

Changes in Some Physical and Chemical Properties of Fruit and Oil in Some Olive Oil Cultivars During Harvesting Stage

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Abstract: This work was carried out through 2004 and 2006 seasons on three olive oil cultivars (Arbequina, Bouteillan and Koroneiki). Trees were 12 years old, grown in sandy soil, planted at 5x5 meters apart under drip irrigation system. The investigation aimed to study the changes in some physical and chemical fruit and oil properties in relation to harvesting stage. Results proved that the increment in fruit size prior to fruit coloration comes mainly from increased moisture content of the fruit. Therefore, it is important that trees should be supplied with adequate water for several weeks just before harvest. Where, oil begins to accumulate in the fruit, increases gradually through July, August and reaches its maximum as fruit become completely black. Oil properties were also related to fruit harvesting stage. The purple color is the proper harvesting stage for producing olive oil of adequate quantity and best quality.

Kew words: Olive (*Olea europaea*) % Arbequina % Bouteillan % Koroneiki % Harvesting stage % Fruit quality % Oil content

INTRODUCTION

The evergreen olive tree (*Olea europaea*, L.), thrives best in the subtropical climates of the countries bordering the Mediterranean Sea and North Africa. Most of olive fruits are utilized as naturally ripe olive in brine or as a source of oil. As fruit color develops some changes occur including fruit weight, moisture content and flesh to pit ratio, fat content and oil compositions [1, 2]. Fresh fruit weight increased with maturity for most olive cultivars. The moisture content of the fruit decreased as the fruit matured. Oil content showed a rapid increase during the first part of maturation, followed by a slower increase later in the season [3, 4]. The oil content in the fruit is related to their degree of maturity [5]. The content of palmitic acid and saturated fatty acid were decreased during fruit ripening while oleic and linoleic acids were increased. The amount of stearic and linolenic acids were decreased. The amount of saturated acids, palmitic, stearic and the polyunsaturated acid, linoleic and linolenic dependent on the time of harvest [6, 7]. Acidity, peroxide index, UV absorption at 232 and 270 nm, sensory characteristics, fatty acid composition, tocopherols, phenolic compounds,

orthodiphenolic compounds, sterols, pigments and oxidative stability for virgin olive oil from olives of two cultivars 'Picual' and 'Hojiblanca' were increased at different ripening stages [8]. Free acidity, peroxide number and delta K were increased during olive ripen [9,10]. Skin color classes seemed to be a good method to determine the beginning of harvesting period for olive cultivar Arbequina [11].

The present experiment was performed to study the changes in some physical and chemical fruit and oil properties during harvesting stages of Arbequina, Bouteillan and Koroneiki olive cultivars in order to obtain fruit and oil of highly quantity and best quality.

MATERIALS AND METHODS

The present study was conducted out on twelve mature trees of the three olive oil cultivars (Arbequina, Bouteillan and Koroneiki). The trees were 12 years old, grown in a sandy soil at planting distance of 5x5 meters apart under drip irrigation system in El-Kassassen Experimental Station, belonging to the Horticulture Research Institute, Ministry of Agriculture, Egypt.

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Experimental trees were subjected to the ordinary horticultural practices and the work conducted during 2004 and 2006 seasons, because of reasons beyond control (unfavorable weather conditions prevailing in the 2005 season) results of 2005 season were eliminated.

The fruits of each cultivar were distributed to harvest in three ripening groups according to their skin color (green, purple and black).

Green: in Arbequina (13/9/2004 and 26/9/2006), Bouteillan and Koroneiki (20/9/2004 and 3/10/2006)

Purple: in Arbequina (3/10/2004 and 20/10/2006), Bouteillan and Koroneiki (13/10/2004 and 1/11/2006)

Black: in Arbequina (13/10/2004 and 1/11/2006), Bouteillan and Koroneiki (20/10/2004 and 7/11/2006)

For each cultivar only healthy fruits, without any kind of infection or physical damage were selected.

Fruit Physical Characteristics:

- C Fruit weight was determined by weighing the samples (100 fruits) by using electric balance with 0.01 gm sensitivity and average weight per fruit was calculated.
- C Fruit volume was measured by water displacement method.
- C Pit weight was determined by weighing the sample (100 pit) and average weight of pit was calculated.
- C Flesh / Pit ratio was calculated by dividing the weight of the flesh over the weight of the pit.

Chemical Characteristics

Moisture Content: It was determined by drying the flesh in an oven at 60-80°C until a constant weight according to A.O.A.C. [12].

Oil Percentage: Fruit oil content was determined by means of the Soxhlet fat extraction apparatus using Hexane of 60-80°C boiling point as described by A.O.A.C. [12].

Oil Extraction: Oil was extracted from the samples using chloroform: methanol mixture (2:1, v/v) according to the method described by Kates [13].

According to the data of oil chemical characteristics and oil fatty acid composition of Arbequina, Bouteillan and Koroneiki cvs., results were determined only during 2006 season.

Acid Percentage: It was determined according to the A.O.C.S. method [14].

The Peroxide Value: The peroxide value was determined according to Jacobs [15].

Ultraviolet Spectrum: The ultraviolet absorbance at 232 nm (conjugated diene) and 270 nm (conjugated triene) of the oil samples were measured on Spectrophotometer according to A.O.A.C [16].

Determination of Fatty Acid by G.L.C.: Methyl esters of fatty acid of olive oil were prepared in methanol containing 2.5-3% sulphuric acid and the methylation was carried out for 2.5-3 hours according to the method reported by Anon [17].

Statistical Analyses: The data were subjected to analysis of variance and Duncan's multiple rang test was used to differentiate means at 5% [18].

RESULTS AND DISCUSSIONS

Fruit Physical and Chemical Characteristics: Fruit weight, fruit volume, flesh weight, flesh/pit ratio and oil percentage increased significantly in purple fruits compared to green one in all studied cultivars (Table 1). However, during fruit ripening (black fruits), a slight and an insignificant increase in fruit physical parameters were observed compared to their values in purple stage. Meanwhile, pit weight values obtained during green, purple and black harvesting stages, exhibited no significant differences in this concern in all studied cultivars. The obtained results are in agreement with those obtained by Hegazi [19] who found that seed weight did not change during the successive stages of development of eight seedling olive cultivars, [1, 5] who found that the stone weight remained nearly unchanged during fruit maturity and flesh to stone ratio therefore, they increased constantly with increasing fruit maturity. Similarly, results are in agreement with the findings of Uceda [8, 20] for other olive cultivar like 'Picual' and 'Hojiblanca' which induced higher fresh weight due to black fruits and slow oil increasing due to green fruits to black ones. It is clear that, Fruit weight, flesh weight, flesh/pit ratio and oil percentage in purple fruits were higher than those in green fruit, while such parameters in purple fruits did not differ significantly than in black fruits.

Table 1: Effect of harvesting stage on some fruit physical and chemical characteristics of Arbequina, Bouteillan and Koroneiki olives during 2004 and 2006 seasons

Harvesting stage	Fruit weight (gm)		Fruit volume (cm ³)		Flesh weight (gm)		Pit weight (gm)		Flesh/Pit ratio		Oil %	
	2004	2006	2004	2006	2004	2006	2004	2006	2004	2006	2004	2006
Arbequina												
Green	1.74 b	1.68 b	0.8 b	0.8 b	1.19 b	1.15 b	0.55 a	0.53 a	2.16 b	2.17 b	34.4 b	31.2 b
Purple	2.29 a	2.25 a	1.1 a	1.1 a	1.71 a	1.68 a	0.58 a	0.57 a	2.95 a	2.95 a	39.6 a	39.3 a
Black	2.30 a	2.26 a	1.2 a	1.2 a	1.72 a	1.69 a	0.58 a	0.57 a	2.96 a	2.96 a	38.9 a	39.1 a
Bouteillan												
Green	1.16 b	1.01 b	0.8 b	0.9 b	0.82 b	0.71 b	0.34 a	0.30 a	2.41 b	2.40 b	35.3 b	33.3 b
Purple	1.23 a	1.19 a	1.0 a	1.2 a	0.88 a	0.86 a	0.35 a	0.33 a	2.51 a	2.61 a	36.8 a	40.0 a
Black	1.24 a	1.20 a	1.0 a	1.2 a	0.89 a	0.87 a	0.35 a	0.33 a	2.54 a	2.64 a	36.3 a	40.0 a
Koroneiki												
Green	1.13 b	0.95 b	0.8 a	0.7 b	0.80 b	0.67 b	0.33 a	0.28 a	2.42 b	2.40 b	31.8 b	30.0 b
Purple	1.19 a	1.10 a	1.1 a	0.9 a	0.85 a	0.79 a	0.34 a	0.31 a	2.50 a	2.55 a	34.0 a	34.9 a
Black	1.21 a	1.11 a	1.2 a	1.0 a	0.87 a	0.80 a	0.34 a	0.31 a	2.56 a	2.58 a	34.6 a	35.5 a

Means having the same letters within a column are not significantly different at 5% level

Table 2: Effect of harvesting stage on some oil chemical characteristics of Arbequina, Bouteillan and Koroneiki olives during 2006 season

Harvesting stage	Oil acid %	Peroxide value (meq O ₂ /kg)	K ₂₃₂	K ₂₇₀) K
Arbequina					
Green	0.7 c	16.1 a	0.14 b	0.14 b	0.001 a
Purple	0.9 b	16.4 a	0.15 b	0.15 b	0.001 a
Black	1.0 a	16.6 a	0.23 a	0.23 a	0.001 a
Bouteillan					
Green	0.6 b	15.5 b	0.15 b	0.15 b	0.001 a
Purple	0.9 a	16.5 a	0.15 b	0.15 b	0.001 a
Black	0.9 a	16.7 a	0.20 a	0.23 a	0.001 a
Koroneiki					
Green	0.4 b	13.5 b	0.16 a	0.16 a	0.001 a
Purple	0.5 ab	13.9 a	0.16 a	0.16 a	0.001 a
Black	0.6 a	14.4 a	0.18 a	0.18 a	0.001 a

Means having the same letters within a column are not significantly different at 5% level

Table 3: Effect of harvesting stage on oil fatty acid composition of Arbequina, Bouteillan and Koroneiki olives during 2006 season

Fatty acids	Carbon chain	Arbequina			Bouteillan			Koroneiki		
		Green	Purple	Black	Green	Purple	Black	Green	Purple	Black
Palmitic	C16:0	20.10	20.0	19.5	17.7	17.5	17.2	17.6	17.5	18.2
Palmitoleic	C16:1	1.60	1.6	1.7	1.1	1.3	1.2	2.7	2.2	2.8
Stearic	C18:0	2.30	2.3	2.6	2.3	2.2	2.0	1.9	1.2	1.4
Oleic	C18:1	56.90	56.3	57.9	63.6	63.3	63.7	68.7	68.2	64.7
Linoleic	C18:2	17.90	18.3	17.0	14.0	14.2	14.3	7.6	9.5	11.6
Linolenic	C18:3	1.20	1.5	1.3	1.3	1.5	1.6	1.5	1.5	1.3
Total saturated		22.40	22.2	22.3	20.0	19.7	19.2	19.5	18.6	19.6
Total unsaturated		77.60	77.8	77.7	80.0	80.3	80.8	80.5	81.4	80.4
Unsaturated/saturated		3.46	3.5	3.5	4.0	4.1	4.2	4.1	4.4	4.1

Oil Chemical Characteristics: Data in Tables 2 and 3 shows the effect of harvesting stages on some chemical characteristics of extracted oils from Arbequina, Bouteillan and Koroneiki olive cultivars during 2006 season.

Acidity Percentage: It could be noticed that the acidity percentage increased during fruit ripening, especially in black stage which had the highest acidity percentage. Acidity percentage of extracted oil from Arbequina cultivar recorded (0.7, 0.9 and 1.0%) in green, purple and black fruits, respectively. As for extracted oil from Bouteillan cultivar, acidity percentage recorded (0.6, 0.9 and 0.9%) in green, purple and black stages respectively. However, extracted oil from Koroneiki cultivar at different harvesting stages had lower acidity percentages than those in extracted oils from Arbequina or Bouteillan cultivars. Acidity in extracted oils from Koroneiki cultivar ranged from 0.4 to 0.6% at different harvesting stages.

Peroxide Value: The effect of harvesting stages on peroxide values varied due to the cultivar studied. Peroxide values of extracted oils from Arbequina cv. ranged between 16.1 to 16.6 meq O₂/kg. However, no significant differences were noticed during different harvesting stages, while peroxide values in extracted oils from Bouteillan and Koroneiki cultivars ranged between (15.5 to 16.7 meq O₂/kg) and (13.5 to 14.4 meq O₂/kg), respectively. On the other hand, peroxide values in extracted oils from Bouteillan and Koroneiki cultivars in purple as well as in black fruits were significantly higher than in those from green fruits. In this respect, Rahmani *et al.* [5] mentioned that peroxide values did not change significantly during the maturation periods.

2-3-K₂₃₂, K₂₇₀ and ^aK: K₂₃₂ and K₂₇₀ values were similar in extracted oil from Arbequina, Bouteillan and Koroneiki cultivars. These values ranged between 0.14-0.23, 0.15-0.20 and 0.16-0.18 in extracted oil from Arbequina, Bouteillan and Koroneiki cultivars, respectively. Results showed that K₂₃₂ or K₂₇₀ values increased significantly in extracted oil from Arbequina and Bouteillan cultivars from purple to black fruits, while this trend was not noticed in Koroneiki oil. However, no significant differences were observed in ^aK values in all cultivars during different harvest stages. In Arbequina, Bouteillan and Koroneiki oils, ^aK recorded 0.001 in green, purple and black fruits.

The obtained results are disagreement with the findings of Rahmani [5] who mentioned that K₂₇₀ did not change significantly during the maturation periods.

Oil Fatty Acid Composition: The results of fatty acids composition for extracted oils from Arbequina, Bouteillan and Koroneiki cultivars were saturated fatty acids: Palmitic (C16:0) and Stearic (C18:0) and unsaturated fatty acids: Oleic (C18:1), Linoleic (C18:2), Palmitoleic (C16:2) and Linoleinc(C18:3) are shown in Table 3.

In Arbequina oil, Palmitic acid ranged between 19.5-20.1%, Stearic acid between 2.3-2.6%, Oleic acid between 56.3-57.9%, Linoleic acid between 17.0 -18.3%, Palmitoleic acid between 1.6 -1.7% and Linoleinc acid between 1.2 -1.5%. While fatty acid composition in Bouteillan oil Palmitic acid ranged between 17.2-17.7%, Stearic acid between 2.0-2.3%, Oleic acid between 63.3-63.7%, Linoleic acid between 14.0-14.3%, Palmitoleic acid between 1.1-1.3% and Linoleinc acid between 1.3-1.6%. As for fatty acid composition in Koroneiki oil, Palmitic acid ranged between 17.5-18.2%, Stearic acid between 1.2-1.9%, Oleic acid between 64.7%-68.7%, Linoleic acid between 7.6%-11.6%, Palmitoleic acid between 2.2 -2.8% and Linoleinc acid between 1.3 -1.5%.

Palmitic acid percentage in extracted oil from green, purple and black stages for Arbequina cultivar recorded 20.1, 20.0 and 19.5%, respectively. While, Oleic acid percentage was 56.9, 56.3 and 57.9%, respectively. It seems that in Arbequina cultivar, saturated fatty acid (Palmitic acid) percentage was decreased with the advanced harvesting stages while, unsaturated fatty acid Oleic acid percentage was raised in the extracted oil from green fruits to black ones.

Total saturated and unsaturated fatty acids in Arbequina cultivar ranged between 22.2-22.4% and 77.6-77.8%, respectively. However, the unsaturated/ saturated fatty acids ratio ranged between 3.46-3.5. It is cleared that Palmitic acid is the main saturated fatty acid, while Oleic acid is the main unsaturated fatty acid in all studied cultivars.

As for extracted oil from Bouteillan fruits during harvesting stages (green, purple and black), data showed that Palmitic acid values were 17.7, 17.5 and 17.2%, respectively. Meanwhile, Oleic acid percentage values recorded 63.6, 63.3 and 63.7%, respectively.

In Bouteillan cultivar, it seems that Palmitic acid percentage was too close in extracted oil from each green, purple and the black fruits. Also, the oleic acid percentage showed the same trend with a slight increment in black stage. Total saturated and unsaturated fatty acids percentage in extracted oil from Bouteillan cv. ranged between 19.2-20.0% and 80.0-80.8%, respectively. However, the unsaturated/ saturated fatty acids ratio in extracted oil from Bouteillan fruits at different harvesting stages ranged between 4.0-4.2. These results are in

harmony with Sa'nchez [8, 20, 21] observed an increase in C18:2, while C18:1 remained almost constant. The same trend were observed by Zarrouk [22] on Tunisian varieties, also noticed a decrease in C16:0 and in C18:1 but an increase in C18:2.

In Koroneiki cv., harvesting stages (green, purple and black), palmitic acid values were 17.6%, 17.5% and 18.2%. While, oleic acid percentage was 68.7, 68.2 and 64.7%, respectively. It seems that in this cultivar, palmitic acid percentage decreased from green to purple fruit stages while increased from purple to black fruits. On the other hand, oleic acid percentage decreased from green to black fruits harvested stages. Total saturated and unsaturated fatty acids composition in Koroneiki ranged between 18.6-19.6% and 80.4-81.4%. However, the unsaturated/ saturated fatty acids ratio ranged between 4.1-4.4. The obtained results are in agreement with Parlati [23] who worked on some olive cultivars and noticed an increase in C16:0 along with ripping.

From the above results it could be mentioned that, in Arbequina cultivar, acidity, K_{232} and K_{270} values were lower in extracted oil from purple fruits than in black fruits, while no differences were detected in peroxide value, K and unsaturated/ saturated ratio.

As for Bouteillan, K_{232} and K_{270} values in purple were lower; also unsaturated/saturated ratio was higher than in black fruits while, no changes in acidity, peroxide values and K were observed. Meanwhile, unsaturated/ saturated ratio in purple fruits in Koroneiki cultivar was higher than in black fruits. Moreover, no differences in acidity, peroxide, K_{232} , K_{270} and K values between purple and black fruits were detected. From the above results it is interest to notice that the improvement in fruit physical characteristics during harvesting stages from green to purple varied among studied cultivars. The increase in fruit weight and flesh weight could be explained due to oil accumulation during fruit development from green to purple.

It could be concluded that, purple stage is the best time for harvesting Arbequina, Bouteillan and Koroneiki cultivars.

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