

Studies on physico-chemical characteristics and fatty acid composition of commercially available Algerian frying edible oils

*Sadoudi, R. and Ali Ahmed, D.

Agriculture Department, Faculty of Biology and Agriculture, "Mouloud Mammeri" University of Tizi-Ouzou, 15000, Algeria

Article history

Received: 20 September 2015

Received in revised form:

12 May 2016

Accepted: 6 June 2016

Keywords

Frying

Vegetable oils

Algeria

Characterization

Abstract

In the present study various physical and chemical characteristics have been studied and may be used for quality control of main edible vegetable oils sold on the Algerian market, namely: Afia, elio, fleurial, La Belle and Oleor. Result obtained indicated that all oils were consistent with norms established indicative of edible oils with good quality: Free Fatty Acid ranged from 0.044 to 0.054%, peroxide value varied from 1.61 to 2, iodine value ranged from 124.07 to 129.91, saponification value (189.01 to 192.21), density at 20°C (0.917-0.921) and refractive index at 40°C (1.4663-1.4670). However, the oils recorded high PUFA content (mean 60%) suggesting that our oils highly unsaturated and may be susceptible to rancidity. "Fleurial" oil could be more sensitive to oxidation and thermal alteration when compared with the others; this oil had the lowest induction period (8.27 h), lowest activation energy (438.16KJ/mol) and the highest PUFA content (mean 65%); however, at the factory, this oil was enriched on vitamins A and D, which makes it suitable for use as a salad oil.

© All Rights Reserved

Introduction

Vegetable oils are substances derived from oil plants; they are composed of triglycerides which contain primarily polyunsaturated and monounsaturated fatty acids. Oil is extracted primarily from seeds. However, crude oil obtained needs to be refined in order to transform it into a range of useful products for industry and consumers. Oils improve flavor, lubricity, texture, and satiety to foods. They have also been found to have a major role in human nutrition. Oils and fats are the highest energy in comparison to carbohydrates and proteins, carriers for oil soluble vitamins, and many contain fatty acids essential for health that are not manufactured by the human body (O'Brien, 2009).

Algeria shows a large deficit in edible oils. The main produced oil is olive oil. But production hardly covers the needs, what makes it remains highly dependent on imports to supply its market. Thus, high quantities of crude oils are imported. After refining, these oils are sold under different marks. Some oils are pure and others are a blend of two oils. These oils, sold at different prices, are used in cooking and frying notably. The main objective of this study was to characterize frying refined vegetable oils commercialized in Algeria to improve understanding of the oil quality, stability and applicability.

Materials and Methods

Commercially refined vegetable frying oils in Algeria including: Afia, elio, Fleurial, La Belle and Oleor. These oils represent all (five) Algerian manufacturers, i. e. Cevital Bejaïa (two oils: Fleurial and elio), C.O.G.B/La Belle Bejaïa (one oil: La Belle) and Afia International Oran (two oils: Oleor and Afia). These oils are available in the market; they are relatively cheap comparatively to olive oil and available in huge amounts. «La Belle, Oleor and fleurial » oils are pure, while "elio and Afia" oils are obtained by blending two of the following three oils: soybean, sunflower and corn.

These oils, commercialized in a plastic bottle (polyethylene terephthalate), were purchased from local supermarket, Tizi-Ouzou, Algeria, and immediately analyzed separately. Both physical and chemical characteristics of oils were determined. For chemical analysis and fatty acid composition, each oil was analyzed in triplicate. Data were given as arithmetic means \pm standard deviation (SD) for each refined vegetable oils.

Chemical constants of oils

The percentage of free fatty acids (FFA) as oleic acid, the number of milligrams of potassium hydroxide required to neutralize the fatty acids (FA) resulting from complete hydrolysis of one gram of

*Corresponding author.

Email: Sadoudirab@yahoo.fr

oil dissolved in a mixture of diethyl ether and ethanol in the presence of phenolphthalein was determined according to AFNOR NF T 60-204, (1988) recommended method. Placed 10 g of oil into a 200 mL conical flask; added 50 mL ether, 50 mL 95% ethanol, 2 to 3 drops of 1% phenolphthalein indicator; and titrated the mixture with 0,1N sodium hydroxide ethanol solution until the mixture turns pink for at least 10 seconds. The volume of the titrant consumed was recorded as V. FFA content was calculated using the following equation.

$$A(\%) = \frac{V * N * M}{10 * m}$$

Where:

A represents acidity content (%)

V volume of KOH solution used (mL)

N the normality of the KOH solution (0,1N)

m weight of the oil sample (g)

M oleic acid molar mass (282,5 g/mol).

Peroxide value (PV) measures the miliequivalents of oxygen (hydroperoxides) per 1000 gram of oil. This parameter is a measure of the concentration of substances that oxidize potassium iodide to iodine. The PV was determined according to the official method NF T60-220 of the Association Française de Normalisation (AFNOR, 1988) (French normalization association). Weigh 2 g of oil into Erlenmeyer flask, add 10 mL chloroform and 15 mL acetic acid, and 1 mL saturated potassium iodide (KI) solution. Close immediately the Erlenmeyer. Stir the solution for 1 min and allow in dark and then add 75 mL distilled water and 2 to 3 drops of 1% soluble starch indicator. Slowly titrate with 0.01N sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) and shaking simultaneously the flask vigorously until the blue color just disappears. A corresponding blank test is simultaneously prepared. The PV was calculated with the equation:

$$PV(\text{meq O}_2/\text{Kg Oil}) = \frac{(V - V_0) * N}{m} * 10^3$$

Where:

PV represents peroxide value;

V volume of $\text{Na}_2\text{S}_2\text{O}_3$ solution used for the sample test (in mL);

V_0 volume of $\text{Na}_2\text{S}_2\text{O}_3$ solution used for the blank test (in mL);

N normality of $\text{Na}_2\text{S}_2\text{O}_3$ solution (0,01N);

m weight of the oil sample taken (in g).

The iodine value (IV) indicates the degree of unsaturation of the oil. It is defined as the number of grams of iodine absorbed by 100 grams of oil. The

iodine value was determined using (AFNOR – NFT60 – 203, 1968) method. 0,2 g of oil was transferred into a dry, clean 500-mL flask containing 10 mL of ethanol (96%). 10 mL of ethanolic solution of iodine (0,2N) were added to it followed by 30 mL of water. Shake this solution vigorously for 5 min and placed it in the dark for 30 min. The amount of free iodine was titrated with 0.1N sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) gradually and shaking constantly until the yellow color of the solution almost appears. Add 1mL starch test solution (1%), blue color appears; continue the titration until the blue color disappears entirely; the volume of the titrant consumed was recorded as V. A blank (control) was titrated in the same manner and at the same conditions. The IV was calculated by the following equation:

$$IV = \frac{N * (V_0 - V) * 12.69}{P}$$

Where:

IV represents iodine value (g $I_2/100$ g oil);

12,69 number of grams of iodine corresponding to 1 mL of $\text{Na}_2\text{S}_2\text{O}_3$ solution for 100 g of oil;

V volume of $\text{Na}_2\text{S}_2\text{O}_3$ solution used for the sample (mL)

V_0 volume of $\text{Na}_2\text{S}_2\text{O}_3$ solution used for the blank (mL);

N normality of $\text{Na}_2\text{S}_2\text{O}_3$ (0,01N)

P weight of the oil sample (g)

The AFNOR NF T60-206 (1968) method was used to determine the saponification value (SV). This parameter is defined as the weight of potassium hydroxide, in milligrams, needed to saponify one gram of oil. The method for SV determination is based on the oil sample saponification by refluxing with a known excess of alcoholic potassium hydroxide solution. The alkali required for saponification is determined by titration of the excess potassium hydroxide with standard hydrochloric acid, in the presence of phenolphthalein as indicator. A corresponding blank is simultaneously prepared. Two gram of oil was hydrolyzed by adding 25 mL of ethanolic solution of KOH (0,5N) and refluxing on a steam bath for 1 hour with occasional shaking. While the solution was still hot, 3 drops of phenolphthalein indicator (1%) was added and the excess KOH solution was titrated against 0.5N HCl acid. A blank test is simultaneously prepared. The SV was calculated with the equation:

$$SV = \frac{N * Eg * (V_0 - V_1)}{P}$$

Where:

SV represents saponification value, (mg KOH/ g

oil);

V_0 volume of hydrochloric acid solution required for the blank, (mL);

V_1 volume of hydrochloric acid solution required for the sample, (mL);

N normality of HCl solution (0,5N);

Eg equivalent gram of KOH (56,1 g/mol);

p weight of the oil sample (g).

Physical characteristics of oils

Fatty acid methyl esters (FAME) were prepared by transesterification of oils with methanol, using BF₃-MeOH complex as catalyst, according to the standard method (Morrison and Smith, 1964). Into 15 mL screw top test tube, 1mg of each refined oil sample and 500 μ L of C17 (fatty acid standard) were introduced, followed by 1ml of 0.5N methanolic NaOH solution was added. Tubes were tightened with a screw cap provided with a PTEF joint. For saponification reaction, put tube in water bath at 70°C for 15 min. 1mL of BF₃-MeOH was added to each sample in the test tube. Tighten the tube and the mixture was methylated at 70°C for 10 min. 6ml of distilled water and 2ml of pentane were added. Close the test tube and vortex for 10 seconds and allowed to equilibrate for 15 min. The upper layer containing the FAME was extracted and poured into a test tube. Freeze at -20°C until analysis.

The acid esters present in the refined oils were modified to FAMEs by transmethylation as described above and these were determined by a Gas chromatography AGILENT 7890 equipped with a flame ionization detector (capillary fused silica column 30 m x 0.25 mm). The stationary phase consisted of 80% of biscyanopropyl and 20% cyanopropylphénol; hydrogen was used as the carrier gas. The oven temperature was programmed at 45°C, 195°C, 220°C and 240°C for 2 min, 7 min, 2 min and 2 min respectively for a total duration of analysis 21.9 min. The injector and detector temperatures were maintained at 220 and 280°C, respectively. Fatty acids of the refined vegetable oils were expressed as percentage of identified Fatty acids.

UV spectra of fresh refined oils were collected in the region of 200 – 400 nm. The samples were stored in the dark at the room temperature and analyzed shortly after their arrival to the laboratory. UV absorption at 232 nm (K_{232}) and 270 nm (K_{270}) established for respective refined oils types with the help of «Shimadzu UV-160PC» Scanning Spectrophotometer according to the AFNOR T60-223 (1968).

The absorption at 232 and 270 nm is related to the formation of conjugated diene and triene in the oils,

during refining process or storage. Compounds of oxidation of the conjugated dienes contribute to K_{232} while compounds of secondary oxidation (aldehydes, ketones etc.) contribute to K_{270} (Kirkitsakis *et al.* 2002).

The refractive index of the refined fresh oils was measured at 40°C using «Abbemat 200» Refractometer with a precision of $\pm 0.0001\text{dN}$ at a wavelength of 589 nm, according to the methods described in the ISO 6320 4th edition (2000).

Density measurements of the fresh refined vegetable edible oils were carried out using a “DMA 4500” densitometer type equipped with a measurement cell based on the “U” vibrating tube method. The uncertainty in density measurements was $\pm 0.0001\text{ g/cm}^3$; this apparatus only needs 2 cm³ sample volume. The density was determined at temperatures of 10°C, 20°C, 30°C and 40°C.

Oil oxidative stability was evaluated by the Rancimat method. Stability was expressed as the oxidative induction period (IP, hrs), defined as the time during which the oil's natural resistance to oxidation, due to the presence of naturally occurring antioxidants, inhibits oxidation (Frankel, 1998). In this study, IP was measured at 98°C on a Rancimat 743 apparatus using 3 g of oil sample with an air flow of 10 L/hr. Volatile oxidation products were stripped from the oil and dissolved in cold water (60 mL), whose conductivity increased progressively. The time taken to reach a level of conductivity was measured according to the official method No. 6886 of the International Organization for Standardization (ISO 2006).

Activation energy of studied edible oils was determined using non-isothermal thermogravimetry with the help of «NETZSCH STA 449C» thermogravimetric analyzer. A sample mass of 2-5g of each oil was put in a thermobalance and was oxidized at different temperatures (20 to 500°C) with air flow (25 ml/min). On the basis of the Arrhenius equation, activation energies (Ea) for oxidative stability of the vegetable oils were calculated.

Statistical analysis

Statistical analyses were performed with The StatBox software. The data were analyzed by one-way analysis of variance (ANOVA), and the means were compared by the least significant difference (LSD) test at a significance level of 0.05.

Results and Discussion

Chemical properties

The mentioned chemical and physical characteristics of refined oils in us in our country

Table 1. Physical and chemical properties of studied refined oils

	Marks of oils :				
	La Belle	Oleor	elio	Afia	Fleurial
Free fatty acids (%)	0.054±0.003 ^a	0.051±0.003 ^a	0.044±0.003 ^a	0.050±0.001 ^a	0.051±0.005 ^a
Peroxide value (meq kg ⁻¹)	2.00±0.20 ^{b,c}	1.97±0.12 ^{bc}	1.70±0.20 ^c	1.85±0.10 ^b	1.61±0.21 ^a
Iodine value (g 100g ⁻¹)	127.05±2.07 ^a	124.07±4.10 ^a	125.14±4.82 ^a	126.25±4.03 ^a	129.91±2.78 ^a
Saponification value (mg g ⁻¹)	191.06±1.41 ^a	189.32±0.77 ^a	192.21±1.49 ^a	189.22±0.96 ^a	189.01±0.62 ^a
Refractive index at 40°C	1.4664	1.4664	1.4667	1.4663	1.4670
Densities at 20°C	0.921	0.920	0.917	0.920	0.920
A _{232nm} (1%)	3.03	2.93	3.07	2.93	2.52
A _{270nm} (1%)	1.74	2.00	2.34	1.75	2.06
A ₂₃₂ /A ₂₇₀	1.74	1.46	1.30	1.67	1.22

^aValues Followed by different letters in each row are significantly different (P< 0.05).

are shown in Table 1. As is shown, significantly differences were found between these edible oils. FFA content is a conventional expression of the percentage mass-fraction of total oil. In the view of the results shown in Table 1, the percentages FFA (calculated as oleic acid) of the vegetable oils sold on the Algerian market were very low. Results obtained were in the range of 0.044%±0.003 ("elio" oil), 0.050±0.001 ("Afia" oil), 0.051±0.003 ("Oleor" oil), 0.051±0.005 ("fleurial" oil) and 0.054±0.003 ("La Belle" oil). These values were under the value of 0.2%, which is the maximum established by the Algerian standards 1169 (1990) for refined oils. The values were lower than those reported on Slovene sunflower oils (0.043) by Tasic and Klofutar (1999). The low values could be attributed to the efficient removal of the FFA during the refining of crude oil.

The IV is an indicator of the degree of unsaturation of fats and oils. The IV is the mass of iodine in grams that is consumed by 100 grams of oil. The IV provides an overall status of unsaturation of the oils. Iodine value increases with increasing of unsaturation of oil. As in the measurement of %FFA, our oils have acceptable values of IV in comparison with the range established by Algerian Official Journal (120-143gI₂/100g oil) and Codex STAN 210, 1999 (118-141). In addition, these values are in agreement with those suggested by Pocklington, (1990) for edible oils of good quality.

Nevertheless, frying vegetable oils in us in our country are more unsaturated than those commercialized in Romania; Chira *et al.* (2009) obtained a value of 113, 122 and 128 for canola oil, sunflower and soybean oils respectively. Our results were also higher than those of Tasic and Klofutar (1999) on oils commercialized in Slovenia. Then, the high IV indicate a high degree of unsaturation for our oils. From the studied oils, "fleurial" oil is characterized by the greatest IV; this may result from

the fact that this oil has higher polyunsaturated fatty acids. It is has established, the unsaturated character affects the stability of oils, and, as a result, leads to the appearance of degradation effects during storage.

The PV of an oil or fat is used as a measurement of the extent to which rancidity reactions have occurred during storage. This parameter expresses the oxidation in its early stages. Values obtained were low (mean 1.826) compared to the maximum acceptable value 10meq KOH/g by the Codex Alimentarius Commission for oleaginous seed. The oils under investigation have been purchased the same day of their reception by the supermarket, which explain the lowest peroxide value. The low values of PV are indicative of low levels of oxidative rancidity of the oils.

Otherwise, our fresh oils are less peroxidized than those commercialized in Bulgaria; Marinova *et al.* (2012) found values equal to 8.8 and 4 meq for sunflower and soybean oils respectively, while Bazlul Mobin *et al.* (2010) found a value of 2.5 and 5 meq for oils in us in Malaizia. Tasic and Klofutar (1999) determined that the average of the peroxide value for four marks of sunflower oils in us in Slovenia was 2.090.

SV is an indicator of the average molecular weight and hence chain length. It is inversely proportional to the molecular weight of the lipid (Gohari *et al.*, 2011). The results of the SV of refined oils analyzed in this study were similar. These values were in agreement with Algerian Official Journal (189-195) and Codex STAN 210, 1999 (188-194). It is has established that high SV (>194) of fats and oils are due to the predominantly high proportion of shorter carbon chain lengths of fatty acids (Kirk and Sawyer, 1991). Our oils contain fatty acids with a same number of carbon atoms; four fatty acids are present in significant quantities: palmitic, stearic, oleic and linoleic acids which are all basically medium chain

Table 2. Saturated fatty acid composition of different types of vegetable oils (% w/w)

Type of Oil	C14	C16	C18	C20	C24
La Belle	0.080±0.000 ^a	10.611±0.016 ^a	3.984±0.0016 ^c	0.423±0.003 ^b	0.201±0.001 ^c
Fleurial	0.070±0.000 ^e	6.472±0.008 ^f	3.857±0.004 ^e	0.273±0.001 ^f	0.245±0.005 ^a
Oleor	0.080±0.000 ^b	10.637±0.003 ^b	3.919±0.000 ^d	0.432±0.002 ^a	0.202±0.003 ^c
Afia	0.070±0.000 ^c	10.749±0.012 ^b	4.493±0.003 ^b	0.358±0.000 ^d	0.124±0.002 ^e
Elio	0.070±0.000 ^d	8.050±0.001 ^e	3.517±0.000 ^f	0.288±0.002 ^e	0.213±0.002 ^b

Means ± SD (standard deviation) within a column with the same lower case letters are not significantly different at P < 0.05

C14, myristic acid; C16, palmitic acid; C18, stearic acid; C20, behenic acid; C24, lignoceric acid

fatty acids and this account for the high SV values. SV of “fleurial” oil is lower than the result of Chira *et al.* (2009) on sunflower oils in us in Romania (mean 204), but higher than those found by Tasic and Klofutar, (1999) on sunflower oils commercialized in Slovenia (192.077).

Physical properties

Physical properties of vegetable oils depend primarily on composition (and hence on biological origin) and temperature (Coupland and McClements, 1997). They can be used to assess the purity or quality of lipid material in reference to known standards or preferred characteristics (Nichols and Sanderson, 2003).

FA contents (as % total FA) of all oils were significantly different. The percentage of the total saturated fatty acid (SFA) contents changed from 10.959±0.016% (“fleurial” oil) to 15.797±0.010 (“Afia” oil) (Table 2). These results are logical considering the nature of these oils. “Fleurial” oil is constituted only of sunflower oil, while “Afia” oil is 100% soybean. It’s seems that soybean oils contain the highest percentage of SFA than sunflower oil. Indeed, Kostik *et al.* (2013); Tasan *et al.* (2011); Zambiazi *et al.* (2007) reported that soybean oils were more saturated when they were compared to sunflower oils; the values obtained were respectively 13.5% vs 8.8%, 14.24% vs 9.45% and 15.10 vs 12.36%; consequently, soybean oil may be more resistant to oxidation spoilage in comparison to sunflower oil. Otherwise, these values were lowest than those found by Asgary *et al.* (2009) on edible Iranian frying oils (18.9%). In consideration to SFA content, our oils are not suitable to frying. It have been indicated that only saturated oils are considered good sources for cooking and short term frying process, due to their relatively higher SFA content, and consequently higher stability (Clark and Serbia, 1991; McKenzie and Taylor, 1996). In addition, palmitic acid (C16:0)

was the major SFA for all our oils, followed by stearic acid (C18:0). Values of our oils are lower to those of frying Iranian oils; these common SFAs that jointly constitute 21.8% in Iranian frying oils, but only 10.329% in our “fleurial” oil. The distribution pattern of myristic (C14:0) and behenic (C22:0) are almost the same for all vegetable oils and it is independent of the oil origin, only traces were found. However, arachidic (C20:0) and lignoceric (C24:0) were found in considerable amount in our all oils. Besides, our vegetable commercialized oils don’t contain lauric acid (C12:0). This result is in line with Gregorio, (2005); and Gopala *et al.* (2010); these authors reported that only coconut oil is a major source of lauric acid.

The mean values of total unsaturated FAs (UFAs) of our oils varied from 83.934% (“Afia” oil) to 88.886% (“fleurial” oil) of total FAs for all refined vegetable oils used in our study. Oleic (C18:1, ω9) and linoleic (C18:2) acids were the major UFA present in all studied oils (Table 3). “fleurial” oil, pure sunflower oil, contains a low proportion of palmitic acid as well as considerable quantity of oleic acid and very high content of linoleic acid which give it as higher UFA content than other oils. This result is in accordance with Kostik *et al.* (2013); Tasan *et al.* (2011); Zambiazi *et al.* (2007). Then, our commercialized oils are much unsaturated than those used in Iran: frying (72.3%), cooking (83.4%) and hydrogenated oils (34.9%). Oleic acid content of our oils was lowest in comparison to Iranian edible oils: cooking (41.7%) and frying oils (40.2%). However, in consideration of linoleic acid content, ours oils appears superiors; whereas frying, cooking and hydrogenated Iranian oils contains only 28.4%, 37.5% and 7.3% respectively.

The relationship between SFA and PUFA content is expressed as P/S index. All vegetable oils analyzed presented total PUFA higher than SFA content (Table 4); these oils had P/S ratio which varied from 3.560

Table 3. Unsaturated fatty acid composition of different types of vegetable oils (% w/w)

Type of Oil	C18:1 n-9	C18:1 n-7	C18:2 n-6	C18:3 n-3	C20:1 n-9
La	28.055±0.030 ^a	1.458±0.002 ^a	49.366±0.020 ^f	5.199±0.003 ^d	0.250±0.001 ^b
Belle					
Fleurial	23.266±0.004 ^d	0.699±0.002 ^f	64.442±0.043 ^a	0.327±0.001 ^f	0.152±0.001 ^f
Oleor	27.184±0.012 ^b	1.441±0.006 ^b	50.240±0.027 ^e	5.297±0.001 ^c	0.266±0.006 ^a
Afia	20.977±0.003 ^e	1.335±0.001 ^c	55.063±0.007 ^d	6.376±0.000 ^b	0.183±0.001 ^d
Elio	23.537±0.002 ^d	1.059±0.003 ^e	60.475±0.002 ^b	2.320±0.000 ^e	0.173±0.003 ^e

Means ± SD (standard deviation) within a column with the same lower case letters are not significantly different at P < 0.05

C18:1, oleic acid; C18:2, linoleic acid; C18:3, linolenic acid; C20:1, paullinic acid

Table 4. The content of SFA, MUFA, PUFA (% w/w) and the values of P/S indexes in different types of vegetable oils

Type of Oil	Total SFA	Total MUFA	Total PUFA	P / S	n-6 / n-3
La Belle	15.331±0.023 ^c	29.763±0.033 ^a	54.565±0.023 ^f	3.560±0.006 ^f	9.494±0.004 ^c
Fleurial	10.959±0.016 ^f	24.117±0.005 ^d	64.769±0.042 ^a	5.909±0.013 ^a	195.271±0.121 ^a
Oleor	15.281±0.013 ^d	28.891±0.012 ^b	55.537±0.028 ^e	3.633±0.004 ^e	9.474±0.005 ^c
Afia	15.797±0.010 ^b	22.495±0.003 ^e	61.439±0.007 ^d	3.890±0.004 ^c	8.630±0.000 ^d
Elio	12.188±0.000 ^e	24.769±0.002 ^c	62.795±0.003 ^b	5.150±0.001 ^b	26.060±0.000 ^b

(“La Belle” oil) to 5.909 (“fleurial” oil); these values were higher compared to Iranian frying oil (1.66), but similar to the cooking oils used in this country (4.351). Then, all refined vegetable oils used in our country are high unsaturated. The refined oils had higher total PUFAs content than oils used in Iran (60.07% v.s 31.5% for frying oils), which makes our oils suitable for use as a salad oil. Our commercialized vegetable oils, despite containing significantly higher amounts of PUFA, were used in frying. “Fleurial” oil showed high PUFA (C18:2 + C18:3) content (64.769%) with linoleic acid being as the major FA (64.442%) and α-linolenic acid as minor one, when comparing with all other oils; consequently, this oil presented the highest n-6/n-3 ratio (195.271%). It is obvious, the high content of PUFAs of our oils are more prone to oxidation. Thus, none of these oils is suitable for frying.

Both iodine value and refractive index (RI) are important characteristics which determine the degree of saturation or unsaturation of fats and oils. The RI of oils depends on their molecular weight, fatty acid chain length, degree of unsaturation and degree of conjugation (Nichols and Sanderson, 2003). The mean (1.466), obtained at 40°C, for the oils under investigation was within the range established by Codex alimentarius (1992) (1.466-1.470). As for iodine value, “fleurial” oil showed high value for RI (1.467) in comparison to others oils.

Density is one of the important characteristics of a vegetable oil. This parameter is dependent on their PUFA content, oxidation and polymerization level (Wolff, 1968). In this study, the density was

determined for temperature ranging from 283.17K (10°C) to 313.14K (40°C). The density variation with temperature for the studied oils was presented in Table 5. It can be observed that blinded oil (“elio”) has the lower density than the others which have similar densities.

Otherwise, it would be observed from this study that the densities of pure sunflower oil (“fleurial” oil) and pure soybean oil (“La Belle” and “Oleor” oils) were comparable to those of pure soybean oils. These values were within the range established by Codex STAN 210, (1999) at 20°C (0.918-0.923 for sunflower oil and 0.919-0.925 for soybean oil). From Table 5, it can be seen that the density of all oils declined with the rise in temperature. These values were lower than these obtained by Bazlul Mobin *et al.* (2010) on sunflower oil (0.932) and soybean oil (0.931) in us in Malaizia.

The oil stability index directly relates to the oxidative resistance of oil. This quality is proportional to the induction period. This latter represents the time needed for decomposition of hydroperoxides produced by oil oxidation (Läubli and Bruttel, 1986). The Rancimat induction time at 98°C for oils under investigation varied from 8.27 h to 14.05 h (Table 5); the minimum and maximum of oxidative stability was belonged to “fleurial” and “Oleor” oils, respectively.

It can also be seen that pure soybean oil was more stable than pure sunflower oil. “Oleor” oil, with higher induction time, was probably more stable in comparison to others. “Fleurial” oil recorded low induction period and high iodine value suggesting that this oil may be particularly sensitive to oxidation.

Table 5. Densities, UV absorption, induction period and activation energies of refined edibles vegetables oils analyzed

	Densities at :				$A_{232\text{nm}} / A_{270\text{nm}}$	IP (h)	Activation energies (KJ / mol)
	283.17K (10°C)	293.14K (20°C)	303.14K (30°C)	313.14K (40°C)			
Oils	283.17K (10°C)	293.14K (20°C)	303.14K (30°C)	313.14K (40°C)			
M1	0.926	0.921	0.916	0.913	1.741	10.15	550.09
M2	0.926	0.920	0.916	0.912	1.465	14.05	581.52
M3	0.922	0.917	0.912	0.909	1.311	13.46	570.50
M4	0.926	0.920	0.916	0.912	1.674	13.25	570.03
M5	0.926	0.920	0.916	0.912	1.223	08.27	438.16

M1: La Belle; M2: Oleor; M3: elio; M4: Afia and M5: fleurial

The sensibility of this oil ("fleurial" oil) is most likely due to its FA composition which contained high proportion of PUFA (nearly 65%) (Table 4). However, the induction times of our oils was found higher than those in us in some countries. Marinova *et al.* (2012) were noted a value of 6.7 h and 11.5 h respectively for sunflower and soybean oils sold in Bulgaria.

Activation energy represents the minimum energy required to start a chemical reaction. It is expressed, in this study, in units of kilojoules per mole (kJ/mol). The two parameters (activation energy and Rancimat test) showed a good agreement when the results were compared. From Table 5, it is seen that energies values ranged from 438.16 KJ/mol ("fleurial" oil) to 581.52 KJ/mol ("Oleor" oil). The results revealed that a minimum energy required for "fleurial" oil to undergo deteriorations reactions when compared to the others oils, which is an indication of bad oxidative stability of this oil. Energy activation of "fleurial" oil has a direct relationship with Rancimat test and the high degree of unsaturation of this oil.

Conclusion

The quality and properties of fresh refined vegetable oils sold in Algeria were evaluated through this study using different parameters. Results obtained indicated that there was significantly difference in all physical and chemical parameters analyzed among these oils. All the refined vegetable oils had very high IV. This is an indication of high unsaturation in these oils and thus they become more vulnerable to oxidation, making these oils not suitable for deep-fat frying purposes notably "fleurial" oil. This oil had the highest PUFA content, mainly represented by linoleic acid, which makes it particularly sensitive to oxidation. In addition, its induction time and energy activation were very low; this is also another reason to make this oil more vulnerable to oxidation and thermal process like frying. However,

this oil ("fleurial" oil) has nutritional advantages; indeed, during its refining, vitamins A and D were incorporated, which makes this oil suitable for use as a salad oil.

References

- Asgary, S., Nazari B., Sarrafzadegan N., Saber S., Azadbakht, L. and Esmaillzadeh, A. 2009. Fatty acid composition of commercially available Iranian edible oils. Journal of Research in Medical Sciences14(4): 211-215.
- Bazlul, M. S., Anees, A., Mohamad, H. I., Sufia, H., Mohd, R. and Mohd Omar, A.K. 2010. Physico-chemical properties of blends of palm olein with others vegetable oils. Grasas Y Aceites61(4): 423-429.
- Chira, N., Todaşcă, C., Nicolescu, A. Păunescu, G. and Roşca, S. 2009. Determination of the technical quality indices of vegetable oils by modern physical techniques. University Politehnica Bucharest. Scientific Bulletin, Series B71(4).
- Clark, W.L. and Serbia G. W. 1991. Safety aspects of frying fats and oils. Food Technology.45: 84-89.
- Coupland, J. N. and McClements, D. J. 1997. Physical properties of liquid edible oils. Journal of the American Oil Chemists' Society 74(12):1559-1564.
- Frankel, E. N. 1998. Lipid Oxidation. Dundee, Scotland: The Oily Press.
- Gohari, A., Farhoosh, A.R. and Haddad, K. M. H. 2011. Chemical composition and physicochemical properties of pumpkin seeds (*Cucurbita pepo* Var. Styriaka) grown in Iran. Journal of Agricultural Science and Technology13: 1053-1063.
- Gopala, K. A. G., Gaurav, R., Ajit, S. B., Prasanth, K. P. K. and Preeti, C. 2010. Coconut Oil: Chemistry, Production and Its Applications-A Review. Retrieved on August 2010 from: <http://coconutboard.nic.in/English-Article-Gopalakrishna-CFTRI.pdf>.
- Gregorio, C. G. 2005. Fatty Acids and Derivatives from Coconut Oil. 6th ed. John Wiley & Sons, Inc. Bailey's Industrial Oil and Fat Products.
- Kirk, R. and Sawyer, R. 1991. Pearson's composition and analysis of foods. 9th ed. England: Addison Wesley longman ltd.
- Kostik, V., Memeti, S. and Bauer, B. 2013. Fatty acid

- composition of edible oils and fats. *Journal of Hygienic Engineering and Design*. Original scientific paper UDC 664.3:577.115.3: 112-116.
- Kritsakis, A., Kanavouras, A., Kritsakis, K. 2002. Chemical analysis, quality control and packaging issues of olive oil. *European Journal of Lipid Science and Technology* 104(9-10): 628-638.
- Läubli, M. V. and Bruttel, P. A. 1986. Determination of the oxidative stability of fats and oils. *Journal of the American Oil Chemists' Society* 63(6): 792-795.
- Marinova, E. M., Seizova, K.A., Totseva, I. R. S., Panayotova, S., Marekov, N. I. and Momchilova, S. M. 2012. Oxidative changes in some vegetable oils during heating at frying temperature. *Bulgarian Chemical Communications* 44(1) :57-63.
- McKenzie, S. and Taylor, D. C. 1996. Seed oils: a new age. *Plant Biotechnology* 1(1): 1-4.
- Morrisson, W. R. and Smith, L.M. 1964. Preparation of fatty acid methyl ester and dimethyl acetals from lipids with Boron Fluoride-Methanol. *The Journal of Lipid Research* 5: 600-608.
- Nichols, D. and Sanderson, S. K. 2003. The Nomenclature, Structure and Properties of Food Lipids. In Sikorski, Z. E. and Kolakowska, A. (Eds). *Chemical and Functional Properties of Food Lipids*, p. 29-59. CRC Press.
- O'Brien, R. D. 2009. *Fats and Oils*. 3rd ed. CRC Press, Taylor and Francis Group.
- Pocklington, W. D. 1990. Determination of the Iodine Value of Oils and Fats, Results of a Collaborative Study. *Pure and Applied Chemistry* 62(12): 2339-2343.
- Tasan, M., Gecgel, U., and Demirci, M. 2011. Comparison of geometrical isomerization of unsaturated fatty acids in selected commercially refined oils. *Grasas y Aceites* 62(3): 284-289.
- Tasic, D. R. and Klofutar C. 1999. Characteristics of vegetable oils of some Slovene manufacturers. *Acta Chimica Slovenica* 46(4): 511-521.
- Wolff, J. P. 1968. *Manuel des corps gras*. 1^{ère} ed. Paris : Tec and Doc, Lavoisier.
- Zambiazi, R. C., Przybylski, R., Zambiazi, M. W. and Mendonca, C. B. 2007. Fatty acid composition of vegetable oils and fats. *Boletim do Centro de Pesquisa de Processamento de Alimentos*, Curitiba 25(1): 111-120.