LIMNOFISH-Journal of Limnology and Freshwater Fisheries Research 10(2): 109-125 (2024)

Journal of Limnology and Freshwater Fisheries Research

http://www.limnofish.org

Effect of low-dose irradiation on lipid quality and fatty acid composition in vacuum-packed hot smoked trout (*Oncorhynchus mykiss*) fillets during cold storage

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ABSTRACT

The effects of gamma irradiation at different doses (0, 3 and 5 kGy) on lipid quality and fatty acid composition in vacuum-packed hot smoked rainbow trout (*Oncorhynchus mykiss*) fillets during cold storage (2 °C) were investigated. The major fatty acids were identified as palmitic, oleic, linoleic and docosahexaenoic acids (DHA). The fatty acid compositions were not affected by the irradiation process initially. However, the increase on the total saturated fatty acids (SFA) of irradiated fillets was higher than the control group at the end of the storage. While a significant decrease was observed in the control group of total polyunsaturated fatty acids (PUFA), no change was observed in the groups irradiated with 3 and 5 kGy doses at the end of the storage. The TBA values of 0, 3 and 5 kGy irradiated groups were 1.27, 1.46 and 1.58 mg MA / kg, respectively, the PV values were 6.12, 9.18 and 9.97 meq / kg and the FFA values were 5.36%, 5.67% and 6.10%, respectively, at the end of the storage. Using a combination of techniques to various processed or fresh seafood products will likely play a significant role in enhancing the manufacture of safe meals with extended shelf lives.

Keywords: Irradiation, hot smoked, *Oncorhynchus mykiss*, fatty acids, lipid quality

ARTICLE INFO

RESEARCH ARTICLE

Received : 27.06.2024

Revised : 08.07.2024

Accepted : 08.07.2024

Published : 25.08.2024

DOI: 10.17216/LimnoFish.1505799

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Düşük Doz Işınlamanın, Soğukta Muhafaza Sırasında Vakumla Paketlenmiş Sıcak Tütsülenmiş Alabalık (*Oncorhynchus mykiss*) Filetolarında Lipit Kalitesi ve Yağ Asidi Bileşimi Üzerine Etkisi

Öz: : Farklı dozlarda (0, 3 ve 5 kGy) gama ışınlamasının, soğukta (2 °C) depolanan vakum paketli sıcak tütsülenmiş gökkuşağı alabalığı (*Oncorhynchus mykiss*) filetolarında lipit kalitesi ve yağ asidi bileşimi üzerine etkileri araştırılmıştır. Başlıca yağ asitleri palmitik, oleik, linoleik ve dokosaheksaenoik asitler (DHA) olarak tanımlanmıştır. Yağ asidi bileşimleri başlangıçta ışınlama işleminden etkilenmemiştir. Ancak depolama sonunda ışınlanmış filetoların toplam doymuş yağ asitleri (SFA) artışı kontrol grubuna göre daha yüksek olduğu tespit edilmiştir. Depolama sonunda toplam çoklu doymamış yağ asitleri (PUFA) miktarında kontrol grubunda önemli bir azalma gözlenirken, 3 ve 5 kGy dozları ile ışınlanan gruplarda herhangi bir değişiklik gözlenmemiştir. Depolama sonunda 0, 3 ve 5 kGy ışınlanan grupların TBA değerleri sırasıyla 1,27, 1,46 ve 1,58 mg MA/kg, PV değerleri 6,12, 9,18 ve 9,97 meq/kg, FFA değerleri ise %5,36, %5,67 ve %6,10 olarak belirlendi. Çeşitli işlenmiş veya taze su ürünlerine yönelik tekniklerin bir kombinasyonunun kullanılması, uzun raf ömrüne sahip güvenli yiyeceklerin üretiminin arttırılmasında muhtemelen önemli bir rol oynayacaktır.

Anahtar kelimeler: Işınlama, sıcak tütsüleme, *Oncorhynchus mykiss*, yağ asitleri, lipit kalitesi

How to Cite

Özkütük AS, Özyurt G, Özoğul Y. 2024. Effect of low-dose irradiation on lipid quality and fatty acid composition in vacuum-packed hot smoked trout (*Oncorhynchus mykiss*) fillets during cold storage. LimnoFish. 10(2): 109-125. doi: 10.17216/LimnoFish.1505799

Introduction

The great increase in foodborne poisoning and infections in recent years has revealed the need for investments in this area. Changes in consumer lifestyles and the demand for ready-made food, especially in developed and developing countries, have accelerated research on food processing and preservation methods. If appropriate additives are not added to ready-made foods, especially ready-to-use meat products, their shelf life is limited. Since meat and seafood products create an ideal environment for microorganisms, pathogenic organisms that may occur in these products pose a great risk to human health. Due to the recent trend towards foods that do

not contain food additives and the frequent problems in cold chain applications, the desired shelf life cannot be achieved in the final products and microbial risks are observed.

Consumers' preference for fresh products and their unwillingness to eat products with additives or frozen and thawed products has led producers to adopt methods that ensure food safety with minimal changes to the product. Since there is no significant temperature increase in the product during the "irradiation application" of foods, this method is called "cold sterilization". Irradiation causes minimal changes in the appearance of the food and can preserve the nutritional properties of the food better than other food processing methods. No chemical residue formation is observed in the environment with irradiation. For this reason, it enables the reduction of the use of additives used in foods today or the processing of foods of very different sizes and shapes (Yagiz 2008).

Food irradiation, in its simplest definition, is the treatment of any food substance with a certain type of energy. In this application, the food item in a package or box is exposed to ionizing radiation for a certain period. In this process, no matter how long the food is exposed to radiation or how much of the dose used is absorbed, the normal radioactivity in the food's own structure does not increase (ICGFI 1999). It has been proven that irradiated foods are safe for health and do not have any effects on humans (Tauxe 2001). The safety of food irradiation has been confirmed by the studies of many organizations such as USDA, FDA, FSIS, IAEA, FAO and WHO, and its effect on maintaining food quality safety has been demonstrated.

Smoked trout exports in Türkiye are just over 4000 tons according to TUİK (2021) data. The application of gamma irradiation to increase the export of healthy and reliable products with a longer shelf life without changing the taste of the smoked product brings to mind the idea that these products can create an attractive product class in the foreign market. Therefore, in this study, the combined effect of low doses (0, 3 and 5 kGy) irradiation with methods used in food preservation such as smoking and vacuum packaging on the shelf life of trout fillets was focused. For this aim, the effects of low-dose irradiation on lipid stability (TBA, FFA and PV) and fatty acid compositions in vacuum-packed hot smoked trout (*Oncorhynchus mykiss*) fillets during cold storage (2 °C) were investigated.

Materials and Methods

Fish Samples

Preparation, packaging and storage

The trout samples (*Oncorhynchus mykiss*) were obtained from a local processing company (Sasu A.Ş., Adana, Türkiye). The mean weight of the fish was 238.78±21.00 g. After gutting, beheading and skinning, the fish was filleted for the smoking process. The fillets were then kept waiting in a brine solution of 8-9 % salt for 12 hours and smoked at 60-70 °C in a smoking oven. After smoking, samples were divided into 150 g of fillets, wrapped in polyethylene bags and sealed under a vacuum (Özkütük 2002).

Irradiation Process

Packed samples were placed in styrofoam boxes (50x30x35 cm) surrounded with cooling cartridges and transported to the Sarayköy Nuclear Research and Training Center (SANAEM, Ankara) within 24 hours under cold conditions (0-2 °C). Control group samples were transported under the same conditions but were not subjected to irradiation. The fillets were irradiated with doses of 3 and 5 kGy using ^{60}Co source irradiator (PX-g-30 Issodovateji, dose rate 2.72 kGy/h and power 316,000 curries). Absorbance rate was measured by dosimeters (3042 Harwell Amber acrylic, polymethyl methacrylate, PMMA) stuck to the surfaces of the boxes. The absorbance rates measured for 3 kGy were 3.10, 3.08 and 3.52 and for 5 kGy, 5.17, 5.27 and 5.24 (Etyemez 2011). All groups were returned to seafood processing laboratory at University of Cukurova, Faculty of Fisheries, without breaking the cold chain.

Sampling

Samples stored in cold storage (2 °C) were analyzed on storage weeks 0, 2, 4, 6, 8, 11, 14, 17, 20 and 23. On each analysis day, three randomly chosen packages from all groups were evaluated chemically.

Analytical Methods

Thiobarbituric acid (TBA) value was determined according to Tarladgis et al. (1960) by using a spectrometer (Perkin Elmer Lambda 25 UV/VIS Spectrometer). The samples were analyzed in triplicates for each treatment group. 10 mg homogenized samples weighed out and 97.5 mL of distilled water and 2.5 mL of 1:2 HCl were added on to the samples. The mixture was distilled until 200 mL of distillates were gathered by using a distillation unit (Buchi Distillation Unit B-324). The distillates and TBA reactive were added in capped tubes in equal measures of 5 mL in duplicates and boiled in water for 35 minutes until the solution turned to a reddish color. After cooling at room temperature, the solutions were measured by using a spectrometer under 538 nm wavelength. The results were expressed as values of mg malonaldehyde in 1000 g of samples.

Peroxide value (PV) was determined according to AOCS 1994 method Cd8-53. The samples were

analyzed in triplicates for each treatment group. 50 mL of acetic acid: chloroform (60:40) solution was added and the samples were shaken until the lipid was dissolved. After adding 1 mL of satiated potassium iodide and shaking the solutions for 20 seconds, the solutions were kept waiting for 30 minutes in an enclosed dark closet. The samples were titrated with 0.002 M sodium thiosulphate until an opaque solution was observed, after adding 100 mL of distilled water and 4-5 drops of 1% starch solution. Calculations for PV content were carried out as follows:

$$Peroxide\ Value\ = \frac{2(C-B)}{W}\ \text{meq O2/kg}$$

C: Spent 0.002 M sodium thiosulphate (mL)

B: Spent 0.002 M sodium thiosulphate for null (mL)

W: Sample weight

Free fatty acid (FFA) analysis was determined according to AOCS 1994 method Ca 5a-40. The samples were analyzed in triplicates for each treatment group. Initially, 0.5 g of lipid samples were dissolved in 50 mL of diethylether:ethanol (50:50). After that 1 mL of 1 % phenolphthalein indicator was added to the samples. The aliquots were titrated under 0.1 M sodium hydroxide until a pinkish color was obtained (at least 15 seconds). % of free fatty acids in oleic acid were calculated as follows:

$$\%\ Free\ fatty\ acids = \frac{(C-B)\times 2.805}{W}$$

C: Spent 0.1 M sodium hydroxide (mL)

B: Spent 0.1 M sodium hydroxide for null (mL)

W: Sample weight

2.805: Conversion factor

Lipid samples (extracted by the method of Bligh and Dyer 1959) were converted to their fatty acid methyl esters as described by Ichihara et al. (1996). Transmethylation was carried out by 20 mg of extracted lipid sample (in duplicate) dissolved in 4 mL of *n*-heptane and mixed with 4 mL of 2 M KOH in methanol. The mixture was vortexed for 10 s and then centrifuged for 10 min at 4000 rpm. After the process *n*-heptane layer was taken for GC analyses. The fatty acid composition was analyzed by using a Clarus 500 gas chromatography with an autosampler (Perkin Elmer, Shelton, Conn., U.S.A.) equipped with a flame ionization detector and a fused silica capillary SGE column (30 m × 0.32 mm ID × 0.25 m BP20 0.25 UM; SGE Analytical Science Pty. Ltd., Victoria, Australia). Initially, the oven temperature was held at 140 °C for 5 min. After that, the temperature was increased to 200 °C at a rate of 4 °C/min and then to 220 °C at a rate of 1 °C/min. The injector temperature was set at 220 °C and the detector temperature was at 280 °C. The carrier gas was controlled at 16 ps. The split used was 1 : 100. Fatty acids were identified by comparing the retention times of fatty acid methyl esters (FAMEs) with the Standard 37-component FAME mixture (Sigma-Aldrich Chemie Gmbh, Munich, Germany). Two replicate analyses were performed and the results were expressed as gas chromatographic area (%, mean ± standard deviation).

Statistical Analysis

Statistical analyses were performed using SPSS 14. The mean values and standard deviations were calculated from data obtained from the samples for each irradiation dose and storage time treatments. Data were subjected to analysis of variance (one-way ANOVA), Duncan's multiple range test and t-test at 5% confidence level.

Results

The fatty acid composition of smoked rainbow trout fillets irradiated at different doses (0, 3 and 5 kGy) is shown in Tables 1, 2 and 3. It was determined that the essential fatty acids of control and irradiated (3 and 5 kGy) smoked rainbow trout fillets were palmitic acid (C16:0), oleic acid (C18:1ω9), linoleic acid (C18:2ω6) and docosahexaenoic acid (DHA, C22: 6ω3). Similar results for rainbow trout were reported by Haliloğlu et al. (2004), Oraei et al. (2011) and Yıldız et al. (2006).

Initially, fatty acid values of control, irradiated at 3 and 5 kGy doses generally showed no statistically significant differences ($p>0.05$). Fluctuations in fatty acid values in all groups were observed during cold storage. The main saturated fatty acids (SFA) were palmitic acid (C16:0), myristic acid (C14:0) and stearic acid (C18:0) (Table 1). Palmitic acid was observed to be significantly ($p<0.05$) higher in the group irradiated with a dose of 5 kGy throughout the storage period than in the other groups. While the palmitic acid values of the control group were higher than the 3 kGy group at the beginning of storage, it was observed that the palmitic acid contents of the 3 kGy group were higher towards the end of storage. Similarly, it was observed that stearic acid rates were significantly ($p<0.05$) higher in the 5 kGy group throughout the storage than in the other groups. In addition, it was observed that the stearic acid values of the 3 kGy groups were generally higher than the control group during storage period. At the end of the

storage period, no significant change was observed in the myristic acid values of the control, 3 and 5 kGy dose irradiated groups ($p>0.05$). It was determined that the myristic acid values of the 5 kGy group were significantly higher than the group irradiated with a dose of 3 kGy in the 23rd week of storage ($p<0.05$). While no change was observed in palmitic acid values at the end of storage in the control group ($p>0.05$), a significant increase was observed in the irradiated groups (3 and 5 kGy) ($p<0.05$). Therefore, it can be concluded that there was an increase in total saturated fatty acid values in parallel with the increase in the irradiation dose applied during storage.

Table 1. Saturated fatty acids (SFA) changes during cold storage of non-irradiated (0 kGy), 3 kGy and 5 kGy irradiated smoked trout fillets

		Storage Period (Weeks)									
Fatty Acids		Day 0	2	4	6	8	11	14	17	20	23
C12	0	-	0.68 (0.01)^{dB}	-	0.34 (0.00)^{b} B		0.17 (0.07)^{aA}	0.43 (0.06)^{bc} A	0.49 (0.01)^{cA}	0.47 (0.01)^{cB}	-
	3	-	0.53 (0.01)^{eA} B	-	0.23 (0.01)^{ab} A	-	0.14 (0.08)^{aA}	0.28 (0.04)^{bc} A	0.44 (0.03)^{deA}	0.35 (0.01)^{bc} dA	-
	5	0.42 (0.01)^{d} A	0.38 (0.06)^{ab} cA	-	0.27 (0.03)^{a} A	0.39 (0.05)^{ab} cA	0.27 (0.12)^{aA}	0.42 (0.05)^{ab} cA	0.43 (0.01)^{bcA}	0.35 (0.06)^{ab} A	0.51 (0.06)^{c} A
C14	0	2.50 (0.23)^{ab} cA	2.20 (0.01)^{aA}	2.66 (0.10)^{bcd} B	2.41 (0.04)^{ab} A	2.21 (0.02)^{aA}	2.24 (0.10)^{aA} B	2.72 (0.04)^{cd} A	2.81 (0.06)^{dB}	2.72 (0.25)^{cd} A	-
	3	2.58 (0.04)^{ab} A	2.35 (0.05)^{aA}	2.27 (0.06)^{aA}	2.30 (0.09)^{a} A	2.35 (0.06)^{aA}	2.73 (0.30)^{bc} B	2.90 (0.07)^{cA}	2.38 (0.19)^{abA}	2.41 (0.06)^{ab} A	2.48 (0.04)^{ab} A
	5	2.99 (0.15)^{de} A	2.44 (0.09)^{bc} B	2.45 (0.01)^{bcA} B	2.40 (0.01)^{bc} A	2.35 (0.09)^{b} A	2.08 (0.11)^{aA}	3,14 (0.06)^{eB}	2.49 (0.01)^{bcA} B	2.59 (0.06)^{cA}	2.85 (0.13)^{d} B
C16	0	12.83 (1.00)^{bc} dA	12.50 (0.01)^{bc} B	12.26 (0.38)^{bcA}	12.46 (0.13)^{bc} B	11.46 (0.08)^{aA}	12.45 (0.23)^{bc} A	12.53 (0.09)^{bc} A	13.30 (0.40)^{cdA}	13.74 (0.05)^{d} A	-
	3	12.06 (0.27)^{ab} A	11.95 (0.13)^{ab} A	11.78 (0.18)^{aA}	11.64 (0.06)^{a} A	12.89 (0.43)^{bc} B	13.03 (1.29)^{bc} dA	13.16 (0.20)^{cd} AB	14.03 (0.25)^{dA}	13.88 (0.00)^{cd} A	13.17 (0.01)^{cd} A
	5	12.43 (0.57)^{aA}	12.64 (0.04)^{aB}	12.42 (0.06)^{aA}	12.69 (0.03)^{aB}	13.50 (0.12)^{bB}	12.67 (0.05)^{aA}	13.73 (0.31)^{bc} B	14.94 (0.07)^{eB}	14.43 (0.18)^{de} B	14.07 (0.30)^{cd} B
C17	0	0.10 (0.01)^{b} A	0.09 (0.00)^{b}	0.10 (0.01)^{bB}	0.09 (0.00)^{b}	0.06 (0.03)^{aA}	0.08 (0.00)^{ab} A	0.09 (0.01)^{bA}	0.09 (0.01)^{abA}	0.09 (0.01)^{ab} A	-
	3	0.10 (0.01)^{bc} A	0.09 (0.00)^{ab} cA	0.08 (0.00)^{aA}	0.09 (0.00)^{ab} cA	0.09 (0.01)^{ab} A	0.10 (0.01)^{bc} A	0.10 (0.00)^{cA}	0.09 (0.01)^{abA}	0.09 (0.06)^{ab} cA	0.09 (0.00)^{ab} cA
	5	0.09 (0.00)^{aA}	0.09 (0.00)^{aA}	0.09 (0.00)^{aA} B	0.09 (0.00)^{a} A	0.08 (0.00)^{aA}	0.10 (0.09)^{aA}	0.10 (0.01)^{aA}	0.08 (0.00)^{aA}	0.12 (0.00)^{aA}	0.12 (0.00)^{a} A
C18	0	3.27 (0.51)^{aA}	3.96 (0.01)^{cB}	3.34 (0.34)^{abA}	3.78 (0.01)^{ab} cB	3.55 (0.06)^{ab} cA	3.74 (0.14)^{ab} cA	3.77 (0.12)^{ab} cA	3.73 (0.05)^{abc} A	3.88 (0.11)^{bc} A	
	3	4.09 (0.06)^{cA}	3.89 (0.08)^{bc} AB	3.51 (0.15)^{abA}	3.41 (0.10)^{a} A	3.82 (0.37)^{ab} cA	3.46 (0.34)^{ab} A	3.91 (0.07)^{cA} B	4.10 (0.19)^{cA} B	4.08 (0.08)^{cA}	4.12 (0.20)^{c} A
	5	4.10 (0.11)^{ab} A	3.76 (0.01)^{aA}	3.74 (0.06)^{aA}	3.88 (0.09)^{aB}	4.09 (0.36)^{ab} A	3.81 (0.45)^{aA}	4.21 (0.06)^{ab} cB	4.38 (0.21)^{bcB}	4.63 (0.11)^{cB}	4.38 (0.28)^{bc} B

C20	0	0.12 (0.01)^{ab} A	0.11 (0.01)^{ab} A	0.11 (0.01)^{abA}	0.12 (0.00)^{ab} A	0.11 (0.00)^{ab} A	0.12 (0.00)^{ab} A	0.10 (0.01)^{aA}	0.13 (0.02)^{bA}	0.10 (0.00)^{aA}	-
	3	0.11 (0.00)^{ab} A	0.10 (0.03)^{aA}	0.10 (0.00)^{aA}	0.13 (0.00)^{ab} cA	0.12 (0.01)^{ab} A	0.14 (0.01)^{bc} A	0.15 (0.00)^{cB}	0.11 (0.03)^{abA}	0.11 (0.00)^{ab} A	0.15 (0.00)^{c} A
	5	0.12 (0.01)^{ab} A	0.13 (0.03)^{ab} A	0.12 (0.01)^{abA}	0.13 (0.01)^{ab} A	0.11 (0.01)^{aA}	0.15 (0.01)^{bc} A	0.11 (0.01)^{aA}	0.12 (0.01)^{abA}	0.10 (0.01)^{aA}	0.17 (0.01)^{cB}
C23	0	0.05 (0.01)^{ab} A	0.04 (0.00)^{aA}	0.07 (0.01)^{cB}	0.05 (0.00)^{ab} A	0.06 (0.00)^{bc} A	0.06 (0.00)^{bc} A	0.05 (0.00)^{ab} A	0.06 (0.01)^{bcA}	0.05 (0.00)^{ab} A	
	3	0.06 (0.00)^{ab} A	0.06 (0.00)^{ab} B	0.06 (0.00)^{abA} B	0.07 (0.01)^{b} B	0.06 (0.01)^{ab} A	0.06 (0.01)^{ab} A	0.05 (0.00)^{aA}	0.07 (0.01)^{bA}	0.07 (0.01)^{bB}	0.06 (0.00)^{ab} A
	5	0.06 (0.01)^{ab} A	0.08 (0.01)^{cC}	0.05 (0.00)^{aA}	0.06 (0.00)^{b} AB	0.05 (0.00)^{aA}	0.05 (0.00)^{aA}	0.08 (0.00)^{cB}	0.05 (0.00)^{aA}	0.05 (0.00)^{aA}	0.05 (0.00)^{a} A
C24	0	0.62 (0.09)^{bc} A	0.59 (0.00)^{ab} A	0.71 (0.01)^{dB}	0.55 (0.01)^{ab} A	0.59 (0.04)^{ab} cA	0.72 (0.02)^{d} A	0.56 (0.00)^{ab} A	0.65 (0.01)^{cdA}	0.52 (0.01)^{aA}	-
	3	0.62 (0.01)^{ab} A	0.69 (0.01)^{bc} C	0.60 (0.04)^{aA}	0.59 (0.01)^{aB}	0.62 (0.08)^{ab} A	0.73 (0.05)^{cA}	0.63 (0.03)^{ab} A	0.68 (0.06)^{abc} AB	0.60 (0.00)^{ab} B	0.96 (0.01)^{d} A
	5	0.75 (0.06)^{cd} eA	0.63 (0.01)^{ab} B	0.66 (0.02)^{abc} AB	0.58 (0.00)^{a} AB	0.70 (0.05)^{bc} dA	0.89 (0.05)^{fB}	0.81 (0.08)^{ef} B	0.77 (0.01)^{deB}	0.61 (0.01)^{ab} B	1.02 (0.01)^{g} B
ΣSFA	0	19.48 (0.82)^{bc} A	20.14 (0.06)^{cA}	19.24 (0.15)^{bB}	19.79 (0.18)^{bc} B	18.03 (0.06)^{aA}	19.58 (0.23)^{bc} A	20.25 (0.06)^{cA}	21.24 (0.36)^{dA}	21.54 (0.40)^{d} A	-
	3	19.99 (0.18)^{bc} A	19.64 (0.32)^{ab} A	18.39 (0.30)^{aA}	18.45 (0.03)^{a} A	19.93 (0.82)^{bc} B	20.37 (1.41)^{bc} dA	21.25 (0.05)^{cd} eB	21.88 (0.38)^{eA}	21.59 (0.09)^{de} A	21.02 (0.16)^{cd} eA
	5	21.25 (0.56)^{b} A	20.14 (0.01)^{aA}	19.52 (0.16)^{aB}	20.10 (0.11)^{aB}	21.25 (0.06)^{bB}	20.00 (0.54)^{aA}	22.57 (0.34)^{cC}	23.25 (0.31)^{cB}	22.85 (0.16)^{cB}	23.16 (0.67)^{cB}

(table continues)

[*] The values are expressed as mean ± standard deviation, n=3.

[a-e] Values in a same row followed by different letters indicate significant differences (P<0.05) during storage periods.

[A-C] Values in a same column followed by different letters indicate significant differences (P<0.05) of the parameter with respect to the irradiation treatment

It was found that the dominant fatty acids among monounsaturated fatty acids (MUFA) were oleic acid (18:1ω9), palmitoleic acid (C16:1) and vasenic acid (C18:1ω7) (Table 2). At the beginning of storage, palmitoleic acid, oleic acid and vasenic acid values, which were 3.35%, 21.27% and 2.76%, respectively, in the control group, were determined as 3.13%, 25.23% and 2.61%, respectively, in the irradiated group at a dose of 5 kGy. While palmitoleic and oleic acid values were detected as 3.43% and 24.51%, respectively, in the 3 kGy dose irradiated group, vasenic acid could not be detected. The differences observed in palmitoleic and oleic acid values because of irradiation treatment were not found to be statistically significant (p>0.05). The values of all fatty acids in MUFA fluctuated during storage (Table 2).

Table 2. Mono unsaturated fatty acids (MUFA) changes during cold storage of non-irradiated (0 kGy), 3 kGy and 5 kGy irradiated smoked trout fillets

		Storage Period (Weeks)									
Fatty Acids		Day 0	2	4	6	8	11	14	17	20	23
C14:1	0	0.04 (0.00)^{ab} A	0.01 (0.00)^{a} A	0.06 (0.03)^{b} A	0.02 (0.01)^{ab} A	0.05 (0.03)^{ab} A	0.05 (0.03)^{ab} A	0.01 (0.00)^{a} A	0.04 (0.00)^{ab} A	0.04 (0.00)^{ab} A	-
	3	0.04 (0.00)^{aA}	0.04 (0.00)^{a} B	0.04 (0.01)^{a} A	0.06 (0.02)^{aA}	0.06 (0.02)^{a} A	0.07 (0.04)^{a} B	0.05 (0.01)^{a} B	0.04 (0.01)^{aA}	0.04 (0.00)^{aA}	0.03 (0.00)^{a} A
	5	0.04 (0.00)^{abc} A	0.08 (0.01)^{d} C	0.03 (0.02)^{a} A	0.04 (0.01)^{ab} A	0.07 (0.01)^{cd} A	-	0.04 (0.00)^{ab} cB	0.06 (0.02)^{bc} dA	0.04 (0.00)^{abc} A	0.04 (0.01)^{ab} A
C15:1	0	0.03 (0.00)^{ab} A	0.03 (0.00)^{ab} A	0.17 (0.02)^{c} A	0.04 (0.01)^{ab} A	0.07 (0.06)^{b} A	0.02 (0.00)^{ab} A	0.03 (0.01)^{ab} A	0.01 (0.00)^{aA}	0.03 (0.01)^{ab} A	-
	3	-	0.05 (0.02)^{a} A	0.20 (0.08)^{b} A	0.03 (0.03)^{aA}	0.06 (0.01)^{a} A	0.02 (0.01)^{a} A	0.03 (0.01)^{a} A	-	-	-
	5	0.04 (0.00)^{bc} A	0.01 (0.00)^{a} A	0.11 (0.03)^{e} A	0.06 (0.00)^{cd} A	0.08 (0.02)^{d} A	0.04 (0.00)^{bc} B	0.02 (0.00)^{ab} A	-	0.02 (0.00)^{ab} A	0.01 (0.00)^{a} A
C16:1	0	3.35 (0.30)^{aA}	2.89 (0.01)^{a} A	3.29 (0.13)^{a} A	3.23 (0.03)^{aA}	3.16 (0.44)^{a} A	3.31 (0.38)^{a} A	3.24 (0.09)^{a} A	3.19 (0.19)^{aA}	2.92 (0.09)^{aA}	-
	3	3.43 (0.04)^{abc} dA	2.94 (0.06)^{a} A	3.04 (0.06)^{ab} A	3.66 (0.31)^{abc} dA	3.81 (0.50)^{bc} dA	3.91 (0.38)^{cd} A	4.26 (0.33)^{d} B	3.79 (0.77)^{abc} dA	3.58 (0.14)^{abc} dB	3.27 (0.01)^{ab} cA
	5	3.13 (0.01)^{ab} A	3.60 (0.10)^{ab} B	3.60 (0.49)^{ab} A	3.25 (0.02)^{ab} A	3.08 (0.16)^{a} A	3.22 (0.45)^{ab} A	3.76 (0.14)^{b} AB	3.45 (0.48)^{ab} A	3.40 (0.11)^{ab} B	3.37 (0.10)^{ab} B
C17:1	0	0.12 (0.01)^{abc} A	0.10 (0.01)^{a} A	0.13 (0.00)^{bc} B	0.11 (0.00)^{ab} A	0.11 (0.01)^{ab} A	0.11 (0.01)^{ab} B	0.14 (0.03)^{c} A	0.12 (0.01)^{abc} A	0.11 (0.01)^{ab} A	-
	3	0.13 (0.00)^{cA}	0.10 (0.00)^{ab} A	0.12 (0.01)^{ab} cA	0.11 (0.01)^{abc} A	0.10 (0.02)^{a} A	0.13 (0.02)^{bc} B	0.12 (0.00)^{ab} cA	0.12 (0.01)^{abc} A	0.11 (0.00)^{abc} AB	0.12 (0.00)^{ab} cA
	5	0.10 (0.03)^{bA}	0.13 (0.01)^{c} A	0.13 (0.00)^{c} B	0.11 (0.00)^{bc} A	0.11 (0.00)^{bc} A	0.06 (0.00)^{a} A	0.13 (0.01)^{c} A	0.11 (0.00)^{bc} A	0.13 (0.01)^{cB}	0.12 (0.00)^{bc} A
C18:1 ω9	0	21.27 (3.22)^{aA}	21.37 (0.01)^{a} A	20.31 (0.15)^{a} A	22.45 (0.21)^{aA}	21.37 (0.04)^{a} A	22.30 (0.28)^{a} A	22.37 (0.73)^{a} B	21.93 (0.93)^{aA}	21.81 (0.28)^{aA}	-
	3	24.51 (0.68)^{aA}	24.26 (0.69)^{a} B	21.81 (0.51)^{a} B	23.95 (0.26)^{aB}	23.66 (0.96)^{a} A	23.18 (4.75)^{a} A	20.44 (0.40)^{a} A	21.70 (4.45)^{aA}	23.53 (0.39)^{aB}	23.52 (0.01)^{a} A
	5	25.23 (1.43)^{aA}	25.11 (0.09)^{a} B	23.10 (0.52)^{a} B	23.58 (0.35)^{aB}	23.46 (1.37)^{a} A	24.67 (0.34)^{a} A	24.13 (0.26)^{a} C	23.61 (0.26)^{aA}	24.28 (0.06)^{aB}	25.11 (2.26)^{a} A
C18:1 ω7	0	2.76 (0.01)^{cd} B	2.71 (0.01)^{cd} A	2.38 (0.04)^{ab} A	2.81 (0.04)^{cd} A	2.93 (0.26)^{d} A	2.82 (0.09)^{cd} A	2.89 (0.04)^{d} B	2.59 (0.08)^{bc} A	2.14 (0.10)^{aA}	-
	3	-	2.58 (0.08)^{ab} A	2.48 (0.15)^{a} A	2.89 (0.11)^{cd} A	2.89 (0.28)^{cd} A	2.81 (0.01)^{bc} dA	2.39 (0.04)^{a} A	2.66 (0.01)^{abc} A	2.82 (0.02)^{bcd} B	3.07 (0.01)^{d} B

table continue

	5	2.61 (0.01)^{abc} A	2.61 (0.21)^{ab} cA	2.59 (0.01)^{ab} A	2.93 (0.06)^{ef} A	3.02 (0.05)^{f} A	2.82 (0.01)^{de} fA	2.46 (0.06)^{a} A	2.71 (0.06)^{bc} dA	2.88 (0.08)^{def} B	2.79 (0.06)^{cd} eA
C20:1	0	0.88 (0.06)^{dA}	0.78 (0.01)^{bc} A	0.63 (0.04)^{a} A	0.84 (0.01)^{cd} A	0.71 (0.00)^{b} A	0.83 (0.04)^{cd} A	0.82 (0.01)^{cd} A	0.80 (0.05)^{cA}	0.80 (0.01)^{cC}	-
	3	0.85 (0.01)^{bc} A	0.88 (0.03)^{c} B	0.75 (0.00)^{a} B	0.85 (0.01)^{bc} A	0.80 (0.06)^{ab} cA	0.98 (0.01)^{d} A	0.99 (0.01)^{d} B	0.86 (0.01)^{bc} A	0.77 (0.00)^{ab} B	0.80 (0.00)^{ab} cA
	5	0.81 (0.08)^{ab} A	0.77 (0.03)^{a} A	0.78 (0.02)^{a} B	0.85 (0.02)^{ab} A	0.82 (0.05)^{ab} A	0.96 (0.01)^{c} A	0.84 (0.01)^{ab} A	0.90 (0.01)^{bc} A	0.75 (0.00)^{aA}	0.83 (0.04)^{ab} A
C22:1 ω9	0	0.09 (0.01)^{abc} A	0.07 (0.00)^{a} A	0.09 (0.01)^{ab} cA	0.09 (0.00)^{bc} A	0.08 (0.00)^{ab} A	0.10 (0.01)^{c} A	0.07 (0.00)^{a} A	0.09 (0.01)^{abc} A	0.09 (0.00)^{bc} A	-
	3	0.10 (0.01)^{ab} A	0.10 (0.01)^{ab} B	0.09 (0.00)^{ab} A	0.08 (0.01)^{aA}	0.08 (0.01)^{a} A	0.11 (0.02)^{b} A	0.11 (0.00)^{b} C	0.10 (0.01)^{ab} A	0.08 (0.00)^{aA}	0.08 (0.01)^{a} A
	5	0.09 (0.00)^{ab} A	0.09 (0.00)^{ab} B	0.09 (0.00)^{ab} A	0.08 (0.01)^{aA}	0.08 (0.00)^{a} A	0.08 (0.00)^{a} A	0.10 (0.01)^{ab} B	0.11 (0.02)^{bA}	0.09 (0.01)^{aA}	0.09 (0.01)^{a} A
C24:1	0	0.04 (0.00)^{aA} B	0.08 (0.01)^{c} B	0.06 (0.01)^{b} A	-	0.04 (0.01)^{a} A	0.06 (0.01)^{b} A	-	0.04 (0.00)^{aA}	0.04 (0.00)^{aA}	-
	3	0.03 (0.00)^{aA}	0.05 (0.00)^{cd} A	0.04 (0.00)^{ab} cA	-	0.03 (0.00)^{a} A	0.05 (0.01)^{bc} d	0.05 (0.01)^{bc} dA	0.06 (0.01)^{dA}	0.04 (0.01)^{ab} A	0.04 (0.00)^{ab} cA
	5	0.05 (0.01)^{bc} B	0.04 (0.00)^{ab} A	0.05 (0.01)^{bc} A	-	0.04 (0.00)^{ab} A	-	0.05 (0.01)^{bc} A	0.06 (0.01)^{cA}	0.03 (0.00)^{aA}	0.04 (0.00)^{ab} A
ΣMUFA	0	28.56 (2.86)^{aA}	28.04 (0.07)^{a} A	27.08 (0.28)^{a} A	29.58 (0.28)^{aA}	28.65 (0.84)^{a} A	29.58 (0.11)^{a} A	29.56 (0.84)^{a} AB	28.78 (1.09)^{aA}	27.96 (0.28)^{aA}	-
	3	29.08 (0.72)^{aA}	30.99 (0.84)^{a} B	28.56 (0.52)^{a} AB	31.61 (0.21)^{aB}	31.69 (2.11)^{a} A	31.24 (4.22)^{a} A	28.42 (0.69)^{a} A	29.30 (3.59)^{aA}	30.96 (0.52)^{aB}	30.92 (0.01)^{a} A
	5	32.10 (1.46)^{aA}	32.43 (0.21)^{a} B	30.46 (1.10)^{a} B	30.88 (0.45)^{aB}	30.74 (1.65)^{a} A	31.85 (0.05)^{a} A	31.52 (0.04)^{a} B	30.99 (0.22)^{aA}	31.61 (0.01)^{aB}	32.38 (2.33)^{ab} A

* The values are expressed as mean ± standard deviation, n=3.

a-e Values in a same row followed by different letters indicate significant differences (P<0.05) during storage periods.

A-C Values in a same column followed by different letters indicate significant differences (P<0.05) of the parameter with respect to the irradiation treatment

The dominant fatty acids among polyunsaturated fatty acids (PUFA) were docosahexaenoic acid (DHA, C22:6ω3), linoleic acid (18:2ω6), linolenic acid (C18:3ω3), arachidonic acid (C20:4ω6) and eicosapentaenoic acid (EPA, C20:5ω3) (Table 3). As a result of irradiation, no statistically significant difference was observed in PUFAs except linoleic acid ($p>0.05$). Linoleic acid rate in the control group was found to be significantly higher than the irradiated groups at 3 and 5 kGy doses ($p<0.05$). The effect of irradiation on linolenic acid varied between groups during storage, but generally, no difference was observed between groups. Generally, no difference was observed in EPA values between the control and irradiated groups during the storage period (except for the 17th week). The effects of irradiation on DHA were remarkably observed and it was determined that the control group had generally higher values than the group irradiated at a dose of 5 kGy (Table 3). In this study, ω6 series fatty acids in total PUFA in rainbow trout fillets at the beginning of storage were determined as 19.12%, 17.01% and 16.20% in the control, 3 and 5 kGy dose irradiated groups,

respectively. Likewise, ω3 series fatty acids were determined as 20.77%, 18.49% and 17.97% in the control, 3 and 5 kGy dose irradiated groups, respectively. It is observed that the initial irradiation treatment was effective on the ω6 series fatty acid ratios, and the ω6 series fatty acid values of the control group were significantly higher than the group irradiated at a dose of 5 kGy ($p<0.05$). No significant effect of irradiation application was observed on the total ω6/ω3 ratios. While the lowest value of ω6/ω3 ratios was determined as 0.75 in the 2nd week in the control group, the highest value was determined as 1.03 in the 14th week in the 5 kGy dose irradiated group (Table 3).

Table 3. Polyunsaturated fatty acids (PUFA) changes during cold storage of non-irradiated (0 kGy), 3 kGy and 5 kGy irradiated smoked trout fillets

		Storage Period (Weeks)									
Fatty Acids		Day 0	2	4	6	8	11	14	17	20	23
C18:2ω6	0	14.76 (0.96)^{eB}	11.39 (0.01)^{aA}	13.81 (0.61)^{d} ^{eB}	12.64 (0.50)^{bc} ^{A}	11.38 (0.13)^{aA}	13.95 (0.26)^{de} ^{A}	11.81 (0.33)^{ab} ^{A}	13.40 (0.49)^{cd} ^{A}	13.40 (0.13)^{cd} ^{C}	-
	3	12.93 (0.16)^{ab} ^{cA}	12.55 (0.24)^{ab} ^{B}	12.39 (0.30)^{a} ^{bA}	12.91 (0.16)^{ab} ^{cA}	12.32 (0.17)^{ab} ^{AB}	13.66 (1.23)^{cA}	13.10 (0.01)^{bc} ^{B}	12.82 (1.20)^{ab} ^{cA}	13.02 (0.01)^{bc} ^{B}	11.90 (0.01)^{a} ^{B}
	5	12.44 (0.08)^{cd} ^{A}	12.02 (0.18)^{bc} ^{B}	11.19 (0.09)^{a} ^{A}	12.68 (0.50)^{cd} ^{A}	12.71 (0.49)^{dB}	12.69 (0.14)^{d} ^{A}	13.32 (0.26)^{eB}	12.45 (0.28)^{cd} ^{A}	12.46 (0.09)^{cd} ^{A}	11.54 (0.31)^{a} ^{bA}
C18:3ω6	0	0.24 (0.02)^{aA}	0.24 (0.01)^{ab} ^{A}	0.28 (0.01)^{b} ^{B}	0.24 (0.00)^{ab} ^{A}	0.25 (0.03)^{ab} ^{A}	0.26 (0.01)^{ab} ^{A}	0.26 (0.01)^{ab} ^{A}	0.26 (0.03)^{ab} ^{A}	0.27 (0.00)^{ab} ^{A}	-
	3	0.26 (0.01)^{aA}	0.25 (0.01)^{aA}	0.25 (0.00)^{a} ^{A}	0.28 (0.02)^{aA}	0.26 (0.05)^{aA}	0.29 (0.04)^{aA}	0.28 (0.03)^{aA}	0.28 0.00)^{aA}	0.28 (0.00)^{a} ^{A}	0.30 (0.00)^{a} ^{A}
	5	0.24 (0.01)^{ab} ^{A}	0.28 (0.03)^{ab} ^{A}	0.24 (0.00)^{a} ^{bA}	0.27 (0.03)^{ab} ^{A}	0.21 (0.10)^{aA}	0.31 (0.01)^{bB}	0.24 (0.00)^{ab} ^{A}	0.26 (0.03)^{ab} ^{A}	0.28 (0.04)^{ab} ^{A}	-
C18:3ω3	0	2.64 (0.18)^{cA}	2.23 (0.01)^{aA}	2.59 (0.08)^{b} ^{cB}	2.42 (0.01)^{ab} ^{A}	2.24 (0.04)^{aA}	2.45 (0.08)^{b} ^{A}	2.40 (0.06)^{ab} ^{A}	2.49 (0.08)^{bc} ^{A}	2.66 (0.03)^{c} ^{B}	-
	3	2.48 (0.04)^{aA}	2.37 (0.02)^{aB}	2.31 (0.06)^{a} ^{A}	2.45 (0.06)^{aA}	2.39 (0.09)^{aA} ^{B}	2.57 (0.28)^{aA}	2.32 (0.10)^{aA}	2.50 (0.28)^{a} ^{A}	2.48 (0.04)^{a} ^{A}	2.48 (0.00)^{a} ^{A}
	5	2.37 (0.09)^{bc} ^{A}	2.46 (0.02)^{cd} ^{C}	2.16 (0.01)^{a} ^{A}	2.41 (0.02)^{cd} ^{A}	2.46 (0.02)^{cd} ^{B}	2.18 (0.09)^{aA}	2.55 (0.09)^{d} ^{A}	2.25 (0.01)^{ab} ^{A}	2.47 (0.01)^{cd} ^{A}	2.51 (0.09)^{d} ^{A}
C20:2 cis	0	0.70 (0.08)^{b} ^{A}	0.83 (0.01)^{cC}	0.70 (0.00)^{b} ^{B}	0.69 (0.01)^{bB}	0.70 (0.03)^{bB}	0.68 (0.01)^{b} ^{A}	0.68 (0.01)^{bB}	0.63 (0.01)^{ab} ^{A}	0.60 (0.00)^{a} ^{A}	-
	3	0.59 (0.02)^{aA}	0.69 (0.01)^{cd} ^{B}	0.64 (0.01)^{a} ^{bcA}	0.60 (0.01)^{aA}	0.60 (0.01)^{aA}	0.57 (0.01)^{aA}	0.73 (0.01)^{dC}	0.67 (0.06)^{bc} ^{dA}	0.61 (0.00)^{ab} ^{A}	0.65 (0.01)^{a} ^{bcA}
	5	0.62 (0.00)^{ab} ^{cA}	0.57 (0.01)^{ab} ^{A}	0.65 (0.01)^{b} ^{cA}	0.68 (0.00)^{cB}	0.58 (0.03)^{ab} ^{A}	0.62 (0.01)^{ab} ^{cA}	0.53 (0.00)^{aA}	0.61 (0.01)^{ab} ^{cA}	0.65 (0.04)^{bc} ^{A}	0.60 (0.11)^{a} ^{bcA}
C20:3ω6	0	0.26 (0.03)^{ab} ^{A}	0.25 (0.00)^{aA}	0.29 (0.02)^{b} ^{B}	0.24 (0.00)^{aA}	0.23 (0.00)^{aA}	0.25 (0.00)^{aA}	0.26 (0.01)^{aA}	0.25 (0.01)^{a} ^{A}	0.23 (0.00)^{a} ^{AB}	-
	3	0.27 (0.01)^{bc} ^{dA}	0.27 (0.01)^{bc} ^{dA}	0.24 (0.01)^{a} ^{A}	0.25 (0.00)^{ab} ^{cA}	0.25 (0.01)^{ab} ^{cA}	0.29 (0.02)^{d} ^{A}	0.27 (0.00)^{cd} ^{A}	0.27 (0.02)^{bc} ^{dA}	0.23 (0.00)^{a} ^{A}	0.24 (0.00)^{a} ^{bA}

table continue

	5	0.26 (0.02)^{ab} A	0.25 (0.00)^{ab} A	0.23 (0.00)^{a} A	0.25 (0.01)^{ab} A	0.25 (0.01)^{ab} A	0.27 (0.01)^{b} A	0.26 (0.01)^{ab} A	0.26 (0.00)^{b} A	0.24 (0.00)^{ab} B	0.25 (0.01)^{a} bA
C20:4ω6	0	3.87 (0.33)^{b} A	3.97 (0.00)^{bB}	3.83 (0.01)^{b} A	3.67 (0.08)^{bA}	3.81 (0.12)^{b} A	3.97 (0.03)^{b} A	4.51 (0.10)^{cC}	3.63 (0.18)^{b} A	3.24 (0.04)^{a} A	-
	3	3.56 (0.03)^{b} A	3.42 (0.09)^{ab} A	3.46 (0.54)^{a} bA	3.60 (0.05)^{bA}	3.20 (0.27)^{ab} A	3.42 (0.49)^{ab} A	3.71 (0.04)^{bB}	3.57 (0.26)^{b} A	3.07 (0.08)^{ab} A	2.91 (0.08)^{a} A
	5	3.51 (0.39)^{bc} dA	3.36 (0.01)^{cd} eA	3.74 (0.11)^{e} A	3.64 (0.13)^{de} A	3.49 (0.24)^{cd} eA	3.29 (0.37)^{bc} deA	3.51 (0.04)^{bc} deA	3.13 (0.17)^{ab} cA	2.83 (0.23)^{a} A	2.86 (0.18)^{a} bA
C20:5ω3	0	2.91 (0.30)^{cd} A	2.41 (0.01)^{ab} A	2.81 (0.40)^{b} cdA	2.58 (0.03)^{ab} cA	2.48 (0.01)^{ab} cA	3.03 (0.03)^{d} A	2.73 (0.10)^{bc} dA	2.66 (0.15)^{ab} cdB	2.25 (0.01)^{a} A	-
	3	3.12 (0.11)^{cd} A	3.27 (0.16)^{dB}	2.64 (0.01)^{b} A	2.69 (0.09)^{bA}	2.77 (0.36)^{bc} A	3.18 (0.20)^{d} A	3.14 (0.01)^{cd} B	2.69 (0.13)^{b} B	2.19 (0.17)^{a} A	1.87 (0.05)^{a} A
	5	3.28 (0.51)^{d} A	3.04 (0.00)^{cd} B	2.73 (0.11)^{b} cA	2.65 (0.01)^{bc} A	3.06 (0.23)^{cd} A	3.34 (0.40)^{d} A	3.11 (0.04)^{cd} B	2.24 (0.01)^{ab} A	1.97 (0.06)^{a} A	1.96 (0.04)^{a} B
C22:2 cis	0	0.07 (0.00)^{b} A	0.06 (0.00)^{aA}	0.08 (0.01)^{b} cA	0.07 (0.00)^{bA}	0.06 (0.00)^{aA}	0.08 (0.00)^{cB}	0.06 (0.00)^{aA}	0.07 (0.00)^{b} A	0.06 (0.00)^{a} A	-
	3	0.06 (0.00)^{aA}	0.07 (0.01)^{ab} A	0.10 (0.04)^{b} A	0.06 (0.00)^{ab} A	0.06 (0.01)^{aA}	0.07 (0.01)^{ab} A	0.08 (0.01)^{ab} B	0.09 (0.01)^{ab} B	0.07 (0.00)^{ab} A	0.07 (0.00)^{a} bA
	5	0.06 (0.01)^{ab} cA	0.06 (0.01)^{ab} A	0.08 (0.00)^{c} A	0.07 (0.01)^{ab} cA	0.05 (0.00)^{aA}	0.07 (0.00)^{bc} AB	0.06 (0.00)^{ab} A	0.06 (0.00)^{ab} A	0.07 (0.01)^{bc} A	0.07 (0.01)^{a} bcA
C22:6ω3	0	14.82 (0.38)^{b} A	16.59 (0.01)^{dC}	16.48 (0.34)^{c} dB	15.27 (0.26)^{bc} B	15.95 (0.88)^{bc} dA	13.04 (0.33)^{aA}	15.10 (0.74)^{bB}	13.58 (0.81)^{a} A	12.87 (0.37)^{a} A	-
	3	12.89 (0.57)^{ab} cA	14.65 (0.81)^{cB}	14.55 (0.45)^{b} cA	14.49 (0.44)^{bc} AB	12.43 (1.20)^{ab} A	12.08 (2.04)^{aA}	13.85 (0.42)^{ab} cB	13.70 (0.22)^{ab} cA	12.35 (0.48)^{a} A	12.88 (0.01)^{a} bcB
	5	12.32 (3.25)^{aA}	12.97 (0.0.6)^{a} A	13.55 (0.64)^{a} A	13.76 (0.60)^{aA}	12.88 (1.50)^{aA}	11.30 (0.74)^{aA}	11.07 (0.02)^{aA}	12.90 (0.22)^{a} A	12.63 (0.27)^{a} A	12.20 (0.25)^{a} A
ΣPUFA	0	40.66 (2.86)^{b} A	37.97 (0.03)^{aB}	40.87 (0.01)^{b} C	37.80 (0.33)^{aA}	37.08 (0.82)^{aA}	37.70 (0.62)^{aA}	37.80 (0.35)^{aB}	36.95 (0.25)^{aB}	35.58 (0.57)^{a} B	-
	3	36.14 (0.24)^{ab} A	37.51 (0.48)^{bB}	36.57 (0.62)^{a} bB	37.31 (0.58)^{bA}	34.25 (1.07)^{ab} A	36.10 (4.37)^{ab} A	37.48 (0.59)^{bB}	36.58 (0.01)^{ab} B	34.29 (0.34)^{ab} A	33.28 (0.14)^{a} B
	5	34.85 (2.68)^{ab} cA	34.99 (0.11)^{ab} cA	34.55 (0.57)^{a} bcA	36.36 (0.71)^{cA}	35.74 (1.04)^{bc} A	33.96 (0.45)^{ab} cA	33.49 (0.35)^{ab} A	34.12 (0.24)^{ab} cA	33.58 (0.18)^{ab} cA	32.25 (0.31)^{a} A
EPA+DHA	0	18.13 (1.26)^{b} A	19.00 (0.03)^{bB}	19.29 (0.74)^{b} B	17.85 (0.28)^{bB}	18.43 (0.87)^{bB}	16.07 (0.25)^{aA}	17.83 (0.64)^{bB}	16.24 (0.66)^{a} A	15.12 (0.38)^{a} A	-

table continue

	3	16.01 (0.46)^{ab} cA	17.92 (0.64)^{cB}	17.19 (0.47)^{b} cA	17.18 (0.35)^{bc} AB	15.19 (0.83)^{ab} A	15.26 (2.24)^{ab} A	16.99 (0.42)^{bc} B	16.39 (0.09)^{ab} cA	14.54 (0.31)^{a} A	14.74 (0.06)^{a} B
	5	15.60 (2.74)^{aA}	16.01 (0.06)^{aA}	16.27 (0.54)^{a} A	16.40 (0.59)^{aA}	15.94 (1.27)^{aA} B	14.64 (1.13)^{aA}	14.17 (0.06)^{aA}	15.13 (0.21)^{a} A	14.60 (0.33)^{a} A	14.16 (0.21)^{a} A
PUFA/SFA	0	2.09 (0.06)^{dB}	1.89 (0.00)^{cA} B	2.13 (0.02)^{d} C	1.91 (0.03)^{cA}	2.06 (0.05)^{dB}	1.93 (0.05)^{cB}	1.87 (0.01)^{cC}	1.74 (0.01)^{b} C	1.65 (0.06)^{a} B	-
	3	1.81 (0.01)^{bc} AB	1.91 (0.06)^{cd} B	1.99 (0.00)^{d} B	2.02 (0.03)^{dB}	1.72 (0.13)^{b} A	1.77 (0.09)^{cA} B	1.77 (0.04)^{cB}	1.67 (0.03)^{ab} B	1.59 (0.01)^{a} B	1.59 (0.02)^{a} B
	5	1.64 (0.17)^{bc} A	1.77 (0.05)^{cd} A	1.77 (0.04)^{c} dA	1.81 (0.04)^{dA}	1.68 (0.06)^{cd} A	1.70 (0.03)^{cd} A	1.53 (0.04)^{ab} A	1.47 (0.01)^{a} A	1.47 (0.01)^{a} A	1.39 (0.06)^{a} A
Σω6	0	19.12 (1.34)^{dB}	15.85 (0.03)^{aA}	18.22 (0.66)^{c} dB	16.78 (0.03)^{ab} A	15.66 (0.04)^{aA}	18.43 (0.29)^{cd} A	16.83 (0.24)^{ab} A	17.53 (0.34)^{bc} B	17.14 (0.16)^{bc} C	-
	3	17.01 (0.20)^{bc} AB	16.48 (0.16)^{ab} cB	16.34 (0.23)^{a} bcA	17.03 (0.18)^{bc} A	16.02 (0.14)^{ab} A	17.65 (1.77)^{cA}	17.37 (0.06)^{bc} A	16.94 (0.11)^{bc} AB	16.59 (0.07)^{ab} cB	15.35 (0.09)^{a} B
	5	16.20 (0.16)^{cd} eA	15.91 (0.16)^{bc} A	15.39 (0.01)^{a} bA	16.80 (0.10)^{ef} A	16.72 (0.23)^{de} fB	16.46 (0.60)^{cd} eA	17.18 (0.31)^{fA}	16.08 (0.45)^{cd} A	15.79 (0.11)^{bc} A	14.93 (0.08)^{a} A
Σω3	0	19.12 (1.34)^{dB}	15.85 (0.03)^{aA}	18.22 (0.66)^{c} dB	16.78 (0.03)^{ab} A	15.66 (0.04)^{aA}	18.43 (0.29)^{cd} A	16.83 (0.24)^{ab} A	17.53 (0.34)^{bc} B	17.14 (0.16)^{bc} C	-
	3	18.49 (0.42)^{ab} cdA	20.28 (0.62)^{dB}	19.50 (0.40)^{c} dA	19.63 (0.40)^{cd} AB	17.58 (0.92)^{ab} cA	17.82 (2.52)^{ab} cA	19.31 (0.52)^{bc} dB	18.89 (0.18)^{ab} cdB	17.02 (0.27)^{a} A	15.35 (0.09)^{a} bA
	5	17.97 (2.84)^{aA}	18.46 (0.04)^{aA}	18.43 (0.54)^{a} A	18.81 (0.62)^{aA}	18.39 (1.24)^{aA}	16.82 (1.05)^{aA}	16.72 (0.04)^{aA}	17.38 (0.22)^{a} A	17.07 (0.34)^{a} A	16.67 (0.12)^{a} B
Σω6/Σω3	0	0.92 (0.00)^{d} A	0.75 (0.00)^{aA}	0.83 (0.06)^{b} cA	0.83 (0.01)^{bc} A	0.76 (0.03)^{ab} A	1.00 (0.00)^{eA}	0.84 (0.04)^{cA}	0.94 (0.05)^{de} A	0.96 (0.01)^{de} AB	-
	3	0.92 (0.03)^{cd} A	0.82 (0.04)^{aA} B	0.84 (0.01)^{a} bA	0.87 (0.01)^{ab} cAB	0.91 (0.14)^{cA}	0.99 (0.04)^{eA}	0.90 (0.01)^{cA}	0.90 (0.00)^{c} A	0.98 (0.01)^{de} B	0.89 (0.00)^{b} cA
	5	0.92 (0.13)^{ab} A	0.86 (0.01)^{aB}	0.84 (0.02)^{a} A	0.90 (0.02)^{ab} B	0.91 (0.07)^{ab} A	0.98 (0.10)^{ab} A	1.03 (0.02)^{bB}	0.93 (0.04)^{ab} A	0.93 (0.02)^{ab} A	0.90 (0.01)^{a} bA
DHA/EPA	0	5.25 (0.22)^{b} A	6.88 (0.03)^{dB}	5.93 (0.73)^{b} cA	5.92 (0.03)^{bc} A	6.45 (0.38)^{cd} A	4.31 (0.21)^{aB}	5.54 (0.47)^{bc} B	5.13 (0.59)^{ab} A	5.72 (0.13)^{bc} A	
	3	4.15 (0.32)^{ab} A	4.50 (0.47)^{ab} cdA	5.51 (0.14)^{c} dA	5.41 (0.35)^{cd} A	4.56 (1.03)^{ab} cdA	3.79 (0.40)^{aA} B	4.42 (0.14)^{ab} cA	5.10 (0.33)^{bc} dA	5.67 (0.66)^{d} A	6.91 (0.18)^{e} B
	5	3.88 (1.59)^{ab} cA	4.28 (0.01)^{ab} cA	4.98 (0.43)^{b} cdA	5.20 (0.24)^{cd} A	4.25 (0.82)^{ab} cA	3.40 (0.18)^{aA}	3.57 (0.04)^{ab} A	5.77 (0.11)^{d} A	6.42 (0.05)^{d} A	6.23 (0.26)^{d} A

table continue

N/A	0	11.31	13.85	12.82	12.84	16.25	13.15	12.40	13.04	14.93	-
	3	14.79	11.86	16.50	12.63	14.14	12.30	12.86	12.25	13.17	14.79
	5	11.81	12.45	15.49	12.68	12.28	14.20	11.43	11.65	11.98	12.22

* The values are expressed as mean ± standard deviation, n=3.
a-e Values in a same row followed by different letters indicate significant differences (P<0.05) during storage periods.
A-C Values in a same column followed by different letters indicate significant differences (P<0.05) of the parameter with respect to the irradiation treatment

PUFA/SFA ratios in this study were determined as 2.09, 1.81 and 1.64, respectively, in the control and irradiated groups at 3 and 5 kGy doses after irradiation. While the PUFA/SFA ratio of the control group was observed to be statistically higher than the irradiated group, especially at the 5 kGy dose ($p<0.05$), it was observed that there was no change in the PUFA/SFA ratios of the 3 kGy and 5 kGy dose irradiated groups ($p>0.05$). Statistical decreases in PUFA/SFA ratios were observed in all groups during storage ($p<0.05$) (Table 3). A similar picture was observed at the end of storage, and in general, the PUFA/SFA ratios of the 5 kGy dose irradiated group were observed to be low, while the control group was found to have higher ratios.

In this study, the initial TBA values of the control and the fillets that were irradiated with doses of 3 and 5 kGy were found as 0.96, 0.83 and 0.72 mg MA/kg (Table 4). Initially, while the group irradiated at 5 kGy had the lowest level of TBA, TBA values of 5 kGy dosed group increased quickly during storage and reached to higher values than the other groups. In addition, 3 kGy group had significantly higher values than the control group ($P<0.05$). Therefore, it can be said that gamma irradiation accelerated lipid oxidation in our study.

Table 4. The changes on thiobarbituric acid value (TBA, mg MA/kg) for smoked trout fillets irradiated with different doses during cold storage

Storage Period (Week)	Control (0 kGy)	3 kGy	5 kGy
0	0.96 ± 0.01^{cC}	0.83 ± 0.12^{aB}	0.72 ± 0.10^{aA}
2	0.99 ± 0.02^{dA}	1.04 ± 0.01^{cB}	1.22 ± 0.02^{bC}
4	0.90 ± 0.04^{bA}	0.94 ± 0.04^{bB}	1.50 ± 0.02^{eC}
6	1.21 ± 0.03^{fB}	1.00 ± 0.02^{bcA}	1.49 ± 0.09^{eC}
8	1.26 ± 0.01^{gA}	1.26 ± 0.05^{eA}	1.23 ± 0.11^{bA}
11	0.76 ± 0.02^{aA}	1.19 ± 0.04^{dB}	1.36 ± 0.01^{cC}
14	0.75 ± 0.01^{aA}	0.97 ± 0.04^{bB}	1.38 ± 0.01^{cC}
17	1.13 ± 0.03^{eA}	1.30 ± 0.05^{eB}	1.40 ± 0.01^{cdC}
20	1.27 ± 0.031^{gA}	1.40 ± 0.03^{fB}	1.45 ± 0.02^{deC}
23	---	1.46 ± 0.03^{gA}	1.58 ± 0.01^{fB}

* The values are expressed as mean ± standard deviation, n=6.
a-g Values in a same column followed by different letters indicate significant differences (P<0.05) during storage periods.
A-C Values in a same row followed by different letters indicate significant differences (P<0.05) of the parameter with respect to the irradiation treatment

The PVs of the control and irradiated groups during cold storage are shown in Table 5. Initially, the peroxide values of control, 3 kGy and 5 kGy groups were found to be 6.84, 7.03 and 5.63 meq/kg and fluctuations were detected in the following weeks. At the beginning of storage, it was seen that irradiation did not affect the peroxide value. However, peroxide values of the irradiated groups at 3 and 5 kGy doses at the 20th week of storage (11.35 and 12.08 meq/kg, respectively) were significantly higher than the control group (6.12 meq/kg) ($p < 0.05$). There was also a difference between the irradiated groups at 3 and 5 kGy doses at 23rd week (9.18 and 9.97 meq/kg, respectively) ($p<0.05$) and the peroxide value of irradiated group at 5 kGy dose was found to be higher.

Table 5. The changes on peroxide value (PV, meq/kg) for smoked trout fillets irradiated with different doses during cold storage

Storage Period (Week)	Control (0 kGy)	3 kGy	5 kGy
0	6.84±0.83^{aA}	7.03±1.76^{aA}	5.63±1.89^{aA}
2	7.99±0.39^{aB}	7.09±0.56^{aB}	4.99±0.55^{aA}
4	8.41±1.08^{aA}	9.18±1.01^{abAB}	10.74±1.01^{bcB}
6	10.39±1.47^{bA}	11.12±2.20^{bA}	12.06±1.90^{bcA}
8	7.48±1.03^{aA}	9.25±1.31^{abA}	13.13±1.08^{cB}
11	10.67±1.51^{cA}	11.94±1.43^{bA}	12.69±1.10^{bcA}
14	10.82±1.66^{cA}	11.74±1.59^{bA}	9.80±0.84^{bA}
17	8.22±0.95^{abA}	10.92±0.29^{bA}	10.40±1.99^{bcA}
20	6.12±0.73^{aA}	11.35±1.20^{bB}	12.08±1.07^{bcB}
23		9.18±1.56^{abA}	9.97±2.61^{bB}

* The values are expressed as mean ± standard deviation, n=3.
a-c Values in a same column followed by different letters indicate significant differences ($P<0.05$) during storage periods.
A-B Values in a same row followed by different letters indicate significant differences ($P<0.05$) of the parameter with respect to the irradiation treatment

As can be seen in Table 6, the FFA values of control and irradiated groups at 3 and 5 kGy doses were 1.89%, 2.40% and 2.54%, respectively, at the beginning of storage. Even if there were no significant differences between irradiated groups of 3 and 5 kGy doses, there was a significant difference between the control group and irradiated groups (3 and 5 kGy) ($p < 0.05$). The FFA values of the control group were significantly lower than the irradiated groups except for the 11th, 14th and 17th weeks of storage. The control group (5.36 %) had similar FFA values to the irradiated group at 3 kGy dose (5.62 %) at the 20th week ($p > 0.05$) but the 5 kGy irradiated group (5.95 %) had a significantly higher FFA value than the other groups ($p < 0.05$). Similarly, in the 23rd week of storage, the FFA values of irradiated group at 5 kGy dose (6.10 %) were found to be significantly higher than the irradiated group at 3 kGy dose (5.67 %) ($p < 0.05$).

Table 6. The changes on free fatty acids (FFA, % oleic acid) for smoked trout fillets irradiated with different doses during cold storage

Storage Periods (Week)	Control (0 kGy)	3 kGy	5 kGy
0	1.89±0.13^{aA}	2.40±0.06^{aB}	2.54±0.33^{aB}
2	1.98±0.13^{aA}	2.47±0.12^{aB}	2.63±0.28^{abB}
4	2.12±0.08^{abA}	2.76±0.29^{abB}	3.06±0.45^{abcB}
6	2.36±0.14^{abA}	3.15±0.30^{bcB}	3.16±0.22^{bcB}
8	2.53±0.13^{bA}	3.18±0.27^{bcB}	3.16±0.36^{bcB}
11	3.16±0.83^{cA}	3.55±0.15^{cdA}	3.51±0.15^{cA}
14	3.51±0.27^{cdA}	3.82±0.20^{deAB}	4.19±0.16^{dB}
17	3.86±0.27^{dA}	4.21±0.50^{eA}	4.57±0.15^{dA}
20	5.36±0.07^{eA}	5.62±0.14^{fA}	5.95±0.08^{eB}
23	-	5.67±0.46^{fA}	6.10±0.09^{eB}

* The values are expressed as mean ± standard deviation, n=3.
a-f Values in a same column followed by different letters indicate significant differences (P<0.05) during storage periods.
A-B Values in a same row followed by different letters indicate significant differences (P<0.05) of the parameter with respect to the irradiation treatment

Discussion

Surendra et al. (2018a) investigated the fatty acid changes in tilapia muscles irradiated at 1 kGy and 3 kGy levels. The researchers reported that while no change was observed in saturated fatty acids in the control and 3 kGy groups, there was a significant decrease in the samples irradiated at 1 kGy. In addition, a significant increase in PUFA was observed in tilapia samples irradiated with 1 kGy, while a decrease was reported in samples irradiated with 3 kGy. Therefore, researchers reported that the safest irradiation level for tilapia during ice storage was 1 kGy. El-Ghafour et al. (2018) studied the effects of commercially used gamma irradiation (0, 0.75, 1.5, 2.25 and 3 kGy) on fatty acids in mullet fish (*Mugil cephalus*). They observed that total SFA and MUFA values increased in direct proportion to the increase in irradiation dose. Significant decreases were observed in PUFA values between control and irradiated samples. Asamoah et al. (2022) observed on smoked Atlantic chub mackerel, that SFA and PUFA values increased significantly with smoking, but MUFA values decreased significantly. Researchers attributed the cause to dehydration. Al-Kuraieef (2021) irradiated fresh bolti fish and smoked herring and mackerel at different levels (1.5, 3.0 and 4.5 kGy). The researcher found that the total PUFA percentages decreased slightly with increasing radiation dose and reported that this may be due to lipid oxidation. It was also determined that there were no significant differences between control and irradiated samples in terms of saturated or unsaturated fatty acids.

Oraei et al. (2011), irradiated rainbow trout fillets at 0, 1, 3 and 5 kGy levels and found that irradiation did not initially cause any change in fatty acid levels. In our study, no statistically significant effect of irradiation was observed on other fatty acids except linoleic acid under initial 3 and 5 kGy doses of irradiation. In addition, researchers found that initial irradiation did not affect total SFA, MUFA and PUFA values, similar to the results obtained in this study. Oraei et al. (2011) found that low temperatures reduce the production of free radicals and thus slow down fatty acid changes. Mbarki et al. (2008) irradiated bonito fish (*Sarda sarda*) at 0, 1.5, 4.5, 6 and 7 kGy levels and stored them at 2 ºC. They detected an increase in SFA values and a significant decrease in PUFA values of the control and irradiated

groups during 21 days of storage. It was observed that irradiation was initially effective on EPA+DHA values, and as the amount of irradiation increased, there was a decrease in EPA+DHA values. Researchers stated that there was a decrease in EPA+DHA values during storage and that this decrease was high in the control group, but as the irradiation dose increased, the amount of decrease decreased. In our study, while a decrease was observed in the EPA+DHA values of the control group during storage, it was observed that storage did not cause any change in the groups irradiated at 3 and 5 kGy doses. Etyemez (2011) reported that irradiation did not cause any change in SFA and MUFA values in frog legs (*Rana esculenta*) irradiated at 4 and 5 kGy levels While some decrease was observed in PUFA values with irradiation, it was stated that there was no difference in PUFA values in the groups irradiated at a dose of 4 or 5 kGy.

It is stated in HSMO (1994) that the most appropriate ω6/ω3 ratio should be below 4.0. A low omega-6/omega-3 ratio has been linked to a lower risk of breast cancer in women and has been shown to benefit asthmatic patients. It was crucial to lower the ratio of w6 to w3 fatty acids in the human diet in order to lower the risk of cancer and coronary heart disease. (Durmuş 2019) The obtained ω6/ω3 ratios were included in these values. Yıldız et al. (2006) found the ω6/ω3 ratio to be 0.80 for rainbow trout. Likewise, Senadheera et al. (2012) found the ω6/ω3 ratio to be 0.98 in their study on rainbow trout. Similar results to our study of PUFA/SFA ratios were reported by Mbarki et al. (2008) and Gecgel (2011). It was also reported that the PUFA/SFA ratio recommended by HMSO (1994) should be at least 0.45. An index called PUFA/SFA is typically used to evaluate how food affects cardiovascular health (CVH). The theory suggests that while all SFAs contribute to elevated serum cholesterol, all PUFAs in the diet can suppress LDL-C and lower serum cholesterol levels. Therefore, the effect is more favorable the larger this ratio (Chen and Liu 2020). The lowest PUFA/SFA ratio detected in this research was 1.39.

Lipid oxidation is one of the main factors that affects fatty acids, especially PUFA and causes the spoilage of the food (Fernandez et al. 1997; Pearson et al. 1983). Lipid oxidation in fish can increase or decrease by several factors. Species, gender, size, process and storage conditions, prooxidants and antioxidants in fish, packaging methods and some other factors are quite effective on lipid oxidation (Polat and Tokur 2000; Ju-Woon et al. 2002; Mbarki et al. 2009). The first stage of the lipid oxidation starts with the connection of oxygen to the double bonds between carbon atoms on PUFA and the occurrence of peroxides. After that the second stage starts and peroxides degrade to aldehydes, ketones and carboxylic acids (Porter et al. 1992). Malonaldehyde, which was generated at this stage, reacts with thiobarbituric acid and a reddish pigment occurs (Fernandez et al. 1997). Rancidity can be determined by measuring this reddish pigment by calorimetric methods. Thiobarbituric acid value (TBA) is an important parameter that shows the rancidity levels of lipids (Piranavatharsan et al. 2023).

Many studies on gamma irradiation have obtained similar results (Lakshmanan et al. 1999; Cozzo-Siqueira et al. 2003; Chouliara et al. 2004; Özden et al. 2007; Mbarki et al. 2009). Moini et al. (2009) reported that ionizing radiation increases the formation of free radicals in lipids. Some researchers also reported that smoking has a significant effect on lipid oxidation and increases the TBA level by twofold or higher (Goulas and Kontominas 2005; Tokur 2007; Koral et al. 2009). Al-Kuraieef (2021) examined the effects of gamma irradiation (1.5 kGy, 3 kGy and 4.5 kGy) on raw tilapia and smoked herring and mackerel. Increases were observed in the TBA values of smoked fish compared to raw tilapia. In addition, TBA values increased in parallel with the increase in irradiation. The highest increase was observed in samples irradiated with 4.5 kGy (tilapia: 0.592 mg MDA/kg; herring: 0.635 mg MDA/kg and mackerel 0.722 mg MDA/kg) and thus it was concluded that peroxides and hydroperoxides decomposed more quickly into lower molecular weight compounds. Mbarki et al. (2009) stated that when low doses of radiation were used, an oxygen-impermeable form of packaging should be used to increase the storage life of fish in the refrigerator or on ice. Surendra et al. (2018a) examined the quality changes of tilapia stored in ice as a result of gamma irradiation (1 kGy and 3 kGy). The researchers reported that TBA values were between 0.014 and 0.003 mg MDA/kgduring ice storage and did not exceed the consumption limits.

One of the most important factors in the deterioration of the quality of the fish is the decrease of the polyunsaturated fatty acids and consequently an increase of the peroxide value (Oraei et al. 2012). In some studies, the peroxide value of 5 meq/kg or less was reported as fresh fish and between 5 meq/kg and 10 meq/kg as the start of the deterioration (Javanmard et al. 2006; Oraei et al. 2012). Additionally, Connell (1995) reported that over 10 meq/kg was marked as not suitable for human consumption. Egan et al. (1997) in their studies suggested that, deterioration in flavor perceived when the peroxide value reached between 20-40 meq/kg.

Many researchers have reported that gamma irradiation increases peroxide values (Hussain et al.

1985; Hampson et al. 1996; Javanmard et al. 2006; Al-Bachir and Zeinou 2009; Gecgel 2011). Reale et al. (2008) reported that one of the factors that increase lipid oxidation is microbial enzymes. The decrease in microbial load in the environment by gamma irradiation positively affected lipid oxidation. Al-Kuraieef (2021) observed the effects of gamma irradiation (1.5 kGy, 3 kGy and 4.5 kGy) on raw tilapia and smoked herring and mackerel. In the study, it was determined that the peroxide values of gamma-irradiated raw tilapia, smoked herring and mackerel fish (14.3, 15.9 and 13.9 meq O_2/kg at 4.5 kGy, respectively) were statistically higher than the control values (5.7, 7.5 and 8.3 meq O_2/kg). The researchers reported that peroxide values increased with increasing doses**.** However, Surendra et al. (2018a) found that there were fluctuations in the PV values of tilapia fish gamma irradiated (1 kGy and 3 kGy) during storage, and there was no statistically significant change in terms of the irradiation doses at the end of the study.

Hydrolytic degradation is caused by lipase enzymes and triggers the formation of free fatty acids (FFA). The FFA then undergoes oxidation to form low molecular weight compounds which produce unpleasant odors and taste in fish and seafood products (Pacheco-Aguilar et al., 2000). The development of lipid hydrolysis depends considerably on the hydrolytic enzyme contents under the influence of different internal and external factors. Separation of free fatty acids from the triglyceride matrix can increase the rate of lipid oxidation and unpleasant odor development (Jasour et al., 2011).

The observed values show that irradiation affects the FFA values of the smoked trout fillets and raises the FFA values. However, it was found that different irradiation doses (3 and 5 kGy) did not make a significant difference until the last 2 weeks. The study conducted by Surendra et al. (2018b) reported that the FFA values of control and yellowfin tuna (*Thunnus albacares*) irradiated at 10 kGy levels were quite high, but the samples irradiated at 5 and 7 kGy levels were at very low levels. Hussain et al. (1985) studied Indian mackerel (*Rastrelliger kanagurta*) irradiated at 0, 1, 1.5, 2 and 3 kGy levels and examined the free fatty acid change. While they found the FFA value to be 1.82% in the control group, they found the FFA values to be 1.63%, 1.95%, 2.65% and 2.26% in the groups irradiated at 1, 1.5, 2 and 3 kGy levels, respectively.

It was determined that irradiation did not cause a statistically significant difference in the fatty acid components of smoked trout fillets However, there was a statistical increase in the myristic,palmitic and stearic acid values of the irradiated groups during storage. The highest increase in total SFA level was observed in the 5 kGy irradiated group, while the lowest increase was in the control group. On the other hand, irradiation did not affect PUFAs except linoleic acid. As for linoleic acid, it was determined that linoleic fatty acid levels in the control group were higher than those irradiated at 3 and 5 kGy doses. It was determined that the total PUFA values of the groups irradiated at 3 and 5 kGy doses during storage were lower than the control group. In this study, it was observed that the lipid stability of the control and 3 kGy irradiated groups was better than the 5 kGy irradiated group. In addition to gamma irradiation, the use of other processing methods such as smoking and vacuum packaging was effective in reducing the effect on lipids. With this research, it is thought that the application of combined methods including low dose irradiation to different processed or fresh seafood products will bring important contributions to the production of safe foods with longer shelf life.

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