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Comparison of fruit characteristics, oil properties and fatty acid composition of local Syrian Kaissy cv olive (*Olea europaea*)

M. Al-Bachir[1]

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Abstract Characterization of Syrian (Kaissy cultivar) olive fruits and evaluation of physic-chemical properties of oils were carried out during 3 years of production. The mean values of data for both measured and calculated variables of fruits were: grain length (21.89 mm), grain width (17.92 mm), length/width (1.22), weight of grain (3.79 g), weight of pulp (flesh) (3.19 g), weight of pit (0.60 g), pulp/pit ratio (5.35), crude oil (17.13%), water content (moisture) (51.34%). The 3 year average values of chemical properties of Syrian Kaissy cultivar olive oils (SKOO) including acid value, peroxide vale, Thiobarbituric acid value, iodine value(IV), saponification value, and phenolic content were 0.58%, 4.33 mEq O_2 kg^{-1}, 0.028 mg MDA kg^{-1} oil, 90.77 g I_2, 100 g^{-1}, 194.91 mg KOH g^{-1}, and 218.08 g gallic acid kg^{-1}, respectively. Pefractive index (RI), and viscosity were 1.4666 nD at 25 °C and 139.56 mPa.s, respectively. However, the 2 years average values of Hunter's color parameters of SKOO were; the lightness (L*= 66.91), redness (a* = 18.80), yellowness (b* = 29.08) and the color differences (ΔE = 65.49). FA analysis of the SKOO used showed a high content of monounsaturated fatty acids (oleic acid 70.82% and palmitic acid 1.01%) and low polyunsaturated fatty acids (Linoleic acid 10.72% and Linolenic 0.82%) and saturated fatty acids (Palmitic 14.10% and stearic 2.57%). Results for 3 years production of Syrian Kaissy cultivar olive fruit and oil are discussed in detail.

✉ M. Al-Bachir
ascientific2@aec.org.sy

[1] Radiation Technology Department, Atomic Energy Commission of Syria, P.O. Box 6091, Damascus, Syria

Keywords Kaissy cultivar · Olive fruits characteristics · Olive oil properties · Production year · Syria

Introduction

Olive (*Olea europaea* L.) and olive oil, a traditional food product with thousands of years history, is continually evolving toward a more competitive global market. Being one of the most studied foods across different disciplines, olive oil still needs intensive research activity to face some vulnerabilities and challenges [1]. In the context of religious importance, olive tree and its fruit (olives) are narrated over several times in the Bible, both in the New and Old Testaments as well as in the Quran [2]. Olive is praised as a blessed fruit in Chap. 24 Al-Nur (Quran 35). Olives are known as one of widely cultivated fruit crops world over. Olive trees usually grow between the 30° and 40° latitudes and are cultivated in around 35 countries [3]. About 90% of olives are used for oil production and ten percent for table olives [4]. Several studies have assigned to virgin olive oil (VOO) most of the beneficial effects on human health attributed to the Mediterranean diet [5]. The Mediterranean region nowadays serves as the major international olive growing area, accounting for almost 98% of the world's olive tree plantation [2].

Olive oil is widely used for food preparation (as salad oil, cooking oil, in frying and pasta sauces), in cosmetics and the pharmaceutical industry [6]. Olive oil as a very popular for its nutritive and health-promoting potential, due to the presence of high levels of mono-unsaturated fatty acids (MUSFA) and other valuable minor components [7].

Olive oil quality is affected by several factors, such as agronomic techniques, sensorial conditions, sanitary state of drupes, ripening stage, harvesting and carriage systems, methods and duration of storage, processing technology, cultivar and growing medium [8–11]. In the case of olive oil, the molecular composition is the result of complex interactions between cultivars, fruit ripening, pedo-climatic conditions and orchard management [12]. These changes also affect the oil composition; changes in fatty acids have been described during olive ripening [9].

Syria has an important place in the world's olive production, holds fifth position in world olive production. Oil produced in Syria is to make up more than 7% of the world's total production [2]. However, little studies had been done on the olive fruits and olive oils produced in Syria. This work was carried out during 3 year, with one olive cultivar only, and the results cannot be generalized. The objective of this study was to evaluate the olive fruit characterization, and olive oil properties (physico-chemical properties and fatty acid composition) of Syrian Kaissy cultivar of olives.

Materials and methods

Plant materials and preparation

The studied olive cultivar was Kaissy, the most widespread in Syria. The olive fruits of good quality and in the mature firm condition were harvested during 2007/2008, 2008/2009 and 2009/2010 growing seasons, from the trees grown in grove located at Deer Al Hajar research station, southeast Damascus, Syria (33° 21′ N, 36° 28′ E) at 617 m above sea level., under conventional agriculture practices. The climate of the area is sub-Mediterranean with average annual temperature between 19 and 36 °C in July–August and a minimum of 3 °C in January- February. Annual rainfall varies from 100 to 150 mm with most falling in winter.

Physical and chemical characterization of olive fruit

Physical description was performed according to the International Olive Council standards [13]. Fruit, pit and pulp (flesh) weights was determined by weighting the samples (100 fruits) by using electric balance with 0.01 gm sensitivity and average weight per fruit was calculated. Length/width (L/W) ratio were calculated by dividing the length of the grain over the width of the grain. Pulp/pit ratio were calculated by dividing the weight of the flesh over the weight of the pit.

Moisture (water content) was determined by drying for 6 h at 105 °C. Fruit oil content was determined by means of the Soxhlet fat (as extractable component in Soxhlet apparatus) according to standard methods [14].

Oil extraction

The oils from whole fruit were extracted at the shortest time possible using a mechanical and physical processes [15]. Olive fruits with or without stone were crushed with hummer crusher and slowly mixed for about 30 min at 27 °C, then, the past mixed was centrifuged at 3000 rpm for 3 min without addition of water to extract the oil. Finally, the oils were decanted and immediately transferred into dark glass bottles and stored at room temperature (20–25 °C). Physical and chemical analysis of oils extracted from olive fruit samples were performed immediately after extraction.

Chemical and physical analysis of oils

Acid value (AV) in term of (Oleic acid %), peroxide value (PV) in term of mEq O_2 kg^{-1} oil, iodine value (IV) in g I_2 100 g^{-1}, saponification (specification) value (SV) in term of mg KOH g^{-1} oil sample and the refractive index (RI) at 25 °C were determined according to standard methods [14] (AOAC, 2010). TBA number (Thiobarbituric acid) in mg MDA kg^{-1} sample was measured according to IUPAC direct method [16]. The viscosity of the oils was measured with HAAKE viscometer 6 R plus Model (RTM) using a R2 spindle at 200 rpm. Viscosity values were determined and expressed as mPa.s. The refractive index of olive oil samples was measured in daylight with a Abbe refractometer (VED Carl Zeiss JENA, German) calibrated against pure water at 25 °C.

Determination of total phenol content of olive oil extracts

Phenolic compounds were isolated from olive oil by a three time extraction of solution of oil in hexane with water mixture (60:40 v/v). The Folin–Ciocalteau reagent (Merck Schuchardt OHG. Hohenbrunn, Germany) was added to a suitable aliquot of the combined extracts, and the absorption of the solution was measured at 725 nm using UV–Vis spectrophotometer. Results were expressed in milligrams of gallic acid per kilogram of oil [17].

Fatty acids (FA) determination

The fatty acid methyl esters (FAME) were prepared [18]. The fatty acids (FAs) profile was determined by gas chromatography in a GC- 17 A Shimadzu chromatograph (Shimadzu Corp., Koyoto, Japan) equipped with a flame ionization detector and a capillary column (CBP20-S25- 050, Shimadzu, Australia). The selected chromatographic conditions were; oven temperature 190 °C, detector temperature 250 °C, injector temperature 220 °C; N_2 was used as a carrier gas with split ratio 29:1, the sample volume injected was 1 µl. Peak areas were integrated and converted to FA percentages (direct area normalization) by means of the CLASS—VP 4.3 program (Shimadzu Scientific Instruments, Inc., Columbia, MD). The FA identification was carried out by retention times and by addition of standards.

Colour determination

The color of olive oil was measured using AvaSpec Spectrometer Version 1, 2 June 2003 (Avantes, Holland) and expressed as color L* (lightness), a* (redness), and b* (yellowness) values. Reflectance values were obtained at wave length of 568 nm by exposing the samples to the illuminant [19]. The reported results (L*, a*, b*) are the mean of 9 determination.

Statistical analysis

Results are displayed as means of triplicate determinations and standard deviation. Data were subjected to the analysis of variance test (ANOVA) using the SUPERANOVA computer package (Abacus Concepts Inc, Berkeley, CA, USA; 1998). The p value of less than 0.05 was considered statistically. The degree of significance was denoted as: $p<0.05$*, $p<0.01$** [20].

Results and discussion

Physical and chemical properties of Syrian Kaissy cv. olive fruits

Physical and chemical criteria for various olive fruits are described in detail in the international olive council standards [13]. The data for the characteristics of Syria Kaissy cultivar olive fruits (SKOF) obtained during the period of this study (3 years) are given in Table 1. The mean values of the 3 years data for both measured and calculated variables of Kaissy cultivar olive fruits were; grain length (21.89 mm), grain width (17.92 mm), length/width (L/W) (1.22), weight of 100 grain (379.44 g), weight of 100 pulp (flesh) (319.31 g), weight of 100 pit (60.14 g), pulp/pit ratio (5.35), crude oil (17.13%), water content (moisture) (51.34%).

The international olive standards [13] has defined the characteristics of olive fruit based on grain weight, pit weight and shape of grains. Grains weight are classified into low (<2 g), medium (2–4 g), high (4–6 g) and very high (>6 g). Pit weight are classified into low (<0.3 g), medium (0.3–0.45 g), high (0.45–0.7 g) and very high (>0.7 g). Also olive fruits are classified into spherical (L/W < 1.25), ovoid (L/W = 1.25–1.45) and elongated (L/W > 1.45). Since the characteristics of Syrian Kaissy cv olive fruit (SKOF) used in this study were; grain weight (3.79 ± 0.38 g), pit weight (0.60 ± 0.45 g) and the L/W ratio (1.22 ± 0.04) it could be classified SKOF as medium grain weight, high pit weight and spherical. The pulp/pit ratio was considered low if it was less than four, medium if it was between 4 and 6, high if it was more than six. The pulp/pit ratio of kaissy cultivar was 5.35 ± 0.99, and it could be classified SKOF as medium.

The grain length (mm), grain width (mm), length/width ratio (L/W), pulp/pit ratio, and moisture content (%) of SKOF varied significantly ($p<0.05$) among the years. While the rest determined parameters were not changed significantly ($p>0.05$) due to production year (Table 1). These differences are probably due to growth conditions, agricultural practices, harvest time and processing

Table 1 Characteristics of the Syrian Kaissy cultivar olive fruit (SKOO) produced in 2007, 2008 and 2009

Fruit characteristics	Mean ± SD	2007	2008	2009	p level
Grain length (L) (mm)	21.89 ± 2.00	21.44 ± 0.40[b]	20.15 ± 0.11[c]	24.07 ± 0.32[a]	**
Grain width (W) (mm)	17.92 ± 1.35	18.13 ± 0.24[b]	16.48 ± 0.18[c]	19.15 ± 0.39[a]	**
Length/width (L/W)	1.22 ± 0.0.04	1.18 ± 0.01[c]	1.22 ± 0.01[b]	1.26 ± 0.0.01[a]	**
Weight of 100 grain (g)	379.44 ± 37.38	407.00 ± 18.41[a]	336.90 ± 11.46[a]	394.43 ± 109.10[a]	NS
Weight of pulp (100 grain) (g)	319.31 ± 40.18	352.03 ± 17.77[a]	274.47 ± 4.99[a]	331.43 ± 103.28[a]	NS
Weight of Pit (100 grain) (g)	60.14 ± 4.48	54.97 ± 0.67[a]	62.43 ± 6.72[a]	63.01 ± 7.43[a]	NS
Pulp/Pit Ratio	5.35 ± 0.99	6.40 ± 0.25[a]	4.43 ± 0.43[b]	5.21 ± 1.15[ab]	*
Oil cobtent (fresh weight) (%)	17.13 ± 0.50	17.46 ± 0.19[a]	16.55 ± 0.81[a]	17.37 ± 0.42[a]	NS
Water content (%)	51.34 ± 11.20	54.26 ± 4.35[b]	38.96 ± 0.74[c]	60.79 ± 0.72[a]	**
Dry matter (%)	48.66 ± 11.20	45.74 ± 4.35[b]	61.04 ± 0.74[a]	39.21 ± 0.72[c]	**

NS not significant

*Significant at $p<0.05$

**Significant at $p<0.01$

[abc]Means values in the same row not sharing a superscript are significantly different

parameters. Results were similar to the value found in the literature. Differences between the weight of fruits and pits were significant ($p < 0.05$) for five olive cultivars grown in Turkey [21]. Tanilgan et al. [21] reported that the pit weight of edible olive oil fruits as ranging from 0.2 to 0.6 g. The olive fruits contained high water content (moisture) (51.34 ± 11.20%) (Table 1) and they were not safe for long period storage without spoilage, because, generally, fresh olive fruits having this high moisture content are highly susceptible to microorganisms attack [22].

The content of oil was considered low if it was less than 18%, medium (between 18% and 22%), and high (more than 22%). (fresh weigh) [13]. The oil content of SKOF is 17.13 ± 0.05, and it could be classified as low oil content. Therefore, SKOF is usually preferred for the purpose of table olive and could be used for the purpose of olive oil production. The oil content in SKOF was not varied significantly ($p > 0.05$) among the years. (Table 1).

Effect of production year on chemical properties of Syrian Kaissy olive oils

The values of the chemical parameters of the Syrian Kaissy cultivar olive oils (SKOO) in the 3 year study are presented in Table 2. The 3 year average values of acid (AV), peroxide (PV), TBA, iodine (IV), saponification (SV), and phenolic values were 0.58%, 4.33 mEq O_2 kg^{-1}, 0.028 mg MDA kg^{-1} oil, 90.77 g I_2 100 g^{-1}, 194.91 mg KOH g^{-1}, and 218.08 g gallic acid kg^{-1}, respectively. According to the international olive council [23] there should be a maximum of 0.8, 2.0 and 3.3% acidity in the extra-virgin, virgin and ordinary olive oil, respectively. Since the AV of SKOO was slightly lower than 0.8 (0.58%) it could be classified as extra- virgin olive oil. According to the IOC the max allowable peroxide value for the extra-virgin, virgin and ordinary olive oil is 20 meq O_2 kg^{-1} oil [23]. The peroxide values of 4.33 meq O_2 kg^{-1} in SKOO is under the max allowable limits.

Acid value

The changes of the acid value (AV) of SKOO during 3 years study are shown in Table 2. The AV of SKOO produced in 2007, 2008 and 2009 were 0.39, 1.04 and 0.32%, respectively. The AV of the SKOO produced in 2008 was significantly ($p < 0.05$) higher than those oil produced in 2007 and 2009. Acid value was not significantly different for the oils sampled in 2007 versus the oils sampled in 2009. The higher acid value of SKOO produced in 2008, could be attributed to high lipolytic activity of the native lipases. This is indicative of the high state of rancidity of the oil, which could be due to poor handling, improper storage as well as length of time between harvesting and oil extraction [24]. The AV of the SKOO produced during the three studying years were lower than 2%, which is limit set for VOO quality. The results are well within the IOC standards, implying that the oils sampled in 2007 and 2009 were of extra virgin quality, while the oils sampled in 2008 were of virgin quality [23].

Peroxide value

The effect of year production on peroxide value (PV) of SKOO is shown in Table 2. The PA value of SKOO produced in 2008, 2009 and 2010 were 5.15, 3.06 and 4.79 mEq O_2 kg^{-1} oil, respectively. It was also found that the effect of production years on the PV of SKOO samples was statically important ($p < 0.01$). The pattern of the peroxide parameters supports the importance of evaluating crops over several years versus 1 year. The peroxide value of oil is an important indicator of deterioration of oils. As oxidation takes place the double bonds in the unsaturated fatty acids are attacked forming peroxides [25].

The challenge of producing a high quality olive oils. According to the literature, hydroperoxides, the initial products of oxidation, comparatively unstable, are a very

Table 2 Chemical characteristics of Syrian Kaissy cultivar olive oil produced in 2007, 2008 and 2009

Chemical properties	Mean ± SD	2007	2008	2009	p value
Free fatty acid (%)	0.58 ± 0.05	0.39 ± 0.0.05^{b}	1.04 ± 0.08^{a}	0.32 ± 0.01^{b}	**
Peroxide value (mEqO_2 Kg^{-1} oil)	4.33 ± 0.13	5.15 ± 0.25^{a}	3.06 ± 0.03^{b}	4.79 ± 0.12^{c}	**
TBA value (mg MDA Kg^{-1} oil)	0.028 ± 0.001	0.0019 ± 0.02^{c}	0.0249 ± 0.001^{b}	0.0565 ± 0.001^{a}	**
Iodine number (g I_2 100 g^{-1} oil)	90.77 ± 0.91	94.53 ± 0.57^{a}	93.38 ± 0.46^{a}	84.41 ± 1.71^{b}	**
Saponification value (mg KOH g^{-1} oil)	194.91 ± 0.89	194.37 ± 0.85^{a}	194.88 ± 1.08^{a}	195.48 ± 0.75^{a}	NS
Total phenolic (mg gallic acid kg^{-1} oil)	218.08 ± 6.68	–	314.71 ± 6.48^{b}	339.52 ± 13.56^{a}	**

NS not significant

*Significant at $p < 0.05$

**Significant at $p < 0.01$

^{abc}Means values in the same row not sharing a superscript are significantly different sensitive indicator of the early stages of oxidative deterioration and a good guide to evaluation of olive oil quality [26].

Thiobarbituric acid (TBA) value

The effect of the production year on Thiobarbituric acid (TBA) value of SKOO is shown in Table 2. Production year has a significant ($p < 0.01$) effect on TBA of olive oil. While the lowest value (0.0019 mg MDA kg^{-1} oil) were acquired from the SKOO sample which is produced in 2007, and relating to the production year this values increased to be (0.0249 mg MDA kg^{-1} oil) in SKOO produced in 2008, and finally the higher value (0.0565 mg MDA kg^{-1} oil) were recorded in the SKOO sample was produced in 2009. Some significant changes were observed in creation of TBA in olive oil due to production year. But the changes were in the standard limits given by FDA and European standards [27].

Iodine value

Iodine value(IV) (degree of un-saturation) of SKOO produced in 2007, 2008 and 2009 were found to be 94.53, 93.38 and 84.41 g I_2 100 g^{-1} oil, respectively (Table 2). It was also found that the effect of production years on the IV of SKOO samples was statically important ($p < 0.01$). The values support that the oil is unsaturated but not highly. Saturated oils have low iodine values and unsaturated oils have high iodine values. Iodine value depends directly on the number of double bonds present in oils [28, 29].

Saponification value

Table 2 shows the saponification value (SV) data of SKOO reported as mean value of oils obtained from olives produced in 2007, 2008 and 2009 year production. However, no significant ($p > 0.05$) differences were noticed among the years. The SVs were similar in SKOO produced in 2007, 2008 and 2009. These values were 194.37, 194.88 and 195.48 mg KOH g^{-1} oil in SKOO produced in 2007, 2008 and 2009, respectively. SKOO had a high SVs, and could therefore be industrially useful for soap, shampoo and paints making [30]. Saponification value of oil is an index of average molecular weight of the triglyceride composition of the oil. Values above 200 mg KOH g^{-1} oil indicate the presence of fatty acids of low or fairly low molecular weight, while values below 190 mg KOH g^{-1} oil is an indication that high molecular weight fatty acids is present [31].

Phenolic content

The content of total phenols in SKOO was measured by the folin Ciocalteu assay [17] and expressed as gallic acid equivalents. The concentration of total phenols in SKOO produced in 2008 and 2009 years are presented in Table 2. The concentration of total phenolics in the SKOO of 2008 and 2009 years were 314.71 and 339.52 mg gallic acid kg^{-1} oils. This data indicate that production year is capable of affecting the phenolic composition in olive oil.

Poly-phenols in olive oil are proven antioxidants, and hold the largest contribution to olive oil's stability [32]. It has been recognized that polyphenols are substances with natural antioxidant properties and their presence in olive oils has been associated to their general quality, improving storability, nutritional value and sensorial properties [33].

Factor contributing to the variability in phenolic distribution include cultivar, climate, and agricultural practices [34]. Indeed, there have been proposal to include phenols in olive oil standard [35].

Effect of production year on physical properties of Syrian Kaissy olive oils

The values of the physical parameters of the SKOO in the 3-year study are presented in Table 3. The 3-year average values of refractive index (RI), and viscosity were 1.4666 nD at 25 °C and 139.56 $mPa.s^{-1}$, respectively. However, the 2 years average values of Hunter's color parameters of SKOO were; the lightness (L*= 66.91), redness (a*= 18.80), yellowness (b*= 29.08) and the color differences ($\Delta E = 65.49$).

Refractive index

Refractive index (RI) of oil is an important characteristics for determining the purity or quality of substances. Refractive index of SKOO during this study are presented in

Table 3 Physical characteristics of Syrian Kaissy cultivar olive oil (SKOO) produced in 2007, 2008 and 2009

	Mean ± SD	2007	2008	2009	*p* value
Refractive index (nD 25 °C)	1.4666 ± 0.001	1.4670 ± 0.001^a	1.4659 ± 0.001^a	1.4669 ± 0.001^a	**
Viscosity (mPa.s)	139.56 ± 0.89	137.67 ± 0.58^b	151.67 ± 1.53^a	129.33 ± 0.58^c	**

NS not significant

*Significant at $p < 0.05$

^{abc}Means values in the same row not sharing a superscript are significantly different

Table 3. The RI values were 1.4670, 1.4659 and 1.4669 nD 25 °C in SKOO produced in 2007, 2008 and 2009, respectively. The RI of SKOO varied significantly ($p < 0.01$) among the years. The RI of SKOO in the present study showed that it is not as thick as most drying oil whose refractive index fell between 1.475 and 1.485 [36]. This results is similar to that reported in the literature, and falls within the recommended codex of 1.4677 and 1.4707 for VOO [37].

Viscosity of olive oil

The mean value of the viscosity of the SKOO produced in 2007, 2008 and 2009 were found to be 137.67, 151.67 and 129.33 mPa.s, respectively (Table 3). It is clear that, the viscosity value significantly ($p < 0.01$) changed due to production year. There is a huge variation reported in the literature concerning the vegetable oils. The viscosity value of SKOO was higher than that reported for vegetable oils including Canola, peanut, sesame soybean, sunflower and walnut oils which has viscosities that fell within the range from 40.5 to 57.4 mPa.s [38]. It has been claimed that such differences in the oil viscosity can be attributed to the concentration of saturated fatty acids in the oils. It was observed that when the amount of saturated fatty acids in the vegetable oil was above 16%, the absolute viscosity was higher [38].

Colour of olive oil

The color of SKOO samples was evaluated from the chromatic coordinates a* corresponding to the green zone, b* corresponding to the yellow zone, Lightness L*, and ΔE values of the absorption spectrum (Fig. 1).

The parameters of colour L*, a*, b* and ΔE were measured for SKOO produced in 2008 and 2009, and the results of the measurement were present in Fig. 1. The results indicate that the L* value of SKOO produced in 2008 (71.51) was significantly ($p < 0.01$) higher than those produced in 2009 (62.31). While, a* value of SKOO produced in 2008 (14.65) was significantly ($p < 0.01$) lower than those produced in 2009 (22.95). On the other hand, a significant ($p < 0.01$) higher b* parameters for SKOO produced in 2008 show rather remarkably yellow coloring. Due to production year a significant ($p < 0.05$) higher ΔE value for SKOO produced in 2009 was observed. However, above mentioned changes would not have any negative impact on the consumer [39].

The increase in a* and b* values of olive oil may be due to the decrease in concentration of chlorophyll pigments and lutein, respectively. The color of olive oil can relate to the maturity of the olives used to make it: more green

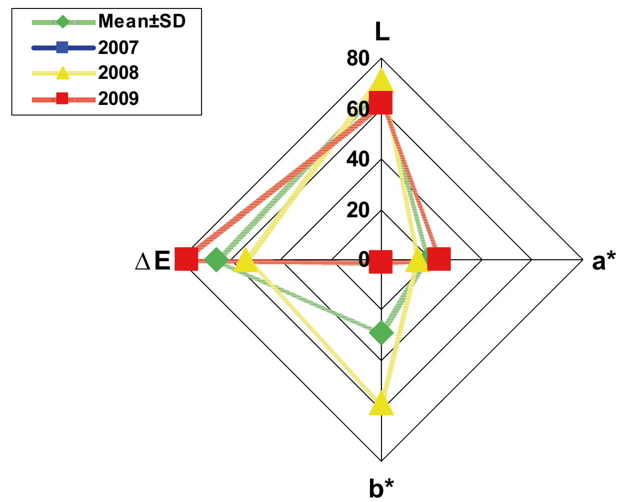

Fig. 1 Color Values measurment of Syrian Kaissy cultivar olive oil (SKOO) produced in 2007, 2008 and 2009

indicates more chlorophyll hence younger olives, more yellow indicates more lutein hence riper olives [15].

It has been demonstrated that change in colour, and increased viscosity are indicators of poor oil quality [40]. VOO has colour from green- yellow to gold. The total pigment content of olive oil is an important quality parameter because it correlates with colour, which is the first attribute of VOO evaluated by consumer [41].

Effect of production year on fatty acids compositions of Syrian Kaissy olive oil

The Syrian Kaissi cultivar olive oil (SKOO) samples during 3– years study were analyzed on the composition of fatty acids using gas chromatographic methods. The mean values of fatty acid FA characteristics of the SKOO during three years in this experiments are reported in Table 4. FA analysis of the SKOO used showed a high content of monounsaturated fatty acids (MUFA) (oleic acid 70.82% and palmitic acid 1.01%) and low polyunsaturated fatty acids (PUSA) (Linoleic acid 10.72% and Linolenic 0.82%) and saturated fatty acids (SFA) (Palmitic 14.10% and stearic 2.57%). Our results are similar in fatty acid composition, when compared to the values in the literature. The oil triglycerides are mainly represented by monounsaturates (oleic acid), along with small amount of saturates and considerable quantity of polyunsaturates (mainly of linoleic acid) [42]. The absence of arachidonic acid and low levels of linolenic and stearic acids in authentic olive oil allow these compounds to serve as a signal for adulteration with other vegetable oils [15]. The allowable fatty acids ranges for extra VOO (according to IOC [23]): (Palmitic (C16:0) (7.5–20.0%); Palmitolic

Table 4 Fatty acids content (%) of Syrian Kaissy cultivar olive oil (SKOO) produced in 2007, 2008 and 2009

	Mean ± SD	2007	2008	2009	p value
Fatty acid					
C16:0	14.10 ± 0.14	13.11 ± 0.14[c]	13.92 ± 0.19[b]	15.27 ± 0.09[a]	**
C16:1	1.01 ± 0.05	0.90 ± 0.02[b]	1.18 ± 0.07[a]	0.95 ± 0.06[b]	**
C18:0	2.57 ± 0.23	3.08 ± 0.29[a]	2.87 ± 0.38[a]	1.74 ± 0.03[b]	**
C18:1	70.82 ± 0.22	71.37 ± 0.17[a]	70.47 ± 0.28[b]	70.61 ± 0.22[b]	**
C18:2	10.72 ± 0.12	10.31 ± 0.07[b]	10.87 ± 0.13[a]	10.98 ± 0.15[a]	**
C18:3	0.82 ± 0.12	1.22 ± 0.32[a]	0.69 ± 0.04[b]	0.55 ± 0.01[b]	**
SFA	16.67 ± 0.18	16.19 ± 0.26[b]	16.79 ± 0.22[a]	17.02 ± 0.07[a]	**
USFA	83.37 ± 0.21	83.81 ± 0.26[a]	82.22 ± 0.21[c]	83.08 ± 0.15[b]	**
USFA/SFA	5.01 ± 0.07	5.18 ± 0.10[a]	4.96 ± 0.08[b]	4.88 ± 0.02[b]	**
PUSFA/SFA	0.69 ± 0.02	0.71 ± 0.03[a]	0.69 ± 0.01[a]	0.68 ± 0.01[a]	NS

NS not significant

*Significant at $p<0.05$

**Significant at $p<0.01$

[abc]Means values in the same row not sharing a superscript are significantly different

(C16:1) (0.3–3.5%); Stearic (C18:0) (0.5-5.0%); Oleic (C18:1) (55.0–83.0%); Linoleic (C18:2) (3.5–21.0%); Linolenic (C18:3) (< 1.0%); Arachidic (C20:0) (< 0.6%); Gadoleic (C20:1) (< 0.4%)). However the individual fatty acid composition, total saturated fatty acids (SFA), total unsaturated fatty acids (USFA), and the ratio USFA/SFA of the olive oil were significantly ($p<0.05$) changed by the year of production (Table 4).

The fatty acid composition in olives can very depending on the olive variety, the ecological locations of the location where the olives are cultivated, and the cultivation methods [9, 43]. Cooler climates produce higher amounts of the polyunsaturated fatty acids (PUSFA) linoleic acid compared with warmer climates where the monounsaturated (MUSFA) oleic acid is more dominants [44].

Conclusion

To the best of our knowledge, this is the first study on the characterization of olive fruits and olive oil of Syrian Kaissy cultivar, during 3- years of production. The analytical parameters studied were within the limits established by the International Olive Council [23] for high quality category extra- virgin or virgin olive oils. However, production year appears to have a significant effect on the quality characteristics and their chemical composition of olive fruits and its oil.

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References

1. D.L. Garcia-Gonzalez, R. Aparicio, Research in olive oil: challenges for the near future. J. Agric. Food Chem **58**(24), 12569–12577 (2010)
2. R. Ghanbari, F. Anwar, K.M. Alkharfy, A.H. Gilani, N. Saari, Valuable nutrients and functional bioactives in different parts of olive (*Olea europaea* L.): a review. Int. J. Mol. Sci **13**, 3291–3340 (2012)
3. M. Ogutcu, M. Mendes, E. Yilmaz, Sensorial and physic- chemical characterization of virgin olive oils produced in Canakkale. J. Am. Oil Chem. Soc **85**, 441–456 (2008)
4. K. Unal, C. Nergiz, The effect of table olive preparing methods and storage on the composition and nutritive value of olives. Grasas y Aceites **54**(1), 71–76 (2003).
5. C. Huang, B. Sumpio, Olive oil, the Mediterranean diet, and cardiovascular health. J. Am. Col. Surg. **207**, 407–416 (2008)
6. N. Kalogeropoulos, A. Mylona, A. Chiou, M.S. Ioannou, N.K. Andrikopoulos, Retention and distribution of natural antioxidants (α-Tocopherol, polyphenols and terpenic acids) after shallow frying of vegetables in virgin olive oil. LWT **40**, 1008–1017 (2007).
7. P. Viola, M. Viola, Virgin olive oil as a fundamental nutritional component and skin protector. Clin. Dermatol. **27**, 159–165 (2009)
8. F.B. Samia Dabbou, S. Dabbou, M. Issaoui, S. Sifi, M. Hammami, Antioxidant capacity of Tunisian virgin olive oils from different olive cultivars. African J. Food Sci. Technol. **2**, 92–97 (2011).
9. A. Esmaeili, F. Shaykhmoradi, R. Naseri, Comparison of oil content and fatty acid composition of native olive genotypes in different region of Liam, Iran. Int. J. Agri. Crop. Sci. **4**(8), 434–438 (2012)
10. H. Jabeur, A. Zribi, R. Abdelhedi, M. Bouaziz, Effect of olive storage conditions on Chemlali olive oil quality and the effective role of fatty acids alkyl esters in checking olive oils authenticity. Food Chem. **169**, 289–296 (2015)
11. C.S. Santos, R. Cruz, S.C. Cunha, S. Casal, Effect of cooking on olive oil quality attributes. Food Res. Int. **54**, 2016–2024 (2013)
12. P. Ninfali, M. Bacchiocca, S. Esposto, M. Servili, A. Rosati, G. Montedoro, A 3-year study on quality, nutritional and

organoleptic evaluation of organic and conventional extra-virgin olive oils. J. Am. Oil. Chem. Soc. **85**, 151–158 (2008)
13. International olive council standards (IOO). 1997. Methodology for primary characterization of olive varieties, project RESGEN-CT (67/97), EU/IOC.
14. AOAC. 2010. Official Methods of Analysis. 15th edn. Association of Official Analytical Chemists" Washington, D.C
15. R.A. Blatchly, Z. Delen, P.B. O'Hara, Making sense of olive oil: Simple experiments to connect sensory observations with the underlying chemistry. J. Chem. Educ. **91**(10), 1623–1630 (2014)
16. IUPAC. 1992. Determination of 2-thiobarbituric acid Value: Direct Method.Vol.61, No, 6, PP.1165–1170. Standard Methods for the Analysis of Oils, Fats and Derivates, 7th edn (Paquot C; Hautffenne A, eds). International Union of Pure and Applied Chemistry, Blackwell Scientific Publications Inc., Oxford, UK.
17. Gutfinger, Polyphenols in olive oil, J. Am. Oil Chem. Soc **58**, 966–968 (1981)
18. M. AL-Bachir, R. Zeinou, Effect of gamma irradiation on the microbial load, chemical and sensory properties of goat meat. Acta Aliment. **43**(2), 72–80 (2014)
19. J.H. Kwon, J. Lee, C. Wajea, J.J. Ahn, G.R. Kim, H.W. Chung, D.H. Kim, J.W. Lee, M.W. Byun, K.S. Kim, K.S. Kim, S.H. Park, E.J. Lee, D.U. Ahn, The quality of irradiated red ginseng powder following transport from Korea to the United States. Radiat. Phys. Chem. **78**, 643–646 (2009)
20. G. Snedecor, W. Cochran, Statistical methods. The Iowa State University Press, Ames, Aiwa, pp. 221–221 (1988)
21. K. Tanilgan, M.M. Ozcan, A. Unver, Physical and chemical characteristics of five Turkish olive (*Olea europea* L.) varieties and their oils. Grasa y Aceites **58**(2), 142–147 (2007)
22. A. Gohari Ardabili, R. Farhoosh, M.H. Khodaparast, Chemical composition and physicochemical properties of pumpkin seeds (*Cucurbita pepo* Subsp- pepo Var. Styriaka) grown in Iran. J. Agr. Sci. Tech. **13**, 1053–1063 (2011)
23. International Olive Council (IOC). 2015. Trade standard applying to olive oils and olive pomace oil. COI/T.15/NC No 3/Rev.9 June 2015. (p. 17)
24. J.Y. Talabi, V.N. Enujiugha, Physical and chemical evaluation of oils from selected underutilized oilseeds. Der. Chemica Sinica **5**(6), 9–12 (2014)
25. V.N. Enujiugha, S.A. I.O. Olotu, Malomo The effect of gamma irradiation and cooking on physicochemical properties of African oil bean seed (*Pentaclethra macrophylla* benth) and its oil extract. J. Food Res. **1**(2), 189–201 (2012)
26. S.A. Vekiari, P. Papadopoulou, A. Kiritsakis, Effect of processing methods and commercial storage conditions on the extra virgin olive oil quality indexes. Grasas Y Aceites **58**(3), 237–242 (2007)
27. M. Suhaj, J. Racova, M. Polovka, V. Brezova, Effect of gamma irradiation on antioxidant activity of black pepper (*piper nigrum* L). Food Chem **97**, 696–704 (2006)
28. H. Sanli, M. Canakci, E. Alptekin, Predicting the higher heating values of waste frying oils as potential biodiesel feedstock. Fuel **115**, 850–854 (2014)
29. M.O. Dawodu, G.O. Olutona, S.O. Obimakinde, Effect of temperature on chemical characteristics of vegetable oils consumed in Ibadan, Nigeria. Pakistan J. Nutr. **14**(10), 698–707 (2015)
30. O.E. Sabinus, Oscar, Physico-chemical properties of oil seeds available for biodiesel preparation. Afr. J. Biotechnol **11**(42), 1003–10007 (2012)
31. M.O. Aremu, O.D. Akinwumi, Extraction, compositional and physicochemical characteristics of cashew (*Anarcadium occidentale*) nuts reject oil. Asian J. Appl. Sci. Eng **3**(1), 33–40 (2014)
32. C. Borchani, S. Besbes, Ch. Blecker, H. Attia, Chemical characteristics and oxidative stability of sesame seeds, sesame paste, and olive oils. J. Agric. Sci. Technol. **12**, 585–596 (2010)
33. A.A. Fernandes-Silva, J.B. Gouveia, P. Vasconcelos, T.C. Ferreira, F.J. Villalobos, Effect of different irrigation regimes on the quality attributes of monovarietal virgin olive oil from cv. "Cobrancosa". Grasa y Aceite **64**(1), 41–49 (2013)
34. D.K. Asami, Y. Hong, D.M. Barret, A.E. Mitchell, Comparison of the total phenolic and ascorbic acid content of freeze- dried and air- dried marionberry, strawberry and corn grown using conventional, organic and sustainable agricultural practices. J. Agric. Food Chem **51**, 1237–1241 (2003)
35. G. Blekas, E. Psomiadou, M. Tsimidou, D. Boskou, On the importance of total polar phenols to monitor the stability of Greek of virgin olive oil. Eur. J. Lipid Sci. Technol. **104**(6), 340–346 (2002)
36. H.N. Ogungbenle, M.F. Afolayan, Physical and chemical characteristization of roasted cashew nut (*Anacardium occidentale*) flour and oil. Int. J. Food Sci. Nutr. Eng **5**(1), 1–7 (2015)
37. Codex standard for olive oils and olive pomace oils. 2003. Codex Stan 33- 1981 (Rev. 2–2003), p: 1–8.
38. L.M. Diamante, T. Lan, Absolute viscosities of vegetable oils at different temperatures and shear range of 64.5 to 4835s-1. J. Food. Process. **2014**, 234583 (2014). doi:10.1155/2014/234583
39. P. Dvorak, J. Kunova, M. Vodnansky, Change of colour and pH-value in pheasant meat after exposure to ionizing radiation. Acta Vet. Brno **76**, S67–S71 (2007)
40. S. Turan, A. Yalcuk, Regeneration of used frying oil. J. Am. Oil Chem. Soc **90**, 1761–1771 (2013)
41. B. Gargouri, S. Ammar, A. Zribi, A. Ben Mansour, M. Bouaziz, Effect of grpwing region onquality characteristics and phenolic compounds of chemlali extra- virgin olive oils. Acta Physiol. Plant **35**, 2801–2812 (2013)
42. R. Aparicio, R. Aparicio-Ruiz, Authentication of vegetable oils by chromatographic techniques. J. Chromatogr **881**, 93–104 (2000)
43. E. Sakar, B. Erol Ak, H. Unver, M. Celik, H. Turkoglu, S. Keskin, Determination total olive oil and cis–trans fatty acids composition of Sirnak Province olive genotypes as southeastern Anatolia. J. Agric. Environ. Sci. **3**(4), 119–129 (2014)
44. B. McKevith, Nutritional aspects of oilseeds. Nutr. Bull. **30**, 13–26 (2005)