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Effect of Extraction Methods and Olive Oil Grades on Physio-Chemical Properties and Sensory Attributes of Olive Oil

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ABSTRACT

The present work aims to study the physio-chemical properties, sensory evaluation, overall quality index, fatty acids composition, oxidative stability and sterol fractions of olive oil extracted in the lab from Maraki, Coratina and Koroneiki olive verities (pressing method) and compared them with oil extracted from three-phase extraction method for the same varieties, as well as study the characteristics of extracted lampante olive oil. The results showed that extracted olive oil from the olive varieties by pressing method were better in the physio-chemical characteristics, and overall quality index than the other obtained oils by three-phase decanters. The results indicated that there were clear changes in percentages predominant saturated and unsaturated fatty acids between extracted oils by pressing technique and three-phase decanters, and they recorded a higher change compared with lampante oil. Analysis of sterols fractions of all olive oil verities revealed that the extracted oils by pressing technique contained a higher percentage of B-sitosterol compared to the oils extracted by three-phase system. On the other hand, the extracted oils by three-phase system and lampante olive oil contained a higher percentage of Δ-7 Avenasterol and Δ-5 Avenasterol compounds compared with extracted oils by pressing method. Also, the results observed that, Δ-7 stigmasterol fraction was detected in all olive oils obtained by three-phase system, and it was presented by closed percent in lampante olive oils, but was not detected in all extracted oils by pressing method. The extracted oils by pressing method from olive verities were classified as extra virgin olive oil. While, produced oils by three phase system were described as virgin olive oil.

Key words: Olive oil, Extraction methods, Oil quality, Fatty acids, Sterols.

Introduction

Olive tree, (*Olea europaea* L.) is a major agricultural crop in the Mediterranean Basin and its economical role in the countries of these regions is well recognized. Olive oil is the most commonly consumed vegetable oil in the Mediterranean area owing to its sensorial quality and beneficial health effects (IOC, 2018).

Olive oil is actually one of the best oils for cooking and frying, it is commonly used in cosmetics, pharmaceutical, soap and as a fuel for traditional oil lampante Olive oil is healthier than other sources of alimentary fat. In addition, it is necessary for human's health, because of its high content of monounsaturated fat (mainly oleic acid), high content of antioxidative substance and polyphenol (Jumat and Nesrain, 2012).

Olive oil quality depends on market preferences and is based upon consumer perception of aroma, taste and colour, which may change over time and with location. Objectionable aroma and taste may lead to product rejection. The absence of sensory defects in olive oil is necessary for the oil to be classified as "extra virgin" whereas the presence and intensity of sensory defects is used to categories oils of other qualities. Both positive and negative sensory attributes in olive oil can be associated with volatile compounds (Kalua *et al.,* 2007).

Olive oils, particularly virgin olive oils, are highly valued because they are traditionally pressed from olives without the use of heat, also because they are considered to be better tasting and nutritionally favorable. Because of the high price of virgin olive oils, there is a great temptation to adulte rate them with oils of similar FA and sterol profiles. (Damirchi *et al.,* 2005).

There are many factors that affect olive oil quality and composition such as; the location (altitude, climatic conditions and soil type), cultivar, fruit maturity stage, fruit health, time and method

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of harvesting, olive storage, oil extraction technique (mill type, extraction temperature and duration), olive oil storage conditions and packaging (Ayoub, 2006).

Olive oil quality is affected by processing system and various stages in the olive oil extraction procedures. The traditional pressing systems have been gradually substituted by the three-phase centrifugal systems, while the two-phase centrifugal systems are being used more recently (Torres and Maestri, 2006).

Various techniques of oil extraction are used, including traditional press, two- and three-phase systems (Torres and Maestri, 2006). Press technique might be considered as the oldest process for obtaining olive oil, this method does not need addition of water to the olive paste. Also, this system has disadvantages such as discontinuity of the process, oil contamination diaphragms and high labor cost (Ayoub, 2006). Three-phase decanters require adding water to the system that dilutes out water soluble components resulting in the separation of the paste into three phases; oil, pomace and wastewater. One of the disadvantages of the three-phase system is the production of a considerable amount of waste water which has a negative effect on the environment (Torres and Maestri, 2006).

Ranalli and Angerosa (1996) compared the oil obtained from three olive cultivars by two and three-phase processes. Oil obtained by the two-phase system was comparable to the oil obtained by the pressure process, but it had better quality characteristics than that of the three-phase decanter oil. They also found that oil obtained from the two-phase system has higher amounts of polyphenols and aroma volatile compounds than oil obtained by the three-phase system.

Sensory quality plays an important factor in olive oil overall quality. Aroma, taste and appearance are particularly significant for extra virgin olive oil. Flavour, olive oil quality and hence its commercial value varies markedly depending on several factors. The complex flavour of virgin olive oil is mainly produced by volatile and phenol compounds most of which have been identified (Morales *et al.,* 1997). The quantities of these substances in olive depend on agronomic factors, olive ripeness, cultivar, olive storage conditions, handling, milling, malaxation and extraction processing (by pressing or centrifugation) (Tzia *et al.,* 1997).

Olive oil has a unique position among edible oils due to its delicate flavour, stability and health benefits. An abundance of oleic acid, a monounsaturated fatty acid, is the feature that sets olive oil apart from other vegetable oils (Tayeb, 2013).

Because of high monounsaturated and low poly-unsaturated fatty acid composition and minor components such as phenolic compounds, tocopherols and sterols, virgin olive oil has stronger oxidation stability.

But the stability is affected by a number of factors such as cultivar, location, harvesting time, processing, and storage. Oil of different cultivars can show different characteristics because of their chemical composition. Environmental condition also influences oil properties such as phenolic compounds, tocopherols, and sterols in the same cultivar (Ügurlu and Özkan, 2011).

In olive oil, content and composition of sterols can vary due to the agronomic and climatic conditions fruit quality, oil extraction and refining procedures and strange conditions. Plant sterols or phytosterols make up the main part of the un-saponifiable fraction of olive oil compositional analysis of the sterol fraction of olive oil can be used to assess the degree of purity of the oil and the absence of other plant oils. This determination also permits characterization of the type of olive oil in question: extra virgin, virgin, refined etc.…. (EEC, 2003). The most abundant olive oil sterol is β-Sitoslerol, followed by Δ-Avenasterol. Composterol and stigmasterol are present in lower concentrations (IOC, 2006).

Sterols from two specimens of olive oil showed a marked difference in their Δ-5-Avenasterol content. Also, the sterol fraction from France and Italy olive oil and common olive oil showed a marked difference in their fractions (Itoh *et al.,* 1973).

The aim of this study was to determine the physio-chemical properties, sterol fractions, stability, fatty acid composition, and organoleptic characteristics of extracted oils from Maraki, Coratina and Koroneiki olive verities by pressing method and three-phase decanters, as well as study the properties for lampante olive oil.

Materials and Methods

1. Materials

I. Olive Fruits

Olive fruits of Maraki, Coratina and Koroneiki varieties were obtained from farm of Horticulture inst. Agric. Res. Center, Giza governorate. The oils for each variety were extracted by pressing mill at the Fats and Oils laboratory. The extracted oil was dried over anhydrous sodium sulphate, filtered through a whatman filter paper No.1 and kept in brown glasses bottles at 5° C till analysis.

Produced oils from the same varieties (Maraki, Coratina and Kroneiki) by three-phase decanters and Lampante olive oil were obtained from International Company for oils and industrial production, Badr city – Industrial zone. Suez desert road – Egypt. Three phase continuous centrifuge system were used in extraction.

2. Methods

I. Physical and chemical properties of olive oils

Acidity and peroxide values were determined according to the A.O.A.C (2016). Absorbency in ultraviolet at 232 and 270 nm (Diene and Triene) and were determined as described by Regulations EEC/1989/2003 of the Commission of the European Union (EEC, 2003). Iodine value was calculated from fatty acids content according to Nelson, S. (1995). K270 and K232 extinction coefficients were calculated from absorbance at 270 and 232 nm, respectively, with a UV spectrophotometer (JENWAY 6405 UV/Vis. Spectrophotometer, England) using a 1% solution of oil in cyclohexane and a path length of 1 cm.

3. Fatty acids composition of olive oils

I. Methylation of fatty acids

An aliquot of fatty acids, about 10 mg, was dissolved in 2ml hexane and then 0.4 ml of 2N KOH in anhydrous methanol was added (Cossiganani *et al.,* 2005) , after 3 min, 3 ml water was added. The organic layer, separated by centrifugation, was dried over anhydrous sodium sulfate, and then concentrated, with a N2 stream to around 0.5 ml for GC analysis of fatty acids methyl esters (FAME) as described below.

II. GC analysis of FAME

Agilent 6890 series GC apparatus provided with a DB-23 column (60 m 0.32 mm 0.25 μm) was used. Oven temperatures were 150°C ramped to 195°C at 5°C min -1, ramped to 220°C at 10°C min -1 and flow rate was 1.5 min -1. Fatty acids results after the previous procedures steps were transformed into methyl esters and directly injected into the GC.

III. PI, AI and COX factors of olive oils

PI (Peroxideability index), AI (Atherogenicity index) and COX (Calculation of Oxidative Stability) were calculated from fatty acids as described by Cortinas *et al.,* (2003), Ulbricht and Southgate (1991) and Fatemi and Hammond (1980), respectively.

Where:

PI: indication the intrinsic peroxide ability index (PI) value of oils was calculated utilizing the following equation; PI=(% monoenoic FA×0.025)＋(% dienoic FA×1)＋(% trienoic FA×2)＋(% tetraenoic FA×4)＋ (% pentaenoic FA×6)＋(% hexaenoic FA×8).

Cox: Calculation of Oxidative Stability of Oils and was calculated utilizing the following equation; COX= 1(C 16:1%+C18:1%+C20:1%+C22:1%) +10.3 (C18:2%) +21.6 (C18:3%)/100.

Atherogenic index (AI) was calculated using the following equation; AI = (C12:0 × (4 × C14:0) + C16:0)/UFA.

IV. Sterol fractions of olive oils

Five g oil sample was dissolved in 3 mL of hexane (purity 99.5%), and then 0.5 mL of 5 α-cholestane (0.4 mg mL^{-1}) internal standard was added. The mixture was saponified with sodium

hydroxide solution in methanol (2N) at water bath for 1-2 h then, unsaponifiable matters were extracted. Then 1 µl of the sample was injected into Agilent 6890 series GC apparatus (setup: DB-5 capillary column, N_2 carrier gas at 0.9 mL min-^{1} and held for 10 min., the internal standard method (5 α-cholestane) was used for quantification (Szterk *et al.,* 2010).

V. Oxidative stability of olive oils

Oxidative stability of the extracted oils was evaluated by Rancimat method (Gutierrez *et al*., 2002). Stability was expressed as the induction time (hours), measured with the Rancimat 679 apparatus (Metrohm Herisou,Co., Switzerland), using an oil sample of 5 g heated to 100°C with air flow rate of 20 L/h.

VI. Sensory evaluation of olive oils

The oil samples (15 mL/each) were presented in covered blue glasses (diameter 70 mm. capacity 30 mL) at 28 ±2°C. The glass was warmed and after removing the cover the sample was smelled and then tasted by the panelists to judge its flavour which is evaluated, as a median value of the panelists score. The organoleptic assessment of virgin olive oil was conducted according to the method (profile sheet) described by IOC, (2007).

3. Determination of overall quality index of olive oil

For a global quality evaluation of virgin olive oil, the Overall Quality Index (OQI) (Kiritsakis *et al.,* 1998) was used as following equation:

QOI = 2.55+0.91 SE-0.78 AV-7.35 K270-0.066 PV

Where: SE: Sensory evaluation (from 3.5-9.0), AV: Acid value (from 0.1-3.3), K270: Absorbance at 270 nm (from 0.08-0.22), PV: Peroxide value (from 1.0-20.0).

Statistical analysis

Data of sensory evaluation were analyzed by the analysis of variances using the general linear model (GLM) procedure within a package program of the statistical analysis system (Copyright 1987, SNS institute Znc. Carry, NC, 2755128, USA, SAS proprietary software, release 6.03). Results were tested for degree of significant level at $P<0.05$.

Results and Discussion

1. Physical and chemical properties of olive oils:

Physico-chemical characteristic of extracted oils by pressing and three-phase methods from olive varieties and lampante olive oil was shown in Table (1) The data revealed that, there are differences among all samples found in values of acidity, peroxide value, iodine value, K_{232} and K_{270}, these values were higher in olive oils extracted by three-phase system compared to extracted oils by pressing method .This differences may be due to that the three-phase decanters require adding water to the olive paste (during malaxation step) which may has a negative effect on the physio-chemical properties of oil (Torres and Maestri, 2006 and Ayoub, 2006), but all these parameters recorded higher increased in lampante olive oil compared with those in oils obtained from the previous three olive varieties by pressing and three-phase decanters.

On the other hand, stability of olive oils obtained from all olive varieties by three-phase system recorded a lowest values (18.2, 30.88 and 31.2 h) compared with lab extracted oils by pressing system (18.8, 31 and 31.9 h) for Maraki, Coratina and Koroneiki varieties respectively, but it was 1.5 h of lampante olive oil.

Data in Table (1) reveal those values of iodine; k_{232} and K_{270} of oils obtained from three-phase system were parallel with the values of lampante olive oil. This may be due to the quality of produced oils by three-phase system affected by extraction and storage conditions (Ayoub, 2006).

Also, from the results in the same Table (1) overall quality index (OQI) of olive oil influenced by extraction methods, the values of OQI for lab extracted oils by pressing technique recorded a higher increased (7.42, 7.76 and 6.77) compared them with industrial produced oils by three-phase decanters (0.58, 1.21 and 0.81) from Maraki, Coratina and Koroneiki vars. respectively but lampante olive oil has the lowest value from OQI (-0.78). This may be due to lab extracted oils of all olive varieties has

the highest value from fruitiness and lower values from acidity, peroxide value and K_{270} nm compared them with industrial produced from the same previous varieties.

Finally, lab extracted oils by pressing technique have good parameters compared them with obtained oils by three-phase system. This good quality could be affected by the considerable amount of β-Sitosterol as natural antioxidant as shown in Table (4), which results in self-protection during oxidation stages.

Table 1: Physical and chemical characteristics of olive oils

Physic-chemical properties of oils	Extracted oils from olive varieties by						Lampante olive oil
	Pressing			Three-phase decanters			
	Maraki	Coratina	Koroneiki	Maraki	Coratina	Koroneiki	
Acidity (%)	0.63	0.49	0.43	1.99	1.27	1.30	4.91
Peroxide value (meq/kg oil)	3.85	2.23	2.73	6.06	7.26	3.88	26.31
Iodine value I_2/100g	93.86	90.24	88.99	96.87	93.16	95.97	96.65
K_{232} nm	1.79	1.70	1.89	2.03	2.23	2.56	2.89
K_{270} nm	0.09	0.11	0.16	0.25	0.23	0.25	0.28
Stability at 100°C (h).	18.8	31.0	31.99	18.2	30.88	31.2	1.5
OQI	7.422	7.764	6.774	0.5804	1.2097	0.807	- 0.778

2. Fatty acids composition of olive oils

Separation and determination of fatty acid methyl esters were carried out by GC-glass coiled column chromatography to identify their types and amounts. It is clear from the data presented in this Table (2) there was difference in fatty acids percentages in lab extracted oils by pressing technique and obtained oils by three-phase system form Maraki, Coratina and Koroneiki olive varieties.

With regarding the results in the same Table, it could be found that, the extracted oils from Maraki ,Coratina and Koroneiki olive varieties by pressing were higher of the percentage of palmitic acid ($C_{16:0}$) (13.76, 15.01 and 15.66%, respectively) than the others obtained by three-phase system (10.7, 12.84 and 11.86%, respectively). But values of oleic acid of oils extracted by pressing were lower than those obtained by three-phase system.

On the other hand, fatty acids $C_{17:0}$, $C_{17:1}$, $C_{22:0}$ and $C_{24:0}$, were not detected of the obtained oils by three-phase system, as well as lampante olive oil, but they were noticed a slight value of extracted oils by pressing method.

Values of palmetic ($C_{16:0}$), palmetoleic ($C_{16:1}$), linoleic ($C_{18:2}$) and lenolenic ($C_{18:3}$) acids were recorded higher increased in lampante olive oil compared with them of extracted oils by pressing and three-phase methods and vice versa, of oleic acid. The percentage of stearic acid in lampante olive oils was nearly of the same percentage as in extracted oils by pressing and three-phase system.

Also results revealed that ratios of PUFS/SFA and C18:2/C18:3 (n-6/n-3) of pressing extracted oil were lower than those of oil extracted by three-phase system for all varieties and lampante olive oil.

Generally, a ratio of PUFA to SFA above 0.45 and a ratio of n-6/n-3 below 4.0 are required in the diet to prevent some diseases such as coronary heart disease and cancer (Simopoulos, 2002).

Finally, extracted oils by pressing and three-phase methods and lampante olive oil showed a marked difference in their fatty acid composition, this may be due to oil extraction technique (malaxation conditions, mill type, extraction temperature and duration) (Ayoub,2006).

3. AI, PI and COX factors of olive oils

Atherogenic index (AI), peroxidability index (PI) and calculation of oxidative stability (COX) of extracted oils by pressing, three-phase systems and lampante olive oils are presented in Table (3). The results showed that AI of pressing extracted oils from Maraki, Coratina and Koroneiki verities were found to be 0.19, 0.22 and 0.22 respectively, but these values were reduced to 0.14, 0.18 and 0.16 of extracted oils by three-phase decanters for the same previous varieties, respectively. But the lampant olive oil had the highest value from AI (0.20). Hence, this factor (AI) is important for the human health diets with a high AI are considered harmful to health.

On the other side, no clear changes of PI and COX values for oils extracted from Maraki, Coratina and Koroneiki varieties by pressing and three-phase methods. But, lampante olive oil

recorded higher values of PI and COX, which were 20.3 and 2.63, respectively. The increase in COX value of lampante olive oil compared with oils extracted from olive varieties under study by pressing and three-phase decanters, may be due to that this oil contains a higher amount from polyunsaturated fatty acids (C18:2 and C18:3), which have a higher molecular weight than the mono-unsaturated fatty acids (oleic acid C18:1) as a shown in Table (2). Also, the difference in values of PI and COX factors which are as indicators for prediction of the oxidation stability may be related to the oxidative stability varied with olive varieties and olive oil grade as well as extraction methods (Traditional and industrially) as a shown in Table (1).

Table 2: Fatty acid composition of olive oils

Fatty acids Composition (%)	Extracted oils from olive varieties by						Lampant olive oil
	Pressing			Three-phase decanters			
	Maraki	Coratina	Koroneiki	Maraki	Coratina	Koroneiki	
Palmitic C16:0	13.76	15.01	15.66	10.70	12.84	11.86	16.50
Palmitoleic C16:1	0.61	1.63	1.31	0.53	1.18	0.42	1.73
HeptadecanoicC17:0	0.05	0.04	0.05	-	-	-	-
Heptadecenoic C17:1	0.06	0.06	0.07	-	-	-	-
Stearic C18:0	2.51	2.07	2.20	2.78	2.33	2.39	2.36
Oleic C18:1	69.80	65.83	70.33	73.62	68.50	73.10	62.04
Linoleic C18:2	10.83	12.72	7.98	10.38	12.25	10.09	15.20
Linolenic C18:3	0.81	0.99	0.90	0.84	1.05	0.99	1.94
Arachidic C20:0	0.36	0.45	0.49	0.59	1.18	0.60	0.65
Eicosenoic C20:1	0.29	0.46	0.34	0.56	0.67	0.55	0.41
Behenic C22:0	0.08	0.11	0.13	-	-	-	-
Lignoceric C24:0	0.84	0.63	0.54	-	-	-	-
TSFA	17.60	18.31	19.07	14.07	16.35	14.85	19.51
TMUFA	70.76	67.98	72.05	74.71	70.35	74.07	64.18
TPUFA	11.64	13.71	8.88	11.22	13.3	11.08	11.08
PUFA/SFA	0.66	0.75	0.465	0.797	0.813	0.75	0.75
n-6/n-3	0.074	0.078	0.113	0.080	0.085	0.098	0.098

Table 3: PI, COX and AI factors of olive oils:

Factors of oils	Extracted oils from olive varieties by						Lampante olive oil
	Pressing			Three-phase decanters			
	Maraki	Coratina	Koroneiki	Maraki	Coratina	Koroneiki	
PI	14.20	16.35	11.54	13.90	16.06	13.90	20.63
COX	2.00	2.20	1.74	2.00	2.20	2.00	2.63
AI	0.19	0.22	0.22	0.14	0.18	0.16	0.20

4. Sterol fractions of olive oils

The sterol fractions of extracted oils by different methods from olive fruits was compared with Lampante olive oil (Table 4). Cholesterol, campesterol, stigmasterol, clerosterol, B-sitosteorl, stiostanol, Δ5, 24-stigmastadienol, Δ7-stigmasterol and Δ7- aveno sterol were identified by GLC for all samples, except for Δ7- stigmasterol was not detected of extracted olive oils by pressing. For comparison, the data of the percent distribution of individual sterols of extracted oils by pressing and three-phase system from olive varieties and lampante olive oil are presented in the same previous Table.

B-sitosterol was occurred of extracted oils by pressing from all olive varieties as a larger amount than of produced oils by three-phase system and lampante olive oils. On the contrary, Δ5- Avenasterol was detected in obtained oils by three-phase system and lampant olive oil, as a larger amount than of pressing extracted oils. The samples of olive oil showed marked differences in their Δ7-stigmasterol and Δ7- Avenasterol contents.

Δ7-Stigmasterol was recorded small values in obtained oils by three-phase and lampante oil, but it was not detected for pressing extracted oils, while Δ7- Avenasterol was occurred in obtained oils from all fruits varieties by three-phase system and lampante olive oil as a larger amount than of lab extracted oils by pressing method from the same varieties.

Also from the results, it was clear that there was abundant from β-sitosterol fraction followed by Δ5-Avenasterol and Δ7- Avenasterol fractions, but stigmasterol was present in lower percentage in all olive oils under study. These results are compatible to IOC, (2006).

Finally, results indicated a wide difference of these sterol fractions between lab extracted oils by pressing and industrial obtained oils by three- phase system, but these results showed slight similarity of sterol fractions between obtained oils by three-phase system and lampante olive oils.

Table 4: Sterol Fractions of Olive Oils.

Sterol fractions (%)	Extracted oils from olive varieties by						Lampant olive oil
	Pressing			Three- phase decanters			
	Maraki	Coratina	Koromeiki	Maraki	Coratina	Koroneiki	
Cholesterol	0	0.30	0.45	0.12	0.20	0.98	0.45
Compesterol	1.36	3.15	3.90	3.86	2.98	1.10	3.11
Stigmasterol	0.4	0.46	0.65	0.36	0.71	0.20	0.57
Clerosterol	1.45	1.16	1.10	0.22	1.24	ND	1.36
B-sitosterol	80.33	84.24	83.63	64.48	61.04	68.88	59.22
Sitostand	1.25	1.82	1.6	1.18	1.22	0.84	1.33
Δ5 Avenastered	8.66	6.12	6.32	10.28	9	20.01	9.24
Δ-5, 24- stigma stadienol	1.97	1.03	1.12	0.23	0.38	0.29	0.47
Δ7- stigma sterol	0.00	0.00	0.00	0.34	0.28	0.11	0.36
Δ-7 Avenasterol	01.81	0.62	1.24	10.56	22.92	7.47	23.80

5. Organoleptic characteristics of olive oil

Results in Table (5) showed the organoleptic test of extracted oils from olives by pressing and three-phase methods. From the results, the median of the positive properties (fruity attribute) recorded a higher values for extracted oils from all olives varieties by pressing method than values of the industrial obtained oils by three-phase system, while defect properties (Musty and fusty attributes) were equal to zero in extracted oils for all olive varieties by pressing methods, but these values of the defect properties were more than zero in produced oils by three-phase decanters, whereas they were ranged from 0.8 to 1.2 (Fusty attributes) and from 0.3-0.5 (Musty attributes) in these oils. Therefore, olive oils under investigation can be divided into Lab extracted oils from all previous olive varieties by pressing method being within the limit of extra-virgin olive oils, while the obtained oils from the same varieties by three-phase system were classified as virgin olive oil, according to **IOC, (2006).**

Table 5: Sensory evaluation of olive oil.

Extracted oils from olive varieties by	Olive varieties	Positive attributes			Negative attributes	
		Fruity	Bitter	Pungent	Fusty	Musty
Pressing	**Maraki**	6.8^{b}	1.5^{b}	4.4^{b}	-	-
	Coratina	7.2^{a}	2.1^{a}	5.6^{a}	-	-
	Koroneiki	6.5^{c}	1.0^{c}	4.0^{c}	-	-
Three- phase decanters	**Maraki**	2.0^{G}	1.2^{b}	3.8^{d}	1.2^{a}	0.3^{b}
	Coratina	2.0^{e}	1.8^{ab}	4.5^{b}	0.8^{ab}	-
	Koroneiki	1.5^{h}	0.5^{d}	3.2^{e}	1.1^{a}	0.5^{b}
	L.S.D	0.5415	0.3750	0.8241	0.8661	0.8825

References

A.O.A.C, 2016. Official methods of analysis of the association of official analytical chemists. Published by the A.O.A.C. 20th Ed., Maryland 20850-3250, U.S.A.

Ayoub, S., 2006. Olive industry in Jordan. Proceeding of the 2nd International Seminar on Olivebioteq, November 5-10, 2006, Marsala, Italy, 65-71.

Cortinas, L., J. Galobart, A.C. Barroeta, M.D. Baucells and M.A. Grashorn, 2003. Change in a-tocopherol contents, lipid oxidation and fatty acid profile in eggs enriched with linolenic acid or very long-chain w3 polyunsaturated fatty acids after different processing methods. J. Sci. Food Agr., 83: 820-829.

Cossiganani, L., M.S. Simonetti, and P. Damiani, 2005. Biocatalyzed acidolysis of olive oil triacylglycerols with 9c, 11t and 10t, 12c isomers of conjugated linoleic acid Eur. Food Res. Technol., 220: 267-271.

Damirchi, S.A., G.P. Savago and P.C. Dulta, 2005. Sterol fractions in hazelnut and virgin olive oils and 4, 4-dimethyl sterols as possible markers for detection of adulteration of virgin olive oil. JAOCS, 82(10): 717-725.

EEC, 2003. Characteristics of olive and olive pomace oils and their analytical methods. EEC Regulation 1989/ 2003. Official J. European communities, 295: 57-66.

Fatemi, S.H. and E.G. Hammond, 1980. Analysis of oleate linoleate and linolenate hydroperoxides in oxidized ester mixture. Lipids, 15:379-385.

Gutiérrez F., M.J. Villafranca and J.M. Castellano, 2002. Changes in the main components and quality indices of virgin olive oil during oxidation, J. Am. Oil Chem. Soc. 79 (7), 669-676.

International Olive Council, IOC, 2018. Trends in World Olive Oil Consumption-IOC Report. Available online: https://www.oliveoilmarket.eu /trends-in-world-olive-oil consumption-ioc-report / (accessed on 3 September 2018).

IOC, 2006. Trade standard applying to olive oils and olive pomace oils in in COI/ T.15/ NC. No.3/ Rev.2.

IOC, 2007. International olive council organoleptic assessment of virgin olive oil. 20 sept. French.

Itoh, T.T.T. and T. Matsumoto, 1973. Sterol composition of 19 vegetable oils. College of Science and Tech., 50: 122-125.

Jumat, S. and F. Nesrain, 2012. Physiochemical properties of Saudi extra virgin olive oil. International Journal of Chemical and environmental enginee, 3(3): 205-208.

Kalua, C.M., M.S., Allen, D.R. BedgoodJr, A.G. Bishop, P.D. Prenzler and K. Robards, 2007. Olive oil volatile compounds, flavour development and quality: A critical review. Food chem., 100: 273-286.

Kiritsakis, P., A.K. Kiritsakis, E.B. Lenart, W.C. Willet and R.J. Hernandez, 1998. Olive Oil: From the Tree to the Table. 2nd Edn., Wiley-Blackwell, USA., ISBN-13: 978-0917678424, Pages: 348.

Morales, M.T., J.J. Rios and R. Aparicio, 1997. Changes in the volatile composition of virgin olive oil during oxidation: Flavors and off-flavors. J. Agric. Food Chem., 45: 2666-2673.

Nelson, S., 1995. Food analysis fat characterization (Oscar, A. pike), chapter 14.

Ranalli, A. and F. Angerosa, 1996. Intregral centrifuges for olive oil extraction. The quality characteristics of products. JAOCS, 73 (4): 417-422.

Simopoulos, A.P., 2002. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed. Pharmacother., 56: 365-379.

Szterk, A.M.R., E. Sosinska, D. Derewiaka and P.P. Lewicki, 2010. Chemical composition and oxidation stability of selected plant oils. J. An oil Chem. Soc., 87: 637-645.

Tayeb, I., 2013. Physical and chemical characteristics of a local Jijel's olive oils. "Nature and Technology" Journal. B-Agronomic and Biological Sciences, Issue n° 08/January, 13-16.

Torres, M.M. and D.M. Maestri, 2006. The effects of genotype and extraction methods on chemical composition of virgin olive oils from Traslasierra Valley (Cordoba, Argentina). Food Chem., 96: 507-511.

Tzia, C., E. Touzopoulou and S. Kontou, 1997. Sensory control of olive oil. Acta Hort., 474: 663-666. Youssef, O., G. Mokhtar, C. Abdelly, S.N. Mohamed, Z. Mokhtar and F. Guido, 2013. Changes in volatile compounds and oil quality with malaxation time of Tunisian cultivars of Olea europea. Int. J. Food Sci. Technol., 48: 74-81.

Ugurlu, H.S. and G. Özkan, 2011. Physical, chemical and antioxidant properties of olive oil extracted form Momecik cultivar. AcademikGida/ Academic food Journal, 9(2): 13-18.

Ulbricht, T.L.V., and D.A.T Southgate., 1991. Coronary heart disease: seven dietary factors. The Lancet 338:985-992.