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Research Article

Effect of Yield and Quality on Olive and Olive Oil in Olive Orchards Located at Different Altitudes

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Abstract

Olive trees can be grown in marginal areas and adapt to different climatic and soil conditions which is easier to grow than other plants. It has positive effect of olive oil for human health. Therefore, olive cultivation is increasing day by day with the modern of olive techniques and it is preferred to grow by farmers thanks to the positive effects of olive oil and olive.

The study was carried out in Ayvalik olive fields in which have different altitudes, in order to examine the current status of olive cultivation in Manisa/Ahmetli area, to soil and leaf analyzes and nutritional status and to determine the suitable harvest periods on high altitude and low altitude in terms of olive and olive oil quality. The current status (age, education, land positions) of the olive farmers were determined by survey in the Manisa/Ahmetli area. Fruit samples were harvested during 4 different periods (10 October, 13 November, 23 November and 5 December). In fruit samples: fruit weight (g), maturity index, color (CIE L*, a*, b*), dry matter (%) were determined. Oil samples, free fatty acidity and fatty acid composition were determined on high altitude and low altitude.

In conclusion soil and leaf analyzes indicated that there were nutrient deficiencies and recommendations were made about olive cultivation in olive farmers. The suitable harvest periods were determined of high altitude and low altitude in terms of olive and olive oil quality. In this research, suggestions were given about olive cultivation and it is provided to shed light on future studies.

Keywords: Olive; Olive Oil; Nutrient; Harvest; Quality; Yield

Introduction

Olive tree is a medicinal plant for healthy that are cultivated and consumed as olive and oil in the Mediterranean region. In recent years, Olive plantation areas are increasing day by day. Turkey takes place after Spain, Italy, Greece, Portugal in olive oil production in the world. According to FAO data, olive cultivation of Turkey is about 846.061 hectares in 2017/2018 years [1]. According to the International Olive and Olive Oil Council, it is predicted that olive production is 1 million 515 thousand tons and olive oil production is 225 thousand tons in 2019 [2]. The olive production is carried out more than half of the Aegean region in Turkey.

The most common olive varieties are in the Aegean region; Memecik, Ayvalık, Domat, Erkence and Gemlik varieties [3]. Manisa/Ahmetli province where the study is conducted is a region that has a high olive cultivation potential in The Aegean Region. Manisa/Ahmetli region has Mediterranean climate where is range of minimum 3°C, maximum 34.3°C in the temperature and Gemlik and Ayvalık varieties are cultivated in this region.

The variety of changes that occur in fruit constituents at ripening play a major role in determining the quality characteristics of olive oil. Ripeness is a function of harvest time [4]. However, olives harvested before or after fruits reach optimum weight and size suffer from a substantial loss in quantity and quality [5]. Oil content of full mature olive fruit varies within the same cultivars in different locations. Nevertheless, the trend of oil accumulation is not affected by cultivars, rather by cultural and environmental condition [6].

Olive ripening is a long process whose varieties depending on topographic and climatic conditions of orchards [7]. Geographical

features such as altitude or local topography can affect to significant changes on olive growing (Tang and Fang, 2006). In addition to efficient and balanced fertilization is important to increase in yield and quality of olive trees. During the ripening of olive, many organic substances are synthesized and occur chemical and physicochemical changes in the olive. It has been determined that weight of olive increases during the ripening period [7,8]. However, it has been observed that oil content of olives increased during ripening [9]. In a study conducted at different altitudes (100 and 800m), the cv 'Mastoides' olive was harvested on three dates in two places and determined the average weight, oil composition, moisture content and oil quality characteristics. As a result of research, altitudes affected not only the phenol content, but also its composition. Olives contained higher phenolic substance in high altitude locations than low altitude locations [10]. In Turkey, another study conducted on Memecik olive table variety about the changes of fatty acids in the black period. During olive ripening, palmitic and linoleic acid values decreased while stearic, oleic and linoleic acid values increased [11]. In all studies, it was determined that oleic and palmitic acid decreased, linoleic acid increased and harvest time did not progress during the olive ripening period [12].

This research is important because growers do not have a clue when to harvest their olives fruit for high oil quality and quantity. The result of the particular area, the terrain, the quality of the soil, the microclimate, temperature, relative humidity and altitude all play their part in helping to obtain an quality olive oil with organoleptic characteristics different from the rest.

In this study, we aimed to investigate the current status of Ayvalık olive cultivation under the conditions (fertilization and altitude) of Manisa/Ahmetli, the effects of fertilization, harvest time of Ayvalık olive in different altitudes on olive and olive oil quality. In addition, we provided to determine the optimum harvest time of the Ayvalik olive variety in high altitude and low altitude in this region.

Materials and Methods

The study material was carried out in Ayvalik olive variety in the 40 years old in Manisa/Ahmetli region. Survey were conducted with 50 people to determine the current status of farmers olive cultivated in Manisa/Ahmetli region. Ayvalik olive variety; the fruit is medium in size, the number of olive per kg is 280 - 300, the amount of olive oil is 24 - 26% and flesh/pit ratio is 1/5 (ORI, 2018). At the same time, Ayvalik olive oil has a golden-yellow color, and it has first class oil quality with its aromatic, chemical and physical properties (ORI, 2018).

Research orchards were carried out: 1. Orchard (mountain area + fertilization) and 2. Orchards (mountain area + none fertilization) 3. Orchards (rural-base + fertilization) 4. Orchards (rural-base + none fertilization) from 4 different orchards (Table 1).

Orchards	Agricultural application (fertilization)	Location	Altitudes
Orchard	Yes	High Altitude (Mountain)	210
Orchard	None	High Altitude (Mountain)	210
Orchard	Yes	Low Altitude (Rural-base)	85
Orchard	None	Low Altitude (Rural-base)	85

Table 1: Features of research orchards.

It was determined that the altitudes of these orchards are respectively 210m and 85m from above the sea (Table 1) Ayvalık olive variety was planted at a distance of 7 x 7m. Olive fruits were picked homogeneously from the whole round of olive tree by hand in four different ripening stages (green size, green-violet, violet and black period) as 400 - 500g. Olive samples were pickled on 10 October, 13 November, 23 November and 5 December in the harvest season. In order to determine the plant nutrient content of olive orchards, soil samples were taken from 2 different depths from 0 - 30 cm and 30 - 60 cm depth from 4 different Olive orchards. In the study, leaf samples were taken during the rest period of olive trees, that is, in December. It was taken from opposite leaf pairs in the middle of the annual shoots, which can receive sufficient light from 4 directions of each tree, which do not have any diseases and pests (Özer, 1978).

Determination of effect of different altitudes and fertilization on fruit yield and quality

Soil analysis [13], Leaf Analysis [14-16], 100 olive weight, color determination, dry matter (%), maturity index, determination of free acidity, fat content, fatty acids composition [12].

Experimental design and statistical analyses

The design of the experiments was completely randomized block design with tree replicates of a tree. Duncan's Multiple Range Test was used to identify differences between the treatments. Statistical analyses were conducted mostly at a significance level of $P < 0.05$. All calculations were performed using SPSS software.

Results and Discussion

According to the results of the survey cultivated olives with farmers in Manisa/Ahmetli region; 80% of the olive orchards are Ayvalik olive varieties and 20% are Gemlik olive varieties in the region and also 67% of the olive cultivation in the mountainous region (high altitudes), 37% in the rural-base (low altitudes). Another results, 60% of farmers are at low education level, 40% of them have advanced education. It was determined that 63% agricultural application (fertilization, irrigation, pestisit) used, 37% none used agricultural application (fertilization, irrigation, pestisit). The findings obtained were evaluated using table 3 according to the results of the chemical analysis of the soil in Manisa region. According to the results of the chemical analysis, it is determined that the soils are medium-calcareous in the high altitude locations and the soils are less calcareous as seen in table 2 in the low altitude locations. The olive trees shows optimum growth at the rate of 10 - 20% lime [17]. Accordingly, there are suitable areas for olive cultivation in Manisa region. Excessive lime reduces the uptake of micronutrients such as Fe and Zn in the soil [14].

The salinity of soil samples is evaluated and the soil salt % values are the light salty class between 0.17 and 0.26 both high altitude and low altitude olive orchards (Table 2). In general results of study, it turns out to be that it is a suitable region for olive cultivation and there is no salinity problem and it is in the slightly alkaline group. pH of soil is important as it plays a leading role in many physical, chemical and biological events and also affects nutrient availability and uptake of microelements in soil. Since the pH range of 6 - 8 is determined as appropriate in olive cultivation [17]. Manisa region has been determined to be in the range of 7,09 - 7,80 pH (Table 2) and it has been revealed that there are suitable areas for cultivation.

Results of macro and micronutrient content of soil samples taken from 2 different depths in olive orchards are given in table 4. P content is between 0.86 and 4.31 in soil of olive orchards (Table 4). It is understood that the plants do not need phosphorus in the soils. Phosphorus is important as well as Nitrogen and potassium in plants [14]. Because Phosphorus plays an important role in cell division, blossom and fruit growth. It helps the effective use of water by regulating the intake of plant roots [18-22]. According to potassium contents of the soils, it is seen that the potassium content is between 52 and 114 mg kg^{-1} that is middle class (Table 4). It turned out to be that there is no potassium problem in Olive orchards. Potassium is very important for plants. It is effective in activation of enzymes and coenzymes, photosynthesis, protein formation, starch formation and sugar transfer, cell sap, and the plant's water balance and its ability to withstand drought [22-24].

No	Altitude	Depths	Lime (%)	Salt %	Ph
1 Orchard	High	0 - 30 cm	14,94	0,17	7,80
		0 - 60 cm	13,72	0,18	7,70
2 Orchard	High	0 - 30 cm	11,70	0,25	7,31
		0 - 60 cm	13,26	0,26	7,34
3 Orchard	Low	0 - 30 cm	0,78	0,20	7,25
		0 - 60 cm	0,78	0,14	7,09
4 Orchard	Low	0 - 30 cm	1,95	0,21	7,52
		0 - 60 cm	2,34	0,24	7,73

Table 2: Chemical analysis values of soil samples taken from different depths.

Results of micronutrient content of soil samples taken from 2 different depths in olive research orchards are given in table 4. According to micro element levels, useful Fe content of the soil is between 0.3 and 0.8 mg kg^{-1}, useful Cu content is between 1.1 - 1.5 mg kg^{-1}, useful Zn content is between 0.06 - 0.35 mg kg^{-1} and useful Mn content is between 2.3 - 5.6 mg kg^{-1} in Orchards. Accordingly, it has been revealed that useful Cu and Mn values are sufficient and useful Fe and Zn values are low in the Orchards. Although Fe element is not found in the structure of chlorophyll in the soil, chlorophyll process decreases in iron deficiency. The iron element acts on the protein mechanism in the plant [14,22,23]. It has been determined that it is the most common nutrient element in arid and semi-arid lands in plants. As the soils of arid areas contain high amounts of lime and have high pH, iron deficiency is observed. Because the pH occurs high in calcareous soils, iron compounds do not dissolve and cannot be taken by plants. In addition, soil compaction, flood-

Properties	Proficiency Class				
	Very little	Little	Sufficient	Excessive	Over excessive
P (mg kg^{-1}) (Olsen ve Sommers, 1982)	< 2,5	2,5 - 8	8 - 25	25 - 80	> 80
K (mg kg^{-1}) (Sumner ve Miller, 1996)	< 50	50 - 140	140 - 370	370 - 1000	> 1000
Mn (mg kg^{-1}) (Lindsay ve Norwell, 1978)	< 4	4 - 14	14 - 50	50 - 170	> 170
Zn (mg kg^{-1}) (Lindsay ve Norwell, 1978)	< 0,2	0,2 - 0,7	0,7 - 2,4	2,4 - 8,0	> 8,0
Fe (mg kg^{-1}) (Lindsay ve Norwell, 1978)	Little	Middle	Sufficient		
< 0,2	0,2 - 4,5	> 4,5			
Cu (mg kg^{-1}) (Lindsay ve Norwey, 1978)	Unsufficient	Sufficient			
<0,2	> 0,2				
Boron (mg kg^{-1}) (Wolf, 1971)	Sufficient				
1,0 - 2,5					
Ph, U.S. Salinity Laboratory Staff (1954)	Middle Acid	Light Acid	Nötr	Light Alkaline	Excessive Alkaline
4,5 - 5,5	5,5 - 6,5	6,5 - 7,5	7,5 - 8,5	> 8,5	
Salt %, U.S. Salinity Laboratory Staff (1954)	None	Light	Middle	Excessive	
0 - 0,15	0,15 - 0,35	0,35 - 0,65	> 0,65		
Lime (%) (Hızalan ve Ünal, 1996)	Light Lime	Lime	Middle Lime	Excessive Lime	Over Excessive Lime
0 - 1	1 - 5	5 - 15	15 - 25	> 25	

Table 3: Limit values for interpreting some chemical properties of soils.

No	Depth (cm)	NO_3-N (mg kg^{-1})	Useful P (mg kg^{-1})	Useful K (mg kg^{-1})	Useful Na (mg kg^{-1})	Useful Fe (mg kg^{-1})	Useful Cu (mg kg^{-1})	Useful Zn (mg kg^{-1})	Useful Mn (mg kg^{-1})
1 Orchard	0 - 30	3,10	2,80	72	5	0,8	1,3	0,17	5,6
	30 - 60	3,40	2,75	52	6	0,5	1,1	0,08	4,5
2 Orchard	0 - 30	3,40	2,34	112	10	0,7	1,1	0,08	5,0
	30 - 60	3,30	2,13	104	9	0,8	1,4	0,05	3,0
3 Orchard	0 - 30	4,00	0,86	113	8	0,5	1,3	0,35	2,7
	30 - 60	2,80	0,94	96	14	0,5	1,2	0,08	2,0
4 Orchard	0 - 30	5,30	0,75	114	6	0,5	1,5	0,23	4,6
	30 - 60	3,20	0,85	104	7	0,3	1,3	0,06	2,3

Table 4: Macro and micronutrient content of olive orchards.

ing, prolonged precipitation or excessive irrigation constitute the iron deficiency. It also occurs with the high availability of heavy metals such as manganese, copper, zinc, chromium and nickel [20]. It turned out to be that a plant requires copper for chlorophyll production, respiration and protein synthesis. It affected protein and carbohydrate metabolism. It has been found to play a role in symbiotic nitrogen fixation [22,25].

Mn element plays a role in the breakdown of water in photosynthesis and absorption of iron, calcium and magnesium in the

No	N %	P %	K %	Ca %	Mg %	Fe (mg kg ^{1})	Cu (mgkg^{1})	Zn (mg kg $^{-1}$)	Mn (mg kg $^{-1}$)
1 Orchard	1,54	0,19	0,91	2,36	0,21	93	16	10	32
2 Orchard	1,82	0,15	1,32	1,57	0,20	105	14	12	33
3 Orchard	1,82	0,14	2,08	2,07	0,26	114	15	11	32
4 Orchard	1,83	0,09	1,54	1,70	0,35	117	15	9	35

Table 5: The result of macro and micronutrients analyzed by leaf analysis.

soil. It acts together with iron in the formation of chlorophyll and increases the germination and fruit ripening [14,19,25]. According to a study, it was revealed that as the pH increases in the soil, Zn solubility decreases [24]. In researched orchards, $N0_3$-N content is low. Ammonium and nitrate forms of nitrogen, which are vital for plants, are inorganic nitrogen sources taken by the roots of higher plants [26].

In the leaves of Ayvalık olive variety, the content of N, P and K decreases in the research orchards in the crop year and the most appropriate leaf sample is between late December and early February [28]. In this study, leaf samples were taken in December. N %, P %, Ca %, Mg %, K % content are sufficient in high altitude location (1. Orchard, 2. Orchard) but are excess in low altitude location (3. Orchard, 4. orchard). Fe (mg kg^{-1}), Cu (mg kg^{-1}), Mn (mg kg^{-1}) values of leaves were sufficient and Zn (mg kg^{-1}) contents were low in research orchards both high altitude and low altitude locations (Table 5). The study was carried out to the seasonal change of the micronutrients and fruits of 6 olive varieties (Uslu, Domat, Memecik, Gemlik, Kilis Yağlık and Ayvalık) and the most appropriate leaf sample time in the leaves. As a result of the research, it was determined that the content of other nutrients (Fe, Zn, Cu and B) of leaves, except Mn, is high in on year than none year. Researchers have found that there are differences between the varieties in terms of leaf nutrient contents. It was stated that all micro nutrients (Fe, Mn, Zn, Cu and B) remained the same or changed very little and this period was the most suitable to take leaf samples on November-January in the 6 product types [29].

Sufficient	N %	P %	K %	Ca %	Mg %	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})
	1,4 - 2	0,08 - 0,2	0,7 - 1,4	1,4 - 2,5	0,2 - 0,45	7 - 200	6-18	15-30	25-70

Table 6: Referans values of macro and micronutrients analyzed by leaf analysis [27].

The effect of different harvest times on fruit quality

In the study, olive samples were harvested on October 10, November 13, November 23 and December 5 at four different maturity stages (green, green-violet, violet and black period).

The effect of harvest time ($p < 0.005$) and Colour Index (L*, a*, b*) were found to be statistically significant (Table 7). L* value of 66.31 in the first harvest decreased significantly, 16.90% in the second harvest, 17.76% in the third harvest (Table 7). In the first harvest, the fruits have a* value of -21, the green colour demonstrated to be significantly dominant. In the second harvest, a* value increased by 55.34%. The a* value increased to + values in the harvests time later and became closer to each other (Table 7). Olive, which is 37.08 in the first harvest, b* of fruit decreased to 9.33 in the second harvest, at the next harvest times respectively decreased by 40.9% to 24.26% (Table 7). Olive fruits it is green in color in the first harvest, a significant change in all color parameters in the second harvest (L* and decrease in b* value, increase in a* value), the crust color becomes darker. Color of fruit has changed from green to black as the harvest time progresses [30].

The effect of harvest time ($p < 0.005$) and dry matter (%) were found to be statistically significant (Table 8). Rate of dry matter is difference in 4 different harvest times (%). While it respectively increased by 16.28% and 9.12% in November, dry matter (%) ratio increased by 8.77% in December. As the harvest maturity progresses dry matter ratio (%) exceeded 60% (Table 8). According to Dursun [31] different Ayvalık varieties carried out in Kemalpaşa (İzmir) where he practices calcium and boron. As of June, analysis of olive fields taken, in dry amount and water rates, fruit quality in different periods. There are no statistically significant differ-

Harvest Time	L*	a*	b*
1. Harvest	66.31 a	-21.16 c	37.08 a
2. Harvest	55.10 b	-9.45 b	27.75 b
3. Harvest	45.31 c	7.34 a	16.40 c
4. Harvest	29.20 d	7.36 a	12.42 d

Table 7: Effect of different harvest times to fruit color (L*, a*, b* values).

Means bearing different letters in a column are significantly different ($p < 0.05$).

ences depending on the applications, but towards fruit maturity, the amount of water decreases in the fruit while the amount of dry matter increased by 60% (Table 8).

Harvest Time	Dry Matter (%)
1. Harvest	49.53 d
2. Harvest	57.60 c
3. Harvest	62.86 b
4. Harvest	68.33 a

Table 8: Effect of different harvest times to dry matter (%).

Means bearing different letter in a column is significantly different ($p < 0.05$).

According to another study, the effect of altitude on fruit and oil quality characteristics of Mastoides olive variety to investigate the moisture content of fruits at a height of 100m. The relative humidity of the air, precipitation were observed on olive fruits at an altitude of 800m. In consequences, moisture content and oil content changed. Both at the altitudes, water content decreases with maturation, however dry matter and the fat content increased [10]. Result of present study is parallel compared to other studies.

The effect of fertilization and altitude on olive yield

There is a significant difference ($p < 0.05$) on the average fruit weights in high and low altitude where fertilization applied and none applied (Table 9). The average fruit weights were 8.4% less in 3. Orchard (fertilization+low altitude) according to 1. Orchards (fertilization + high altitude). There is a 24.83% difference between 2. Orchard (none fertilization + high altitude) and 4. Orchard (none fertilization + low altitude) on average fruit weight (Table 9). As a result of, a lack of nutrients was detected in low altitude, so average fruit weight remained at a low level in 4. Orchard (none fertilization) (Table 9).

Fertilization	Altitude	Fruit weight (g)
Yes	High	36,6 a
	Low	33,2 b
None	High	30,2 c
	Low	22,7 d

Table 9: Effect of fertilization and altitude on average fruit weight.

Means bearing different letter in a column is significantly different ($p < 0.05$).

The effect of different altitude on olive oil quality

In the study, olive samples were harvested on October 10, November 13, November 23 and December 5 at four different maturity stages (green, green-violet, violet and black period). After that, olive oil analyzed for free fatty acid. According to result, it was determined that the highest free fatty acid value is 4. harvest time in low altitude location. The values of olive orchards were close to each other and ranged from 0.52% to 0.70% in high altitudes. It is included in the extra virgin olive oil group since the free fatty acid value is below 1% which is the maximum limit value for natural extra virgin olive oil [32].

The dominant acids are respectively oleic (C 18: 1), palmitic (C: 16: 0), linoleic (C: 18: 2) and stearic acid (C: 18: 0) in olive oils [12]. The amount of oleic acid (C18:1) respectively increased by 71.43%, 74.05%, 74.11%, 75.19% in four different harvest times in low altitude's olive orchards. The oleic acid (C18:1) value respectively decreased from 73.98% to 71.46% at the 2nd harvest time and there is no difference between the 2nd and 3rd harvest times between the oleic acid (C18:1) value. The amount of oleic acid (C18: 1) increased (72.61%) by 4. harvest time in high altitude's olive orchards. The effect of linoleic acid (C18: 2) is between 7.94% and 9.20% in the low altitude's olive orchards. On the other hand, linoleic acid is increased respectively by 7.19%, 9.70% and 10.26% in 3 harvest times in high altitude. Just linoleic acid is decreased during the 4th harvest period (9.50%). The highest amount of linoleic acid (C18:2) is determined to be at the 3rd harvest time (10.26%) in high altitude's olive orchards (Table 10).

Fatty Acid Composition %	Low altitude				High Altitude			
	1. Harvest	2. Harvest	3. Harvest	4. Harvest	1. Harvest	2. Harvest	3. Harvest	4. Harvest
C 16:0	14.12 a[z*]	12.23 ab	12.04 b	11.72 b	13.50[ö.d.]	14.26	13.79	13.18
C 18:0	2.62	2.94	3.00	2.60	2.74	2.12	2.11	2.15
C 18:1	71.43 a	74.05 a	74.11 a	75.19 b	73.98 a	71.46 ab	71.50 ab	72.61 c
C 18:2	9.20	8.50	8.51	7.94	7.19 a	9.70 a	10.26 a	9.50 b
∑SFAs	17.38 a	15.82 b	15.69 b	15.04 c	16.95 a	16.87 b	16.29 bc	15.92 c
PA-L	1.53	1.46	1.44	1.51	1.89 a	1.47 b	1.35 b	1.40 b
∑O-L	7.80	8.90	8.88	9.78	10.40 a	7.38 ab	6.98 b	7.69 b

Table 10: Fatty acid composition of Ayvalik olive variety at low and high altitudes of different harvest times.

Z The differences between the averages in each column were determined by Duncan test according to $P < 0.05$. ö.d does not matter, * $P \leq 0.05$ or ** $P \leq 0.01$ is important.

Fatty acids: Palmitic: C 16: 0; Stearic: C 18: 0; Oleic: C 18: 1; Linoleic: C 18: 2; Linolenic: C 18: 3; Saturated Fatty Acids(SFA); Linoleic (PA-L); Oleic/Linoleic (O-L); (SFA) Saturated Fatty Acids.

Amount of linolenic acid (C18:3) is similar in 4 different harvest times and varies between 0.51% and 0.68% in low altitude's olive orchards. The amount of linolenic acid is similar between 0.48% and 0.65% in high altitude's olive orchards. The amount of palmitic acid (C16:0) decreased in the 3. and 4. harvest time. The highest palmitic acid value (14.2%) is in first harvest time. In the third and fourth harvest, palmitic acid decreased respectively 12.04% and 11.72% (Table). Palmitic acid is similar during the harvest period and is between 13.18% and 14.26% in high altitudes olive orchards. The amount of stearic acid (C18: 0) is similar during the harvest period and is between 2.60% and 3.00% in low altitude's olive orchards. Stearic acid (C18: 0) is similar during the harvest period and is between 2.11% i.e. 2.74% in high altitudes olive orchards (Table 10).

The value of saturated fatty acid (SFA) decreased with maturity index. The amount of saturated fatty acid (SFA) decreased slightly in 3 harvest, while the 4th harvest time decreased the highest (0.37%) in high altitudes olive orchards (Table 8). Palmitic/Linoleic (PA-L) value is similar and ranged between 1.44% and 1.53% in low altitude's olive orchards. The highest Palmitic/Linoleic (PA-L) value is in the first harvest in high altitudes olive orchards. At other harvest times, it decreased by 0.42%, 0.12% and 0.5% respectively in high altitudes olive orchards. Oleic/Linoleic (O-L) values are close to each other and ranged between 7.80% and 9.78% in low altitude. While the highest (10.40) amount (O-L) value is decreased by 3.02% in first harvest time in high altitudes olive orchards. It decreased by 0.4% in the third harvest, but increased by 0.71% in fourth harvest in high altitude.

According to Kutlu and Şen [12] in their study on the effects of different harvest times on fruit and olive oil qualities in Gemlik Olive (*Olea europea*) variety and the fruit quality characteristics such as flesh/pit ratio, fat content, maturity index increased and the color changed from green to black as the harvest time process. It has been stated that palmitoleic and linoleic acid increases, palmitic and linolenic acid decreases and as a result, it is appropriate to harvest at the end of November for Olive table varieties and in December for Olive oil varieties and oleic acid is the highest rate (72.5%) in the composition of fatty acids, a significant change depending on the harvest time. They demonstrated that, linoleic acid and palmitoleic acid increased while palmitic and linolenic acid decreased in the progress of harvest time [12]. Another a study conducted at different altitudes (100 and 800m), the cv 'Mastoides' olive was harvested on three dates in two places and determined the average weight, oil composition, moisture content and oil quality characteristics. As a result of research, altitudes affected not only the phenol content, but also its composition. Olives contained higher phenolic substance in high altitude locations than low altitude locations [10]. Another study was conducted to determine the effect of harvesting date and altitude on olive oil quality, a field experiment was done in two locations (400 and 700) meters above sea level. As a

result of research, oil content increased with delaying fruit harvest at high altitude. Oil content was greater at low altitude than high altitude. Oil quality was influenced by harvest date at both high and low altitude locations. Peroxide and acidity value increased significantly with late harvesting at both high and low altitude locations (Freihat and N El Assi 2008). In a study conducted in Picual olive variety which is an important oil variety of Spain, it has been revealed that palmitic, stearic and linoleic acids decreased and oleic, linoleic acids increased with olive ripening [33,34].

The study results are parallel compared to other studies. Efficient and balanced fertilization is important to increase in yield and quality of olive trees. Olive fertilization programs, olive varieties, age of the tree, amount of yield, soil structure should be taken into consideration, also soil and leaf samples should be taken at the appropriate time.

Conclusion

According to results, it has been determined that fruit weight is higher in high altitude compared to low altitude. In a study by Nergiz and Engez (2000), fruit weight increases with maturity index. It has been shown that the lands where fertilization is applied increase the fruit quality characteristics. It has been observed that olive cultivation generally carried out in the high altitude in Manisa/Ahmetli region and they obtained better results in terms of yield and quality in high altitude compared to in low altitude due to the effect of the different altitude. Olive fruits are green in the first harvest, a significant change (decrease in L* and b* value, increase in a * value) has been observed in the second harvest. The fruit color has changed from green to black as the harvest time progresses [30]. Results show that the amount of oil increased from 23 November (3^{rd} harvest) to 5 December (4^{th} harvest) 5.78% in the last harvest. While the amount of oleic acid is the highest rate (75.19%) in the fatty acid compositions, Palmitic acid, Linoleic acid and Saturated fatty acids decreased according to the harvest time. During the autumn and winter seasons, it has been determined the amount of oil reaches the highest level [31,35]. In this respect, the results showed parallels, especially low altitude's region can make harvest to December. While this difference is not obvious high altitude and the highest amount of oleic acid is observed at the first harvest so it can be suggested that early harvest would be appropriate in high altitude. As a result, Ayvalik variety which cultivated in the Manisa/Ahmetli region are included averages in terms of fruit characteristics, oil content and fatty acid composition in the Aegean Region and that the harvest time is carried out earlier in high altitude than low altitude in the countryside in December. In addition to this study carried out that agricultural input application (fertilization, irrigation, disease-pest control) positively affect olive and olive oil the quality and yield [36-40].

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