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Determination of Some Metallic Elements and their Effect on Physical Properties of Edible Olive Oil in Palestine

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Abstract

The physical properties such as: density, refractive index, viscosity, and acidity of samples of olive oil from different geographical locations and heights in Palestine were measured. The measured physical properties are in agreement with the international and local assigned value. The concentration of Al, Cd, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and Zn elements in olive oil samples are measured by inductively coupled plasma mass spectrometry ICP-MS. It was found that Magnesium (Mg) is the most concentrated metal detected (294.738-782.968 µg/g), followed by concentration of sodium (Na) (73.401-390.699 µg/g) and potassium (K) (18.473-168.883 µg/g).

Concentrations of iron, copper and lead in Palestinian olive oil don't agree with concentration of International Olive Council (IOC). The differences in concentration in metals of olive oil depend on several factors among the type of olive tree, storage age, height and geographical location. There is a positive relation between the concentration of metals in olive oil and physical properties as density, refractive index, viscosity, and acidity. The daily intake rate of these metals shows no risk to human health according to US Environmental Protection Agency (EPA).

Keywords: Metallic elements; Metals; Inductive

Introduction

Olive oil is a fat that is widely used in pharmaceuticals, cosmetic and cooking. Olive oil is popular in cooking due to its cholesterol lowering effect. Unlike animal fats that have cholesterol effect on humans.

The quality of olive oil depends on the regional conditions of the producing country. Freshness, storability and toxicity of olive oil can be evaluated by determining the levels of several trace metals in the oil [1].

Individual metals or metals compounds can affect human health. There are essential metals for human body like sodium, potassium, calcium, magnesium, iron, copper and zinc [2]. There are harmful elements like cadmium, chromium, lead, mercury, selenium and silver. These metals are called heavy metals which exist in the environment at low levels but if they accumulate in large quantities they become dangerous and cause many health problems [3]. It is important to determine the metals in olive oil and their concentration since olive oil is an essential component in our daily life.

Vegetable oils are important for global nutrition and metals concentration can affect human health, so many researchers are interested in studying the edible vegetable oils. Benincase and his group studied the elements of Italian virgin olive oils from different regions aiming to develop a reliable method for traceability of the origin of olive oils. Benincase found that the inductively coupled plasma mass spectrometry ICP-MS afford a simple and rapid way to trace the geographical origin of olive oil [4]. Zeiner and Savio in their studies determination of elements in edible oil used ICP-MS to analyze edible oil [5,6].

In her study, Nierat proposed fitting equation to describe the relationship between the acidity and storage age of olive oil samples collected from different regions in Palestine [7]. Bahti studied the acidity and the refractive index of olive oil from Palestine for different crops, he conclude that the acidity increased with storage age [8,9].

In this work, the concentrations of metals in edible olive oil from different geographical locations and heights in Palestine are determined by ICP-MS. We propose a relationship between metal concentration in edible olive oil and storage age of the edible olive oil.

Experimental

Sample collection

The olive oil samples used in this study were collected from different Palestinian regions (Yata, Yasid, Meithalun, Saida, Allar, Jenin) and produced in Palestinian mills for olive oil from the crop of 1997 to 2012.

The entire samples were kept at the same conditions at room temperature in dark place and packed in closed plastic bottles.

Apparatus and methods

Inductively coupled plasma mass spectrometry ICP-MS (Perkin Elmer Elan 9000) was used to determined concentration of metals in edible olive oil samples for different regions and different ages. The physical properties of olive oil measured by: 10 ml volume pycnometer and HR-200 analytical balance for determine the density. A digital refractometer the way 2sABBE for determines refractive index value. DV-I viscometer for determine viscosity. Titrimetric method was used for measuring the acidity value of olive oil.

Sample preparation

The way that is used in this study to digestion the olive oil sample is the digestion by nitric acid (HNO_3). A 0.5 g of olive oil sample is

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transferred into special tubes. A 2 ml of NHO_3 is transferred into the tube. The tubes were closed with stoppers, and the temperatures of the tubes increased from 75°C to 100°C gradually each hour. The final step was adding hydrogen peroxide (H_2O_2) to the tubes. The temperatures of the tube increased from 75°C to 100°C gradually each hour. Finally the olive oil samples were ready to be inserted into ICP-MS device to determine the elements concentration.

Data analyses

The daily intake of metals that olive oil supply to human body can be calculated by the following relation

$$DIR = \frac{M_C\left(\mu g/g\right)\times D_i\left(\text{kg}/\text{person}\right)}{M\left(\text{kg}\right)}$$

Where DIR is daily intake rate, M_C is metal concentration in olive oil (μg/g), D_i is daily intake of olive oil (kg/person), and M is average body mass in (kg) [10].

Results

Physical properties

The physical properties density, refractive index, viscosity and acidity for olive oil samples of different regions and different storage ages were determined at room temperature as represented in Table 1.

Metals concentration

11 metals were studied in 12 olive oil samples. The concentrations of the metals in the samples are given in Tables 2a and 2b. Variations in concentration of metals were observed among Palestinian olive oil samples from different regions and different storage ages. These variations could be affected by soil, fertilizers, maturation and processing methods, or may be affected by weather and environmental conditions (rain, temperature, wind).

The Mg levels are ranged from 294.738 to 782.968 μg/g. Results indicate that concentrations of Mg may change according to maturation and processing methods. Concentrations of Mg in olive oil sample were compared with other studies. In Zeiner's study the concentrations of Mg is ranged between 2.91-3.62 μg/g [5]. Nergiz and Engez reported that the range of Mg concentration in green olive is between 114-373 μg/g [11].

Region (Altitude)	ρ(mg/cm³)	Acidity(%)	n	η(Pc)
Yata (818m)				
2012	0.91068	1.20	1.4647	54.8
Yasid(698m)				
2011	0.91784	1.32	1.4641	51.8
Meithalun(372m)				
2010	0.91549	2.30	1.4633	57.6
2007	0.91241	3.32	1.4628	57.2
Saida (379m)				
2012	0.91911	2.34	1.4639	54.5
2010	0.91810	2.84	1.4630	56.1
2008	0.91810	4.53	1.4635	55.7
1997	0.91740	13.80	1.4615	89.6
Allar (238m)				
2012	0.91862	2.59	1.4633	53.2
1998	0.91300	6.46	1.4629	47.7
Jenin(187m)				
2010	0.91754	0.94	1.4637	52.2
2007	0.91678	3.05	1.4626	59.8

Table 1: Physical properties of olive oil samples.

Metal		Allar 1998	Allar 2012	Jenin 2007	Jenin 2010	Meithalun 2007	Meithalun 2010
Aluminum	Al	16.126	11.616	19.918	17.397	46.293	21.170
Cadmium	Cd	0.011	0.005	0.016	0.013	0.177	0.012
Copper	Cu	1.684	1.642	1.877	2.344	1.987	1.648
Iron	Fe	35.420	32.796	85.880	60.333	90.076	50.610
Potassium	K	30.986	25.022	86.494	168.883	130.213	35.865
Magnesium	Mg	529.997	303.024	624.804	701.964	440.512	345.677
Manganese	Mn	0.721	0.583	1.265	1.012	1.383	0.848
Sodium	Na	115.363	102.164	237.555	390.699	266.552	107.251
Nickel	Ni	0.647	0.685	1.285	1.227	1.742	1.014
Lead	Pb	0.221	0.166	0.271	0.297	0.773	0.241
Zinc	Zn	36.555	25.298	116.658	61.634	59.885	55.524

Table 2a: Concentration of metals in olive oil (μg/g).

Metal		Allar 1998	Allar 2012	Jenin 2007	Jenin 2010	Meithalun 2007	Meithalun 2010
Aluminum	Al	11.961	15.675	15.279	11.872	11.964	6.452
Cadmium	Cd	0.007	0.006	-	0.001	0.005	0.006
Copper	Cu	2.223	1.647	1.147	1.229	1.702	1.407
Iron	Fe	33.175	40.926	18.473	21.827	43.979	25.089
Potassium	K	27.227	23.070	28.405	28.072	33.051	28.101
Magnesium	Mg	360.351	294.738	473.037	540.592	629.021	782.968
Manganese	Mn	0.524	0.639	0.354	0.452	0.858	0.576
Sodium	Na	73.401	92.355	139.045	187.950	232.403	176.359
Nickel	Ni	0.966	0.762	0.323	0.591	0.699	0.434
Lead	Pb	0.841	0.202	0.017	0.405	0.242	0.109
Zinc	Zn	22.369	26.800	13.743	17.926	53.644	24.337

Table 2b: Concentration of metals in olive oil (μg/g).

Concentration of elements may affect the quality of olive oil as storability, freshness or toxicity. The levels of Cu, Fe, and Zn cause an increase in the rate of oxidation. The concentration levels of these elements in olive oil samples are given in Figures 1-3.

Figure 1 shows that the levels of copper (Cu) in olive oil samples vary between 1.147 to 2.394 μg/g. The concentration of Cu is influenced by fertilizers and fungicides which are added to olive trees to fight fungal disease. Moreover a small concentration of Cu can act as a catalyst in oxidation process so the Cu concentration should be controlled because it influences the olive oil quality [12].

Figure 2 shows the levels of iron (Fe) in olive oil samples which vary between 18.473 and 90.076 μg/g. Our results were higher than those of other studies but close to Ziena and his group results which are about 10.76-180.06 μg/g. The values of Fe metal influenced by the maturation, production condition and variety properties [12].

Figure 3 shows the concentration of zinc (Zn) in the analyzed samples varied between 13.743 and 116.658 μg/g this value is higher than other studies. According to FAO/ WHO the allowed provisional tolerable daily intake of Zn element for adult (60 kg) is about 60 mg [1].

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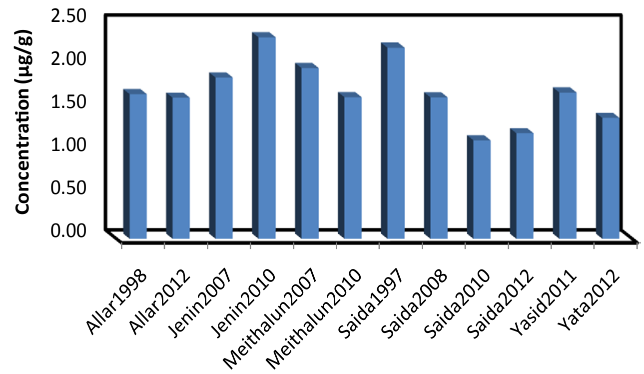

Figure 1: Concentration of copper (Cu) of different olive oil samples.

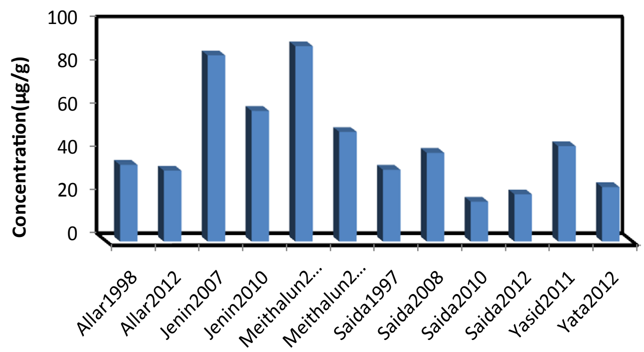

Figure 2: Concentration of iron (Fe) of different olive oil samples.

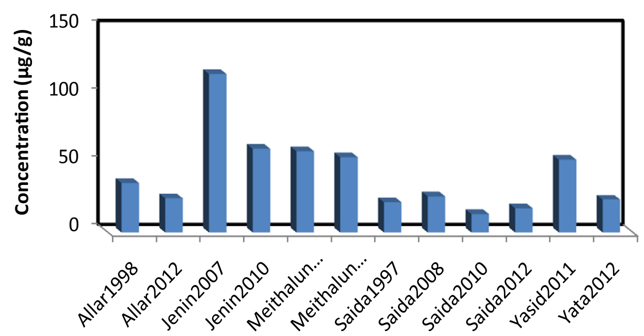

Figure 3: Concentration of zinc (Zn) of different olive oil samples.

The concentration levels of the 11 metals for the same region but different storage age are shown in Figures 4 and 5. The upper columns in Figure 4 represent the metals that have high concentrations in Allar olive oil samples which range between 1 and 1000 µg/g. The lower columns represent the metals that have low concentrations which range between 0.001 and 1 µg/g. Figure 4 shows that the concentrations of metals in Allar's samples change from one year to another. There are small variations in the concentration of metals, olive oil sample of 16 years storage age have more metals than the sample of 2 years storage age.

Figure 5 shows a variation in the concentration of metals in Jenin samples where the sample of 4 years storage age has more metals than the sample of 7 years storage age. Figures 4 and 5 shows that the change in the concentrations of metals is not due to the storage age period.

Concentration of metals and the physical properties

Concentration of metals with the density: The effect of concentration of metals on density as function of temperature is shown in Figures 6-8. Figure 6 represent the effect of Cu concentration on the sample density. It is observed that the concentration of Cu in Jenin's sample of 2010 crop (2.344 µg/g) is higher than Saida's sample of 2012 crop (1.229 µg/g).

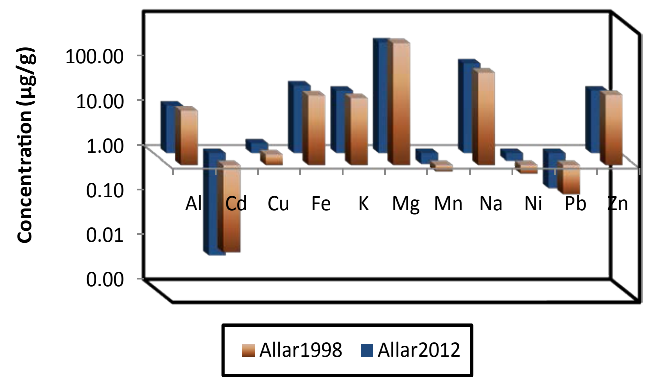

Figure 4: The comparison between the levels of metals for two different storage age olive oil samples of same region(Allar).

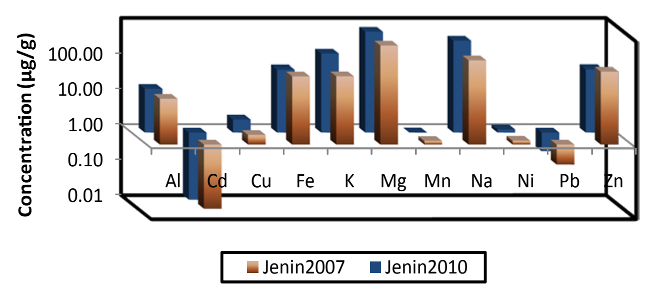

Figure 5: The comparison between the levels of metals for two different storage age olive oil samples of same region (Jenin).

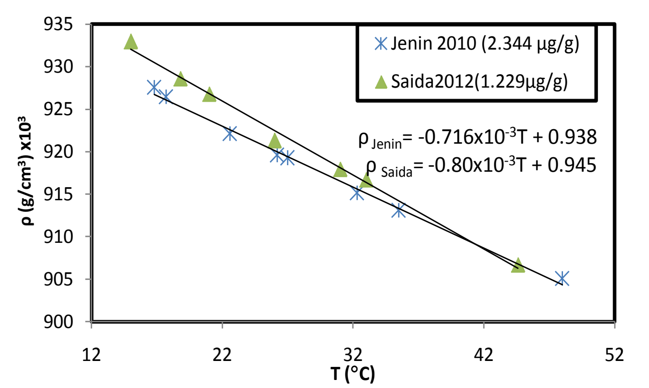

Figure 6: The effect of two different concentrations of copper (Cu) on the density as function of temperature.

The change rate of the density with temperature for Jenin's sample is fit by Eq.(1)

$$\rho_{Jenin} = -0.716*10^{-3}T + 0.938 \quad (1)$$

While the change rate of the density with temperature for Saida's sample given is fit by Eq.(2)

$$\rho_{Saida} = -0.80*10^{-3}T + 0.945 \quad (2)$$

The change rate of the density with temperature for Saida's sample is higher than the change rate of Jenin's sample. The sample that has more concentration of Cu has less change rate of density with temperature.

The effect of Fe element on the sample density is represented in Figure 7. Jenin's sample of 2010 crop has higher concentration of Fe than Yata's sample of 2012 crop. At room temperature the density of Jenin's sample is higher than Yata's sample may because Jenin's sample has more Fe concentration than Yata's sample. The density of Fe element at room temperature is (7.874 g/cm^3) which is considered to be high value compared with elements in the periodic table. The relationship between the density and temperature for Jenin 2010 crop sample is represented by the following Eq.(3)

$$\rho_{Jenin} = -0.698*10^{-3}T + 0.938 \quad (3)$$

And the relationship for the 2012 Yata crop given by

$$\rho_{Yata} = -0.950*10^{-3}T + 0.936 \quad (4)$$

Eq.(3 and 4) show that the change rate for the density with temperature for Yata's sample is higher than the change rate of Jenin's sample. It seems that there is inverse relation between the change rates for the density with temperature and the concentration of Fe element.

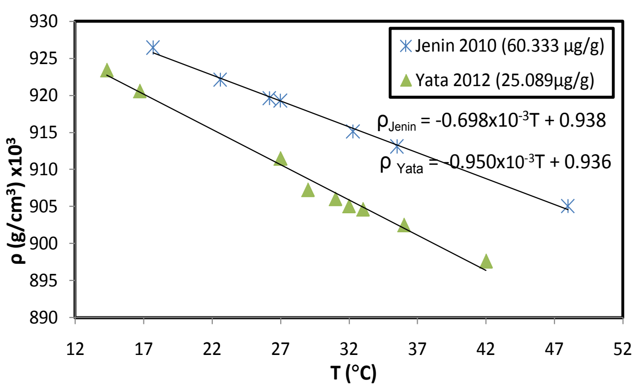

Figure 7: The effect of two different concentrations of iron (Fe) on the density as function of temperature.

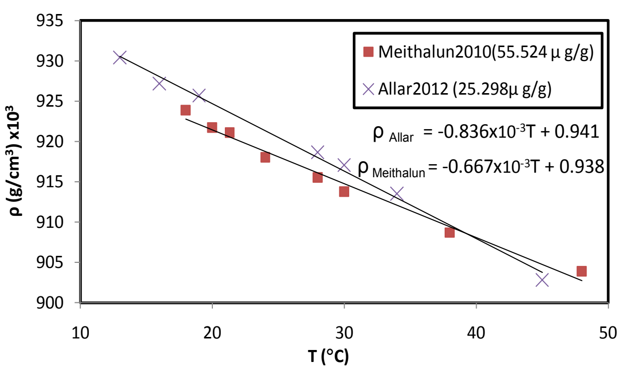

Figure 8: The effect of two different concentrations of zinc (Zn) on the density as function of temperature.

The effect of the concentration of Zn element on the sample density represent in Figure 8. The relationship between the density and temperature for 2012 crop Allar sample is represented in the following Eq.

$$\rho_{Allar} = -0.836*10^{-3}T + 0.941 \quad (5)$$

And the relationship for 2010 crop Meithalun sample is given by

$$\rho_{Meithalun} = -0.667*10^{-3}T + 0.938 \quad (6)$$

Eq.(5 and 6) show that the change rate for the density with temperature for Allar's sample higher than the change rate of Meithalun's sample. Meithalun's sample of 2010 crop has higher concentration of Zn than 2012 crop Allar's sample. It seems that the sample density is not affected by Zn concentration, where the storage age affected the sample density.

Concentration of metals and the refractive index: The refractive index values of 12 samples of olive oil compared with the concentrations of 11 elements. The highest value of refractive index is for Yata 2012 olive oil crop, while the lowest value is for 1997 crop Saida sample. This difference in the refractive index may refer to the storage age, and it may refer to the concentration of metals. It is observed that olive oil from Yata has the highest concentration of magnesium (Mg) (782.968 µg/g) and Saida has (360.352 µg/g). Also Yata has concentration of sodium Na (176.359 µg/g) and Saida has (73.401 µg/g) the lowest concentration value of Na of all samples.

The refractive index of olive oil samples of 2012 crop at 28°C decreased in the order Yata (1.4647), Saida (1.4639) and Allar (1.4633). The concentration of Mg for these samples also decreased the obtained result are (782.968, 540.592, 303.024 µg/g, respectively). The concentration of Na is arranged in decreasing order as (176.359, 187.950, 102.164 µg/g, respectively). It seems that the concentrations of Mg and Na affect the refractive index value for the olive oil while the concentration of Mg affect more than Na.

Jenin, Meithalun and Saida 2010 crops have the refractive index values (1.4637, 1.4633 and 1.4630) and the concentration of Mg (701.964, 345.677 and 473.037 µg/g, respectively). The concentration of Mg in Saida olive oil is larger than Meithalun, the refractive index of Saida sample may be affected by the concentration of Cu, Fe and Zn where the concentration of these elements in this sample is the lowest compared with all samples.

Concentration of metals with viscosity: The highest and the lowest values of concentration for each of the 11 elements change form sample to another. The comparison between the viscosity as function of temperature for two samples that has the highest value of element and the lowest value element are represented in Figures 9-11.

Figure 4 shows the effect of the concentration of Cu element on the viscosity of olive oil. The best fit of the experimental data for Saida's sample of 1997 crop represented by quadratic equation

$$\eta_{Saida1997} = 0.1T^2 - 10.5T + 296.0 \quad (7)$$

The best fits for Saida's sample of 2010 crop represented

$$\eta_{Saida2010} = 0.1T^2 - 6.4T + 182.1 \quad (8)$$

The Eq.(7) shows the change rate of the viscosity with temperature

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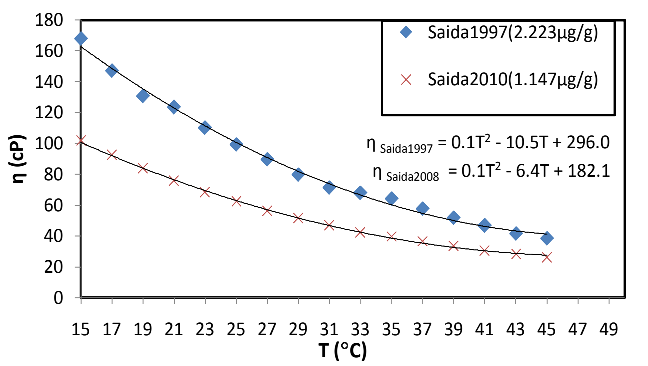

Figure 9: The effect of the highest and lowest concentrations of copper (Cu) on viscosity as function of temperature.

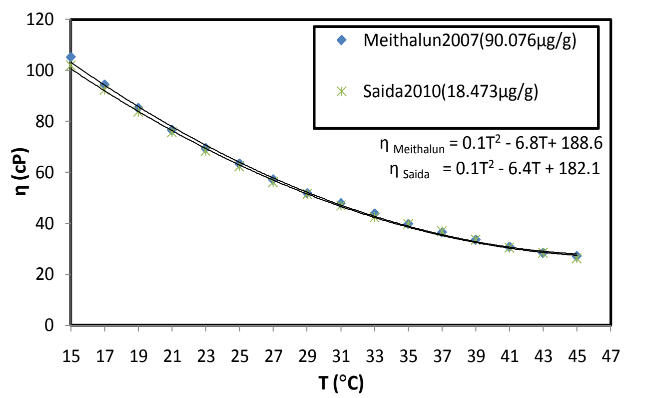

Figure 10: The effect of the highest and lowest concentration of iron (Fe) on viscosity as function of temperature.

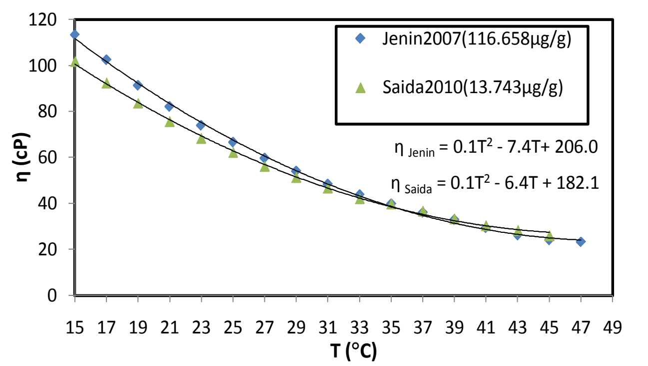

Figure 11: The effect of the highest and lowest concentrations of zinc (Zn) on viscosity as function of temperature.

of 1997 crop Saida sample (which has concentration of Cu equals 2.223 μg/g) larger than 2010 crop Saida sample (which has the lowest concentration of Cu 1.147 μg/g). It seems that the concentration of Cu may affect the change rate of the viscosity of the samples.

Figure 10 shows the effect of the concentration of Fe element on the viscosity of olive oil. 2007 crop Meithalun sample has the largest concentration of Fe (90.076 μg/g). The best fit for the experimental data for viscosity is given by

$$\eta_{Meithalun} = 0.1T^2 - 6.8T + 188.6 \quad (9)$$

The 2010 crop Saida sample has the lowest concentration of Fe element (18.473 μg/g). The best fit of the experimental data for viscosity is given by

$$\eta_{Saida} = 0.1T^2 - 6.4T + 182.1 \quad (10)$$

The change rates of the viscosity with temperature from the two Eq. (9 and 10) are small. It seems that the concentration of Fe may not affect the viscosity of the olive oil. Figure 11 shows the effect of the concentration of Zn on the viscosity of olive oil. The highest concentration of Zn is found in the 2007 crop Jenin sample (116.658 μg/g) while the lowest in the 2010 crop Saida sample (13.743 μg/g). The best fit for the viscosity function of temperature for the Jenin olive oil represented by.

$$\eta_{Jenin} = 0.1T^2 - 7.4T + 206.0 \quad (11)$$

The best fit for the viscosity function of temperature for Saida olive oil represented by

$$\eta_{Saida} = 0.1T^2 - 6.4T + 182.1 \quad (12)$$

The change rate of the viscosity with temperature from Eqs.(11 and 12) is small so we expect that the concentration of Zn does not affect on the viscosity.

Concentration of metals with acidity: The acidity values of 12 olive oil samples compared with the concentrations of 11 elements. It is observed that the acidity value of olive oil of Saida 1997 crop is (13.8%) and Allar sample of 1998 crop is (6.46%) they have nearly the same storage age but there is a big difference in acidity value, this difference may refer to Cu concentration where Saida has 2.223 μg/g of Cu and Allar has 1.684 μg/g. Sahan reported that low concentration of Cu can affect on lipids in olive oil [12] which may affect on the acidity value.

Jenin samples have different storage ages 7 and 4 years and different concentrations of metals. The sample of 7 years storage age has metals concentration of Cu 1.877 μg/g, Fe 85.880 μg/g and Zn 116.658 μg/g, and acidity value 3.07%. 4 years storage age sample has metals concentration of Cu 2.344 μg/g, Fe 60.333 μg/g and Zn 60.634 μg/g, and acidity value 0.94%. The large differs in the acidity values of Jenin samples referring to the storage age and may be to the concentration of metals. Where 7 years storage age sample has the highest concentration of Zn compared with all samples.

Saida samples of 4 and 2 years storage ages have nearly the same acidity 2.84% and 2.34%, respectively. This close value in acidity may refer to the concentrations of Cu, Fe and Zn. The concentrations of these elements in the 4 years storage age sample are the lowest compared with all samples.

Daily intakes of metals

Daily intake of metals from olive oil consumptions depends on the amount of olive oil consumption and the metals concentration in olive oil. The Palestinian adult consumes about 4.8 kg of olive oil per year which means 13.2 g per day. The estimated daily intakes rate of 8 metals by consuming 13.2 g of olive oil per day is calculated in Tables 3a and 3b.

The results in Tables 3a and 3b suggest that the DIR of Al, Cd, Cu, Fe, Mn, Ni, Pb, and Zn in olive oil are all far below the permitted values by US EPA. Consuming 13.2 g of Palestinian olive oil generally does

Metals	Allar 1998	Allar 2012	Jenin 2007	Jenin 2010	Meithalun 2007	Meithalun 2010
Al	3.04×10^{-3}	2.19×10^{-3}	3.76×10^{-3}	3.28×10^{-3}	8.73×10^{-3}	3.99×10^{-3}
Cd	2.07×10^{-6}	9.81×10^{-7}	2.94×10^{-6}	2.41×10^{-6}	3.34×10^{-5}	2.26×10^{-6}
Cu	3.17×10^{-4}	3.10×10^{-4}	3.54×10^{-4}	4.42×10^{-4}	3.75×10^{-4}	3.11×10^{-4}
Fe	6.68×10^{-3}	6.18×10^{-3}	1.62×10^{-2}	1.14×10^{-2}	1.70×10^{-2}	9.54×10^{-3}
Mn	1.36×10^{-4}	1.10×10^{-4}	2.39×10^{-4}	1.91×10^{-4}	2.61×10^{-4}	1.60×10^{-4}
Ni	1.22×10^{-4}	1.29×10^{-4}	2.42×10^{-4}	2.31×10^{-4}	3.29×10^{-4}	1.91×10^{-4}
Pb	4.16×10^{-5}	3.13×10^{-5}	5.11×10^{-5}	5.59×10^{-5}	1.46×10^{-4}	4.54×10^{-5}
Zn	6.89×10^{-3}	4.77×10^{-3}	2.20×10^{-2}	1.16×10^{-2}	1.13×10^{-2}	1.05×10^{-2}

Table 3a: The calculated daily intake rate (DIR) of metals (μg/g)/day.

Metals	Saida 1997	Saida 2008	Saida 2010	Saida 2012	Yasid 2011	Yata 2012
Al	2.26×10^{-3}	2.96×10^{-3}	2.88×10^{-3}	2.24×10^{-3}	2.26×10^{-3}	1.22×10^{-3}
Cd	1.24×10^{-6}	1.21×10^{-6}	3.77×10^{-8}	1.13×10^{-7}	9.43×10^{-7}	1.06×10^{-6}
Cu	4.19×10^{-4}	3.11×10^{-4}	2.16×10^{-4}	2.32×10^{-4}	3.21×10^{-4}	2.65×10^{-4}
Fe	6.26×10^{-3}	7.72×10^{-3}	3.48×10^{-3}	4.12×10^{-3}	8.29×10^{-3}	4.73×10^{-3}
Mn	9.89×10^{-5}	1.20×10^{-4}	6.68×10^{-5}	8.52×10^{-5}	1.62×10^{-4}	1.09×10^{-4}
Ni	1.82×10^{-4}	1.44×10^{-4}	6.09×10^{-5}	1.11×10^{-4}	1.32×10^{-4}	8.18×10^{-5}
Pb	1.59×10^{-4}	3.81×10^{-5}	3.21×10^{-6}	7.63×10^{-5}	4.56×10^{-5}	2.05×10^{-5}
Zn	4.22×10^{-3}	5.05×10^{-3}	2.59×10^{-3}	3.38×10^{-3}	1.01×10^{-2}	4.59×10^{-3}

Table 3b: The calculated daily intake rate (DIR) of metals (μg/g)/day.

Physical Properties	Our Result	Codex Standard [13]	Palestinian Standard [14]
Density (g/cm^3)	0.91068-0.91911	0.910-0.916	0.910-0.916
Refractive index	1.4647-1.4615	1.4677-1.4706	1.4677-1.4705

Table 4: The measured density and refractive index in this work and the standard values.

Our Result		Previous Result [15]	
T (°C)	Dynamic Viscosity	T (°C)	Dynamic Viscosity
15	100.1	15	105.0
19	80.4	20	84.0
25	59.7	25	69.0
35	37.5	35	44.0
39	31.9	40	36.3

Table 5: The measured dynamic viscosity in this work and the other studies.

not pose any health problems on humans. The elements K, Mg, and Na are essential elements that human body needs in large quantities.

Discussion

The present study provides quantitative analysis of concentration of metals in Palestinian olive oil and some physical properties of olive oil (density, refractive index, viscosity and acidity). The physical properties (density and refractive index) of olive oil samples from Palestine agree with the international standard as shown in Table 4. The Measured dynamic viscosity of olive oil at different temperature of Palestinian sample of 2012 crop and previous study are shown in Table 5.

The differences in dynamic viscosity values may be referred to the differences in fatty acid composition of olive oil, the storage age for the samples, and may the differences in the concentration of metals in olive oil. There are some studies on determination the concentration

Metal	Palestinian olive oil (μg/g)	IOC (μg/g) [16]
Fe	18.473-90.076	3
Cu	1.147-2.344	0.1
Pb	0.017-0.841	0.1
As	Not detected	0.1

Table 6: Concentration of metals for this work and IOC.

of metals in edible vegetable oil (specially the olive oil). IOC reported concentration of metals in olive oil for iron (Fe) less than 3 μg/g, copper (Cu) less than 0.1 μg/g, lead (Pb) 0.1 μg/g and arsenic (As) 0.1 μg/g [16].

Mg, Na, K are present in our study in a wide concentrations range in olive oil. IOC did not put a limit of concentration for these metals. Mg, Na, K are essential metals sustain biological growth for any living organism. The daily recommend quantity of Mg 400 mg, Na 2400 mg, K 3500 mg [17].

Cd, Cu, Fe, Mn, Ni, Pb, and Zn are heavy metals that are linked in people's mind to toxic metals. In fact any substance that living organism needs depend on concentration of the substance if above a certain level it become hazardous. US EPA determined the reference dose oral (RfDo) of heavy metals. The calculate DIR for these metals in this study does not exceed the recommend limits by US EPA. Concentration of Pb in Palestinian olive oil range between 0.017 and 0.841 μg/g, IOC recommends the concentration of Pb is 0.1 μg/g this value is smaller compared with Palestinian values, but the calculate DIR for Pb metal range 1.59×10^{-4} to 3.21×10^{-6} (μg/g)/day it is less than the allowed quantity of Pb according to US EPA 3.57×10^{-3} (μg/g)/day [18].

Concentration of metals in Palestinian olive oil are over the limit that established by IOC as represented in Table 6. High concentration of metals in olive oil may refer to the concentration of metals in water that used to irrigate olive trees, the production methods and the weather conditions (temperature, rain and wind). Concentrations of metals may affect the physical properties of the olive oil. It seems that the concentration of Cu, Fe and Zn may affect the density and the acidity of olive oil. The concentration of Cu may affect the viscosity of olive oil. The concentration of Mg and Na may affect the refractive index of olive oil.

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