



Physicochemical characterization and stability of some commercial olive oils imported to Sudan

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Abstract

The objectives of this study are to assess the quality of some commercial olive oils imported to Sudan. Six samples from different origins (Tunis, Turkey, Spain, Saudi Arabia, and Lebanon) were collected from the local markets. Physical properties (Refractive Index, Density, and Viscosity) and chemical properties (Free Fatty Acids, Peroxide value, Saponification value) of the samples were determined to assess their quality and discussed in the light of International Olive Oil Council (IOOC). Furthermore, The FT-IR spectra of all samples were determined to verify their structure. The quality of the oils during storage and heating were also examined. Physical analysis revealed that the refractive index and viscosity are consistent with the value set by the IOOC. As for the density, the samples J and M produced in Tunis and Lebanon, respectively, were slightly higher than the maximum limit of IOOC. The results of chemical properties showed that the acidity, as oleic acid%, falls in the range 0.11 to 1.07. According to IOOC, based on acidity, all the samples are extra virgin olive oils except sample M from Lebanon is virgin olive oil. The peroxide values PVs (meqO₂/Kg) for all samples were found below the maximum limit (20) of IOOC. The saponification values SVs (mg KOH/g) for all samples were in good agreement of the range specified by IOOC (184-196) except sample S (Saudi Arabia) showed, significantly, higher value (233) than the maximum of IOOC. Based on changes in PVs, FFAs and UV absorption (E270) during heating and storage, sample J (originated from Tunis) is the most stable during heating, whereas, sample K (originated from Turkey) showed the highest stability during storage. The present studies indicate that all samples showed good quality for human consumption, during storage and heating, except the sample S (from Saudi Arabia) needs further investigation.

Keywords: olive oil, physicochemical properties, thermal stability

1. Introduction

The olive tree (*Olea europaea* L.) is native to the Mediterranean region. The cultivation of the olive tree is dating back about 5000 - 6000 years and distributed in a wide belt of land by the eastern Mediterranean Sea and in the neighboring zones comprising Asia Minor, part of India, Africa and Europe [1,2]. The major producers of olive oil are Spain, Italy, Greece, Tunisia, Syria, Turkey and Morocco [3].

Olive oil is a natural fruit juice, obtained from the fruit of the tree *Olea europea*, with a unique composition and quality. In addition, crude olive oil can be consumed in diet without treatment preserving its valuable natural constituents. Therefore, olive oil has become a main component of traditional Mediterranean diet and believed to be associated with a relatively long life in good health [4].

Olive oil consumption reduces coronary heart diseases, diabetes, certain cancer risks such as breast, prostate and colon cancers, certain malignant tumors (endometrium, digestive tract, and skin tumors) and some other chronic diseases [5].

Olive oil's characteristic aroma, taste, color and nutritive properties, stability distinguish it from other edible vegetable oils. Hence, there is a matter of great concern for the olive industry to preserve its product without loss of these positive attributes.

One of the primary causes of loss of olive oil quality is oxidation. Olive oil quality depends on many factors such as methods of cultivation, harvesting, extraction and storage. Oxidation takes place either in the presence of light (photo oxidation) or in the

Dark (auto-oxidation) and also by the effect of enzymes (enzymatic oxidation). Olive oil is considered to be resistant to oxidation in comparison with other vegetable oils Because of its low content of polyunsaturated fatty acids and the presence of natural Antioxidants. Abundance of oleic acid, ranging from 56 to 84% of total fatty acids, is the feature that sets olive oil apart from other vegetable oils [6].

The International Olive Oil Council (IOOC) And the European Communities Legislation (EC) have designated the quality of Olive oil, based on parameters that include free Fatty acid (FFA) content, peroxide Value (PV), UV specific extinction coefficients (K232 and K270) and sensory score. Especially, the quantity of FFA is an important factor for classifying olive oil into commercial grades. Apart from the quality parameters that IOOC and EC defined, the changes in major and minor compounds and their concentrations in olive oils give an idea for providing and improving quality of olive oil, especially for storage, marketing and packaging issues [7].

The main purpose of this study is to assess the quality of olive oil sold in local market in Sudan. The study targets samples from different origins namely, Saudi Arabia, Turkey, Tunisia and Lebanon. Specific purposes include:

- To determine the physical properties of the olive oils such as density, viscosity and refractive index.
- To determine some chemical properties of the samples such as acid value, free fatty acids, peroxide values and saponification.

- To investigate the thermo-oxidative stability of the samples and the effect of storage.

2. Materials and methods

2.1 Sample collection

Six (06) samples of olive oils from some Arab and foreign countries were collected from the local markets of Sudan. The olive oils samples were placed into sterilized bottles and stored in the fridge till analysis. Table 1 describes the samples.

Table 1: Samples Descriptions

Code	Trade name	Country of origin
R	Al-Resala	Tunis
K	Khraman	Turkey
J	Jalkhi	Tunis
M	Al-Madina	Lebanon
W	Al-Wazer	Spain
S	-	Saudi Arabia

2.2 Chemicals

- Potassium hydroxide flakes (minimum assay 85%), was purchased from CDH Laboratory Reagent.
- Potassium iodide (assay = 99%), was purchased from Trust chemical laboratories.
- Hydrochloric acid pure (wt per ml at 20°C about 1.18g), (assay 35-38%), purchased from Lobe Chemie.
- Chloroform (density = 1.474-1.480 g/ml at 20°C, assay = 99.5%), was purchased from Oxford laboratory reagent.
- Acetic acid glacial (b.p = 118°C, minimum assay = 99.7%), was purchased from Duksan Reagents. Sodium Thiosulphate (minimum assay 99%), purchased from Alpha Chemika.
- Ethanol absolute anhydrous (density=0.7892g/ml at 20°C, b.p=78.3-78.8°C), was purchased from CARLO ERBA Reagents.
- Phenolphthalein indicator Solution.
- Cyclohexane (density = 0.66 g/ml at 20°C, b.p = 65-70°C, minimum assay = 95%), was purchased from SDFCL.

2.3 Physical and chemical properties

2.3.1 Determination of the relative density

The relative density of the oil was determined using a clean, dried and pre-weighed empty pycnometer. The pycnometer was filled with distilled water and weighed again. Dry pycnometer was refilled by oil and weighed. The experiment was repeated two times and the results were recorded and the mean and standard deviation were calculated [8]. Density was determined using the following equation:

$$\text{Relative density of oil} = (B - A)/(C - A) \dots\dots\dots (1)$$

Where; A is weight of pycnometer,
 B is weight of pycnometer with sample and
 C is weight of pycnometer with water.

2.3.2 Determination of viscosity

The viscosity of the oil was measured by capillary tubes using an Ostwald device at room temperature (25°C) [9]. The viscosity was determined and calculated using the following equation:

$$\eta_s / \eta_w = d_s t_s / d_w t_w \dots\dots\dots (2)$$

Where; η_s is viscosity of the sample.
 η_w is viscosity of water.
 d_s is density of the sample.
 t_s is time flow of the sample.
 d_w is density of water.
 t_w is time flow of water.

2.3.3 Determination of refractive index

The refractive index was determined using refractometer (DR101-60 / DR201-95.KRUSS Optronic GmbH, Germany). A drop of oil was placed on a surface of the lower prism. The prism was closed and left for two minutes to equal the temperature of the sample and the device, and then results were recorded [9]. The refractive indexes of the samples at 20° C were calculated using the following equation:

$$R = R_1 + K (T_1 - T_0) \dots\dots\dots (3)$$

Where:
 R is refractive index at 20° C
 R_1 is reactive index of the sample.
 K (const) is correction coefficient of oil.
 T_1 is temperature at which the reading R_1 is taken.
 T_0 is specified temperature at which the reading R is taken

2.3.4 Determination of acid value and free fatty acids

Oil samples (5.00g) were placed into a 250 ml flask and dissolved in 25 ml of alcohol (previously neutralized by solution of KOH (0.01N)). The contents were titrated against solution of KOH (0.1 N), using phenolphthalein indicator with vigorous shaken until permanent faint pink color appears and persists for 1 min [10]. The experiment was repeated two times and the mean and standard deviation were calculated and the acid value (mg KOH/g oil) and free fatty acids percentages as oleic were determined using the following equations:

$$\text{Acid value (AV)} = (56.1 \times V \times N) / W \dots\dots\dots (4)$$

$$\% \text{ free fatty acid (FFA)} = (M \times N \times V) / W \times 10 \dots\dots (5)$$

Where:
 V is volume in ml of standard potassium hydroxide (KOH) required neutralizing the sample.
 N is Normality of KOH.
 W is the weight of the sample,
 56.1 is molecular weight of KOH.
 M is molecular weight of oleic acid.

2.3.5 Determination of peroxide value (PV)

Oil samples (5.00g) were weighed into a 250 ml flask and 30 ml of a mixture of glacial acetic acid and chloroform (2:1) were added and stirred well for complete dissolution. Saturated KI solution (0.5 ml) was added to the contents of the flask and stirred well for 2min. Distilled water (30 ml) were added to the content and titrated against $\text{Na}_2\text{S}_2\text{O}_3$ (0.01N) with vigorous shaking until the blue color disappeared [11]. The experiment was repeated two times and the mean and standard deviation were calculated and the peroxide value was determined using the following equation:

$$\text{PV (milliequiv peroxide/Kg sample)} = (V \times N \times 1000) / W \dots\dots (6)$$

Where:

V is volume in ml of standard sodium thiosulphate required by the sample,

N is normality of sodium thiosulphate solution used and

W is weight in gm of the sample.

2.3.6 Determination of Saponification Value

Oil sample (5.00 g) were weighed into a 250 ml conical flask and mixed with 50 ml of alcoholic potassium hydroxide solution (0.5 N). The flask was fitted with air condenser. Heating was conducted on a boiling water bath for 30 min with occasional shaking and after completion of the heating process the flask was left to cool and 5 drops of phenolphthalein indicator were added and titrated against a 0.5 N hydrochloric acid until the pink color was disappeared. A blank solution was treated using the same procedure above but without oil [12]. The experiment was repeated two times and the mean and standard deviation were calculated and the saponification value was determined using the following equation:

$$SV = 56.1 (B-S) N/W \dots\dots (7)$$

Where:

B is volume in ml of standard hydrochloric acid (HCl) required for the blank.

S is volume in ml of standard hydrochloric acid (HCl) required for the sample.

N is normality of standard hydrochloric acid and

W is weight in gm of the olive oil.

2.4 Infrared Spectroscopic analysis

Infrared spectra of the oil samples were obtained using an IR 300 model spectrometer (Thermo Nicolet). A drop of olive oil was placed between a pair of salt plates (KBr) to avoid the presence of air. The pair of the plates were inserted into a holder that fits into Infrared spectrophotometer. The scanning was done in the range between 4000 and 500 cm^{-1} . The number of scans was adjusted to 8 scans with resolution of 4 cm^{-1} .

2.5 Storage Stability

To examine the effect of storage on stability, the oil samples were exposed to atmospheric and light for sixty days then the acid value and peroxide value of all sample were determined monthly as prescribed in above mentioned sections [13].

2.6 Thermal stability

To examine the effect of temperature on the oxidative stability of the oil samples. (25g) of each oil were weighed into 50 ml open beaker and placed in an oven test (model: N4C) previously adjusted at 165 °C for 30 min. After completion of the heating time, the oil samples were cooled to ambient temperature. Then, the acid value and peroxide value of all cooled samples were determined as prescribed in previous sections. The oxidative stability of the oils was further investigated by determining the concentrations of conjugated trienes (CTs) for fresh and heated oils using UV-Visible spectrophotometer (Model 7305, Jenway, U.K.). Oil sample (0.5gms) were weighed into 50 ml open beaker and dissolved at ambient temperature in a few milliliters of cyclohexane, then the solution was transferred to 50 ml volumetric flask and made up to the mark with the same solvent

and mixed thoroughly [9]. The prepared solution was used to determine the specific absorbance at 270 nm to determine the CTs at ambient temperature [13].

$$E_{\lambda} = \frac{A_{\lambda}}{C_L \times L} \dots\dots\dots (8)$$

Where:

E_{λ} ≡ Specific absorptivity at A_{λ} .

A_{λ} ≡ The absorbance measured at wavelength λ .

C_L ≡ The concentration of the oil solution in g/100 ml.

L ≡ The path length of the cuvette in cm.

3. Results and Discussion

3.1 The physical properties

3.1.1 Density

Table 2 and fig 1 show the densities of olive oil samples. The results obtained in this study varied in the range 0.836±0.0023 to 0.9232±0.004g/cm³ for samples S (Saudi origin) and J (Tunis origin) respectively. The samples coded M and J originated from Lebanon and Tunis, respectively, showed slightly higher densities than the maximum limit specified by IOOC, (2007) [3] which range from 0.910 to 0.9180g/ml. Whereas, the value of density for the remaining samples were found lower than the minimum limit of IOOC.

Table 2: Density of olive oil samples

Code	Country	Density(g/cm ³)
R	Tunis	0.8936±0.007
K	Turkey	0.8932±0.007
W	Spin	0.8972±0.00003
M	Lebanon	0.9228±0.003
J	Tunis	0.9232±0.004
S	Sudia Aribia	0.836±0.0023

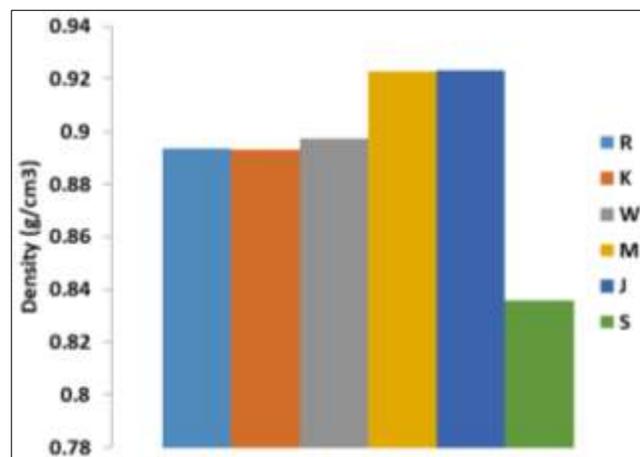


Fig 1: The density values of olive oils samples

3.1.2 Viscosity

It is known that the relative viscosity of edible oils is affected by the insoluble material, overheating, water contamination, air contamination and primary or secondary oxidation products [14]. Moreover, viscosity is related to the chemical properties of the

oils such as chain length, saturation and un-saturation. It is reported that viscosity is increased with un-saturation [15].

The present results as listed in the table 3 and depicted in fig 2 indicated that the sample S, which is Saudi origin have the lowest value (31.84mP.s). The highest level of viscosity (36.3322±0.001mP.s) was observed for sample J, (Tunis origin). This variation is due to the different arrangement of the fatty acids on the glycerol backbone of the triglycerides molecule [14].

Table 3: Viscosity of olive oil samples

Code	Country	Viscosity(m P.s)
R	Tunis	36.3322±0.001
K	Turkey	36.9055±0.00
W	Spin	35.1758±0.003
M	Lebanon	32.3685±0.009
J	Tunis	37.4951±0.00
S	Saudi Aribia	31.8417±0.00

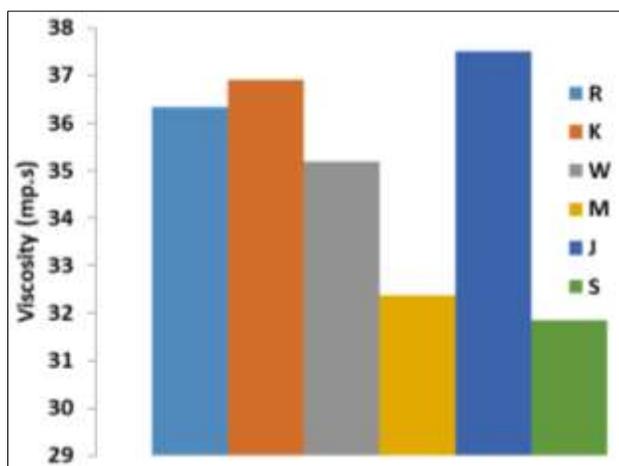


Fig 2: Viscosity values of olive oils samples

3.1.3 Refractive index

The refractive index value is, directly, related to the fatty acid composition of oils [16]. From table 4, it can be seen that all the values of refractive index falls in the range 1.4628 to 1.4642 which is in a good agreement with range preferred by IOOC (1.4608 – 1.4707).

Table 4: Refractive Index of Olive Oil

Code	Country	Refractive index at 20°C
R	Tunis	1.4642±0.000007
K	Turkey	1.4636±0.00001
W	Spin	1.4641±0.00014
M	Lebanon	1.4628±0.0001
J	Tunis	1.4632±0.0001
S	Saudi Aribia	1.4638±0.00042

3.1.4 Color

The samples coded R, M, W originated from Tunis, Lebanon and Spain observed with green color, whereas, the remaining samples from Turkey coded K and Tunis coded J had yellowish color. Green color indicates high contents of chlorophyll, whereas, yellow color indicate high content carotenoids in the olive oil

samples [17].

3.2 Chemical properties

3.2.1 Acid value and free fatty acid

As presented in the table 5 the acid value of the olive oil samples were found in the range 0.22 – 2.14 mg KOH/g oil, equivalent to free fatty acids (% oleic acid) content in the range 0.11 – 1.07 %. According to the IOOC (2007), olive oils should have acidity (% oleic) ≤ 3.3%. Hence, the free fatty acid contents of all studied Samples are below the limits. Referring to table 5 and fig 3, all the samples showed almost similar contents of free fatty acids, except the sample M which is originated from Lebanon exhibited, relatively, higher free fatty acid content (1.07 %). This may be due to pedoclimatic factors and the olive trees species [18]. According to the report of the IOOC in the classification of olive oil, all the analyzed samples are extra virgin olive oil (acidity as oleic acid % < 0.8), except sample M (Lebanon origin) which is classified as virgin olive oil (acidity as oleic acid % ≥ 1).

Table 5: Acid value and free fatty acid value

Code	Country	Acid value	FFA (Oleic %)
R	Tunis	0.34	0.17±0.033
K	Turkey	0.22	0.11±0.07
W	Spin	0.45	0.22±0.032
M	Lebanon	2.14	1.07±0.05
J	Tunis	0.56	0.28±0.041
S	Saudi Aribia	0.34	0.17±0.016

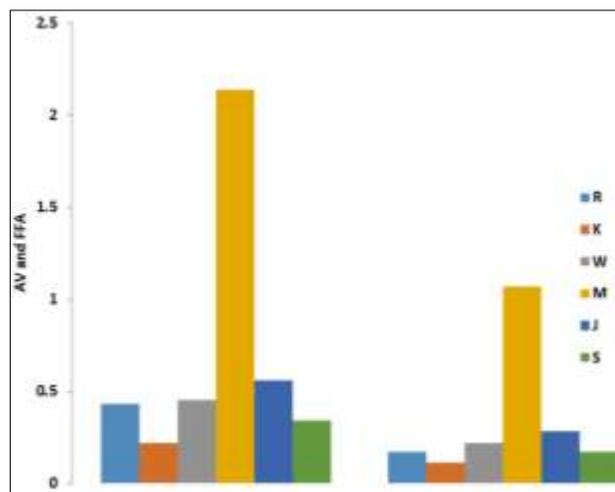


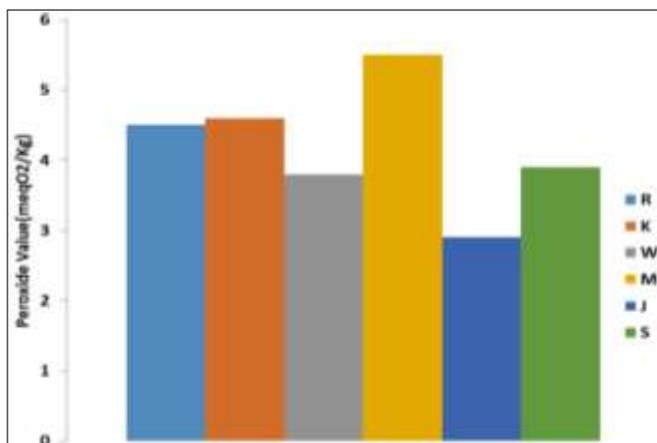
Fig 3: Acid value and free fatty acid value

3.2.2 Peroxide value (PV)

Peroxide values of all olive oils studied as presented in table 6, fall in the range 2.90±0.029 to 5.50±0.033 meqO₂/Kg for sample J (Tunis origin) and M (Lebanon origin) respectively. All the samples are under the value of 20 meq O₂/Kg of olive oil, which is the maximum limit established by the IOOC (2007) [3]. Sample J and R although they are originated from the same country (Tunis), they showed, significantly, difference in PV. The differences may be attributed the location of these samples at different provinces. The PV of the olive oil samples in this study are lower than the results obtained by [18].

Table 6: Peroxide value olive oils samples

Code	Country	PV(meqO ₂ /Kg)
R	Tunis	4.50±0.071
K	Turkey	4.60±0.00
W	Spin	3.80±0.041
M	Lebanon	5.50±0.033
J	Tunis	2.90±0.029
S	Saudi Arabia	3.90±0.070

**Fig 4:** The peroxide values (Meq O₂/Kg) of olive oils samples

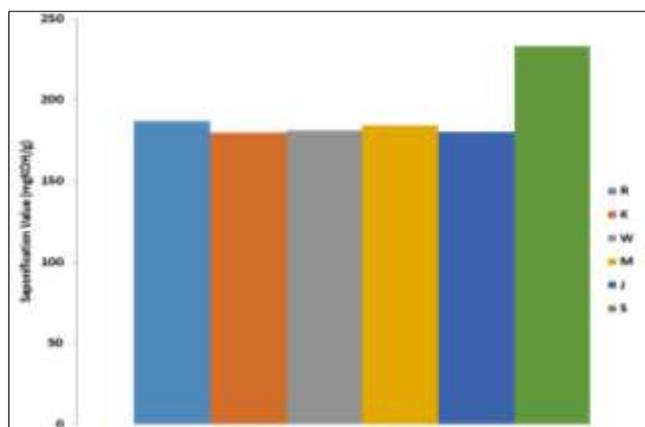
3.2.3 Saponification value (SV)

As it can be noticed from table 7 and fig.5, SV of the olive oil samples in this study, ranged from (179.69 to 233 mg KOH/g) for sample K (Turkey origins) and sample S (Saudi Arabia) respectively. The SV of olive oils according to IOOC (2007) ^[3] should fall in the range (184-196) mg KOH/g). The samples M (Lebanon origin) and R (Tunis) their SV in good agreement with

IOOC standard. However, the samples J, K, W originated from Tunis, Turkey and Spain, respectively, exhibited slightly lower SV than the minimum value specified by IOOC. Sample S (Saudi Arabia) showed significantly higher saponification value (233 mg KOH/g oil) than the maximum value specified by IOOC. The variation in the SV may indicate lack of olive purity or the difference in the length of fatty acid chain ^[19].

Table 7: Saponification value of olive oil

Code	Country	SV(mgKOH/g)
R	Tunis	186.9252±3.18
K	Turkey	179.6995±0.00
W	Spin	181.2703±1.06
M	Lebanon	184.4119±0.46
J	Tunis	180.0137±1.91
S	Saudi Arabia	233.1067±0.65

**Fig 5:** Saponification Value of olive oils samples

3.3 Infrared spectroscopic analysis

The infrared spectrum was used to investigate the structural characteristics of the olive oil sample and the possible changes in the structural characteristics as a result of processing. The x-axis refers to the wavelengths among 4000-500 cm⁻¹ and the y-axis refers to the transmittance values. The characteristics absorption peaks of the samples together with their wave numbers are given in table 8. The IR chromatograms are presented in the fig 6 (A-F). As shown in the table 4.7 and depicted in the fig 6 (A-F), the overall appearance of the FT-IR spectra of olive oil samples are similar with little differences in exact absorbance wave numbers and intensities. All the samples showed a prominent peak in the range (1746 -1745) due to the stretching of C=O. This absorbance in this region is accompanied with small peak at 1162-1157 due to C-O ester group indicate that all samples are typical triglycerides. Some samples S, W, showed C=O

absorbance peak with low intensity which may indicate presence of primarily or secondary oxidation products [20].

Table 8: Displays the IR's wave number and the functional group which give rise to absorption band for the samples.

Wave number	functional group
About 3006 cm^{-1}	-CH stretching vibration of the <i>cis</i> -double bond (-CH)
2924 cm^{-1} , 2852 cm^{-1}	C-H asymmetric and symmetric stretching vibrations of the aliphatic CH_3
1743 cm^{-1}	double bond stretching of carbonyl group C=O of ester of the triglycerides
1463 cm^{-1} , 1377 cm^{-1}	C-H bending vibrations of the CH_2 and CH_3 aliphatic groups
1162 cm^{-1}	Stretching vibration of the C-O ester Group

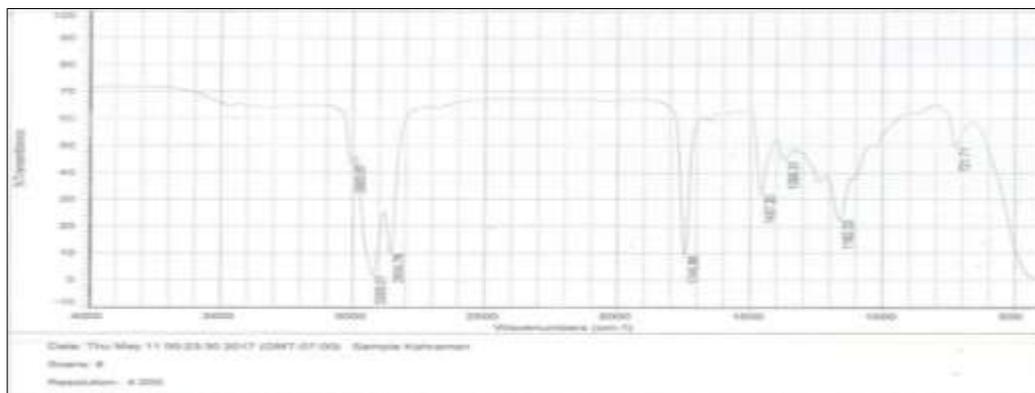


Fig 6A: IR spectrum of sample K

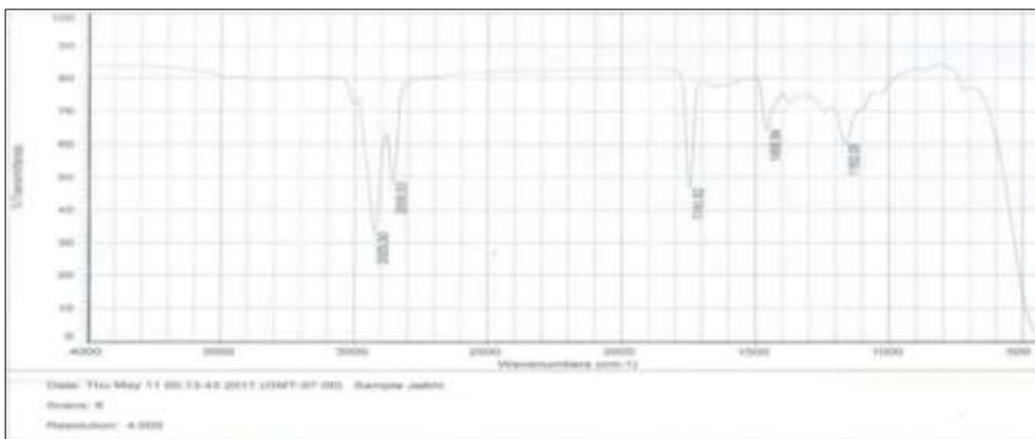


Fig 6B IR: spectrum of sample J

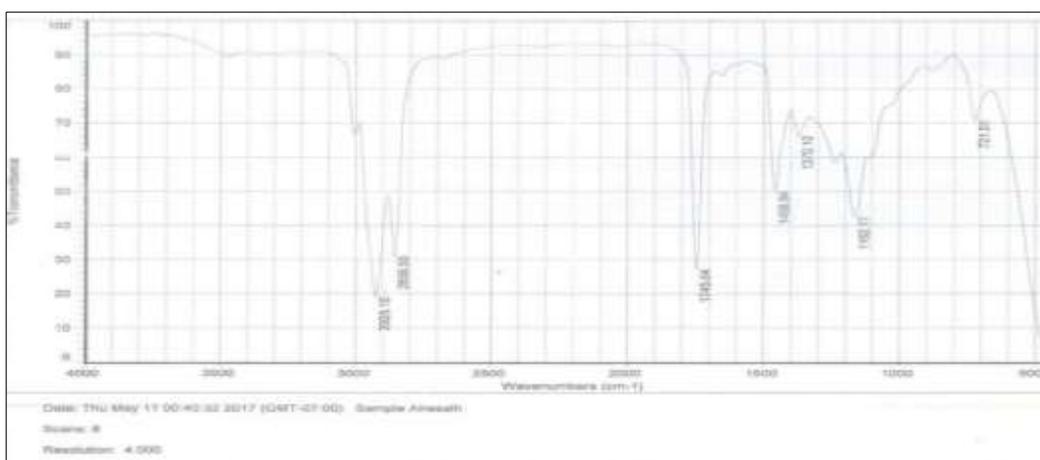


Fig 6 C: IR spectrum of sample R

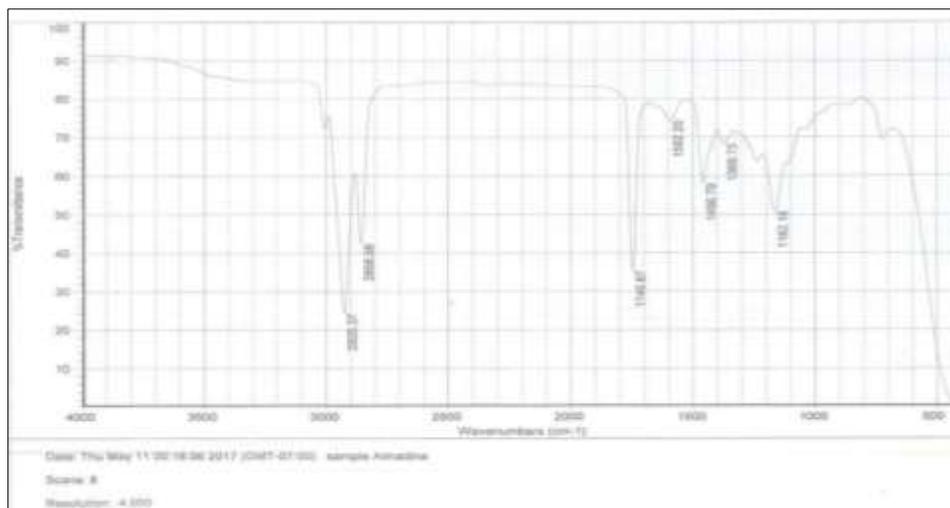


Fig 6D: IR spectrum of sample M

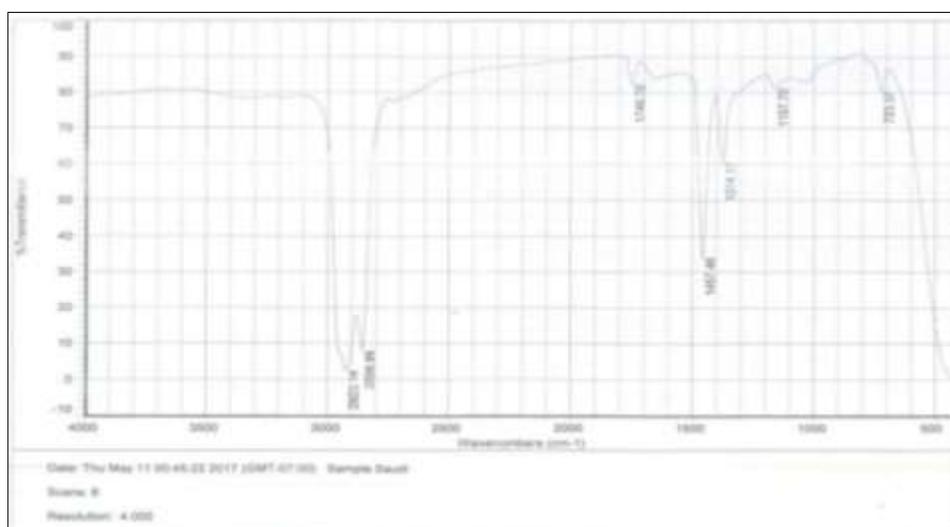


Fig 6E IR spectrum of sample S

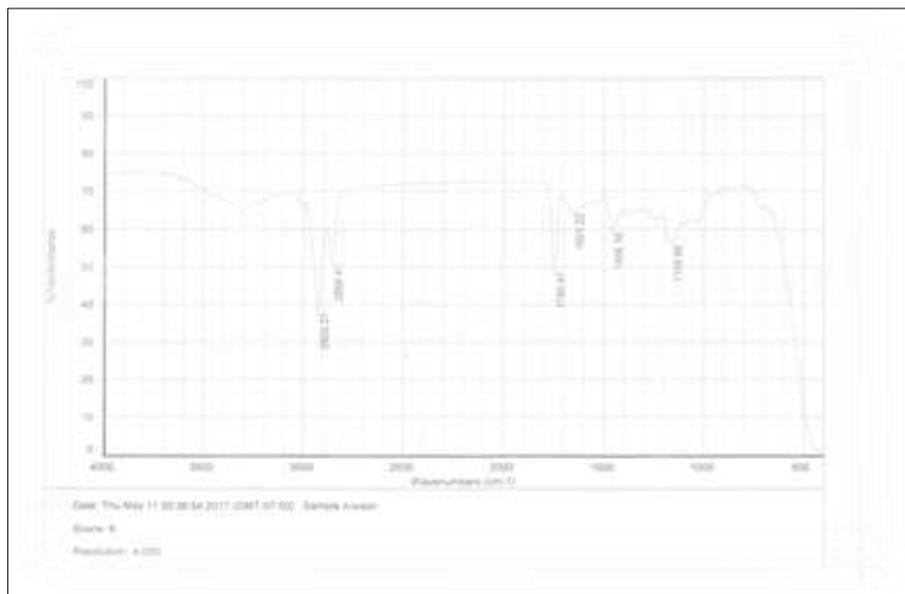


Fig 6F: IR spectrum of sample W

3.4 Storage stability

The oxidative stability of the olive oil samples were examined over sixty days storage period at room temperature, based on peroxide and acid values. Peroxide value is a suitable indicator for the early stage of oxidation [21]. As shown in the table 9 all the samples showed a gradual increase in the peroxide value. No sample exceeds the maximum limit (20 meq O₂/Kg oil) of IOOC. According to the rate of peroxidation the following order of stability was observed among all the olive oil samples:

J> S> K>R=W>M

Table 10 presents the change in the acid value for the all olive samples during the period of storage at room temperature. All the samples showed a gradual increase acid value. However, no samples exceeded the maximum limit (0.8 mg KOH/g oil) of IOOC except sample M (originated from Lebanon) which was

already out of the limit at the initial time. According to the rate of decomposition to carboxylic acids the most stable olive oil was J (originated from Tunisia) and W (originated from Spain) coincides with the results obtained based on peroxide values.

Table 9: Change of PV of olive oil during the storage

Code	PV (meqO ₂ /Kg)			Rate (meqO ₂ /Kg)/day
	0 time	30 days	60 days	
R	4.50±0.071	5.10±0.035	9.90±0.06	0.09
K	4.60±0.00	4.60±0.0140	6.70±0.071	0.04
W	3.80±0.041	3.90±0.040	9.20±0.00	0.09
M	5.50±0.033	6.00±0.00	16.10±0.033	0.18
J	2.90±0.029	3.10±0.07	3.40±0.029	0.008
S	3.90±0.070	4.30±0.05	4.50±0.047	0.01

Table 10: Change of FFA of olive oil during storage period

Code	FFA (m KOH/g)			Rate
	0 time	30 days	60 days	
R	0.17±0.033	0.23±0.00	0.28±0.067	0.002
K	0.11±0.07	0.17±0.081	0.22±0.014	0.002
W	0.22±0.032	0.23±0.040	0.25±0.073	0.0005
M	1.07±0.05	1.09±0.036	1.30±0.06	0.004
J	0.28±0.041	0.28±0.041	0.31±0.028	0.0005
S	0.17±0.016	0.19±0.071	0.23±0.038	0.001

3.5 Thermal stability

Olive oils contain a range of components such as tocopherols, phenolics, sterols, etc., which are beneficial to oil stability during heating [22]. Physicochemical parameters (FFAs, K270 and PVs) of olive oil samples were analyzed to determine their oxidative stability during heating for 30 min at 165°C. PV is widely used as a measure of primary lipid oxidation to indicate the amount of peroxides formed during oil oxidation. In addition, FFAs formation might be an important measure of rancidity of foods. In fact, FFAs resulting from the hydrolysis of triacylglycerides, as well as, the further decomposition of hydroperoxides, is one of the most important indicators of oil deterioration. Moreover, UV absorption at 270 nm is associated with changes in conjugated trienes produced by the oxidation of polyunsaturated fatty acids (secondary oxidation). The higher the proportion of polyunsaturated fatty acids in the oil, the higher is the levels of trienes formed [22].

As presented in table 11 and 12, all samples showed an increase

in the values of oxidative parameters as temperature increases. According to the rate of the decomposition to carboxylic acids, the order of stability observed among all the olive oil samples was W>J>K=R>M=S, whereas, based on the PV the order of stability was K>M>R=S>W>J and based on K270 was J>R>K>S>M>W. The sample originated from Tunisia (J) showed the highest increment percentage in PV and the least increment percentage in the K 270.

Table 11: Change of FFA of olive oil sample during heating

Code	Country	FFA as (oleic %)		Rate (oleic%)/min
		25°C	170°C	
R	Tunisia	0.17±0.033	0.23±0.038	0.002
K	Turkey	0.11±0.01	0.17±0.042	0.002
W	Spain	0.22±0.032	0.23±0.059	0.0003
M	Lebanon	1.07±0.025	1.18±0.078	0.004
J	Tunisia	0.28±0.041	0.31±0.0145	0.001
S	Saudi Arabia	0.17±0.016	0.28±0.039	0.004

Table 12: Change of PV and K270 of olive oil samples during heating

Code	Country	PV (meqO ₂ /Kg)		Increment% of PV	K270		Rate (%)
		25°C	170°C		25°C	170°C	
R	Tunisia	4.50±0.070	12.30±0.070	173	3.7	4.2	13.5
K	Turkey	4.60±0.00	6.80±0.00	47	2.2	3.1	40.9
W	Spain	3.80±0.707	12.50±0.707	228	1.1	7.8	609
M	Lebanon	5.50±0.0408	12.10±0.0408	120	1.3	3.6	176.9
J	Tunisia	2.90±0.0335	12.30±0.0335	324	3.9	4.0	2.6
S	Saudi Arabia	4.30±0.0295	12.30±0.0295	186	0.102	0.206	70.2

Conclusions

This study aimed to assess the quality of some commercial olive oil imported to Sudan based on their physicochemical properties and oxidative stability during heating and storage.

The obtained results revealed that the olive oils samples were of acceptable quality and were classified as virgin and extra virgin olive oil according to IOOC. Physical and chemical characteristics of olive oils samples showed little differences, but

have good properties as they contain low percentages of acidity, therefore could be utilized successfully as a source of edible oil for human consumption, except for sample (S) of Saudi origin, which showed a high saponification value.

Referring to the study of the thermal stability of olive oil samples, our results indicated that the sample (K) from Turkey origin has an excellent profile in terms of stability at high temperature. These results indicate that the Kahraman oil is more suitable, compared to other oils, to be used in frying. Sample (J) from Tunis, showed the highest stability during storage.

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