Journal of Nutrition & Food Sciences
ISSN: 2155-9600
Irmak and Tokusoglu, J Nutr Food Sci 2017, 7:2
DOI: 10.4172/2155-9600.1000582
Research Article
OMICS International

Saturated and Unsaturated Fatty Acids Composition of Olive Oils Obtained from Less Salty Black Table Olives Preserved with Vacuum, MAP and Gamma Irradiation Technologies

Şahnur Irmak[1*] **and Özlem Tokuşoğlu**[2]

[1]*Olive Research Institute, Bornova, Izmir, Turkey*

[2]*Department of Food Engineering, Celal Bayar University, Manisa, Turkey*

[*]**Corresponding author:** Şahnur Irmak, Olive Research Institute, Bornova, Izmir, Turkey, Tel: 2362011000; E-mail: Sahnurirmak@hotmail.com

Received date: December 05, 2016; **Accepted date:** March 01, 2017; **Published date:** March 07, 2017

Abstract

In this project assessed the effect of preservation methods on shelf life and quality of table olives which processed two different methods as low salty (2-4%). For this purpose, black olives were processed two kinds of table olive processing techniques, fermented, then packed with Vacuum Pump (VP) and Modified Atmosphere Packaging (MAP), and applied gamma irradiation (1 kGy, 3 kGy, 5 kGy). Then olives stored under normal conditions for 8 months. In this study, gamma irradiation has been applied first time in extending the shelf-life of table olives in the marketing.

The Olive oils obtained from less salty black table olives were studied. During storage of table olives, the change of the major fatty acids was determined. Processing methods, salt quantity and storage period have affected almost all the quality parameters of the olive oils which obtained from table olives. The dominating fatty acid of all processing methods was oleic acid with ranged between 70.71-75.59%.

Oleic acid quantity wasn't decreased much during processing and storage. In this context, it is determined that the best preservation was performed by modified atmosphere packaging technology.

Keywords: Table olive; Olive oil; Oleic acid; Linoleic acid; Linolenic Acid; Modified atmosphere; Gamma irradiation

Introduction

Table olives are one of the most important fermented vegetables in world trade with an annual production of 2-2.5 million tonnes depending on the season [1]. Spanish-style, naturally black olives in brine, and ripe olives (Californian style) are the main processing methods but there are innumerable elaboration methods strongly influenced by cultural practices [2].

Naturally black olives production is a traditional industrial process, which is still empirical in Turkey despite its economic importance. This kind of preparation accounts for about 30% of the world table olive market [3]. Turkey is the leader producing country with more than 250,000 tons per year.

In this type of preparation, olives are harvested when fully ripe or slightly before full ripeness. After sorting, size-grading and washing, they are placed in 8-14% brine. Fermentation may be carried out in either anaerobic or aerobic conditions. In the anaerobic or traditional system, the natural fermentation is driven mainly by yeasts, due to the high salt concentration used [2].

This type of table olives preparation and fermentation is traditionally carried out in an anaerobic way. However, some producer are exposed to air to olives. Under aerobic conditions, several researchers have found a change of fermentation flora, an improvement of surface colour and a reduction of gas accumulation in the interior of the flesh, which causes a gas-pocket formation [4]. Fermentation develops a high pH and low acidity; besides, the diffusion of water soluble substances from olives to brine, like acids, salts, sugars and phenols, occurs [3].

Gemlik variety olives contain about 25-28% olive oil and olive oil content of olives increase with the loss of water during fermentation. Additionally, olive oil is the most important product of olive that could be mostly affected by the preservation methods of table olives.

Table olives are well-known sources of compounds with beneficial relevance. These benefits are associated with their fatty acids content, mainly monounsaturated fatty acids, and to minor constituents such as tocopherols, phenolic compounds and phytosterols [5]. One of the major components of olive is fatty acids. The fatty acid composition of olive oil varies widely depending on the cultivar, maturity of the fruit, altitude, climate, and several other factors. The major fatty acids in olive oil [6] are:

- Oleic acid (C18:1), a monounsaturated omega-9 fatty acid. It makes up 55-83% of olive oil.
- Linoleic acid (C18:2), a polyunsaturated omega-6 fatty acid that makes up about 3.5-21% of olive oil.
- Linolenic acid (C18:3), a polyunsaturated omega-3 fatty acid that makes up 0-1.5% of olive oil.
- Stearic acid (C18:0), a saturated fatty acid that makes up 0.5-5% of olive oil.
- Palmitic acid (C16:0), a saturated fatty acid that makes up 7.5-20% of olive oil.

Olive oil contains more oleic acid and less linoleic and linoleic acids than other vegetable oils, that is, more Monounsaturated (MUFA) than Polyunsaturated Fatty Acids (PUFA). This makes olive oil more resistant to oxidation. Greater the number of double bonds in the fatty acids they are more unstable and easily broken down by heat, light, and other factors. It is generally accepted that cooler areas will yield oil with higher oleic acid than warmer climates. That means a cool region" olive oil may have more MUFA content than warmer region oil [7]. Fatty acid composition is important for the commercial properties of oils. It has an influence on the stability of oils due to the contribution of PUFAs to oil rancidity. In addition to this, several studies have shown that a diet rich in MUFAs may result in a wide range of health benefits such as an improvement in cholesterol levels, and, in turn, prevention of cardiovascular disorders [6]. In particular, high levels of MUFAs (mainly oleic acid), which have health benefits and are important for human nutrition, are among the major components of the Mediterranean diet, and they play an important role in the nutritional value of table olives [8-10].

The major fatty acids in table olives are oleic, palmitic, stearic, linoleic and palmitoleic acids [11,12]. Because table olives are mainly composed of MUFAs, the consumption of table olives can prevent and reduce the risk of cardiovascular diseases, regulate cholesterol levels, stimulate transcription of LDL-cholesterol receptor mRNA and reduce breast cancer risks [13].

MAP has been used for several years for preserving fresh fruits and vegetables. MAP and Vacuum Packaging (VP) have become increasingly popular preservation methods, which have brought major changes in storage, distribution, and marketing of raw and treated products to meet consumer demands [13]. Degirmencioglu et al. reported that packaging methods positively affected all attributes of olives [14].

Food irradiation is a processing technique applied for decontamination and increasing shelf life of food, exposing food to ionising radiation in order to enhance its shelf-life as well as its safety. The aim is to destroy microorganisms or insects that could be present in the food, and sometimes to improve the functional properties of food or to eliminate toxins, with the least compromise on sensory and nutritive quality [15]. As an alternative to the use of chemicals, a technology that has been increasingly used for inhibiting the growth of pathogenic microorganisms and simultaneously delaying fruit senescence is gamma ray irradiation [16]. Food irradiation is a means of food preservation that has been in development since the early part of the 20th century. If applied properly, irradiation can be an effective way to reduce the incidence of foodborne diseases and also inactivates food spoilage organisms, including bacteria, molds, and yeasts in our food supply. The FAO/IAEA/WHO joint committee on the wholesomeness of irradiated food approved irradiation technology in 1981. It was stated that, irradiation of food at doses up to 10 kGy introduced no special nutritional problem [17].

Gemlik variety olive contains about 30% olive oil. During the fermentation olives lose about 20% water. At the end of fermentation, the amount of olive oil is close to 50%. Therefore, consumption of black table olive consumes more olive oil at the same time. For this reason, olive oil has a significant effect on the quality of the taste of table olive. We can say olive oils as the first component that gamma irradiation will have a quality effect in the table olive. For these reasons, analyzes were carried out to determine the quality of the olive oil. Vacuum and MAP preservation techniques are widely used in the table olive industry and can be applied on very easy conditions. In addition, the fact that there is little work on the quality of the olive oils that table olives contain.

The aim of the present work is to investigate the better preservation and marketing conditions of the less salty table olives. In this project, the changes in the quality of the olives during storage were observed. Physicochemical characteristics (pH and free acidity) and chemical composition (saturated and unsaturated of oils obtained from less salty black table olives preserved with vacuum, MAP (N_2 60% and CO_2 40%) and gamma irradiation technologies) changes occurring in olive flesh during spontaneous fermentation of the most used black olive cultivar (Gemlik cv.) in Turkey.

Material and Methods

In this study, Gemlik variety olives harvested from the collection plant of Bornova Olive Research Institute were used. Olive samples (Gemlik cultivars) were obtained at two different seasons (during the 2012-2013 and 2013-2014 seasons). For each processing method, collected about 240 Kg olives and put into two containers. Debittering olives were packaged at the end of fermentation and irradiated (in accordance with the food irradiation based on Turkish Food Codex) [18,19] at doses up to 5 kGy (0 kGy,1 kGy, 3 kGy, 5 kGy), and stored for 8 months. The harvest times for the Gemlik olive variety were determined according to the specific process techniques stated in Turkish Food Codex [19,20]. Gemlik variety olives were harvested in the second week of November, approximately Maturity Index 5.3 (MI).

Traditional Turkish-style natural turning olive processing

Gemlik variety olives were harvested (5.3 MI) and washed. The olives were transferred into the plastic vessels. 2-4% salt was added on the olives. The covers of the vessels were closed strictly. The olives were kept in their own water until the end of fermentation. Olive vessels were turned every two days to provide fermentation [21].

Processing natural black olives in brine processing

Gemlik variety olives were harvested in the period of maturity index (5.3 MI) and sizing. 200 L capacity fiberglass industrial containers were used. Olives were placed in the container and covered with 2-4% salt in brine. The olives in the brine were exposed to the air. The incorporation of air was performed for 8 h/day; air was bubbled from a circular ring at the bottom of the container at a rate of 0.25 L/h for L of brine. The analyses were taken place on the 4th and 8th months. Consequently, fermentation took place under normal conditions [19].

Olive oil extraction

Olive oil samples were made at the laboratory scale using the Abencor system equipped with a hammer crusher, malaxer, and centrifuge. Prior to the crushing step, the table olives were manually sorted and cleaned, removing damaged fruit, leaves, and other debris. The clean and healthy table olives were crushed and were slowly mixed for 30 mints at 25°C. Then, the resulting paste was subjected to centrifugal separation for 1 mints at 3000 rpm. The oil phase was allowed to decant naturally into specimens. The top oil layer was removed, stored in glass bottles at refrigerator temperature, and kept away from light until its analysis.

Chemicals

The chemicals used in HPLC were obtained from "Merck" as LC grade. Standards, fatty acids were kindly obtained from "Sigma-Aldrich" (Germany). The other reagents were of analytical grade.

Chemical analysis

For the table olives, the pH of samples was measured using a seven compact pH/Ion S220 pH meter (Mettler Toledo, USA). Free acidity of the table olive was determined by titration with NaOH (0.1 mol/l) in the presence of phenolphthalein and expressed as % (w/v) of lactic acid [21].

Free acidity and peroxide value of the olive oils obtained from table olives; acid value, given as percent oleic acid, was determined in accordance with the Turkish Food Codex-Olive oil and Olive Pomace Oil directive [22]. For the free oil acidity, a known weight of olive oil was dissolved in a mixture of diethyl ether/ethanol (1:1 v/v). The mixture was titrated with potassium hydroxide in methanol (0.05 M) in the presence of phenolphthalein as indicator. For peroxide value, about 5 g of olive oil was dissolved in a mixture of acetic acid/chloroform (3:2 v/v), and saturated solution of KI (1 ml) was then added. The liberation iodine was titrated with sodium thiosulphate solution (0.05 M) in the presence of starch as indicator. All parameters were determined in triplicate for each sample.

Fatty acid composition of olive oils was determined by Gas Chromatography (GC) using AOCS method [22]. The methyl esters of the FFA were prepared by vigorous shaking of a solution of oil in hexane (0.2 g in 3 ml) with 0.4 mL of a 2 N methanolic potassium hydroxide solution. The methyl esters were analyzed in a Hewlett-Packard gas chromatograph (HP 6890 Series) equipped with a DB23 column (30 × 0.25 mm i.d.) and an FID. The oven temperature was held at 140°C for 10 mints, and then was increased to 210°C at 2°C/mints and the sample volume 0.5 µL.

Gamma-irradiation of table olives

Gamma-irradiation treatment was applied by automatic tote box irradiator (JS 9600, IR-185, and Canada) in Gamma-Pak Corp. (Cerkezkoy, Tekirdag, Turkey). Olives in packages were placed into aluminium irradiation boxes and moved to irradiation rooms by an automatic conveyor. In irradiation rooms, products were exposed to gamma rays released from Co-60 source by moving with pneumatic pistons around the source. Three irradiation doses (1 kGy, 3 kGy, 5 kGy) were applied on the table olives. After the irradiation, table olives were controlled by dozimeter how much kGy doses applied on the table olives.

Statistical analyses

Data were subjected to the statistical analysis according to Analysis of Variance (ANOVA). Parameters were considered significant when $p<0.05$. For each parameter, two samples were analysed, with all the assays being also carried out in triplicate. The results are expressed as mean value ± Standard Deviation (SD).

Results and Discussion

The pH and free acidity of the table olive are crucial parameters from technological and sanitary point of view when black olives are processed according to the naturally black olives in brine and turning olives, and must be controlled throughout the fermentation and preserving process. pH and free acidity results about table olive fermentation are shown in Table 1.

	Raw material	End of the Fermentation			
Processing methods	-	**Dry salted**		**Brine**	
Salt	-	2% salt	4% salt	2% salt	4% salt
pH	5.03	4.55	4.72	4.07	4.21
Free acidity	0.41	0.71	0.60	0.83	0.78

Table 1: Some chemical values of table olives.

Fat can be classified as SFA, MUFA, and PUFA, corresponding to the different nutritional fractions of fatty acids. As expectable, oleic acid (C18:1c) was the most abundant fatty acid in all "alcaparras" table olives, independently of the olive cultivar, ranging from 66.9% (Cv. Madural and Santulhana) to 76.1% (Cv. Verdeal Transmontana). This same fatty acid was also the major one found in olive oils (around 60-80%) [23].

Free Fatty Acids (FFA)

FFA is a quality criterion in olive oil; olive varieties, growing regions, processing methods, olive fruit fly damage is reported to be dependent on factors such as longer the wait, the olives in unsuitable conditions [24]. FFA values obtained in our study in fermented products were found to be quite high according to the FFA values of crude oil. This situation is caused by lactic acid generated during fermentation. The resulting acidity increases the oxidation of fat and degradation. As a result of the chain reactions are accelerated the increased of acidity.

The changes in free fatty acid amount expressed as a percentage (oleic acid, %) of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacum and MAP) and irradiation doses (Control 1, kGy, 3 kGy, 5 kGy) are shown in Table 2.

Free fatty acid content of the sample obtained by using disc crusher and malaxed without nitrogen flush was found different from other samples with a small variation. Quality of olive drupes greatly affected the free acidity of oils rather than technological treatments [25].

Salt %	Package type	Irrad. (kGy)	Turning olive Analyses period				Nat. black olive in brine Analyses period			
			Raw	Ferm.	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	0.25 ± 0.06	8.62 ± 2.92	10.46 ± 1.05	11.66 ± 1.35	0.25 ± 0.06	6.34 ± 0.1	8.95 ± 1.72	9.54 ± 1.97
		1			11.12 ± 1.5	11.97 ± 1.67			8.61 ± 1.27	9.41 ± 1.64
		3			11.02 ± 1.56	12.76 ± 0.86			8.18 ± 0.86	8.95 ± 1.09
		5			11.63 ± 1.51	13 ± 1.1			7.57 ± 0.2	8.7 ± 1.17
	MAP	0			11.44 ± 1.2	12.25 ± 0.88			7.02 ± 0.2	8.17 ± 0.68
		1			11.36 ± 1.29	12.57 ± 0.56			7.3 ± 0.14	8.41 ± 1.02
		3			11.8 ± 1.56	12.26 ± 1.08			7.55 ± 0.15	8.48 ± 0.78
		5			11.58 ± 1.9	12.16 ± 1.42			8.05 ± 0.59	8.47 ± 1.17
4	V	0	0.25 ± 0.06	8.3 ± 2.4	9.3 ± 2.54	10.77 ± 1.93	0.25 ± 0.06	4.53 ± 0.08	7.49 ± 2.1	8.3 ± 1.81
		1			10.28 ± 2.93	10.16 ± 4.12			7.5 ± 1.96	7.88 ± 2.08
		3			10.13 ± 2.78	9.71 ± 3.31			7.89 ± 2.86	8.62 ± 2.57
		5			10.25 ± 3.05	10.49 ± 3.04			7.28 ± 0.98	8.42 ± 2.37
	MAP	0			10.41 ± 2.24	10.3 ± 2.42			7.32 ± 0.81	8.02 ± 1.23
		1			10.24 ± 2.26	10.51 ± 2.32			7.64 ± 1.11	8.21 ± 1.68
		3			10.26 ± 2.48	10.66 ± 2.33			7.62 ± 1.09	8.33 ± 1.76
		5			10.35 ± 2.6	10.66 ± 2.53			6.77 ± 1.27	8.68 ± 2.09

Table 2: Determination of FFA values in the turning olives and naturally black olives in brine (%).

According to the processing methods, the differences determined in the amount of FFA were shown to be effective on FFA of the olive samples. Statistically, this effect was found important at the level of $p<0.05$. The resulting changes in the amount FFA depending on the amount of salt, in the variation analysis, results were significant at the level of $p<0.05$. All of the low salt olive samples have been found to have higher amounts of FFA. In contrast, all of the high salt olive samples, amount of FFA was found to be lower. Depending on the packaging differences also thought to vary the amount of FFA, these differences were not significant in all olive samples. Statistically, the irradiation and the applied irradiation doses are no effect on the amount of FFA.

Vural and ve Aksu, in their research, adverted that the hydrolysis of triglycerides and phospholipids causing the production of free fatty acids has been reported by numerous researchers [26]. In this study, it was found that irradiation had no important effects on the FFA levels. It was denoted that FFA levels increased during the storage. As the lipolytic deteriorating microorganisms are susceptible to irradiation, the increase in the FFA has been determined to be lower in the irradiated samples. Also, Aziz et al. has been reported that irradiation and microwave treatments did not cause an increase in free fatty acids as values were similar for the raw "control" and all treated beef samples [27].

Peroxide Value (PV)

Indeed, several authors have evaluated its activity during olive ripening and the relation between this enzyme and Peroxide Value (PV), when its activity is low the PV decrease. However, high lipoxygenase activity produces an increase in PV [28,29]. This enzymatic behavior previously described in the literature could explain the result obtained in this work [30].

The changes in peroxide values of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacuum and MAP) and irradiation doses (Control, 1 kGy, 3 kGy, 5 kGy) are shown in Table 3.

In our study, 2% of salt samples, peroxide values were higher in the olive samples obtained by turning method than naturally black olives in brine. In contrast, 4% of salt samples of olives obtained by turning method were detected at lower values. The changes in the peroxide values of olive samples detected depending on olive processing methods were statistically significant at the $p<0.05$ level.

Due to prolonged processing according to natural-style method, the lipid fraction could undergo oxidative and hydrolytic degradations. Moreover, some intermediate and final products of oxidative degradation of lipids may have harmful effects on consumers [31,32]. However, at our best knowledge, no studies have been carried out about the variations induced on the lipid fraction of table olives by natural-style processing. With regard to the indices of oxidative degradation, the PV significantly increased during natural-style treatment, although the final values were relatively low (11.7-13.1 $meqO_2$/Kg oil, depending on cultivar). The observed values were lower than those reported for California-style processed olives [33], and were within the limit of 20 $meqO_2$/Kg oil required for extra virgin olive oils (EC Commission).

Lopez et al., peroxide value (similar in Manzanilla and Hojiblanca raw material) significantly increased during the storage phase; later, it showed a non-significant, slight decrease [33]. The formation of hydro peroxides during storage is due to autoxidation or to the action of lipoxygenase, which requires free fatty acids (preference: linolenic>linoleic>oleic) that are easily available in these olives due to the fatty acid increase during storage. Peroxide value from the final products (both cultivars) exceeded the limit of 20 $meqO_2$/kg of oil, established by EC Regulation for virgin olive oils. This oil oxidation may occur even in anaerobic conditions because some lipoxygenases are able to oxidize fatty acids in the absence of oxygen. The resulting changes in peroxide value depending on the amount of salt, in the applied variance analysis was significant at the level of $p<0.05$.

At the end of the storage period, when compared to the detected amount of peroxide in terms of packaging techniques, the highest peroxide values has been determined in the MAP packaged products except 2% salty of naturally black olives in brine group. Also, in regard to the salt concentration, peroxide values were higher in vacuum package samples of 2% salty of table olives. In the modified packaging of 4% salty samples were detected higher. However, it is thought to vary the amount of peroxide, statistically, occurring the difference on the packaging has not been found important.

Peroxide values in samples which applied high doses irradiation were higher than other groups. Also, in samples which applied low doses irradiation or not irradiated was lower. Vural and ve Aksu reported that they also found that irradiation led to an increase in peroxide values [26], however, this increase was totally independent of the dose of irradiation. Irradiation increased the peroxide levels, but this increase did not seem to correlate with irradiation dosage.

Arıcı et al. reported that the lipid oxidation was attributed to the combination of free radicals with O_2 to form hydro peroxides [34]. In their study, peroxide values were also increased in irradiated samples. They detected a positive correlation between the irradiation dose and peroxide value of the samples. Regarding irradiation exposure, the peroxide value in the oil was gradually increased from 2.2 $meqO_2$/Kg to 3.7 $meqO_2$/Kg. Oxidative change caused by irradiation is the same as in the reaction of unexposed seeds. Radicals and induced molecules form as the result of irradiation exposure. After irradiation exposure, these free radicals can react with O_2 in the long run and cause the formation of hydro peroxides which create alcohols, aldehydes, aldehyde esters and hydrocarbons.

Peroxide values obtained in our study with table olive oil were not exceeding 20 $meqO_2$/Kg. The observed values were lower than those reported for California-style processed olives [34], and were within the limit of 20 $meqO_2$/Kg oil required for extra virgin olive oils (EC Commission). Pasqualone et al. believed that PV was no negative impact on the flavour of table olives.

Palmitic acid

Palmitic acid content in the crude olive samples was determined to be 13.92%. According to different salt concentration and the processing method, palmitic acid quantity of the table olive oil obtained at the end of the fermentation was detected. In the 2% salty olives, Palmitic acid quantity in the turning olive and naturally black olives in brine was 13.73 and 12.84%. Also, in the 4% salty olives, palmitic acid quantity in the turning olive and naturally black olives in brine was 13.85 and 12.30%. The changes in palmitic acid values of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacuum and MAP) and irradiation doses (Control, 1 kGy, 3 kGy, 5 kGy) are shown in Table 4.

The amount of palmitic acid obtained in our study is consistent with many other studies made [13,26,35,36]. Unal and ve Nergiz reported that the amount of palmitic acid in green table olives was found between 16.42–17.38%, and the amount of palmitic acid in black table olives between 0.48–12.71% [37]. Also, Sousa et al. identified that the palmitic acid amount of pitted table olives were between 12.49-13.66% [38].

Palmitic acid value which determined at the end of storage with palmitic acid content determined at the end of fermentation, in the olives sample obtained by turning olive method has been detection higher than olive samples obtained from naturally black olives in brine. The differences in the amount of palmitic acid detected according to the processing methods that processing methods have shown to be effective on palmitic acid. The changes detected in the amount of palmitic acid depending on the olive processing methods was statistically significant ($p<0.05$). Also, the changes detected in the amount of palmitic acid depending on the packaging methods were statistically significant.

It was also determined that the turning olives and naturally black olives in brine in both of salt groups had higher values of palmitic acid of not irradiated samples than those of the irradiated samples. Chen et al. reported that irradiation and storage bring about a change in fatty acids, and that total saturated and MUFAs were increased by

irradiation [39]. Arıcı et al. expressed that palmitic acid was not affected by irradiation, only slightly increased [34].

Salt %	Package type	Irrad. (kGy)	Turning olive Analyses period				Nat. black olive in brine Analyses period			
			Raw	Ferm.	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	4.66 ± 1.48	11.99 ± 1.58	13.69 ± 1.11	14.07 ± 1.05	4.66 ± 1.48	10.82 ± 0.1	10.29 ± 0.91	12.74 ± 0.64
		1			13.84 ± 0.86	14.11 ± 0.53			12.84 ± 1.67	14.13 ± 2.1
		3			13.22 ± 0.47	14.33 ± 0.46			12.72 ± 1.78	14.13 ± 2.11
		5			13.15 ± 0.39	14.13 ± 0.18			13.82 ± 1.87	14.43 ± 2.19
	MAP	0			12.56 ± 0.8	12.95 ± 0.5			10.33 ± 0.89	11.26 ± 0.57
		1			13.27 ± 0.48	14.22 ± 0.25			10.42 ± 1.2	12.02 ± 0.31
		3			13.26 ± 0.71	13.83 ± 0.59			10.13 ± 1.27	11.61 ± 0.48
		5			13.79 ± 0.29	14.8 ± 0.52			11.13 ± 0.19	12.26 ± 0.16
	V	0	4.66 ± 1.48	11.6 ± 0.53	10.57 ± 2.15	12.53 ± 0.65	4.66 ± 1.48	12.9 ± 1.2	11.05 ± 3.51	12.62 ± 2.11
		1			12.33 ± 1.12	12.97 ± 0.5			10.6 ± 3.7	12.53 ± 2.09
		3			11.47 ± 1.34	12.97 ± 0.62			12.33 ± 2.28	13.42 ± 1.43
		5			11.44 ± 1.38	13.09 ± 0.58			11.15 ± 3.04	13.66 ± 1.25
	MAP	0			10.33 ± 2.57	11.15 ± 2.13			13.49 ± 1.17	13.94 ± 0.84
		1			11.63 ± 1.57	12.27 ± 1.29			16.25 ± 1.25	14.83 ± 0.57
		3			14.94 ± 1.38	13.78 ± 0.11			15.4 ± 0.55	14.62 ± 0.75
		5			16.51 ± 2.94	14.4 ± 0.31			12.31 ± 3.06	14.01 ± 1.59

Table 3: Determination of peroxide values in the turning olives and naturally black olives in brine (%).

Stearic acid

The amount of stearic acid in crude olive samples was determined as 3.06%. According to different salt concentration, stearic acid was determined as 2.94% in the 2% salty groups and 3.00% in the 4% salty groups in the end of the fermentation of turning olives (Table 5). In the end of the fermentation of naturally black olives in brine were determined as 3.07% in the 2% salty groups and 3.21% in the 4% salty groups. The changes in stearic acid values of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacum and MAP) and irradiation doses (Control, 1 kGy, 3 kGy, 5 kGy) are shown in Table 5.

Uylaşer ve Yildiz found that the stearic acid contents of some Turkish table olive varieties were 2.85% in Domat variety olives, 2.55% in Kalamata variety, 2.27% in Edremit olive, 2.06% in Edremit green olives and 2.31% in Gemlik olives [13]. Differences in the composition of fatty acids between table olive varieties are statistically important. Lopez et al. states that one of the major fatty acids in fats is stearic acid, and that the difference between the processing steps in terms of stearic acid content in the California style table olives is not significant [34]. Variations in the amount of stearic acid depending on the amount of salt were found to be significant at the $p<0.05$ level for each treatment method in the analysis of variance applied to stearic acid amounts.

The stearic acid data obtained from turning and naturally black olives in brine showed statistically significant difference at each level of $p<0.05$, for this, the amount of salt quantity has effected on the level of stearic acid depending on the olive processing techniques. The change observed in the amount of stearic acid depending on the packaging difference was found to be significant at the level of $p<0.05$ in the analysis of variance.

Salt %	Package type	Irrad (kGy)	Turning olive Analyses period				Nat. black olive in brine Analyses period			
			Raw	Ferm.	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	13.92 ± 0.65	13.73 ± 0.59	12.6 ± 0.23	13.06 ± 1.12	13.92 ± 0.65	12.84 ± 0.16	13.04 ± 0.63	12.98 ± 0.92
		1			12.73 ± 0.38	13.12 ± 0.5			12.5 ± 0.54	12.41 ± 0.46
		3			12.96 ± 0.54	12.95 ± 0.25			12.17 ± 0.2	12.23 ± 0.81
		5			13.05 ± 0.45	13.19 ± 0.23			12.55 ± 0.33	12.59 ± 0.45
	MAP	0			12.9 ± 0.17	13.6 ± 0.89			12.45 ± 0.29	13.05 ± 1.01
		1			13.23 ± 0.43	13.25 ± 0.36			12.66 ± 0.12	12.5 ± 0.26
		3			12.79 ± 0.73	13.23 ± 0.51			12.58 ± 0.18	12.63 ± 0.41
		5			12.93 ± 0.53	13.03 ± 0.62			12.97 ± 0.67	12.88 ± 0.54
4	V	0	13.92 ± 0.65	13.85 ± 0.17	12.65 ± 0.52	13.1 ± 0.97	13.92 ± 0.65	12.3 ± 0.28	12.64 ± 0.19	12.83 ± 0.7
		1			12.95 ± 0.49	13.3 ± 1.07			12.79 ± 0.43	12.71 ± 0.31
		3			12.99 ± 0.5	13.16 ± 0.89			12.73 ± 0.67	12.82 ± 0.51
		5			12.76 ± 0.5	12.99 ± 0.99			12.39 ± 0.14	12.63 ± 0.59
	MAP	0			13.02 ± 0.61	13.42 ± 1.22			12.24 ± 0.21	12.47 ± 0.25
		1			13.53 ± 0.93	13.82 ± 1.45			12.17 ± 0.21	12.66 ± 0.91
		3			13.15 ± 0.61	13.51 ± 1.11			12.53 ± 0.19	12.59 ± 0.19
		5			13.11 ± 0.53	13.42 ± 0.9			12.47 ± 0.25	12.58 ± 0.29

Table 4: Determination of palmitic acid values in the turning olives and naturally black olives in brine (%).

It was determined that there was no effect of the irradiation on the amount of stearic acid in consequence of the variance analysis was applied separately by grouping according to the processing methods. Stefanova et al. reported that there was an upward trend in saturated fatty acids as parallel to the dose increase, as compared to the results obtained from unexposed samples [40]. Chen et al. determined that there was no effect on the amount of stearic acid in irradiation and storage during 10 days at 7°C after treatment of beef samples with varying amounts of irradiation [39].

The effect of storage period on the amount of stearic acid was determined to be significant at the level of $p<0.05$ in the analysis of variance applied for the different grouping according to processing methods.

Salt %	Package type	Irrad. (kGy)	Turning olive Analyses period				Nat. black olive in brine Analyses period			
			Raw	Ferm.	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	3.06 ± 0.2	2.94 ± 0.19	2.9 ± 0.18	2.74 ± 0.08	3.06 ± 0.2	3.07 ± 0.23	3.27 ± 0.69	2.98 ± 0.25
		1			2.91 ± 0.07	2.8 ± 0.05			3.19 ± 0.38	3.01 ± 0.22
		3			2.89 ± 0.08	2.77 ± 0.02			3.14 ± 0.29	3.02 ± 0.18
		5			2.81 ± 0.11	2.75 ± 0.03			3.09 ± 0.28	3 ± 0.23
	MAP	0			2.98 ± 0.15	2.99 ± 0.18			3.2 ± 0.32	3 ± 0.18
		1			2.95 ± 0.19	2.95 ± 0.16			3.12 ± 0.3	3.03 ± 0.22
		3			2.93 ± 0.15	2.98 ± 0.2			3.11 ± 0.31	3.03 ± 0.23
		5			3.06 ± 0.26	3.03 ± 0.22			3.08 ± 0.31	2.96 ± 0.23
4	V	0	3.06 ± 0.2	3 ± 0.35	2.98 ± 0.12	2.93 ± 0.16	3.06 ± 0.2	3.21 ± 0.18	3.27 ± 0.24	3.13 ± 0.08
		1			2.98 ± 0.08	3.01 ± 0.16			3.26 ± 0.21	3.16 ± 0.1
		3			2.95 ± 0.07	2.91 ± 0.08			3.25 ± 0.2	3.12 ± 0.06
		5			3.03 ± 0.13	2.97 ± 0.07			3.27 ± 0.25	3.14 ± 0.14
	MAP	0			3.01 ± 0.17	2.92 ± 0.1			3.29 ± 0.26	3.15 ± 0.16
		1			3.01 ± 0.09	2.92 ± 0.07			3.27 ± 0.25	3.1 ± 0.09
		3			2.97 ± 0.15	2.94 ± 0.1			3.27 ± 0.2	3.19 ± 0.14
		5			2.96 ± 0.11	2.91 ± 0.07			3.25 ± 0.25	3.11 ± 0.13

Table 5: Determination of stearic acid values in the turning olives and naturally black olives in brine (%).

Oleic acid

Uylaşer ve Yildiz states that the oleic acid content of the fatty acid composition is one of the most important quality parameters of table olive and olive oil [13]. Oleic acid which is the predominant fatty acid in olive oil had the values ranging from 72.26-73.30% [26].

The amount of oleic acid in crude olive samples was determined as 73.16%. According to different salt concentration, oleic acid was determined as 70.97% in the 2% salty groups and 71.99% in the 4% salty groups in the end of the fermentation of turning olives (Table 6). In the end of the fermentation of naturally black olives in brine were determined as 74.24% in the 2% salty groups and 75.12% in the 4% salty groups. The changes in oleic acid values of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacum and MAP) and irradiation doses (control, 1 kGy, 3 kGy, 5 kGy) are shown in Table 6.

The amount of oleic acid (C18: 1) in Gemlik olive oil were determined as 81.1% by Tanılgan [41]; between 72.68-74.08% by Kutlu and Ve Sen [42]; between 62.90-63.89% by Aktaş [6]; between 72.29% Uylaşer ve Yildiz [13]; between 70.56% by Draman et al. [43]. The 73.16% oleic acid value obtained in our study was higher thats of Aktaş [6], Uylaşer ve Yıldız [13] and Dıraman et al. [43], similar to Dıraman et al. [36] and Kutlu and Ve Sen [42], and low from Tanılgan et al. [41].

In this study, The oleic acid contents of oils obtained from raw, fermented and table olives were in compliance with (55-83%) according to Turkish Food Codex-Olive Oil and Prina Oil [23].

Oleic acid values which determined at the end of storage and fermentation, in the olives sample obtained by turning olive method has lower than olive samples obtained from naturally black olives in brine. The change in the amount of oleic acid determined depending on the olive processing methods was found to be statistically significant at the level of $p<0.05$ by the applied variance analysis.

Issaoui et al. reported that oleic acid was the predominantly MUFA in olives and that there was a slight increase in all three types examined during processing [43,44]. Unal and Ve Nergiz found that the content of oleic acid in the Memecik variety green table olives was 67.26-69.33% [37]. Malheiro states that the main fatty acids of conventional pitted green olives were oleic acid and the content was between 66.9% and 76.1% [35]. Malheiro reported that olive varieties were regulated by genetic factors, such as that the fatty acid composition of the different olive varieties was in the oil synthesis, and that they affected the environmental conditions [35].

Salt %	Package type	Irrad. (kGy)	Turning olive Analyses period				Nat black olive in brine Analyses period			
			Raw	Ferm.	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	73.16 ± 0.81	70.97 ± 2.26	74.11 ± 0.28	73.6 ± 0.47	73.16 ± 0.81	74.24 ± 0.87	74.62 ± 0.35	74.3 ± 0.57
		1			73.77 ± 1.06	73.18 ± 1.34			75.59 ± 0.36	75.01 ± 0.5
		3			71.6 ± 2.34	73.53 ± 0.36			75.54 ± 0.3	74.81 ± 1.31
		5			71.75 ± 1.79	73.53 ± 0.28			75.11 ± 0.5	75.01 ± 0.3
	MAP	0			72.36 ± 1.55	70.83 ± 2.9			75.28 ± 0.47	74.66 ± 0.76
		1			72.26 ± 1.43	71.96 ± 1.96			74.9 ± 0.38	75.02 ± 0.43
		3			72.79 ± 0.86	71.93 ± 1.73			74.87 ± 0.22	74.81 ± 0.43
		5			72.68 ± 1.22	72.09 ± 2.05			74.78 ± 0.74	74.72 ± 0.43
4	V	0	73.16 ± 0.81	71.99 ± 1.4	72.83 ± 2.54	72.38 ± 2.5	73.16 ± 0.81	75.12 ± 0.58	75.24 ± 0.43	74.96 ± 0.79
		1			72.14 ± 2.51	71.88 ± 2.56			74.69 ± 0.26	74.79 ± 0.44
		3			71.8 ± 2.75	71.32 ± 3.25			74.57 ± 0.65	74.53 ± 0.56
		5			72 ± 2.9	71.02 ± 3.4			75.54 ± 0.84	75.1 ± 0.87
	MAP	0			71.4 ± 2.98	71.17 ± 3.3			75.26 ± 0.33	74.99 ± 0.4
		1			71.5 ± 2.93	70.97 ± 3.47			75.06 ± 0.32	74.76 ± 1
		3			71.5 ± 2.76	70.99 ± 3.26			74.98 ± 0.29	74.82 ± 0.28
		5			70.71 ± 3.41	70.75 ± 3.4			75.15 ± 0.45	74.51 ± 0.94

Table 6: Determination of oleic acid values in the turning olives and naturally black olives in brine, (%).

Sahan et al. found that the content of oleic acid in raw Gemlik green olives was found to be 73.9%, as 72.74% in the crude sample of black olives, as 71.41% in California type (alkaline applied), as 72.99% in brine black olives and 72.51% in the dry-salted olives. They indicate that fatty acid composition has been affected by processing techniques with factors such as geographical origin, maturity index, environmental conditions and precipitation, that highest oleic acid content was determined in unprocessed Gemlik green olives, and that lowest oleic acid content was in California style processing, and that

the least loss of oleic acid content was observed in naturally black olives in berine [45].

Our findings also show that the least loss of oleic acid is in the naturally black olives in brine. It is thought that more oleic acid loss in the turning olives may be related to the salt treatment directly with olives and more water loss from the inside.

Salt %	Package type	Irrad. (kGy)	Turning olive Analyses period				Nat. black olive in brine Analyses period			
			Raw	Ferm.	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	6.2 ± 0.33	8.38 ± 1.55	6.66 ± 0.1	6.67 ± 0.19	6.2 ± 0.33	6.9 ± 0.47	6.07 ± 0.45	6.62 ± 0.08
		1			7.07 ± 0.92	6.71 ± 0.16			5.88 ± 0.55	6.38 ± 0.16
		3			8.52 ± 3.16	6.81 ± 0.08			6.01 ± 0.26	6.25 ± 0.2
		5			8.61 ± 1.63	6.92 ± 0.19			6.11 ± 0.21	6.22 ± 0.22
	MAP	0			8.03 ± 1.23	7.77 ± 0.9			6 ± 0.25	6.24 ± 0.33
		1			7.97 ± 1.25	8.01 ± 1.09			6.2 ± 0.35	6.28 ± 0.37
		3			7.84 ± 1.14	7.97 ± 0.98			6.19 ± 0.35	6.26 ± 0.29
		5			7.83 ± 1.3	8.07 ± 1.27			5.99 ± 0.35	6.16 ± 0.47
4	V	0	6.2 ± 0.33	7.86 ± 0.98	7.83 ± 1.43	7.8 ± 1.25	6.2 ± 0.33	6.21 ± 0.24	5.93 ± 0.05	6.05 ± 0.19
		1			8.28 ± 1.44	8.11 ± 1.1			6.15 ± 0.11	6.14 ± 0.22
		3			8.62 ± 1.89	8.11 ± 1.22			5.99 ± 0.08	6.02 ± 0.14
		5			8.23 ± 1.61	8.39 ± 1.39			6.07 ± 0.15	6 ± 0.09
	MAP	0			8.33 ± 1.57	8.27 ± 1.54			6.06 ± 0.16	6.03 ± 0.16
		1			8.17 ± 1.29	8.26 ± 1.37			6.18 ± 0.11	6.18 ± 0.07
		3			8.54 ± 1.56	8.61 ± 1.74			6 ± 0.09	6.04 ± 0.08
		5			8.67 ± 1.49	8.56 ± 1.42			6.09 ± 0.05	6.04 ± 0.12

Table 7: Determination of linoleic acid values in the turning olives and naturally black olives in brine (%).

Statistically, it has been determined that irradiation does not have a significant effect on the oleic acid values. Stefanova et al. report that irradiation with increasing doses from 2.5 kGy to 15 kGy to beef meat led to a reduction in the amount of PUFAs, but not to the content of oleic acid. It is well known that fat-containing foods are sensitive to irradiation applications, and that the irradiation of unsaturated fatty acyl groups in oils triggers via reactive the free radical formation, that the oil oxidation rate is directly related to the position and number of double bonds, and therefore the sensitivity to radiation is high, and oleic acid is more resistant to the free radicals because it is a MUFA [40].

In our study, irradiation doses was reduced the amount of oleic acid in some groups, but not in some groups. Statistically, the effect of irradiation was not significant. The change in the amount of oleic acid during storage varied at each olive processing method and at each salt level. It was determined that this difference was significant at the level $p<0.05$. Although it was significant this differences, it is seen that the decrease was not reach the high values.

Linoleic acid

It is noted by many authors that PUFAs are very important for human nutrition and are therefore referred to as essential fatty acids [46-48]. The amount of oleic acid in crude olive samples was determined as 6.2%. According to different salt concentration, oleic acid was determined as 8.38% in the 2% salty groups and 7.86% in the 4% salty groups in the end of the fermentation of turning olives. In the end of the fermentation of naturally black olives in brine were determined as 6.9% in the 2% salty groups and 6.2% in the 4% salty groups. The changes in linoleic acid values of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacuum and MAP) and irradiation doses (Control, 1 kGy, 3 kGy, 5 kGy) are shown in Table 7.

The amounts of linoleic acid belonging to olive oils were determined by Abdalla et al. [49]. Olive oil obtained from olives grown in Morocco is between 6.08% and 11.68%; Aguilera et al. found that the oil obtained from the Frontoio and Leccino varieties in the two regions of Spain ranged from 6.79% to 10.43% and 5.30% to 6.73%, respectively [47]; Aşık ve Ozkan in Memecik variety olive oil found that linoleic acid quantity is 10.31% in the index of maturity of 6.21 [48-50]; Unal and Ve Nergiz found that in the oils of black olives 10.82% [37]; Aktaş Gemlik variety olive oils were between 12.17-15.97% [6]; Bıyıklı in natural extra virgin olive oil samples were between 8.18-10.55% [51]; Ozdemir detected that it was 8.89% in Gemlik variety olive oil of black olives [52]; Dıraman et al. in Gemlik olive oil obtained from different regions found that it was between 6.81% and 9.9% [43]. The 6.2% linoleic acid value obtained in our study was similar thats of Bıyıklı [51] and Dıraman et al. [43], and low from Aktaş [6] and Unal and Ve Nergiz [37].

In the olive samples obtained by the turning olive method the linolenic acid values were found to be higher than the olive samples processed by naturally black olives in brine method at the end of fermentation and the storage period. Differences in the amounts of linoleic acid according to processing methods showed that the processing methods were effective at the linoleic acid ($p<0.05$).

The rise in linoleic acid content was due to the fact that, besides the continuing biosynthesis of triglycerides, with the formation of oleic acid, the enzyme oleate desaturase was active, transforming oleic acid into linoleic. The net result was that the former remained constant while linoleic increased [31].

They found a mild decrease in PUFAs (except Manzanilla) with conventional processing. The fact that olives are kept in water and oil before processing does not have a significant effect on the fatty acids, that significant losses occur in some components during fermentation in conventional processing but fatty acids remain stable and that the processed olives contained enough the health components. They reported that Tunisian processing styles do not use any chemicals (aside from table salt) to process and store olives, but that they found a great lost in constituent of the olive fruit occurring during fermentation. The fatty acid contents showed variations in the saturated and polyunsaturated fatty acids (SFAs and PUFAs, respectively) levels, but these variations are variety dependant [45].

A decrease in PUFAs was found to be significant in both types of table olive varieties during storage. It was stated that three major PUFAs (linoleic acid (C18: 2n-6), trans-linoleic acid (C18: 2t including all trans forms) and linolenic acid (C18: 3n-6) showed a significant decrease in Manzanilla variety olives. Linoleic acid was significantly reduced only Hojiblanca variery olives [53]. Malheiro et al. reported that PUFA contents varied from 3.5% to 11.6% in the Alcaparras table olives, that PUFA consumption helped to decrease LDL cholesterol and HDL cholesterol levels in the blood, contributing to reduce the incidence of cardiac arrhythmia, that the linoleic acid was the third most abundant fatty acid found [35]. Also they noted that, nutritionally, MUFA are very important fatty acids since they can contribute to decrease the concentration of Low Density Lipoprotein (LDL) cholesterol in the blood and at the same time possess the capacity to maintain or raise the concentration of High-Density Lipoprotein (HDL) cholesterol [54].

The amount of linoleic acid measured at the end of fermentation was found to be higher in samples with 2% salt concentration than in samples with 4% salt concentration for each processing methods. The changes in the amount of linoleic acid depending on the amount of salt were found to be significant at the level of $p<0.05$ at each processing methods.

Sahan et al. expressed that fatty acid content was higher in fresh olives compared to those in processed olives cv. Gemlik, and that spanish style green olives had the lowest values for analyzed parameters than other processed olives, according to the effects of the processing techniques, that the lowest values were obtained in Spanish type olives and the highest values were in the natural brine black olives, which expressed that the best processing technique in terms of nutrients was the brine black olive processing method. They noted that fatty acid compositions of table olives were very complicated and variable, and that as they depend on upon olive cultivars, maturation index, agricultural practice, growing conditions, and table olive processing methods [45].

Unal and Ve Nergiz, in studying the effect of processing technique and storage on the composition of fatty acid found in oils of natural black table olives, found that the content of linoleic acid was 10.82% in black crude olive, 9.54% at 4th month of storage, 8.27% at 8th month of storage, and 9.94% at the 12th month of storage. They observed that the decrease was in fermentation that a slight increase was in the later part of the storage [37].

Sahan et al. [45] and Unal and Ve Nergiz [37] reported that although there was not a high change in black table olives, that a slight increase in fermentation and storage was only found in the turning olive. Lanza identified that linoleic acid content was 6.3% in the olives of d'Abruzzo which was processed as table olive [48]. Sakouhi et al. reported that a decrease found in the content of fatty acids in table olives which after processing in the treatment of Meski, Sayali and Picholine varieties grown in Tunusia [11]. Sousa et al. report that the values of linoleic acid content (4.11-4.26% and 3.06%) were similar to those of regional oils [38]. Uylaşer and Yıldız found the linoleic acid content of Gemlik olives as 7.91% [13].

In our study, the content of linoleic acid of naturally black olives in brine and turning olives, respectively, (6.21-6.90% and 7.86-8.38%) determined generally agrees with other studies. There is a difference due to the processing methods. This difference may be due to the fact that osmosis occurs faster in the brine when air is supplied during processing and the salt is processed more effectively in the olive flesh.

In both processing methods and salt amounts, it is observed that the content of linoleic acid in the vacuum packed olives were determined higher than MAP packed olives. However, it was not statistically significant. Lopez et al. found that the amount of linoleic acid in Manzanilla and Hojiblanca variety olives before ripe olive type table olive processing varied between 3% and 20% and decreased with

storage [54]. While changes in MUFAs were not detected, the change in PUFAs was found to be important.

It is observed that the amount of linoleic acid of non-irradiated samples was lower than the irradiated samples at the end of the storage period in the turning olive samples, that the amount of linoleic acid of irradiated samples was lower than the non-irradiated samples at the end of the storage period in samples of the naturally black olives in brine (except for 4% salty and MAP packed olives). However, it was not important as statistically.

Stefanova et al. [40], Chen et al. [39] and Arıcı et al. [34] found that a decrease in the amount of linoleic acid due to the increase in irradiation dose. Etyemez [55] and Pereira et al. [56] found that fatty acids were not affected by the irradiation process and that there was no significant difference between the irradiated and non-irradiated control samples [57].

In relation to the storage time, the results obtained from the olive samples analyzed during storage according to such factors as olive processing method, salt amount, packaging technique and irradiation were shown to be effective on the amount of linoleic acid in the storage period.

Salt %	Package type	Irrad. (kGy)	Turning olive Analyses period				Nat black olive in brine Analys. period			
			Raw	Ferm	Storage (Month)		Raw	Ferm.	Storage (Month)	
					4	8	4		8	
2	V	0	0.65 ± 0.13	0.81 ± 0.02	0.7 ± 0.07	0.77 ± 0.01	0.65 ± 0.13	0.67 ± 0.04	0.63 ± 0.1	0.64 ± 0.09
		1			0.75 ± 0.05	0.77 ± 0.02			0.57 ± 0.14	0.64 ± 0.1
		3			0.78 ± 0.01	0.78 ± 0.01			0.59 ± 0.1	0.62 ± 0.11
		5			0.8 ± 0.02	0.78 ± 0.01			0.61 ± 0.07	0.62 ± 0.09
	MAP	0			0.79 ± 0.01	0.79 ± 0.01			0.6 ± 0.09	0.62 ± 0.1
		1			0.76 ± 0.02	0.81 ± 0.02			0.61 ± 0.08	0.62 ± 0.08
		3			0.75 ± 0.03	0.81 ± 0.02			0.61 ± 0.09	0.62 ± 0.08
		5			0.75 ± 0.02	0.81 ± 0.03			0.61 ± 0.09	0.61 ± 0.09
4	V	0	0.65 ± 0.13	0.77 ± 0.03	0.73 ± 0.03	0.76 ± 0.03	0.65 ± 0.13	0.58 ± 0.02	0.56 ± 0.04	0.56 ± 0.03
		1			0.74 ± 0.03	0.77 ± 0.02			0.55 ± 0.05	0.56 ± 0.02
		3			0.75 ± 0.06	0.76 ± 0.01			0.55 ± 0.04	0.55 ± 0.03
		5			0.74 ± 0.05	0.75 ± 0.07			0.57 ± 0.03	0.56 ± 0.04
	MAP	0			0.79 ± 0.02	0.78 ± 0.03			0.58 ± 0.05	0.58 ± 0.04
		1			0.74 ± 0.03	0.75 ± 0.04			0.58 ± 0.05	0.58 ± 0.04
		3			0.76 ± 0.04	0.78 ± 0.06			0.57 ± 0.03	0.56 ± 0.03
		5			0.78 ± 0.03	0.78 ± 0.03			0.57 ± 0.03	0.55 ± 0.03

Table 8: Determination of linolenic acid values in the turning olives and naturally black olives in brine (%).

Linolenic acid

The amount of linolenic acid in crude olive samples was determined as 0.65%. According to different salt concentration, linolenic acid was determined as 0.81% in the 2% salty groups and 0.77% in the 4% salty groups in the end of the fermentation of turning olives (Table 8). In the end of the fermentation of naturally black olives in brine were determined as 0.67% in the 2% salty groups and 0.58% in the 4% salty groups. The changes in linolenic acid values of the olive oil obtained from table olive samples as a function of storage period (4th and 8th months), packaging methods (vacuum and MAP) and irradiation doses (Control, 1 kGy, 3 kGy, 5 kGy) are shown in Table 8.

The amounts of linolenic acid belonging to olive oils were determined between 0.20-0.48% in Gemlik variety olive oils by Aktaş [6]; as 0.63-0.78% in natural extra virgin olive oil samples by Bıyıklı [51]; between 0.54-0.87% in Gemlik olive oil obtained from different regions by Dıraman et al. [43].

The 0.65-0.81% linolenic acid value obtained in our study was similar thats of Bıyıklı [51] and Dıraman et al. [43], and higher from Aktaş [6].

In our study, the values obtained for linolenic acid were generally consistent with other studies. It was observed to be appropriate according to the criteria specified in the quality of extra oil of Turkish Food Codex Olive Oil and Pirina Oil Notification [23]. The amounts of linoleic acid measured at the end of fermentation, during storage and end of the storage were found to be higher in samples of naturally black olives in brine than in samples of turning olives. The differences in the amount of linoleic acid depending on the processing methods were found to be effective on the linolenic acid quantity.

Issaoui et al. found a slight decrease in PUFAs with conventional processing [44]. Malheiro reported that fats obtained from Alcaparras type pitted olives had a linolenic acid content varying between 1.06-0.82% and showed great variation among the varieties [35].

The amounts of linolenic acid measured at the end of fermentation in the each processing methods were found to be lower in samples of 4% salty olives than in samples of 2% salty olives. The changes in the amount of linolenic acid depending on the salt amount were found to be significant at the level of $p<0.05$ for the each of processing methods.

Sahan et al. in the studying the effects of processing techniques and degree of maturity on the composition of fatty acids in the Gemlik variety table olives, found that maturity stepping and processing techniques affected the amount of fatty acid composition, that linolenic acid increased during from green maturity to black maturity rotation. It was reported that the amount of linolenic acid was determined as 0.53% in Gemlik green olives and 0.65% in black maturity period. In the Green olives, They found that the amount of linolenic acid did not change after the Spanish style processing, that it decreased to 0.68% in California style processing, that it was 0.65% in brine black olive processing and 0.63% in dry-salted style processing [45].

In a study of the effect of processing technique and storage on the fatty acid composition of natural black table olives, the content of linolenic acid was found to be 0.94% in crude oil of black olives, 1.29% in 4th month of storage after fermentation, 1.09% in 8th month of storage and 1.00% in 12th month of storage. A slight decrease has been observed in the later part of the fermentation, while an increase was observed in the first part of the fermentation [37].

In our study, the values of linolenic acid obtained after each processing methods is consistent with other studies. A slight increase was observed during the fermentation and storage in the turning olives while a slight decrease was observed in the naturally black olives in brine. When comparing the results obtained at the end of the storage period to examine the effect of packing techniques on the amount of linolenic acid, it is seen that vacuum packed olives contained lower linolenic acid than MAP packaged olives in both the 2% salted and 4% salted groups of turning olives. Stefanova et al. found that the gamma irradiation doses of 7.5 kGy, 10 kGy, and 15 kGy resulted in a decrease in PUFAs and that the amount of linolenic acid decreased due to the increase in the dose of irradiation [40]. Chen et al. [39,55,56] indicate that the effect of irradiation on linolenic acid in their studies is not significant. Statistically, it was determined that the storage period was effective at the level of $p<0.05$ on the amount of linolenic acid.

Conclusion

Processing methods, salt quantity and storage period have affected almost all the quality parameters of the olive oils which obtained from table olives.

Oleic acid quantity which one of the most important fatty acids for health hasn't decreased much during processing and storage.

Peroxide value increased during fermentation, but this increase stopped during storage period due to the vacuum and MAP packaging.

The effect of irradiation on fatty acids was observed less.

As a result, Table olives are one of the healthy foods consist of much oleic, linoleic and linoleic acids.

Practical Applications

The Traditional natural table olive processing techniques are widely applied in Turkish table olive sector. There are many problems in preserving the products obtained from these products, especially sold in the local markets. In order to overcome this, more easily applicable vacuum and map packaging techniques and additionally the gamma ray application have been studied.

References

1. Anon (2006) International Olive Oil Council.
2. Fernandez AG, Diez MJF, Adams MR (1997) Table Olives: Production and Processing, Chapman & Hall, London, p: 481.
3. Piga A, Del Caro A, Pinna I, Agabbio M (2005) Anthocyanin and colour evolution in naturally black table olives during anaerobic processing. LWT Food Sci Technol 38: 425-429.
4. Alvarez DME, López A, Lamarque AL (2014) Industrial Improvement for Naturally Black Olives Production Of Manzanilla And Arauco Cultivars. J Food Process Preserv 38: 106.
5. Bianci G (2003) Lipids and phenols in table olives. Eur J Lipid Sci Technol pp: 229-242.
6. Aktas AB (2013) Chemical Characterization of 'Hurma' Olive Grown in Karaburun Peninsula. Izmir Institute of Technology.
7. Anon (2007) International Olive Oil Council.
8. Boskou G, Salta FN, Chrysostomou S, Mylona A, Chiou A (2006) Antioxidant Capacity and Phenolic Profile of Table Olives from the Greek Market. Food Chem 94: 558-564.
9. Sakouhi F, Herchi W, Sebei K, Ajsalon S, Kallel H, et al. (2011) Accumulation of total lipids, fatty acyds and triacylglycerols in developing fruits of *Olea europaea* L. Sci Hortic 132: 7-11.

10. Charoenprasert S, Mitchell A (2012) Factors influencing phenolic compounds in table olives (*Olea europaea*). J Agr Food Chem 60: 7081-7095.
11. Sakouhi F, Harrabi S, Absalon C, Sbei K, Boukhchina S, et al. (2008) α-Tocopherol and fatty acids contents of some Tunisian table olives (*Olea europea* L.): Changes in their composition during ripening and processing. Food Chem 108: 833-839.
12. Uylaser V, ve Yildiz G (2013) Fatty Acid Profile and Mineral Content of Commercial Table Olives from Turkey. Not Bot Hortic Agrobo 41: 518.
13. Mendes R, Pestana C, Goncalves A (2008) The effects of soluble gas stabilisation on the quality of packed sardine fillets (Sardina pilchardus) stored in air, VP and MAP. Int J Food Sci Technol 43: 2000-2009.
14. Degirmencioglu N, Gürbüz O, Degirmencioglu A, Sahan Y, Özbey H (2011) Effect of MAP and Vacuum Sealing on Sensory Qualities of Drysalted Olive. Food Sci Biotechnol 20: 1307-1313.
15. Fernandes A, Barreira JCM, Antonio AL, Beatriz M, Oliveira PP, et al. (2014) Effects of gamma irradiation on chemical composition and antioxidant potential of processed samples of the wild mushroom. Food Chem 149: 91-98.
16. Tezotto-Uliana JV, Berno ND, Saji FRQ, Kluge RA (2013) Gamma radiation: An efficient technology to conserve the quality offresh raspberries. Scientia Horticulturae 164: 348-352.
17. Alighourchi H, Barzegar M, Abbasi S (2008) Effect of gamma irradiation on the stability of anthocyanins and shelf-life of various pomegranate juices. Food Chem 110: 1036-1040.
18. Anon (2002) Gida Isinlama Yönetmeligi, Resmi Gazete
19. Irmak S (2015) The shelf life and quality effect of the methods used in the preservation of Gemlik varieties of sofralic black olives, Doctorate Thesis, Ege University Institute of Natural and Applied Sciences, Izmir.
20. Anon (2014) Turkish Food Codex-Table Olive Directive.
21. Irmak Ş (2010) The determination of polyphenol characteristics in some Turkish table olives varieties and study on the influences of processing methods on the polyphenol contents. Result report, TAGEM, Olive Research Institute, İzmir.
22. Anon (2014) Turkish Food Codex-Olive oil and Olive pomace Oil directive.
23. Maggio RM, Kaufman TS, Carlo MD, Cerretani L, Bendini A, et al. (2009) Monitoring of fatty acid composition in virgin olive oil by Fourier transformed infrared spectroscopy coupled with partial least squares. Food Chem 114: 1549-1554.
24. Bozdogan Konuskan D, Didin M, Ve Karayiyen A (2013) Determination of Antioxidant Components and Oxidative Stabilities of Oils Obtained from Important Olives Produced in Hatay ZZ Dergisi 27: 72-77.
25. Yorulmaz A, Tekin A, Ve Turan S (2011) Improving olive oil quality with double protection: Destoning and malaxation in nitrogen atmosphere. Eur J Lipid Sci Technol 113: 637-643.
26. Vural A, ve Aksu H (2006) Effect of gamma irradiation on microbiological and physico-chemical quality of meatballs. Medycyna Wet 62: 1011-1015.
27. Aziz NH, Mahrous SR, Youssef BM (2002) Effect of gamma-ray and microwave treatment on the shelf-life of beef products stored at 5°C. Food Control 13: 437-444.
28. Baccouri O, Guerfel M, Baccouri B, Cerretani L, Bendini A, et al. (2008) Chemical composition and oxidative stability of Tunisian monovarietal virgin olive oils with regard to fruit ripening. Food Chem 109: 743-754.
29. Salvador MD, Aranda F, Fregpane G (2001) Influence of fruit ripening on "Cornicabra" virgin olive oil quality a study of four successive crop seasons. Food Chem 73: 45-53.
30. Bengana M, Bakhouche A, Lozano-sánchez J, Amir Y, Youyou A, et al. (2013) Influence of olive ripeness on chemical properties and phenolic composition of Chemical extra-virgin olive oil. Food Res Int 54: 1868-1875.
31. Billek G (2000) Health aspects of thermoxidized oils and fats. Eur Lipid Sci Tech 9: 587-593.
32. Saguy IS, Dana D (2003) Integrated approach to deep fat frying: engineering, nutrition, health and consumer aspects. J Food Eng 56: 143-152.
33. Lopez-Lopez A, Rodriguez-Gomez F, Cortes-Delgado A, Montano A, Garrido-Fernandez A (2009) Influence of ripe olive processing on oil characteristics and composition as determined by chemometrics. J Agri Food Chem 57: 5973-8981.
34. Arici M, Arslan Colak F, Ve Geçgel Ü (2007) Effect of gamma radiation on microbiological and oil properties of black cumin, Grasas y Aceites. Octubre-Diciembre 58: 339-343.
35. Malheiro R, Sousa A, Casal S, Bento A, Pereira JA (2011) Cultivar effect on the phenolic composition and antioxidant potential of stoned table olives. Food Chem Toxicol 49: 450-457.
36. Dıraman H, Saygı H, Hışıl Y (2009) Fatty Acid Components of Natural Olive Oil Produced During Two Harvest Years in İzmir. Elect J Food Technol 4: 1-8.
37. Unal K, Ve Nergiz C (2003) The effect of table olive preparing methods and storage on the composition and nutritive value of olives. Grasas y Aceites 54: 71-76.
38. Sousa A, Casal S, Bento A, Malheiro R, Beatriz M, et al. (2011) Chemical Characterization of "Alcaparras" Stoned Table Olives from Northeast Portugal. Molecules 16: 9025-9040.
39. Chen YJ, Zhou GH, Zhu XD, Xu XL, Tang XY, et al. (2007) Effect of low dose gamma irradiation on beef quality and fatty acid composition of beef intramuscular lipid. Meat Sci 75: 423-431.
40. Stefanova R, Toshkov S, Vasilev NV, Vassilev NG, Marekov IN (2011) Effect of gamma-ray irradiation on the fatty acid profile of irradiated beef meat. Food Chem 127: 461-466.
41. Tanilgan K, Özcan M, Ve Ünver MA (2007) Physical and chemical characteristics of five Turkish olive (*Olea europea* L.) varieties and their oils. Grasas y Aceites 58: 142-147.
42. Kutlu E, Ve Sen F (2011) Effects of Different Harvest Times on Fruit and Olive Oil Quality in Gemlik Olive (*Olea europea* L.) Ege Univ. Faculty of Agriculture Derg 48: 85-93.
43. Diraman H, Söbüçovali S, Ve Yüksel F (2015) Oxidative Stability and Fatty Acid Components in Gemlik Varieties of Natural Olive Oil Produced in Various Regions. Gida 40: 93-100.
44. Issaoui M, Dabbou S, Mechri B, Nakbi A, Chehab H, et al. (2011) Fatty acid profile, sugar composition, and antioxidant compounds of table olives as affected by different treatments. Eur Food Res Technol 232: 867-876.
45. Sahan Y, Cansev A, Gülen H (2013) Effect of Processing Techniques on Antioxidative Enzyme Activities, Antioxidant Capacity, Phenolic Compounds, and Fatty Acids of Table Olives. Food Sci Biotechnol 22: 613-620.
46. Agar IT, Hess-Pierce B, Sourour MM, Kader AA (1998) Quality of Fruit and Oil of Black-Ripe Olives is Influenced by Cultivar and Storage Period. J Agr Food Chem 46: 3415-3421.
47. Aguilera MP, Beltran G, Ortega D, Fernandez A, Jimenez, et al. (2005) Characterisation of virgin olive oil of Italian olive cultivars: 'Frantoio' and 'Leccino', grown in Andalusia. Food Chem 89: 387-391.
48. Lanza B (2010) Nutritional and Sensory Quality of Table Olives.
49. Abdalla IH, Khaddor M, Boussab A, Garrouj EL, Souhia D, et al. (2014) Physical and Chemical Characteristics of Olive Oils from Cooperatives for Olive Growers in the North of Morocco. Int J Basic Appl Sci.
50. Asik HU, Ve Özkan G (2011) Physical, Chemical and Antioxidant Properties of Olive Oil Extracted from Memecik Cultivar. Akademik Gida 9: 13.
51. Biyikli K (2009) Determination of the Purity Grades of Turkish Olive Oil, Ankara University Institute of Natural and Applied Sciences, Graduate Thesis, Ankara.
52. Özdemir Y (2011) Determination of Physicochemical Properties of Some Hybrid Olives and Their Suitability for Starter Culture (*Lactobacillus plantarum*) Ileveli Table Olive Fermentation, Namik Kemal University, PhD Thesis, Tekirdag.

53. Lopez-Lopez A, Rodriguez-Gomez F, Cortes-Delgado A, Garcia-Garcia P, Garrido-Fernandez A (2010) Effect of the Previous Storage of Ripe Olives on the Oil Composition of Fruits. J Am Oil Chem Soc 87: 705-714.

54. Lanza B, DI Serio MG, Iannucci E, Russi F, Marfisi P (2010) Nutritional, textural and sensorial characterisation of Italian table olives (*Olea europaea* L. cv. 'Intosso d'Abruzzo'). Int J Food Sci Technol 45: 67-74.

55. Etyemez M (2011) Effects of Gamma-Lightening in Different Doses on Sensory, Chemical and Microbiological Quality of Cold-Stored (2°C) Kurbaga Legs (Rana Esculenta), M.Sc. Thesis, Çukurova University, Adana

56. Pereira E, Barros L, Antonio A, Bento A, Ferreira ICFR (2015) Analytical Methods Applied to Assess the Effects of Gamma Irradiation on Color, Chemical Composition and Antioxidant Activity of *Ginkgo biloba* L. Food Anal Method 8: 154-163.

57. Pasqualone A, Nasti R, Montemurro C, Gomes T (2014) Effect of natural-style processing on the oxidative and hydrolytic degradation of the lipid fraction of table olives. Food Control 37: 99-103.