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Physico-Chemical Properties and Fatty Acid Composition of Gemlik Variety Olives

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Olive is one of the basic food takes place in the Mediterranean alimentary model. It is an important food on account of its nutritional value besides its economical contribution to national economy. Olive oil is a rich source of essential fatty acids and its fatty acid composition affected from environmental factors and variety. In this study some quality criteria and fatty acid composition of the Gemlik variety olive, one of the most important table olives of Turkey, were examined. Olives grown in 4 different districts of Bursa were used as material. They were analyzed for their number of olive fruit per kg (248 ± 38.05-295 ± 49.32), flesh/stone weight ratio (4.03 ± 0.66-5.64 ± 0.53), pH (5.27 ± 0.15-5.50 ± 0.29), dry matter (47.28 ± 4.92-49.68 ± 3.65 %), protein (2.23 ± 0.29-2.87 ± 0.54 %), reducing sugar (1.98 ± 0.55-2.52 ± 0.32 %), ash (1.58 ± 0.11-1.79 ± 0.52 %), oil (22.74 ± 9.85-31.34 ± 6.67 %) and fatty acid composition. Growing of olives in different districts are actually very near to each other caused the differences of their composition especially flesh/stone weight ratio, protein value and fatty acid composition.

Key Words: Olive, Olive oil, Fatty acid.

INTRODUCTION

The origin of the olive tree is lost in time, coinciding and mingling with the expansion of the Mediterranean civilizations which for centuries governed the destiny of mankind and left their imprint on Western culture. Table olives belong to the food varieties employed for human consumption since ancient times[1].

A lot of olive varietals are grown in the Mediterranean countries which produce most of the world's olives (Italy, France, Spain, Greece, Tunusia, Morocco, Turkey, Portugal) and Mexico, South Africa, Australia and of course in California[1a]. Production for the 2006-07 season amounted to 1,823,500 ton, the majority of which (*ca.* 41.2 %) was located in the European Union (Spain, France, Greece, Italy, Portugal, Slovenia). Other significant non-EU producing countries include Egypt (11.4 % of the world production), Turkey (11.2 %), Syria (8.7 %), United States (8.1 %) and Morocco (7.5 %)[2].

Table olive is a traditional food of Turkey like other Mediterranean countries and it is one of the most important components of Mediterranean diet. Olive is an important food on account of its nutritional value besides its taste. The benefits of table olives in nutrition are associated, beside the fatty acid especially monounsaturated fat with minor constituents such as phenolic compounds[3,4]. The amount of oil and fatty acid composition are the most important quality criteria of olive and olive oil[5-7]. Besides table olives are well-known sources of compounds with important biological properties. These properties are related to fatty acid composition, mainly monounsaturated fatty acids and to minor constituents, such as tocopherol and phenolic compounds[8]. There are lots of olive varieties grown in Turkey. Among these, Gemlik variety of olive that is produced in Gemlik district is considered among the best quality olives of the world[1b].

Quality characteristics of Gemlik variety olives are suitable for table olive production. For this reason, culture of trees is increased rapidly in other districts apart from Gemlik. This trend causes some changes in quality characteristics of olive due to different ecological conditions[7]. In order to improve quality of the product, raw material quality and processing conditions should be controlled[9]. Some quality characteristics of olive such as the length, width, thickness, arithmetic mean diameter, geometric mean diameter, sphericity, volume, porosity, projected area and oil content are considered to be necessary for the proper design of equipment for handling, conveying, separation, mechanical expression of oil, storage and other processes[10].

The aim of this research was to determine quality characteristics and fatty acid composition of Gemlik variety olives grown in different districts of Bursa, Turkey.

EXPERIMENTAL

Thirty Gemlik variety olive samples from different districts of Bursa (Gemlik, Mudanya, Iznik, Orhangazi), important centers of olive cultivation of Marmara Region, were chosen as the experiment material. Samples were hand-picked, placed in polyethylene bags and stored at -18 °C until analyzed. The number of olive fruits per kg was determined according to the Turkish Standards[11].

For determination of the flesh/stone weight ratio, first of all average 100 g olive fruit was weighed. After olive fruits were cut in half horizontally with a knife and the stones were removed and weighed. After then the flesh content was calculated by subtracting the stone weight from whole olive fruits weight. Then, the flesh/stone weight ratio was determined by dividing the flesh weight to the stone weight. Flesh samples were used for analysis after homogenization in a blender.

Dry matter content was determined by drying the samples at 105 ± 1 °C to a constant weight. The pH of the samples was measured by using pH meter (Nel Model 890). The amount of reducing sugar was determined as spectrophotometric method using Shimadzu UV-1208 UV-Vis spectrophotometer[12]. For this purpose, 6 mL of dinitrosalicylic acid solution which was consisted of 1 g dinitrosalicylic acid, 20 mL 2 M NaOH and 20 g K-Na tartarate per 100 mL distilled water, transferred

in a tube. Then sample was clarified with Carrez I and Carrez II solutions, bleached by using activated charcoal and filtered. After that, 2 mL of this filtrate was added into the tube. The tube was taken into boiling water bath for 5 min and then cooled immediately. The absorbance was read against blank at 540 nm and the amount of reducing sugar was calculated by the help of standard curve prepared with glucose previously. Nitrogen content was determined by using Kjeldahl method as multiplied by a factor (6.25) to determine crude protein[13]. Ash content was determined by ashing the sample at 525 °C[14]. Oil content of the samples was determined by Soxhlet extraction using *n*-hexane[14]. Fatty acid methyl esters (FAME) were prepared with using boron trifluoride (BF_3)/methanol[14]. The fatty acid composition of FAME was analyzed by GC using Hewlett Packard 6890 gas chromatograph equipped with a flame ionization detector (FID). The analytical column was a CP-Sil 5 CB (50 m length, 0.25 mm i.d. and 0.20 μm film thickness). The flow rate of the carrier gas (He) was set at 1.8 mL/min and injection quantity was 0.1 μL. Temperatures of injector, column oven and detector were 225, 200 and 275 °C, respectively. Retention times and peak areas were automatically computed by the data processor.

Data were analyzed statistically using analysis of variance (ANOVA) and differences among the means were determined for significance at $p < 0.05$ or $p < 0.01$ using LSD test.

RESULTS AND DISCUSSION

The results of physical and chemical analyses were given in Table-1.

TABLE-1
RESULTS OF THE PHYSICAL AND CHEMICAL ANALYSIS OF GEMLIK VARIETY OLIVE SAMPLES (MEAN ± STANDARD DEVIATION)

District	Number of olive fruit/kg	Flesh/stone weight ratio	Dry matter (%) (w/w)	Protein (%) (w/w)
Gemlik	276 ± 78.49	4.68 ± 0.85 AB	49.68 ± 3.65	2.43 ± 0.37 b
Iznik	248 ± 38.05	4.45 ± 0.62 B	49.32 ± 5.95	2.51 ± 0.19 b
Mudanya	256 ± 39.37	5.64 ± 0.53 A	48.68 ± 3.50	2.23 ± 0.29 b
Orhangazi	295 ± 49.32	4.03 ± 0.66 B	47.28 ± 4.92	2.87 ± 0.54 a
	Reducing sugar (%) (w/w)	Ash (%) (w/w)	pH	Oil (%) (w/w)
Gemlik	2.52 ± 0.32	1.66 ± 0.31	5.33 ± 0.16	26.27 ± 6.43
Iznik	2.02 ± 0.40	1.79 ± 0.52	5.27 ± 0.15	22.74 ± 9.85
Mudanya	1.98 ± 0.55	1.58 ± 0.11	5.50 ± 0.29	29.35 ± 5.68
Orhangazi	2.14 ± 0.66	1.65 ± 0.40	5.34 ± 0.13	31.34 ± 6.67

*Mean values followed by different small and capital letters are significantly different at $p < 0.05$ and $p < 0.01$, respectively.

The number of olive fruits per kg of sample showed no statistical differences (Table-1, $p < 0.01$). While the smallest olive fruit was determined as 295 fruit/kg in samples grown in Orhangazi. The biggest olive fruit was determined as 248 fruit/kg in samples grown in Iznik. Sahin *et al.*[15] reported that, the number of fruit per kg of sample was changed between 230-304 in Gemlik variety.

All olive samples grown in different districts showed significant differences in flesh/stone weight ratio. Means of flesh/stone weight ratio varied from 4.03-5.64. Maximum flesh/stone weight ratio was determined in the sample which was grown in Mudanya. Previous studies[15,16] have also stated that minimum flesh/stone weight ratio of olive should be 5.00.

There were no statistical differences in dry matter content of the samples (Table-1, $p < 0.01$). Due to climatic condition, a fluctuation can be determined in dry matter content. While the lowest dry matter content (47.28 %) was determined in the samples grown in Orhangazi district. The highest dry matter content (49.68 %) was determined in the sample grown in Gemlik district. Although the samples taken from Gemlik and Orhangazi were the same variety, a small difference was determined in their dry matter contents. It could be originated from ecological conditions and cultivar differences. Sahan[17] determined dry matter content of olives that were grown in Gemlik, Orhangazi and Mudanya as between 42.68-47.16, 47.82-56.64 and 33.96-35.60 %, respectively.

Statistically significant differences in protein were found among the samples (Table-1, $p < 0.05$). Means of protein value varied from 2.23-2.87 %. Soluble and insoluble proteins of olive are important for fermentation besides nutritional value[18]. Samples were superior for their protein content. Barut[6] reported that, protein contents of olives harvested from Gemlik, Orhangazi, Iznik and Mudanya were between 1.55-2.22 %. Moreover, Sahan[17] determined the protein content of olives that were grown in Gemlik, Mudanya and Orhangazi as between 1.77-2.14, 1.20-1.75 and 1.59-2.14 %, respectively.

While the lowest amount of reducing sugar (1.98 %) of olive samples was determined in the samples grown in Mudanya, the highest (2.52 %) was determined in the samples grown in Gemlik. Total fermentable matter as reducing sugar in olive changes between 2.5-6.5 % and it is related with variety, cultivar practices, climatic conditions and harvesting maturity[18]. Sugars are basic soluble matters in olive and give energy for metabolic activities. Also they are the part of cell wall and relevant with textural characteristics. They play a role in olive oil biosynthesis[19]. Reducing sugars are important for olive fermentation as being nutrient for micro-organisms. Although, Garrido *et al.*[20] reported reducing sugars of Gemlik variety olives as 4.45 %, all of Gemlik variety samples had reducing sugar lower than this value. It was especially related with ecological conditions, cultivar differences and maturity.

The mean values of ash content were not significantly different among the samples ($p < 0.01$). Changing the amount of ash in olives of the same county in different districts can be originated from cultivars, harvesting maturity and ecological conditions (Table-1). The ash content of Gemlik variety olives was reported as 1.87 and 2.12 % by Sahin *et al.*[15] and Kumral and Sahin[21], respectively.

pH value of olives was changed between 5.27 and 5.50 (Table-1). Similar values for the pH value of olives were reported by Akçay *et al.*[5] and Türk *et al.*[20] for Gemlik variety.

While the lowest amount of oil (22.74 %) was determined in olive samples from Iznik, the highest amount of oil (31.34 %) was determined in olive samples from Orhangazi (Table-1). Previous studies have also reported that oil content of Gemlik variety olives was changed between 25.00-29.98 %[6,17,23,24]. Olive composition is influenced by environmental and cultivar differences. However, certain fatty acids and minor components determine the quality of the oil. Fatty acid composition of olive can change according to the variety, maturity and ecological conditions[7].

In Table-2, fatty acid composition of oils of olive samples was given. Basic fatty acids determined in samples were oleic, palmitic, stearic, linoleic and palmitoleic acids. All of the samples contain little amount of linolenic, arachidic and behenic acids. Other fatty acids were determined as lower value or could not be determined. All of the samples liked each other but, olives that were taken from Gemlik and Orhangazi districts contained higher level of oleic acid generally.

According to international olive oil council (IOOC)[16], olive oil should contain myristic acid as ≤ 0.05 %. While some samples had not myristic acid, some of them had this fatty acid between 0.1-2.2 %. Oleic, palmitoleic and linolenic acid values of the samples were in harmonious with the data of IOOC. In some samples palmitic, margaric, margoreloic, stearic, arachidic, eicosenoic, behenic and lignoceric acids were determined as higher values than IOOC values.

Paganuzzi[25] and Tiscornia and Bertini[26] determined fatty acid composition of olive oils having different origins. According to results of the study, fatty acid composition of olive oils obtained from Turkey were determined as 71.7 % oleic, 12.8 % palmitic, 11.7 % linoleic, 0.7 % palmitoleic and 2.3 % stearic acid. Linolenic, arachidic and eicosenic acids were determined as 0.2 %. Margaric and margaroleic acid were determined as 0.1 %.

Pardo *et al.*[27] determined fatty acid composition in the olive oil samples collected from Spain. Oleic acid 70.6-80.7 %, palmitic acid 10.0-14.9 %, linoleic acid 3.51-9.05 %, stearic acid 1.70-3.32 %, palmitoleic acid 0.65-2.00 %, linolenic acid 0.62-0.84 %, arachidic acid 0.35-0.50 %, eicosenoic acid 0.20-0.30 %, behenic 0.1-0.14 % and lignoceric acid 0.05-0.10 % were found. They determined *trans* oleic acid was lower than 0.1 %.

Nergiz and Engez[7] reported that fatty acid composition of the oil may differ depending on the variety of olive and degree of fruit ripeness. They determined palmitic, stearic, oleic and linoleic acids as major fatty acids in olive oil. Palmitoleic, linolenic + eicosenic acids were also determined in small amounts. Myristic, arachidic, behenic and lignoceric acids were present less than 0.5 %.

According to another study examined fatty acid composition of oils of 25 olive samples with the same genotypes, harvesting term may affect their fatty acid compositions. Olive trees cultivated in the same environment and by the same agronomical techniques and as olives were picked at the same pigmentation degree, the differences shown are likely to reflect peculiarities of the genotypes examined. Often the ALA (precursor of all omega-3 polyunsaturated fatty acids class) content decreased

TABLE-2
FATTY ACID COMPOSITION OF OLIVE SAMPLES (%)

Districts	Sample No	Caproic (C6)	Caprilic (C8)	Capric (C10)	Lauric (C12)	Myristic (C14)	Palmitic (C16)	Palmitoleic (C16:1)	Margaric (C17)	Heptadecanoic (C17:1)	Stearic (C18)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)	Arachidic (C20)	Eicosenic (C20:1)	Eicosadienoic (C20:2)	Behenic (C22)	Lignoseric (C24)
Gemlik	1	-	-	-	-	2.2	11.6	1.5	1.3	0.3	3.4	68.7	9.0	0.2	0.4	0.5	-	0.2	0.7
	2	-	-	-	-	0.1	12.3	1.3	0.2	-	3.3	73.4	7.1	0.3	0.4	0.5	-	0.1	1.0
	3	0.1	0.9	0.3	0.2	0.5	25.3	1.0	-	-	13.0	54.0	2.2	0.5	0.9	0.1	-	0.2	0.2
	4	-	-	-	-	-	11.9	0.9	-	-	5.9	75.6	4.6	0.5	0.5	-	-	0.1	-
	5	-	-	-	-	-	13.3	0.9	0.2	0.3	4.2	75.5	4.2	0.4	0.5	-	-	0.1	0.3
	6	-	-	-	-	-	12.5	1.8	0.2	-	3.8	70.4	9.0	0.3	0.5	0.5	-	0.1	0.8
	7	-	0.4	0.1	-	0.1	18.8	0.5	0.2	1.3	3.4	68.1	5.5	0.5	0.6	-	-	0.2	-
	8	0.4	0.3	0.1	-	0.1	16.5	1.4	-	-	3.8	67.7	0.9	0.3	0.5	-	4.0	3.9	-
	9	0.2	1.2	0.4	0.2	0.2	26.4	1.2	-	-	10.7	56.9	0.6	0.2	1.0	-	-	0.3	-
	10	-	0.1	0.1	-	-	16.9	1.3	0.2	0.2	4.1	74.4	1.7	0.2	0.5	-	-	0.1	0.1
Iznik	1	-	0.4	0.3	0.3	0.1	20.0	1.3	0.3	-	5.9	69.8	0.2	0.3	0.7	-	-	0.1	0.1
	2	-	-	-	-	0.5	12.1	1.5	0.3	-	3.8	69.5	10.3	0.2	0.4	0.5	-	0.1	0.8
	3	0.1	0.5	0.2	0.2	0.3	20.9	1.5	-	-	6.4	67.5	0.5	0.3	0.7	-	-	0.2	0.1
	4	-	0.4	0.1	0.1	0.1	21.4	0.9	0.2	0.4	7.4	66.9	0.5	0.3	0.6	-	-	0.2	0.3
	5	-	0.1	0.1	-	-	19.3	1.2	0.2	1.9	4.1	70.9	1.0	0.3	0.6	-	-	0.2	-
	6	-	0.2	0.2	0.3	0.1	17.8	1.2	0.2	-	4.9	72.7	1.0	0.7	0.3	-	-	0.2	-
	7	0.5	0.4	0.4	0.3	0.1	19.2	1.3	-	-	4.6	65.8	0.6	0.2	0.6	-	3.1	2.7	-
Mudanya	1	-	-	-	-	-	17.5	0.8	0.2	0.5	9.9	66.3	3.8	0.4	0.4	0.1	-	0.1	0.2
	2	-	0.2	0.1	-	-	17.9	1.3	-	-	5.6	73.1	0.8	0.2	0.6	-	-	0.1	-
	3	-	0.1	-	-	0.8	17.1	1.3	0.1	1.5	3.9	72.2	1.8	0.3	0.5	0.1	-	0.1	0.1
	4	-	-	-	-	-	14.4	1.2	0.2	-	3.9	72.6	6.3	0.2	0.5	0.2	-	0.1	0.4
	5	-	-	-	-	-	12.2	1.2	0.2	-	3.8	72.7	8.2	0.2	0.5	0.4	-	0.1	0.5
	6	-	-	-	-	-	12.6	1.3	0.2	-	3.4	73.0	7.5	0.2	0.4	0.4	-	0.1	0.9
	7	-	0.5	0.1	-	-	25.4	1.0	0.2	0.6	8.4	61.5	0.5	0.3	0.8	0.1	-	0.2	0.3
Orhangazi	1	-	-	-	-	-	13.0	1.1	0.2	-	3.8	76.3	4.4	0.3	0.4	0.2	-	0.2	0.1
	2	-	0.1	0.1	-	-	17.7	1.5	-	-	4.3	74.6	0.8	0.2	0.5	-	-	0.1	-
	3	-	-	-	-	-	13.4	0.8	0.2	0.4	5.3	74.0	4.2	0.5	0.5	-	-	0.2	0.4
	4	-	-	-	-	-	15.2	1.3	0.1	0.2	3.8	74.0	4.3	0.3	0.5	0.1	-	0.1	0.1
	5	-	0.1	0.1	-	-	14.1	1.1	-	-	4.4	73.1	1.2	0.3	0.5	-	2.7	2.4	-
	6	-	0.3	0.1	-	-	21.1	0.8	0.2	0.4	8.0	67.0	0.4	0.3	0.6	0.1	-	0.2	0.3

with harvesting time, though Ogliarola barese and Nociara cvs do not show this trend. Analogously, in general, linoleic/linolenic acid ratio increases with harvesting time, except Nociara and Grossa di Gerace cvs (Caravita ve ark. 2007)[28]. Similarly in present study, differences were determined in the fatty acid composition of the samples of the same genotypes (Gemlik variety) (Table-2). Harvesting terms could be changed due to the environmental factors of different districts. Producing olive fruit with superior properties and ensuring that the positive attributes are transferred to the oil are essential to ensure a consistently high quality olive oil. Processing parameter can be altered to optimize oil production for a particular fruit. The changes in processing parameters should take into account differences in cultivars, maturity, agronomic practices, geographic regions and the impact on the overall quality of olive oil[29].

By the use of raw olives having and keeping superior chemical and physical characteristics, high quality table olives and olive oils could be produced.

Olive is a rich source of essential fatty acids that could not be synthesized in human body. This property may contribute to have good nutritional values of this product in Mediterranean countries. It is also important that preserving the composition of olive and knowing the effective factors change this. According to the findings of the study, chemical composition of the Gemlik variety olives grown in different districts of Bursa was varied. Especially, flesh/stone weight ratio, protein content and fatty acid composition of olives affected from the districts. These discrepancies became more pronounced when the distance increase from the main district (Gemlik).

It was also determined that apart from ecological differences, composition of olives grown in the same district could changed. These dissimilarities may be related with harvesting period of the olive samples.

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