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THE EFFECTS OF DRYING METHODS AND GAMMA IRRADIATIONS ON TOTAL PHENOLIC AND FLAVONOID AMOUNTS, ANTIOXIDANT CAPACITIES AND PHENOLIC COMPOUND CONTENTS OF OLIVE LEAVES

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ABSTRACT

The effects of drying methods such as infrared, ambient condation, microwave and convectional and different dosage gamma irradiations such as 3, 5 and 10 kGy/min on total phenolic and flavanoid amounts, antioxidant capacities and phenolic compound contents of Ayvalık and Gemlik olive leaves were investigated. The antioxidant capacities, total phenolic compound amount, total flavanoid amount and phenolic contents of the samples were determined by 2,2-diphenyl-2-picrylhydracyl hydrate (DPPH) radical scavenging method, Folin–Ciocalteu method, spectrophotometric and high performance liquid chromatography (HPLC), respectively. Microwave method was the most effective drying method in increasing the activity of phenolic, flavanoid and antioxidant compounds; gamma irradiations had different effects on phenolic compounds; the most abundant phenolic compound in olive leaf was oleuropein and the least found compound was gallic acid. In addition, the highest antioxidant content was obtained for Gemlik olive leaf, which applied 3 kGy/min gamma irradiation dosage and dried by microwave method.

Key words: Olive leaves, drying method, gamma irradiation, antioxidant capacity, phenolic content, flavonoid.

INTRODUCTION

Olive is one of the richest plants in phenolic compounds and has been widely used from ancient times in different countries such as Spain, Italy, Greece, France, Israel, Algeria, Tunis, Turkey, and Mediterranean islands due to their nutritional and medicinal properties (Shalaby et al., 2018; Sahin et al., 2018). An important agricultural waste obtained during the harvesting or processing of olive fruits is olive leaves. They are accumulated in high amounts especially during pruning of olive trees and are considered as a cheap raw material. Olive leaves are taken into account to be high value-added phytochemicals in the preparation of nutraceuticals and functional foods (Bouaziz et al., 2008). In this context, olive leaves are used as natural sources of bioactive phytochemicals such as oleuropein, hydroxytyrosol, tyrosol, phenolic acids, rutin, apigenin 7-o-glucoside, caffeic acid and luteolin 4-o-glucoside (Shalaby et al., 2018).

Phenols are one of the most important groups of natural antioxidants. They are found only in plant-derived materials, and are known to protect easily oxidizable components from oxidation (Bouaziz et al., 2008). The polyphenol content of olive leaves varies depending on their regional distribution. In addition, the antioxidant activities of polyphenols differ greatly according to their compositions (Sahin et al., 2018). Olive leaf extracts include many ingredients such as glycosides, flavonoids, simple phenols, phenolics acids and terpenoids. They are of commercial importance due to their rich content (Benavente et al., 2000). Olive leaves can be used not only for therapeutic but also for cosmetic purpose. Besides, olive leaf extracts have been investigated as an additive supplemented to food products, such as oils and meats to extend shelf-life and impart the image of wholesomeness to consumers. Thus, they are commercialized according to several forms (such as intact leaves, powdered leaves, extract) for their advantages to health (Aouidi et al., 2011). Hydroxyl groups of phenols possess the scavenging ability on free radicals that are resistant to oxidative degradation. Phenolic compounds are used against various microorganisms such as *Staphylococcus aureus*, *Salmonella typhi*, *Vibrio parahaemolyticus* and protection from chronic diseases, low blood pressure and protection against heart diseases (Shalaby et al., 2018).

Today, synthetic antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and ter-butyl hydroquinone (TBHQ) are used as food additives to increase the oxidation resistance of vegetable and animal fats. However, synthetic antioxidants have been reported to have many health risks such as toxic, cancer and carcinogenic effects. Therefore, the most powerful synthetic antioxidant (TBHQ) is notallowed for food application in Japan, Canada, Europe and Turkey. Similarly, BHA has been removed from the list of safe compounds (Bouaziz et al., 2008). Olive leaf extracts, which are a natural source of antioxidants, have been widely used in human diet as concentrated liquid, powder, capsule or dry leaf tea. However, after harvesting of olive leaves, they are highly susceptible to degradation and loss of usability characteristics due to their high moisture content. Therefore, the drying and sterilization of the leaves are very important shortly after collection.

In the literature, there are some studies on the phenolic contents of olive leaf extracts. Talhaoui et al (2015) investigated an exhaustive number of olive leaf phenolic compounds in different olive cultivars during their growth and the ripening period under the Andalusian climate, and determined the amount of 28 different phenolic compounds (Talhaoui et al., 2015). Kontogianni and Gerothanassis (2012) studied the antioxidant activity and phenolic contents of certain fractions of a methanolic olive leaf extract (Kontogianni et al., 2012). Some researchers have examined the effect of the drying process on the antioxidant and phenolic content of olive leaves. For example, Şahin et al (2018) studied the effect of microwave drying method on oleuropein, total phenolic content, flavonoid content, and antioxidant activity of olive (*Olea europaea*) leaf (Şahin et al., 2018); Nourhene et al (2008) the drying kinetics of four olive leaf varieties using an indirect forced convective solar dryer (Nourhene et al., 2008); Bahloul et al (2009) the impact of infrared drying on the polypehnols and color of the olive leaves (Bahloul et al., 2009). The above studies showed that the drying process significantly affected the antioxidant and phenolic content of olive leaves. Again, there are also studies showing the effect of gamma irradiation on the antioxidant and phenolic contents of olive leaves dried with different methods. Food irradiation is used for many purposes including the inhibition of sprouting, destruction of food borne insect's band parasites, delay of physiological ripening, and extension of shelf life or improvement of food

qualities (Al-Bachir et al., 2006). Shalaby et al (2018) investigated the antioxidant and antimicrobial activities of olive leaf extracts obtained from olive leaves irradiated at the dose levels such as 5, 10, and 15 kGy (Shalaby et al., 2018). İbrahim et al (2016) found that irradiation increased phenolic compound content and antioxidant activity of pomegranate peel (Ibrahim et al., 2016).

As can be seen from the above studies, no study has been found to systematically examine the effect of different dosage gamma irradiations on the phenolic, flavanoid and antioxidant contents of the olive leaves driedwith different methods. These results indicate that further investigation is necessary to elucidate changes in dried olive leaves induced by gamma irradiations. Therefore, the aims of this study were to i. dry two different types (Ayvalık and Gemlik varieties) of olive leaves with four different methods such as microwave, infrared, convection heater and atmospheric conditions, ii. expose to the dried leaf samples to different dosage gamma irradiation, iii. determine the antioxidant, flavanoid and phenolic contents of differently proceded olive leaves and iv. examine and compare the effects of drying methods and gamma irradiation dosages on the phenolic, flavanoid and antioxidant contents of different olive leaf species. It was applied gamma irradiations to samples up to 3, 5 and 10 kGy/min. The antioxidant capacity, total phenolic content, flavonoid content and phenolics compounds (oleuropein, caffeic acid, tyrosol, vanillic acid, rutin hydrate, gallic acid, luteolin 7-glycoside) of olive leaves were determined by UV-Visible spectrofotometer and HPLC systems.

MATERIALS AND METHODS

Materials

All chemicals were purchased from Sigma-Aldrich and Merck, were analytical purity and used without further purification. The leaves of Gemlik and Ayvalık olive varieties were collected from Ayvalık and Gemlik in Turkey during the pruning period (January-March). The leaves were the same colour and the same size. Collected olive leaves were washed five times with purified water to remove dust, separated into four parts and dried separately as following.

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Drying processes

1. Drying under ambientl conditions: washed olive leaves were dried on a clean bench in the laboratory for one week.

2. Conventional drying: olive leaves were dried in an oven for 24 hours at 65 °C.

3. Infrared method: olive leaves were dried between 50-60 Hz at 2500 Watts at 65 ^{0}C for 24 hours.

4. Microwave method: olive leaves were dried at 180 Watts for 10 minutes (Bouaziz et al., 2008).

Irradiation process

Ayvalık and Gemlik olive leaves dried with different methods such as room conditions, convection, infrared and microwave were exposed to gamma irradiations at three different dosage such as 3, 5 and 10 kGy/min at room temparature.

Preparation of extracts

The samples exposed to gamma irradiation were treated with liquid nitrogen, and were powdered by Warning Blender. The extracts were prepared with methanol/distilled water (80/20 v/v) solutions. 0.5 g of the powdered samples were added into tube (Denver Instruments Sl-234). 5 mL of 80% methanol was added into 0.5 g of each sample and kept in a fridge (+4°C) overnight. The samples were centrifugated for 15 min at 4500 rpm and supernatant was removed. Then, 5 and 2 mL of 80% methanol were added into pellets and centrifugated under the same conditions, respectively. The supernatants were combined. The extracts were stored at -20 °C until analysis (Lee et al., 2009).

Determination of antioxidant capacity

The antioxidant capacity of samples were determined using 1,1–diphenyl-2-picrylhydrazyl (DPPH) by radical scavenging activity. DPPH was weighed as 0.024 g and dissolved in 100 mL methanol at a flask. 0.25 mL extract, 2.5 mL DPPH and 2.5 mL methanol were added into a test tube and were kept in dark for 1 h. For the control, methanol was used instead of extract. Measurements were made using a UV-Visible spevtrophotometer

at 517 nm (Benavente et al., 2000). The radical scavenging activity of the samples was calculated using the following formula;

$$\text{Antioxidant activity (\%)} = \left[1 - \left(\frac{\text{Absorbance of sample}}{\text{Absorbance of control}}\right)\right] \times 100$$

Determination of total phenolic compound amounts

The total phenolic compound contents of Ayvalık and Gemlik olive leaves were determined by the Folin- Ciocalteu method. 0.25 mL of extract, 3.5 mL of distilled water and 0.25 mL of Folin reagent were combined in a test tube and incubated in the dark for 3 min at room temperature. Then, 1 mL of 20% sodium carbonate was added into the test tube and incubated for 40 min at 40 °C. For the control sample, methanol (80 %) was used instead of extract. After the 40 min, absorbance values of the all samples were measured at 685 nm by UV-Visible spectrophotometry. Total phenolic compounds were identified using the gallic acid calibration curve, and the results were calculated as µg gallic acid/g of sample (Lee et al., 2009; Doğan et al., 2005a).

Determination of total flavonoid compound amount

The total flavonoid compound amounts of the extracts were determined according to the method of Ramful et al (Ramful et al., 2011). In this method, 150 mL of 5% $NaNO_2$ and 2.5 mL of extract were added into the test tube by an automated pipette and mixed for 5 minutes before incubation. Then, 150 mL of 10% $AlCl_3$ was added into the test tube and incubated for 1 minute. 1 mL of 1 M NaOH was added into the mixture. To prepare the blank sample, 80% methanol was used instead of the extract. Measurements were taken at 510 nm. The total amount of flavanoid compounds was calculated as µg quercetin per g of sample.

HPLC analysis of the phenolic compound contents

HPLC analysis were carried out by Perkin Elmer HPLC, which consisted of a Series 200 pump, a Binary ternary gradient unit, three channel degasser, and a UV/vis detector set linked to an injection valve with a 20 µL sampler loop. A Macherey-Nagel silica gel (EC 250/4.6 Nucleosil 100-5 C18) column was used. The calibration curve was constructed by

plotting of the peak areas of the analyte against the concentration of oleuropein, caffeic acid, vanillic acid, rutin hydrate and tyrosol at 280 nm, gallic acid at 212 nm, and luteolin 7-glucoside at 350 nm, respectively. It was used pure water (0.1% o-phosphoric acid):acetonitrile mixture in different ratio as mobile phase. Flow rate was recorded as 2 mL/min. Chromatogram and peaks from samples were identified by comparing their spectra with those of pure standards. The peak areas were determined by integration. For each sample, quantitative analysis was performed in triplicate (Doğan et al., 2010).

Statistical analysis

The results were analysed statistical accounts using by IBM SPSS statistic 19. It was carried out evaluation of the differences between the control and experimental groups by independent samples t (Student t) test. The results were interpreted considering the significant level ($p<0.05$).

RESULTS AND DISCUSSION

In the study, antioxidant capacity, total phenolic and flavonoid compound amounts, oleuropein, caffeic acid, rutin hydrate, tyrosol, vanilic acid, luteolin 7-glucoside and gallic acid contents of leaf extracts collected from olive trees belonging to Ayvalık and Gemlik varieties, dried in different methods and exposed to gamma irradiations in three different dosages were determined. Experimental results have been discussed below depending on the literature.

Phenolic Compund Contents of Ayvalik Olive Leaves

Phenolic compound contents such as oleuropein, caffeic acid, tyrosol, vanilic acid, rutin hydrate, gallic acid, luteolin 7-glucoside of olive leaves, which were firstly dried with different methods such as infrared, ambient condition, microwave and convectional methods and then exposed to different dosages of gamma irradiations such as 3, 5 and 10 kGy/min, were given in Table 1. The contents of gallic acid, caffeic acid, luteolin 7-glucoside, rutin hydrate, tyrosol, and oleuropein of Ayvalık olive leaves, which were dried under ambient conditions, were determined as 0.32, 5.16, 11.88, 7.08, 8.88, 19.99 mg/g, respectively, but no vanilic acid was found. While the amounts of phenolic compound contents of olive leaves

dried by microwave method were generally higher than those of other drying methods, the amount of olive leaf phenolic compounds dried by convection method was the lowest. This result showed that drying method is an important parameter in the analysis of phenolic compound contents.

The effects of gamma irradiations on the phenolic compound contents of Ayvalık olive leaves dried with different methods were examined at dosages of 3, 5 and 10 kGy/min. When the phenolic contents of the dried olive leaf samples and then the dried olive leaf samples exposed to 3 kGy/min gamma irradiations were compared, it was observed that luteolin 7-glucoside, rutin hydrate and vanilic acid amounts of the samples exposed to gamma irradiations were higher; the amounts of caffeic acid, tyrosol and oleuropein were lower; and there was no significant change in the amount of gallic acid. This result showed that gamma irradiations could have different effects on phenolic compounds.

When the phenolic compound amounts of olive leaves dried with different methods and then exposed to different gamma irradiation dosages were compared, the effect of gamma irradiations on phenolic compounds was different. There was no significant change in gallic acid amounts of olive leaves dried with different methods and exposed to gamma irradiations ($p>0.05$). Caffeic acid amounts of dried olive leaves were higher than the amounts of gamma irradiated samples in different dosages, but caffeic acid amount increased with increasing dosage amount. While the caffeic acid contents of gamma irradiated olive leaves were in the range of 1.65-4.35 mg/g, caffeic acid contents of dried olive leaves were determined in the range of 3.48-5.4 mg/g. When the data obtained were compared, the gamma irradiation had no effect on the amount of caffeic acid ($p> 0.05$). Luteolin 7-glucoside and rutin hydrate amounts increased with both gamma irradiation application and increasing dosage amounts. The most found compound in olive leaf extracts after oleuropein was luteolin 7-glucoside and its amount varied in the range of 11.40-57.01 mg/g. Japon-Lujan et al (2006) determined that the amount of luteolin 7-glucoside of olive leaves was 10.42 mg/kg (Lujan et al., 2006). When these results were compared with our results, it was concluded that gamma irradiation increased the amount of luteoline 7-glucoside ($p<0.05$). The tyrosol content of samples dried with different methods was higher than that of samples exposed to different dosage gamma irradiations ($p<0.05$). In a study by Flemmig et al (2014), they determined the amount of

tyrosol as 0.42 µM/100 g (Flemmig et al., 2014). In control samples, the amounts of tyrosol was found in the range of 5.4-9.12 mg/g. This result was in good agreement with our experimental results. Vanillic acid was not observed in olive leaves in dried and exposed to 10 kGy/min gamma irradiation. While there was no significant change in the oleuropein content of olive leaves both dried by convectional and infrared methods and exposed to gamma irradiations, it was observed that the oleuropein contents increased with the application of gamma irradiation to the olive samples dried under ambient condition and by microwave methods. Stamatopoulos et al (2012) reported that the oleuropein amounts of fresh olive leaves were in the range of 8.28-29.79 g/kg (Stamatopoulos et al., 2012) and Japon-Lujan and Luque de Castro (2006) that the amounts of oleuropein in the olive leaves dried at 40 °C in the range of 27.96-30.68 mg/g (Lujan et al., 2006). In this study, the amounts of oleuropein of the olive leaves dried with different methods and exposed to gamma irradiations were determined in the range of 11.12-47.90 mg/g. When this result was compared with the studies in the literature, it was determined that gamma irradiation significantly increased the amount of oleurepein ($p<0.05$).

Phenolic compound contents of Gemlik olive leaves

Experimental data on the phenolic compound contents of Gemlik olive leaves dried by different drying methods and exposed to different dosages of gamma irradiations were given in Table 2. Drying method is an important parameter in determining the phenolic content of olive leaves. However, when the experimental results were examined, a regular increase or decrease in the amount of phenolic compounds was not observed. However, it can be said that the microwave method is more effective. Because the amount of gallic acid, caffeic acid, oleuropein and tyrosol in olive leaves dried by microwave method was higher than ambient condition drying method. On the other hand, the amount of gallic acid, caffeic acid, rutin hydrate, tyrosol and oleuropein of the olive leaves dried by the conventional method was lower than the ambient condition drying method. These results generally show that microwave drying method is the most suitable method for determining of phenolic compounds in Gemlik olive leaves and convection drying method not suitable.

The amount of phenolic content of Gemlik olive leaves exposed to different gamma irradiation dosages varies depending on the applied dosage amount. It was found that gallic

acid content of the olive leaves was the highest in the sample dried with microwave method. Again, the highest gallic acid content in the samples exposed to different dosage gamma irradiations was determined for the sample dried by microwave method and exposed to 3 kGy gamma irradiation. However, it can be said that a significant change does not occur between the gallic acid amounts of dried and gamma-irradated samples. When gamma irradiations were applied to the dried samples, decreases in caffeic acid and tyrosol amounts were observed, while increases in luteolin 7-glucoside, rutin hydrate and oleuropein amounts were observed. Again, in parallel with the results of Ayvalık olive leaves, vanilic acid was not found in the extracts of samples dried with different methods, while vanilic acid was found in the extracts of samples exposed to gamma irradiations at dosages of 3 and 5 kGy/min.

It could be said from Tables 1 and 2 that the olive leaves with the highest oleuropein and caffeic acid contents were samples dried by microwave method. Again, it was found that the most abundant phenolic compound in the leaves was oleuropein, followed by luteolin 7-glucoside. Also, considering all the results, it was determined that the least amount of compound in olive leaves was also gallic acid.

Total phenolic and flavonoid compound amounts of olive leaves

Phenolic compounds are widely distributed in plants and contributed to the formation of color and taste in vegetables and fruits. These compounds are responsible for the formation of orange, red and blue colors in the plant. In addition, they play a role in the structuralization of the cell wall (eg lignification) and also undertake the defense function in plants in high light damage, UV radiation, pathogen attack, nutrient deficiency, low temperature, and mechanical damage in biotic and abiotic conditions (Doğan et al., 2005; Doğan et al., 2007). Flavonoids and phenolic compounds generally have very high antioxidant effects. Therefore, information about the total flavonoid and phenolic amounts in a plant are very important. Because with this information, an assumption can be made about the antioxidant capacity of the plant. The total phenolic and flavonoid amounts of Ayvalık and Gemlik olive leaves dried with different methods and then exposed to gamma irradiationswere given in Table 3. When theeffect of the drying method are examined, it can be said that the most effective method for both olive leaf varieties is the microwave method. The total phenolic and flavonoid compound amounts for Ayvalık olive leaves were determined as 20.51 and 17.14 mg/g and those for

Gemlik olive leaves as 25.62 and 17.04 mg/g, respectively. While the flavonoid amount for both olive leaves was approximately the same, the total phenolic content of the Gemlik olive leaves was higher. The effect of different dosage gamma irradiations on the total phenolic and flavaoniod amounts showed that the phenolic and flavanoid amount generally increased with increasing dosages for both olive leaves. For example, the total phenolic and flavanoid amounts of the olive leaves dried by microwave method for Ayvalık olive leaves and then exposed to the dosages of 3, 5 and 10 kGy/min gamma irradiations, were 20.51 and 17.14 mg/g; 23.19 and 41.41 mg/g; 24.65 and 48.18 mg/g; and 23.27 and 50.65 mg/g, respectively. These results show that drying method and gamma irradiation dosage are effective in activating of the phenolic and flavanoid compounds in the structure of plant. In this study, when the correlation between the total phenolic compound amount of olive leaves without gamma irradiations and the total phenolic compound amount of olive leaves exposed to the gamma irradiations was studied,it was determined as $p<0.05$.In the literature, Gökce (2009) determined that the total flavonoid compound amounts of Gemlik olive leaf extracts were in the range of 14.19-22.16 mg/g (Gökce, 2009); Bazylkoa et al (2014) that total flavonoid amount of olive oil was 11.2 mg/g (Bazylkoa et al., 2014); Lee et al (2009) that total flavonoid amount of the dried olive leaves was 19 mg/g (Lee et al., 2009); and Aouidi et al (2011) that the total flavonoid compound amounts of olive leaves exposed to gamma irradiation were in the range of 18.65-18.68 mg/g (Aouidi et al., 2011). In this study, the amounts of flavonoid compound in olive leaves dried with different methods and then exposed to gamma irradiations were determined in the range of 10.70-50.65 mg/g. Again, in the literature, Peker (2012) determined that the total phenolic compound amounts in the fruit yoghurt prepared from olive leaf extracts were in the range of 0.85-1.14 mg/g (Peker, 2012); Aouidi et al (2011) that the phenolic compound amount in olive leaves exposed to gamma irradiations was 50.11 mg/g (Aouidi et al., 2011); and Ahmad-Qasem et al (2013) that the total phenolic amounts of olive leaves were in the range of 21.6-43.4 mg/g (Ahmad-Qasem et al., 2013). In this study, the amount of phenolic compound was determined in the range of 12.16 - 33.3 mg/g. It can be said that the drying method, especially microwave method and gamma irradiation dosages are very effective because our results are higher than the results in the literature.

Antioxidant capacity of olive leaves

The antioxidant capacities of Ayvalık and Gemlik olive leaves were performed in terms of radical scavenging ability according to the DPPH method. DPPH is a common abbreviation for an organic chemical compound 2,2-diphenyl-1-picrylhydrazyl. From Table 3, it can be said that the antioxidant capacities of both olive leaf extracts are higher in the samples dried by microwave method. The antioxidant capacities of Ayvalık and Gemlik olive leaves were 92.76 and 93.42%, respectively. It can be stated that the antioxidant capacities of the leaves of both varieties are quite close to each other. In this study, when the correlation between the total antioxidant capacity of the olive leaves without gamma irradiations and the total antioxidant capacity of the olive leaves exposed to the gamma irradiations was studied, it was determined as $p < 0.05$. It was also found that the antioxidant capacities of the samples exposed to different dosage gamma irradiations increased. However, with the increase in the dosage amounts, there was no more increase in the antioxidant capacity.

In the literature, Brahmi et al (2012) determined the antioxidant capacity of fresh olive leaves as 49.94-55.5% (Brahmi et al., 2012); Bubonja-Sonjeet et al (2011) the antioxidant capacity of olive oil as 69.66% (Bubonja-Sonje et al., 2011); Malheiro et al (2013) the antioxidant capacity of frozen olive leaves as 76.3% (Malheiroa et al., 2013); and Saygın (2009) the antioxidant capacity of frozen olive leaves as 73.86-91.38% (Saygın, 2009). In this study, it was found that the antioxidant capacities of olive leaves exposed to gamma irradiations were in the range of 93.83-95.56%. Considering the literature data above, it was observed that the antioxidant capacity was higher in the samples exposed to gamma irradiation. Lee et al (2012) stated that antioxidant capacity of *Aleo vera* plant exposed to gamma irradiations increased. Again, Lee et al (2012) determined that the antioxidant capacity of *Beta vulgaris* plant exposed to 20 kGy gamma irradiations also increased (Lee et al., 2012). In a study by Khattak and Simpson (2008) with Nigella (*Nigella sativa*), it was found that gamma irradiations applied up to 16 kGy dose increased both antioxidant capacity and phenolic compound amount (Kahattak and Simpson, 2008). When these results compare with the literature, it can be said that the experimental data shows a good agreement with the literature. Khattak and Simpson (2008) investigated the antioxidant capacities of *Nigella sativa* extractions exposed to gamma irradiations. It was reported that gamma irradiations applied to methanolic extracts increased the antioxidant capacity, due to the degradation of

some high molecular weight components and the shift of these components from the insoluble form in solvents to the soluable form (Kahattak and Simpson, 2008).

CONCLUSIONS

In this study, the total phenolic and flavanoid amounts, phenolic contents and antioxidant capacities of the methanol extracts of Ayvalık and Gemlik olive leaves, which were dried with different methods such as microwave, ambient conditions, convectional and infrared and then exposed to 3, 5 and 10 kGy/min gamma irradiaitons were examined by HPLC and spectrophotometric methods. In general, phenolic, flavanoid and antioxidant contents of olive leaves dried with microwave method were higher than other methods. Gamma irradiations were observed to show different effects. The highest phenolic, flavanoid and antioxidant content was obtained for Gemlik, Ayvalık and Gemlik olive leaves, respectively, exposed to 3 kGy/min gamma irradiation dosage and dried by microwave method. It was determined that the gamma irradiations increased the oleuropein amount of olive leaves, the most abundant phenolic compound in olive leaves was oleuropein, followed by luteloin 7-glucoside, and the least abundant phenolic compound was gallic acid. As a result, it can be said that the drying method and gamma irradiaitons are effective in activating the phenolic compounds in the structure of the leaves.

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Table 1: Phenolic compound contents of Ayvalık olive leaves dried with different methods (mg/g).

Gamma dosages	Drying processes	Gallic acid	Caffeic acid	Luteolin 7-glucoside	Rutin hydrate	Tyrosol	Vanilic acid	Oleuropein
	Infrared	0.33	3.72	14.08	5.40	5.88	…	19.59
Dried	Ambient	0.32	5.16	11.88	7.08	8.88	…	19.99
	Microwave	0.41	5.40	16.56	4.44	9.12	…	19.29
	Convectional	0.17	3.48	11.40	5.41	6.72	…	16.06
	Infrared	0.33	1.65	26.59	8.13	4.56	…	15,21
3 kGy	Ambient	0.32	3.02	39.15	11.55	5.52	4.81	11.73
	Microwave	0.37	3.05	41.42	9.15	8.39	4.80	33.43
	Convectional	0.18	2.43	34.01	8.85	5.64	6.01	11.12
	Infrared	0.37	2.85	49.24	13.52	3.72	2.83	17.72
5 kGy	Ambient	0.23	1.82	37.65	11.55	6.24	6.45	36.13
	Microwave	0.38	4.05	57.01	16.95	4.68	2.85	47.90
	Convectional	0.23	1.95	27.72	6.75	5.04	2.12	18.61
	Infrared	0.33	2.69	33.87	25.15	6.96	…	16.53
10 kGy	Ambient	0.23	2.73	33.41	13.78	6.24	…	32.39
	Microwave	0.31	4.35	45.18	16.95	11.04	…	36.95
	Convectional	0.23	3.03	34.74	16.49	6.96	…	16.62

Table 2: Phenolic compound contents of Gemlik olive leaves dried with different methods (mg/g).

Gamma dosages	Drying processes	Gallic acid	Caffeic acid	Luteolin 7-glucoside	Rutin hydrate	Tyrosol	Vanilic acid	Oleuropein
	Infrared	0.31	4.32	12.76	6.12	5.40	…	10.83
Dried	Ambient	0.34	4.20	11.98	7.92	5.88	…	9.56
	Microwave	0.41	4.92	10.02	7.08	8.76	…	10.34
	Convectional	0.23	3.84	12.04	6.84	5.52	…	10.62
	Infrared	0.32	1.29	17.48	4.95	3.72	5.01	10.25
3 kGy	Ambient	0.34	2.73	42.53	17.10	5.39	5.13	25.62
	Microwave	0.53	1.84	26.17	11.25	6.12	5.72	22.14
	Convectional	0.23	1.87	20.15	10.05	4.08	6.04	7.66
	Infrared	0.31	1.65	32.08	4.65	3.84	4.85	10.14
5 kGy	Ambient	0.34	2.39	40.91	9.63	6.84	2.41	29.41
	Microwave	0.38	2.71	49.73	10.33	8.64	1.53	35.26
	Convectional	0.23	1.95	29.45	10.05	4.56	2.55	11.53
	Infrared	0.31	3.15	31.78	9.90	5.16	…	10.14
10 kGy	Ambient	0.23	3.19	34.49	18.04	6.36	…	22.43
	Microwave	0.38	3.18	36.25	9.63	3.96	…	6.26
	Convectional	0.23	1.95	27.16	19.54	4.81	…	6.98

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Table3: Total phenolic and flavonoid contents and antioxidant capacities of Ayvalık and Gemlik olive leaves

		Dry process	Total phenolic	Flavonoid content	Antioxidant capacity			Dry process	Total phenolic	Flavonoid content	Antioxidant capacity
Ayvalık	Dried	Infrared	11.47	23.51	82.76	Gemlik	Dried	Infrared	10.90	21.90	92.76
		Ambient	14.38	25.36	90.36			Ambient	13.49	15.65	92.95
		Microwave	17.14	20.51	92.76			Microwave	17.04	25.62	93.42
		Convectional	11.15	25,56	88.48			Conventional	11.07	16.61	89.76
	3 kGy	Infrared	17.08	21.90	94.83		3 kGy	Infrared	12.00	21.65	93.68
		Ambient	34.65	22.58	94.91			Ambient	31.65	22.28	93.77
		Microwave	41.41	23.19	95.36			Microwave	36.47	23.85	95.57
		Convectional	17.65	18.89	95.09			Conventional	15.98	17.90	94.68
	5 kGy	Infrared	13.20	21.10	94.98		5 kGy	Infrared	13.77	22.91	94.99
		Ambient	38.17	22.83	94.84			Ambient	34.71	23.79	95.39
		Microwave	48.18	24.65	95.15			Microwave	48.53	23.77	95.53
		Convectional	18.40	19.39	95.41			Conventional	18.25	18.89	94.91
	10 kGy	Infrared	15.81	21.36	94.34		10 kGy	Infrared	10.70	23.73	94.88
		Ambient	35.51	21.94	94.84			Ambient	43.79	20.29	94.55
		Microwave	50.65	23.27	94.81			Microwave	29.91	12.16	95.58
		Convectional	18.74	17.96	95.45			Conventional	17.52	17.55	95.41