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The quality of olive oil extracted from some olive varieties cultivated by highly intensive in Egypt

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Abstract

Six olive varieties cultivated by highly intensive, namely (66, 69, Arbosana, Oleana, Koroneiki and Arbequina) and changes in their oil composition under Egypt pedoclimatic conditions were studied. Some characteristics of the extracted oils from cultivation under high-density planting system were evaluated. Fatty acids, minor ones, pigments and phenolic compounds were carried out. Oxidative stability, free acidity, peroxide value, ultraviolet characteristics and changes in the fatty acid levels at fruit ripening were also analyzed. Results showed that significant differences in some analytical parameters in the oils and the majority of studied analytical parameters were noticed that nearly due to the cultivar-environment interaction. Therefore, it can be concluded that both of Koronaikii and variety No. 69 can be cultivated by highly intensive culture to produce high quality olive oil wherefrom high oxidative stability (high shelf life) which high contents form oleic acid, polyphenolic compounds and α-tocopherol.

Keywords: Olive oil, Olive varieties, High-intensive, Phenolic compounds, Olive oil characteristics

1. Introduction

Demand for olive oil is rapidly expanding worldwide because of its healthy image. Olive oil has gained an increasing popularity because of its oleic acid content, which may affect plasma lipid/lipoprotein profiles and richness in antioxidants, which may prevent some human diseases [16]. In front to this dramatic increase in demand for virgin olive oil, the international marketing challenge leads to conceive other olive growing pro-duction systems along with the traditional culture system characterized by low olives production per hectare with high labor use for manual harvesting resulting in high production cost. There are many advantages in implementing the new approach of olive growing using high plantation density under irrigation. This system allows the use of highly efficient mechanical harvesting technique especially toward high yields, with lower labor employment and relative low cost of production.

Olive "Oleae uropaea, L." is one of the most important fruit crops in Egypt since it cultivated in a big area and ranks the fourth place among the fruit crops. The Picual variety is one of the most important commercial olive varieties which can be used for pickling, oil extraction or for the double purposes. Under sandy soil conditions, olive plants gave low yield especially in the newly reclaimed areas such as sides of the desert roads, Sinai and the north western coast [15].

There are currently more than 10 million global hectares of olive orchards in more than 40 countries, with 98% of the orchards planted around the Mediterranean Basin [29]. The expansion and intensification of olive growing and the perception of olive oil and table olives as healthy foods have increased the production and consumption of these products worldwide. The high demand for olive oil was closely followed by an increase in oil production. Olive oil production has risen from ~1,600 K ton in the

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early 90s up to ~2700 nowadays; despite the oil production substantially enhancing, the cultivated land has hardly increased [24]. This significant increase in oil production ha-1 is mostly a result of a modernization in olive cultivation and the growing portion of intensive orchards. Intensive orchards are characterized by: (A) Fast growing and high yielding cultivars. (B) Close spaced planting (higher density). (C) Advanced orchard management: pruning, soil cultivation and plant protection. (D) Micro-irrigation (drippers and sprinklers) which enables fertigation.

Nowadays olive orchards are the widest spread crop among all fruit trees. Approximately 75% of the olive orchards in Israel are traditional rainfed. The remaining 25%, which are grown under intensive cultivation, roughly generate about 70% of the commercial oil production. Such a pronounced improvement in land production is a result of the intensive growth conditions and practices mentioned above. The predominant cultivar in Israeli intensive orchards is 'Barnea'. When given the appropriate conditions, this cultivar bears a commercial yield in its third year and may reach a fruit yield higher than 14 t ha-1 and an oil yield of 2.3 t ha-1. Typical planting spacing was increased from 100-200 to 400-500 trees ha-1, mainly due to regular irrigation throughout the season. One side effect resulting from the intensification of olive orchards is the feasibility to grow olives in extreme dry conditions [10] where commercial yield requires regular and controlled irrigation. Indeed, olive plantations have spread deep into Israel's arid regions.

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2.1.2. Reagents, solvents and standards.

All solvents in this study were purified and distilled before use. Folin-Ciocalteau reagent was obtained from Gerbsaure Chemical Co. Ltd., Germany. α- tocopherol and Gallic acid standards were obtained from Koch Light Laboratories Ltd. England.

2.2. Methods.

2.2.1 Moisture and oil contents of olive fruits:

Moisture content was determined by drying the flesh in an oven at 105˚C until a constant weight according to [8]. Oil content: was determined a Soxhlet apparatus with hexane (60 -80ºC b.p), as described by [1].

2.2.2. Oil extraction.

After harvesting, fresh olives (1.5-2.0 kg) were separated, washed, milled with grinder and pressed with a hydraulic press (carver).

The oil produced from each extraction is filtered and then transferred to dark colored glass bottles and stored in the dark at 4°C until analysis.

2.2.3. Quality characteristics of olive oil:

Acidity, peroxide value and UV absorption characteristics, K232nm (conjugated dienes) and K270nm (conjugated trienes) were carried out following the analytical methods described by [24]. ΔK values were calculated according to the followed equation: $\Delta K = K270 - K266+K274/2$

Table A. Cultivation distances and productivity of olive varieties under study

Varieties		66	69	Arbosana	Oleana	Koronaikii	Arbequina
Cultivation distances		2×4	2×4	2×4	2×4	2×4	2×4
Tree productivity/Kg	3 Years old	7	6	6.5	5	7	7
	4 Years old	4.5	3.5	3	2.5	4	3.5
Number of trees/ acres		525	525	525	525	525	525

2.2.4 The stability of oils.

Oxidative stability was evaluated by the Rancimat method [20]. Stability was expressed as the oxidation induction time (h), measured with the Rancimat 679 apparatus (Metrohm Co., Herisou, Switzerland), using an oil sample of 5.00 g heated to 100˚C ± 2˚C with an air flow of 20 l/hr-1.

2.2.5. Measuring of the oil colour.

The color of six olive oil samples was measured by Lovibond Tintometer, (using 5.25-inch glass) according to the methods described by [1].

2.2.6. Refractive Index.

The refractive index of the tested samples was estimated using a Carl Zeiss Refractometer at 25ºC) according to the methods described by [1].

2.2.7. Iodine value (Calculated).

The iodine value was calculated from the fatty acids composition of tested oils according to [21].

2.2.8. Unsaponifiable matter (%).

Unsaponifiable matter was determined according to the method described in [1].

2.2.9. Determination of total phenolic content.

Phenolic compounds were isolated by triple extraction of a solution of oil (10 g) in hexane (20ml) with 30 ml of a methanol- water mixture (60:40, v/v). The Folin-Ciocalteau reagent was added to a suitable aliquot of the combined extracts, and the absorption of the solution at 725nm was measured. Values are given as milligrams of Gallic acid per kilogram of oil [19].

2.2.10. Fractionation of phenolic compounds (%) by high performance liquid chromatography (HPLC).

Qualitive and quantities determination of phenolic compounds by [14].

2.2.11. Determination of total tocopherol content

The total tocopherol content in oils was determined according to the method of [33]

2.2.12. Determination of pigment content.

Chlorophyll and carotenoid compounds (ppm) were determined at wave length of 670 nm and 472nm, respectively, in cyclohexane using the specific extinction values, by the method of [27].

2.2.13.Determination and identification of the fatty acids composition.

The fatty acids of the analyzed oil samples were determined by GC-Capillary column according to the method reported by [24].

2.2.14. Statistical Analysis.

The results are reported as the mean values. Data were compared on the basis of standard deviation of the mean values. In addition, Duncan′s multiple range tests were used to determine significant differences among data. Statistical analysis was performed using the Statistical 5.00 Package (Stat Soft 97 edition).

3. Results and discussion

3.1. Cultivation distances and productivity of olive varieties under study

From the results, Table 1 the moisture content of olive varieties (66, 69, Arbosana, Oleana, Koroneiki and Arbequina) were 62.05, 62.17, 63.48, 64.07, 58.85 and 64.53%, respectively.

While Koroneiki cultivar recorded lower moisture content compared to the other cultivars under study, on the other hand, the oil content of Koroneiki cultivar was higher than oil 42.74%, followed by Arbosana and 69 with 40.18 and 35.59%, respectively, compared to Oleana cultivar which had a lower percentage of oil (32.90%). according to [18].

3.2. Physical properties of olive oil from olive varieties under study.

Refractive index of edible fats and oils is an important quality assurance characteristic because it is useful for identification processing purposes and for establishing purity, it is the characteristic for each kind of oil linked to acids content, and its saturation degree. As shown in Table 2 the refractive index at 25˚C for olive oil varieties (66, 69, Arbosana, Oleana, Koroneiki and Arbequina) were 1,4676, 1,4669, 1,4682, 1,4673, 1,4676 and 1,4677 respectively [5].

From the data Table 2 it can be seen that the Koroneiki cultivar and the 66 were superior in their scales which found 2.40 and 2.05, compared to the color units of the other cultivars under investigation in the red Lovibond scale. In all tested samples, the yellow gauge was fixed at 35 in a5.25-inch cell. The blue color index for all tested samples was low, and variety 66 had the highest value of 2.15.

From the obtained results of the Table 2, it could be noticed that IP (Induction period) of varieties olive oil Koronakii and 69 were obvious higher than those obtained compared to the other tested samples, which were found to be as 36.90 and 36.59 hours. Meanwhile, it was represented about 29.08, 28.16, 28.01 and 24.54 hours for varieties olive oil 66, Arbosana, Oleana and Arbequina, respectively. Actually, higher induction period (hrs) suggests stronger oxidative stability. The differences in an induction period were mainly due to the different level of total saturated fatty acid content rather than a tocopherol content and other antioxidant compounds.

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3.3. Chemical properties of olive oil from olive varieties under study.

Chemical properties of olive oil extracted from olive varieties (66, 69, Arbosana, Oleana, Koroneiki and Arbequina) were shown in Table 3. Data in Table 3 illustrated that the free fatty acid (% as oleic acid), peroxide value (meq. O2/kg oil) at means were found in the range 0.155% to 0.375 %, and 1.81 to 2.20 (meq. O2/kg oil), respectively.

Table (1): Effect of cultivated by high-intensive on chemical composition (on dry basis) of the fruits of the six investigated olive varieties under study.

Sample		Fruit Weight	Seed Weight	Flesh Weight	Fruit Moisture (%)	Fruit Oil (%) D.W.
66	18/19	3.14 ± 0.8	0.88 ± 0.01	2.25 ± 0.51	64.05 ± 2.75	33.30 ± 2.01
	19/20	3.18 ± 0.91	0.89 ± 0.09	2.27 ± 0.69	60.06 ± 2.66	34.15 ± 1.89
	mean	3.16 ± 0.55	0.88 ± 0.08	2.26 ± 0.74	62.05 ± 2.21	33.75 ± 1.65
69	18/19	3.10 ± 0.36	0.74 ± 0.11	2.36 ± 0.20	62.25 ± 2.09	35.48 ± 1.10
	19/20	3.12 ± 0.28	0.74 ± 0.07	2.36 ± 0.22	62.09 ± 2.11	35.70 ± 1.42
	mean	3.11 ± 0.33	0.74 ± 0.10	2.36 ± 0.25	62.17 ± 2.33	35.59 ± 1.33
Arbosana	18/19	3.72 ± 0.30	0.80 ± 0.12	2.92 ± 0.33	63.27 ± 2.99	40.58 ± 2.50
	19/20	3.70 ± 0.26	0.82 ± 0.11	2.94 ± 0.45	63.70 ± 2.45	39.79 ± 1.89
	mean	3.71 ± 0.25	0.81 ± 0.10	2.93 ± 0.28	63.48 ± 2.74	40.18 ± 2.00
Oleana	18/19	2.18 ± 0.23	0.72 ± 0.08	1.45 ± 0.44	63.92 ± 2.22	32.93 ± 1.14
	19/20	2.18 ± 0.20	0.70 ± 0.09	1.41 ± 0.48	64.23 ± 2.38	32.87 ± 1.15
	mean	2.18 ± 0.20	0.71 ± 0.10	1.43 ± 0.50	64.07 ± 2.44	32.90 ± 1.09
Koronaikii	18/19	3.20 ± 0.31	0.73 ± 0.12	2.35 ± 0.26	58.35 ± 3.10	41.59 ± 1.90
	19/20	3.22 ± 0.48	0.71 ± 0.10	2.37 ± 0.28	59.34 ± 2.87	43.89 ± 1.22
	mean	3.21 ± 0.40	0.72 ± 0.13	2.36 ± 0.20	58.85 ± 2.22	42.74 ± 1.05
Arbequina	18/19	2.74 ± 0.28	0.46 ± 0.07	1.56 ± 0.19	64.83 ± 2.30	32.87 ± 0.99
	19/20	2.80 ± 0.30	0.48 ± 0.09	1.58 ± 0.20	64.23 ± 1.91	32.99 ± 1.11
	mean	2.77 ± 0.22	0.47 ± 0.09	1.57 ± 0.25	64.53 ± 1.85	32.93 ± 1.25
LSD value at $p \geq 0.05$	mean	0.44	0.12	0.35	12.10	6.05

The data (values ± SE) are the mean values of three measurements for the same sample. L.S.D Least significant differences at $p \geq 0.05$.

The variation in free fatty acid value could be attributed to the difference in degree of hydrolysis of some phosphatides and triglycerides and the liberation of free fatty acids. In addition, to be formation of free fatty acids during oxidation as a result of cleavage and oxidation of double bonds. The present results are found to be much greatly lower than the maximum values for human consumption as reported by [24, 28].

Oxidative stability has no official standard, but it is a useful measurement for comparing the relative stability of different oils, and is therefore considered to be a good tool for evaluating the resistance of olive oil to oxidation. The specific extinction values, ultra-violet absorptions at 232 and 268 nm are taken as a good successful index for measuring the formation degree of conjugated fatty acids dienes and trienes, respectively [12].

The quality of the olive oil is studied by measuring the characteristics of the absorption bands between 200 and 300nm. These are frequencies related to conjugated dienes and trienes systems. A low absorption in this region is indicative of a high- quality extra virgin olive oil, whereas adulterated/refined oils show a greater level of absorptions in this region. K232 nm parameter is mainly indicative of the Data in Table 3 showed that the values for the absorbance at 232nm at means were found in the range 0.831 to 1.487 nm. The absorbance at K268 nm, mainly indicative of the conjugated of trienes and of the presence of carbonylic compounds gives the minimum value (0.053) and the maximum value (0.081) nm. The values recorded at 232 and 270 nm for all samples analyzed complied with IOC extra virgin olive oil [24].

Absorption measurements for purity determination were made at 232, 266, 270 and 274 nm. The purity of olive oil can be determined from three parameters: Absorbance at K232, 270 nm and ΔK. Tabulated data in Table 3 showed that the all values for ΔK lie inside the limits specified for extra virgin olive oil in the standard [24].

The iodine value is considered one of the most important chemical properties for quality assurance of lipids and as a good successful measure for changes occurs in the unsaturation degree of their content of fatty acid profiles.

From the same Table 3 that the iodine value (calculated) of the olive oil extracted from olive oil varieties under study (66, 69, Arbosana, Oleana, Koroneiki and Arbequina) at means were 91.67, 86.38, 85.50, 83.73, 89.11 and 78.03 respectively. This is to be expected since it may be attributed to the high proportion of unsaturated fatty acids, also the differences between the degree of saturation to unsaturation and total number of double bonds. These results were found to be in agreement with [22].

Table (2): Physical properties of olive oil extracted from some olive verities cultivated by high-intensive in Egypt.

Sample		**Refractive index at 25℃**	**Induction period (hr)**	**Colour**		
				Y	**R**	**B**
66	18/19	1.4677 ± 0.001	28.27 ± 1.88	35	2.1± 0.09	2.2 ± 0.08
	19/20	1.4675 ± 0.001	29.90 ± 1.56	35	2.0 ± 0.08	2.1± 0.08
	mean	1.4676 ± 0.001	29.08 ± 1.91	35	2.05 ±0.05	2.15 ± 0.09
69	18/19	1.4670 ± 0.001	38.08 ± 2.44	35	2.0 ± 0.10	0
	19/20	1.4668 ± 0.001	35.10 ± 2.65	35	2.2 ± 0.011	0
	mean	1.4669 ± 0.001	36.59 ± 1.75	35	2.1± 0.07	0
Arbosana	18/19	1.4684 ± 0.001	28.70 ± 1.62	35	2.0 ± 0.06	0
	19/20	1.4680 ± 0.001	27.63 ± 1.66	35	1.9 ± 0.05	0
	mean	1.4682 ± 0.001	28.16 ± 1.35	35	1.95 ± 0.03	0
Oleana	18/19	1.4671 ± 0.001	29.40 ± 2.00	35	1.5 ± 0.10	0
	19/20	1.4675 ± 0.001	26.62 ± 1.82	35	1.7 ± 0.09	0
	mean	1.4673 ± 0.001	28.01 ± 1.99	35	1.6 ± 0.06	0
Koronaikii	18/19	1.4679 ± 0.001	35.02 ± 2.08	35	2.30 ± 0.10	1.0± 0.01
	19/20	1.4673 ± 0.001	38.79 ± 2.95	35	2.50 ± 0.11	0.8 ± 0.01
	mean	1.4676 ± 0.001	36.90 ± 1.81	35	2.40 ± 0.09	0.9± 0.01
Arbequina	18/19	1.4679 ± 0.001	25.12 ± 1.09	35	2.0 ± 0.09	0
	19/20	1.4675 ± 0.001	23.96 ± 1.55	35	2.2 ± 0.07	0
	mean	1.4677 ± 0.001	24.54 ± 1.48	35	2.1 ± 0.06	0
LSD value at $p \geq 0.05$	mean	0.002	4.09		0.34	

The data (values ± SE) are the mean values of three measurements for the same sample. L.S.D Least significant differences at $p \geq 0.05$.

That result indicates that olive oil be longed to the non-drying oil category. Also, we can notice from the same Table 3 that the unsaponifiable matter content of olive oils varieties under study was higher content in Koronakii (1.42%) followed by variety 69 (1.29%).

The lowest value of unsaponifiable matter content in variety Arbequina which was found to be as 0.97%. Besides the total polyphenols compounds ranged between 125.81 to 242.35 mg/kg, these results are in the limits of Egyptian standard [13].

3.4. Fatty Acids Composition.

Fatty acids composition of the oil may differ depending on the variety, separation to these fatty acids methyl esters and the determination were carried out by gas-liquid chromatography (GLC) in order to identify their types and the amount, the data in Table 4 showed that the fatty acids composition of olive oil extracted from olive fruits varieties understudy (66, 69, Arbosana, Oleana, Koroneiki and Arbequina).

The fatty acids composition of virgin olive oil has great importance from a health point of view. Olive oil contains mainly monounsaturated fat. The ratio of the different fatty acids in the oil influences the stability of the oil, as well as determining its nutritional value. Some fatty acids are considered to be better than others. The main fatty acid is oleic acid, which can represent between 55 and 83% of the total fat.

Table 4 illustrated that the major unsaturated fatty acids in all samples under study were oleic acid followed by linoleic acid, while, the major saturated fatty acids in all samples under study were palmitic acid followed by stearic acid. Oleic acid (C18:1) is the main mono unsaturated fatty acid and is present in higher concentrations in olive oil obtained from olive varieties under investigation (66, 69, Arbosana, Oleana, Koroneiki and Arbequina) at means were 71.59, 71.34, 58.73, 47.19, 70.47 and 48.42% respectively. These results are in agreement with the [13] except the varieties Oleana and Arbequina which was lower than the minimum range which is 55% [13].

Concerning linoleic acid (C18:2) which is much more susceptible to oxidation than mono unsaturated fatty acid the highest percentage in this olive oil extracted from olive varieties under investigation was 24.26% this value is not in agreement of the [13] and that was for Oleana variety, but the lowest content was for the variety No 69 and that was 5.18% (Table 4), for the other fatty acids palmitoleic (C16:1), stearic (C18:0) and linolenic (C18:3) were found in small amount. These results are similar with those reported by [31, 2].

Table (3): Chemical properties of olive oil extracted from some olive verities cultivated by high-intensive in Egypt.

Sample		F.F.A (as% oleic acid)	Peroxide value (meqO2 /Kg)	ΔK	Conjugated diene at 232 nm	Conjugated triune at 268 nm	Iodine value (calculated)*	Unspecifiable matter %	Total phenolic Mg/kg
66	18/19	0.16±0.02	1.02±0.09	0.0005±0.00	0.580±0.08	0.046±0.001	92.19±2.44	1.24±0.08	139.90±3.05
	19/20	0.15±0.01	2.60± 0.1	0.001±0.00	1.083±0.09	0.061±0.001	91.15±2.59	1.09±0.09	126.00±2.99
	mean	0.15±0.01	1.81± 0.08	0.0007±0.00	0.831±0.07	0.053±0.001	91.67±2.22	1.16±0.06	132.95±2.75
69	18/19	0.21±0.01	1.10± 0.1	0.0005±0.00	0.964±0.09	0.051±0.001	87.05±1.95	1.40±0.03	128.13±3.33
	19/20	0.30±0.03	1.69± 0.07	0.000±0.00	1.054±0.05	0.102±0.001	85.72±1.88	1.19±0.05	125.36±3.21
	mean	0.25±0.01	1.39± 0.05	0.0002±0.00	1.009±0.02	0.076±0.001	86.38±1.65	1.29±0.07	126.74±2.66
Arbosana	18/19	0.19±0.02	1.20± 0.1	0.002±0.00	0.827±0.07	0.055±0.001	85.61±2.09	1.02±0.02	144.8±4.01
	19/20	0.25±0.02	3.20± 0.08	0.00±0.00	1.099±0.06	0.098±0.001	84.48±1.88	1.01±0.05	228.00±3.85
	mean	0.22±0.01	2.20± 0.07	0.001±0.00	0.963±0.05	0.076±0.001	85.50±2.01	1.01±0.06	186.40±2.50
Oleana	18/19	0.35±0.01	1.29± 0.11	0.001±0.00	0.962±0.09	0.049±0.001	83.91±2.69	1.01±0.04	125.22±2.78
	19/20	0.40±0.01	1.89± 0.09	0.01±0.00	1.046±0.08	0.099±0.001	83.55±2.41	1.0±0.05	126.40±2.46
	mean	0.37±0.01	1.59± 0.09	0.005±0.00	1.004±0.05	0.074±0.001	83.73±2.38	1.00±0.02	125.81±1.99
Koronaikii	18/19	0.33±0.01	1.05± 0.1	0.001±0.00	0.829±0.08	0.050±0.001	89.25±2.89	1.46±0.09	245.25±3.40
	19/20	0.40±0.02	3.10± 0.1	0.00±0.00	1.086±0.06	0.099±0.001	88.97±1.98	1.39±0.03	239.44±3.25
	mean	0.36±0.01	2.07± 0.1	0.0005±0.00	0.957±0.02	0.074±0.001	89.11±2.00	1.42±0.03	242.35±2.11
Arbequina	18/19	0.28±0.01	1.33± 0.07	0.001±0.00	0.950±0.03	0.062±0.001	78.20±2.05	0.95±0.01	131.47±2.09
	19/20	0.45±0.01	2.90± 0.08	0.01±0.00	1.074±0.01	0.100±0.001	77.86±2.11	0.99±0.01	143.00±2.41
	mean	0.36±0.01	2.11± 0.06	0.005±0.00	1.487±0.01	0.081±0.001	78.03±2.66	0.97±0.01	137.23±2.15
LSD value at $p \geq 0.05$	mean	0.04	0.30	0.0003	0.17	0.01	11.28	1.14	26.30

The data (values ± SE) are the mean values of three measurements for the same sample. L.S.D Least significant differences at $p \geq 0.05$.
*Iodine value was calculated from the fatty acids composition of tested oils according to (Ham et al., 1998).

It was observed also that olive oil extracted from Arbequina variety was rich in total saturated fatty acids (SFA) (24.99%) essentially due to its high content in palmitic acid, and variety No 66 was rich in total unsaturated fatty acids (USFA) (83.92%) essentially due to its high content of fatty acids composition of olive oil could be mainly due to variety, but also climate latitude and stage of maturity of the olives collected. It was evident that the increase in the total saturated fatty acids reflected the decrease in both iodine value and reflective index. These results are in reasonable agreement with [7].

3.5. Phenolic compounds of olive oil extracted from olive fruits varieties under investigation.

Phenolic compounds, is perhaps the most important of the minor components in olive oil, owing to their powerful antioxidant effect on the oil and the resulting contribution to shelf-life stability. Polyphenol is a general term used to describe natural substances that contain a benzene ring with one or more hydroxyl groups containing functional derivatives that include esters, methyl esters and glycosides According to [32].

Poly phenolic compounds play important role in the quality of the olive oil and affect its stability and flavour. The total poly phenolic were separated and analysed to its composition by HPLC and the peaks were identified by comparing of the relative retention times with these of the standard, were found in olive oil obtained from the olive varieties under investigation (66, 69, Arbosana, Oleana, Koroneiki and Arbequina).

Table (4): Fatty acids composition (%) for olive oil extracted from olive fruits under study.

Fatty acids		66	69	Arbosana	Oleana	Koronaikii	Arbequina
C16:0	18/19	13.7	15.9	19.76	21.28	14.7	22.55
	19/20	12.9	15.8	18.76	21.25	14.71	21.68
	mean	13.3	15.8	19.26	21.26	14.705	22.11
C16:1	18/19	1.07	1.92	3.43	3.13	1.46	3.78
	19/20	0.96	1.81	3.15	3.18	1.49	3.89
	mean	1.01	1.86	3.29	3.15	1.47	3.83
C17:0	18/19	0.04	0.14	0.15	0.16	0.06	0.16
	19/20	0.04	0.15	0.14	0.15	0.06	0.13
	mean	0.04	0.15	0.145	0.155	0.06	0.145
C17:1	18/19	0.07	0.25	0.32	0.24	0.13	0.24
	19/20	0.07	0.25	0.3	0.21	0.10	0.21
	mean	0.07	0.25	0.31	0.225	0.115	0.22
C18:0	18/19	2.14	3.63	1.94	1.88	2.45	1.75
	19/20	2.27	3.7	1.95	1.9	2.44	1.82
	mean	2.2	3.66	1.945	1.89	2.445	1.78
C18:1	18/19	70.2	71.1	57.17	47.17	70.5	47.48
	19/20	73.0	71.5	60.29	47.21	70.45	49.37
	mean	71.6	71.3	58.73	47.19	70.47	48.42
C18:2	18/19	10.6	5.39	15.77	24.27	9.0	22.32
	19/20	8.74	4.98	13.73	24.25	8.84	21.34
	mean	9.69	5.18	14.75	24.26	8.92	21.83
C18:3	18/19	1.25	0.86	0.82	1.04	0.95	0.93
	19/20	1.12	0.9	0.85	1.01	0.94	0.83
	mean	1.18	0.88	0.835	1.02	0.945	0.88
C20:0	18/19	0.45	0.51	0.39	0.44	0.45	0.41
	19/20	0.41	0.53	0.42	0.45	0.49	0.37
	mean	0.43	0.52	0.405	0.445	0.47	0.39
C20:1	18/19	0.4	0.22	0.2	0.24	0.30	0.24
	19/20	0.35	0.25	0.21	0.26	0.30	0.21
	mean	0.37	0.23	0.205	0.25	0.30	0.22
C22:0	18/19	0.12	0.09	0.09	0.12	0.16	0.11
	19/20	0.12	0.09	0.14	0.13	0.15	0.09
	mean	0.12	0.09	0.115	0.125	0.155	0.1
Σ SFA	18/19	16.4	20.2	22.29	23.91	17.66	25.01
	19/20	15.7	20.3	21.47	23.88	17.88	24.98
	mean	16.1	20.2	21.88	23.89	17.77	24.99
Σ USFA	18/19	83.6	79.8	77.71	76.09	82.34	74.99
	19/20	84.3	79.7	78.53	76.12	82.12	75.02
	mean	83.9	79.8	78.12	76.1	82.23	75.00

SFA: Saturated fatty acids, USFA: Unsaturated fatty acids

Table (5): Phenolic compounds (%) for olive oil extracted from olive fruits under study

Phenolic		66	69	Arbosana	Oleana	Koronaikii	Arbequina
Pyrogallol	18/19	34.74	39.66	60.1	185	61.04	190.87
	19/20	34.36	39.74	59.96	184.88	60.82	188.86
	mean	34.36	79.4	60.03	184.94	60.93	189.86
Gallic	18/19	1.05	1.23	1.15	1.09	6.99	1.12
	19/20	1.09	1.27	1.16	1.11	7.01	1.16
	mean	1.07	1.25	1.155	1.1	7.0	1.14
3-OH Tyrosol	18/19	1.47	1.36	1.89	1.11	3.53	0.92
	19/20	1.52	1.41	1.91	1.13	3.6	0.96
	mean	1.49	1.38	1.9	1.12	3.56	0.94
Catechol	18/19	2.54	2.91	7.54	1.9	2.92	1.81
	19/20	2.49	2.85	7.48	1.89	2.98	1.85
	mean	2.51	2.88	7.51	1.895	2.95	1.83
4-Amino-benoic	18/19	13.94	14.58	0	3.36	5.35	4.15
	19/20	14.11	15.01	0	3.5	5.26	4.2
	mean	14.02	14.79	0	3.43	5.3	4.17
Catechein	18/19	10.45	10.0	39.02	26.4	136.63	23.56
	19/20	10.98	10.24	38.89	26.38	136.61	23.36
	mean	10.71	10.12	38.95	26.39	136.62	23.46
Chlorogenic	18/19	66.25	62.13	65.21	69.57	126.17	71.96
	19/20	66.23	61.94	65.31	69.8	126.5	71.91
	mean	66.24	62.03	65.26	69.68	126.33	71.93
P-OH-Benzoic	18/19	14.1	13.22	0	33.26	12.09	45.73
	19/20	13.96	13.0	0	33.28	11.58	46.0
	mean	14.03	13.11	0	33.27	11.83	45.86
Benzoic	18/19	38.84	36.81	158.88	41.02	69.76	34.95
	19/20	38.33	36.99	159.0	40.78	69.81	35
	mean	38.58	36.9	158.94	40.9	69.78	34.97
Caffeic	18/19	9.78	11.52	11.79	8.46	32.34	1.71
	19/20	10.01	11.48	11.86	8.62	33	1.69
	mean	9.89	11.5	11.82	8.54	32.67	1.7
Vanillic	18/19	74.65	65.22	18.49	15.9	175.48	13.83
	19/20	73.99	66.0	18.4	15.98	176.01	14.01
	mean	74.32	65.61	18.44	15.94	175.74	13.92
Caffeine	18/19	17.32	16.4	32.62	8.1	11.12	3.35
	19/20	17.38	16.72	31.94	8.44	10.99	3.23
	mean	17.35	16.56	32.28	8.27	11.05	3.29
Ferulic	18/19	99.54	96.68	51.27	78.99	121.03	82.57
	19/20	99.0	96.99	51.5	79.06	122	81.99
	mean	99.27	96.83	51.38	79.02	121.51	82.28
Ellagic	18/19	216.05	234.11	157.11	126.82	543.13	132.04
	19/20	215.95	233.88	156.61	126.8	538.96	132.5
	mean	216	233.99	156.86	126.81	541.04	132.27
Salyecillic	18/19	24.84	25.03	59.03	32.06	9.3	46.0
	19/20	25.16	24.9	59.0	31.9	9.11	46.08
	mean	25.0	24.96	59.01	31.98	9.2	46.04
Oleuropein	18/19	74.58	73.44	52.79	6.44	575.76	4.48
	19/20	74.12	74.0	52.8	6.51	576	4.5
	mean	74.35	73.72	52.79	6.47	575.88	4.49
Coumarin	18/19	124.43	119.69	109.16	111.2	132.89	113.08
	19/20	125.09	119.58	109.09	110.66	133	112.96
	mean	124.76	119.63	109.12	110.93	132.94	113.02

The results in Table 5 showed that seventeen phenolic acids were identified Pyrogallol, Gallic, 3-OH Tyrosol, Catechol, 4-Amino-benoic, Catechein, Chlorogenic, P-OH-Benzoic, Benzoic, Caffeic, Vanillic, and Caffeine. Ferulic, ellagic, salicylic acids, oleuropein and coumarin. The results in Table 5 showed that the main phenolic compound in olive oil obtained from the alternative olive varieties was coumarin acid with a ratio ranging between 109.12 to 132.94% and the other main

Table (6): Pigments chlorophyll and carotene (Mg/Kg) for olive oil extracted from olive fruits under study

Pigments		66	69	Arbosana	Oleana	Koronaikii	Arbequina	LSD value at $p \geq 0.05$
Chlorophyll	18/19	6.70 ±0.30	7.90±0.40	6.00±0.40	4.70±0.30	7.80±.40	4.60±0.50	1.05
	19/20	6.30 ±0.40	6.50±0.30	6.40±0.30	6.00±0.40	6.70±0.40	6.20±0.40	
	mean	6.50 ±0.35	7.20±0.40	6.20±0.40	5.30±0.30	7.20±0.30	5.40±0.30	
Carotenoids	18/19	6.35 ±0.25	6.55±0.30	6.43±0.40	6.00±0.30	6.77±0.20	6.23±0.40	1.07
	19/20	6.98 ±0.30	6.25±0.50	6.48±0.60	6.51±0.50	6.59±0.50	6.56±0.40	
	mean	6.66 ±0.20	6.40±0.40	6.45±0.30	6.25±0.50	6.68±0.40	6.39±0.40	
α-tocopherol	18/19	54.66 ±0.90	62.40±0.80	58.09±0.70	64.72±0.90	73.26±0.90	56.11±0.40	10.26
	19/20	56.18 ±0.90	64.22±0.90	57.81±0.80	63.50±0.80	72.00±0.80	56.34±0.80	
	mean	55.42±0.80	63.31±0.80	57.95±0.90	64.11±0.80	72.63±0.90	56.22±0.90	

The data (values ± SE) are the mean values of three measurements for the same sample. L.S.D Least significant differences at $p \geq 0.05$.

Phenolic compound was chlorogenic, which ranged from 62.03 to 126.33%, followed by Ferulic, which ranged from 51.38 to 121.51%, followed by Pyrogallol, which ranged from 34.36 to 189.86% and Vanillic, which ranged from 15.94 to 175.74%. The phenolic compounds in olive oil depend on several factors such as the crop, origin, variety, ripeness, conservation of the olives, climate, plantation process, technological processes used for oil extraction, olive oil transport, and the harvesting system [4, 11].

3.6. Pigments chlorophyll and carotene of olive oil extracted from olive fruits varieties under investigation.

Pigments are responsible for the colour of olive oils, and are an important ingredient that is directly related to the quality of this food. Pigments in olive oils can be divided in two main classes: carotenoids and chlorophyll derivatives they are responsible for the colour of olive oils, which is an important feature for the quality of EVOO. Moreover, pigments' bioactivity is associated with their healthy properties for several human organs, such as the brain and nervous system [26].

Chlorophyll has been shown to have a pro-oxidant effect on oil stability under light conditions [29]. Data presented in Table 6 showed that there were significant differences among the six cultivars (66, 69, Arbosana, Oleana, Koroneiki and Arbequina).

The highest chlorophyll content observed for Koronaikii and variety No 69 which were (7.20), while the lowest content obtained for Oleana variety was (5.30). This result could be explained to the decline in chlorophyll pigment as ripening progressed, which allow for the other pigments like anthocyanins, carotene and carotenoids to dominate. Also, we can notice from the same Table 6 that the carotenoids (mg/kg) of olive oils varieties understudy was higher content in Koronakii (6.68) followed by variety 66 (6.66).

The lowest value of the carotenoids content (mg/kg) in variety Oleana which was found to be as 6.25 mg/kg. These results agreed with the previous results by [17, 3]. According to [9], the α-tocopherol (mg/kg) was highest in Koroneiki (72.63), it was the lowest in variety no 66 (55.42).

4. Conclusion

The resuls showed that there were significant differences between the oils of the studied varieties, and the majority of the studied analytical variables were significantly affected by the interaction between the variety and the environment. The results also showed that there are some olive cultivars whose purity specification (fatty acids) do not comply with the standards (International Olive Council - Codex - Egyptian). Therefore, the people cannot expand

The cultivation of these varieties in Egypt and rely on other varieties that are compatible with the environmental conditions, as well as the oil extracted from them that is compatible with the standards.

Conflict of interest

The authors declare no conflict of interest.

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