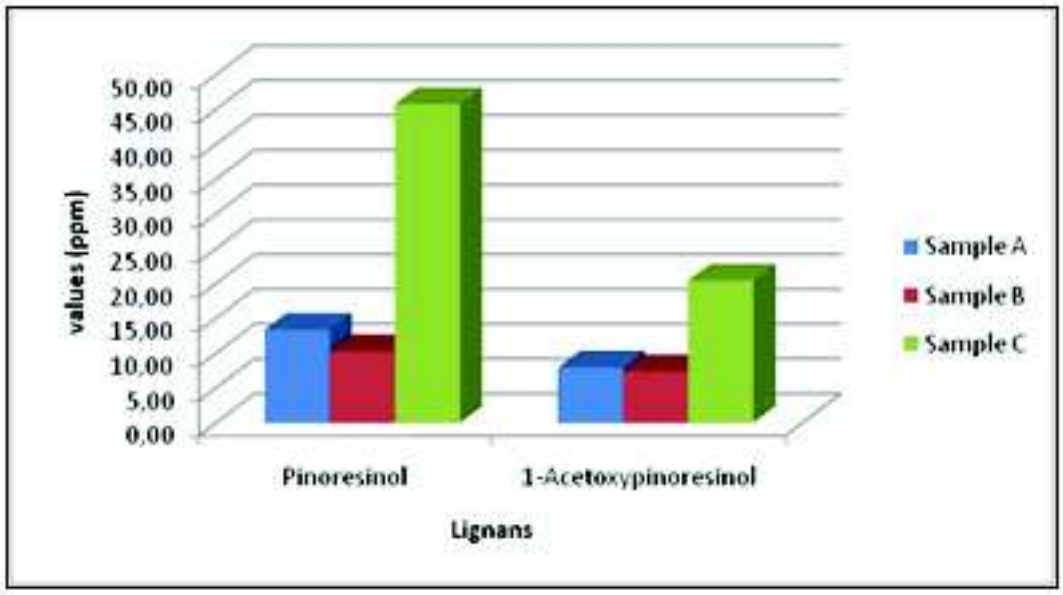

***Figure 14**: histogram of lignans values of the Algerian samples.*

CONCLUSION

From this study, we can tell that the oil of the sample C, which was cultivated in Ifri farm in Ighzer Amokrane (Béjaïa province), extracted with a modern system and the olives were collected in November, when the olives were not completely ripe and directly transformed to oil, has the best characteristics (0.42% of acidity, 7 meq O_2/kg, 144 ppm of total polyphenols, …) and it has also some characteristics which are better than some Italian oils, comparing this oil to the sample E (coming from the Eastern side of Reggio Calabria Province, in the south of Italy) and the sample H (coming from coming from Campania Region, in Avellino Province, the region is upper), we can see that the oil from the sample C, had a better acidity than the two last described samples, had a better peroxide value and better total polyphenol content, comparing it to the last describes samples and the sample G, which is coming from Apulia Region. For the two other Algerian samples, the characteristics are the worst.

Let's say that the oil of sample C, Algerian one can be in the same or better level internationally or at least comparing it to the different Italian oils, it can be acceptable oil because it is adequate to IOC regulation and also to EC regulation.

In Algeria, there is the willing to improve the local production of olive oil and consequently to increase the internal market. The aim in the medium term is to create new marketing channels abroad. From our study, it appears that Algerian olive oil has all potentialities to address these challenges. It is clear that the productive situation should be improved, mainly the harvest and the transformation conditions.

In any case, it is agreed that from the quality point of view, the exposure of olives to the sun, as it is done in some places of Algeria for decreasing the humidity of olives, is not suitable. In fact, this archaic practice already determines the low chemical quality and especially the nearly absence of aromas. The quantitative aspect of the production is not the only one to take into consideration. In fact, the chemical and biological aspects (presence of antioxidants) and also organoleptic ones are fundamental for the commercial success of the olive oil, especially in a market where many competitors promoting high quality products exist.

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ANNEX

Cultivar characteristics	Chemlal	Azeradj	Bouichret
Synonyms	Achamlal, Achamli, and Achemlal	Aradj, Adjeraz	Boutichrat (Avouichert)
Origin	Kabylie	Kabylie (Seddouk region, Béjaia)	Tazmalt (Béjaia)
Diffusion (% of the national area for oliviculture)	40%	10%	Local diffusion
Utilization	olive oil	Double aptitude (olive oil and table olives)	Olive oil
Agronomical and commercial characteristics	- Rustic and late variety - Small rate of rooting - Self-sterile variety, always associated with other varieties which ensured pollination like Azeradj and Sigoise - High productivity and not very alternate - Olive oil yield: 18 to 22% - More often confused wrongly with "Chemlali" Tunisian variety	- Often associated with Chemlal for pollination - Season variety, resistant to drought - Early flowering with weak intensity - Small rate of knotting (0.70%) - High ratio pulp/stone (8.70%) - Difficult separation of the pulp from the stone - Medium and alternate productivity	- In association with Aharoun variety and chemlal - Olive oil yield: 20 to 24% - Rustic and late variety - Early flowering with weak intensity - Medium rate of knotting (2.70%) - Low ratio pulp/stone (4.00%) - Medium and alternate productivity
Morphological characteristic			
Tree: - Vigor - Port - Foliage density - Length between nodes	 - Strong - Upright - Medium - Medium	 - Weak - Spread - Compact - Medium	 - Weak - Upright - Loose - Short
Leaf: - Form - Length - Width - Longitudinal curvature of blade	 - Elliptical lanceolate - Medium - Medium - Plane	 - Elliptical lanceolate - Medium - Medium - Plane	 - Lanceolate - Long - Medium - Plane
Inflorescence: - Length - Number of flowers	 - Medium - Medium	 - Short - Small	 - Short - Small
Fruit: - Weight - Form - Symmetry - Position of the maximal transversal diameter - Top - Base - Nipple - Lenticels - Dimension of lenticels - Beginning of veraison - Color in the full maturation	 - Weak - Elongated - Asymmetric - Central - Pointed - Rounded - Absence - Numerous - Small - Uniform - Black	 - High - Elongated - Slight asymmetry - Toward base - Pointed - Rounded - Bud - Not numerous - Big - From the top - Black	 - Medium - Elongated - Asymmetric - Toward base - Pointed - Rounded - Bud - Not numerous - Big - Uniform - Black
Endocarp - Weight - Form - Symmetry A - Symmetry B - Position of the maximal diameter - Top - Base - Surface - Number of fibro vascular furrows - Distribution of fibro vascular furrows - Extremity of the top	 - Medium - Elliptical - Slightly asymmetric - Symmetric - Central - Pointed - Rounded - Smooth - Medium - Uniform - With mucro	 - High - Elliptical - Slightly asymmetric - Symmetric - Central - Pointed - Rounded - Smooth - Medium - Uniform - With mucro	 - High - Elongated - Asymmetric - Symmetric - Central - Pointed - Rounded - Rough - Medium - Uniform - With mucro

Cultivars' characteristics