Impacts of gamma radiation on nutritional components of minimal processed cultured sea bass (*Dicentrarchus labrax*)

Özden, Ö. *; Erkan, N.

Received: March 2009 Accepted: November 2009

Abstract

Eviscerated sea bass, *Dicentrarchus labrax* were irradiated by Cobalt-60 at commercial irradiation facility at dose of 2.5 and 5 kGy at 2–4°C. The influences of the irradiation on proximate, fatty acid and amino acid composition in cultured sea bass were investigated. Significant differences (P<0.0.5) were found between non-irradiated and irradiated sea bass in terms of moisture, protein, fat, ash and carbohydrate contents. Total saturated and total monounsaturated fatty acid contents were 27.97-24.72% for non-irradiated sea bass respectively. The amonts of these two fatty acids in irradiated samples increased to 28.18-25.75% for 2.5 kGy and 29.08-28.54% for 5 kGy. Total polyunsaturated fatty acid content for irradiated samples was higher than non- irradiated samples. Aspartic acid, glutamic acid, asparagines, histidine, serine, glycine, arginine, alanine, tyrosine, cystine, methionine, lysine, hydroxyproline and proline contents for 2.5 and 5 kGy irradiated sea bass were significantly different (P<0.05).

Keywords: Fish, gamma irradiation, fatty acid, amino acid, proximate composition

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

Department of the Seafood Processing and Quality Control, Faculty of Fisheries, Istanbul University. Ordu Cad. No:200 34470 Laleli/ Istanbul- Turkey.

*Corresponding author's email: ozden@istanbul.edu.tr

Introduction

The major problem with respect to distribution of seafood or fishery products is their susceptibility to spoilage, mainly due to the contamination of spoilage and pathogenic microorganisms (Gram & Huss, 1996). Food irradiation is a process that has proven to be successful, not only in ensuring the safety, but also in extending the shelf life of fresh meats because of its high effectiveness in inactivating pathogens without deteriorating product quality (Mahapatra *et al.,* 2005). Gamma radiation is a process which has a potential for the extension of refrigerated shelf life and decontamination of fishery products (Venugopal *et al.* 1999; Lakshmanan *et al*., 1999; Jeevanandam *et al*., 2003; Özden *et al.,* 2007a; Özden *et al.,* 2007b). The shelf-life of unirradiated and non packaged irradiated whole anchovy (*Stolephorus commersonii*) was evaluated by Lakshmanan *et al.,* (1999) 13 and 17 day period of storage in ice. Jeevanandam *et al.* (2003) reported a for fresh unsalted and unirradiated threadfin bream (*Nemipterus japonicus*) of 8 days, for unsalted irradiated at 1 and 2 kGy bream 12 and 22 of days. Mendes *et al.,* (2005) reports similar increase (4 days) of the shelf life of fresh Atlantic horse mackerel (*Trachurus trachurus*) when irradiated with 1 and 3 kGy. Özden *et al.,* (2007a) reported a shelf life for unirradiated, irradiated at 2.5 and 5.0 kGy sea bream of 13, 15 and 17 days. Food irradiation at a dose of up to 10 kGy has been used in both animal and vegetable foods as an effective, safe and economical method of food preservation posing to nutritional, toxicological or microbiological problems (O' Bryan *et al.,* 2008). Food irradiation is development non-thermal minimal processing techniques. Undesirable changes also occur such as loss of nutrient components in minimal processing terms play an important role in consumer acceptation of the product. Also chemical characterization of irradiated fish is important. The purpose of this study was to determine changes of nutritional components in cultured fish (sea bass) after irradiation process.

Materials and methods

Cultured fresh sea bass (*Dicentrarchus labrax*) were cultivated at 35°C in net cages on the fish farm of PINAR¸ in Turkey and harvested during June 2005. The average weight and length of the fish ware 335±42 g and 33±3.1 cm, respectively. The fish were slaughtered by immersing in ice-cold water (hypothermia) (Council Directive 86/609/EEC*)* and delivered to the laboratory (whole) within 12 h of harvesting, packed in separate insulated expanded polstyrene (EPS) (20-22 g/dm^3) boxes (Council Directive 91/493/EEC) with ice (2:1, fish:ice). This study was conducted in two steps, employing 9 kg (33 pieces) sample in each step. The un-eviscerated, whole fish were divided into three lots. Non- irradiated (control) and 2.5 kGy and 5 kGy irradiated fish samples. Each lot, consisting of 3 kg (11 pieces) fish, was packed in polystyrene boxes (60x40x27 cm, length x width x height) with packed ice. Plastic pouches (100-150 g) were filled with tap water and froze and then placed under an over the fishes in polystyrene boxes.

Irradiation was conducted in Gamma-Pak Sterilization Co. irradiation facility, which is located in Çerkezköy

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

using a Nordion-Canad model JS 9600 boxed irradiation which had a source loading capacity up to 3000000 Ci. It was a category 4 device, liquid source storage and box carrier type gamma irradiator registered in International Atomic Energy Agency (model number JS 9600 and serial number IR-185). As a source for irradiation, double capsule Co 60 radioactive welding chisels in metallic form were used. The source panel had a total capacity of 101 PBq (3000000 Ci) and a 16.83-PBq (500000 Ci) Co 60 source was loaded. The given irradiation doses in this study were 2.5 and 5.0 kGy. Exposure time was 120 and 240 min (dose rate of 0.02 kGy per min). The absorbed dose was monitored by polymethyl methacrylate type dosimeters (Harwell Amber Perspex dosimeter, batch R Type 3042 Range 1-30 kGy, UK). The absorbance signal was measured using a Camspec M 201 UV spectrophotometer at 640 nm (ISO/ASTM 51276:2002 (E). Harwell dosimeters were calibrated to ISO/ASTM 51205-2002 (E) Standard Practice for Use of a Ceric-Cerous Sulfate Dosimetry System, an "International Organization for standardization"approved by"American Society for Testing and Materials standard. The Ceric-Cereus dosimeters with F 2003 batch number which were used during this study were calibrated by MDS Nordion Science Advancing Health. MDS Nordion's dosimetry Laboratory is recognized under NIST's national Voluntary Laboratory Accreditation program (NVLAP lab Code 200370-0) (USA) for the evaluation of Ceric-Cereus reference standard and transfer standard dosimeters. Dosimeters were placed a box in front, middle and rear side and total dosimeters was 6 per/run. From the preliminary irradiation experiment, the distribution of the absorbed dose was as follows: front side 100 %, middle side 98.4 % and rear side 96.8 % for 2.5 kGy (max. 2.53 and min. 2.45) irradiated samples, front side 100 %, middle side 96.5 % and rear side 94.8 % for 5 kGy (max. 5.24 and min. 4.97) irradiated samples. Fish samples were maintained at 2±2°C during irradiation by using sealed ice covering the samples. Internal temperature of the facility was 18–20°C. Non- irradiated (control) fish samples were kept in polystyrene boxes with sealed ice at the ambient temperature of 18–20°C for 4 hours (240 min).

Moisture content was determined by drying samples at 105°C (FN500, Nüve, Turkey) to constant weight. The weight difference before and after drying was multiplied by 100 and divided by the initial weight of the sample (Mattissek *et al.,* 1992) to determine the moisture.

Homogenized sample (5 g) was weighed in a well-dried porcelain basin and subjected to a low bunsen flame. Samples were subjected to high temperature, 550–570°C (MF100, Nüve, Turkey) and cooled in desiccators. Amount of ash was calculated based on the difference of weight after and before this procedure (AOAC, 1998a). Crude protein was determined by the Kjeldahl method (AOAC, 1998b). The sample was heated to 420°C for 20 min with 98% H_2SO_4 and catalyst using DK6 Heating digester (Velp Scientifica, Italy), and then treated with 33% NaOH and 4% boric acid by Velp UDK 140 distillation unit (Velp Scientifica, Italy). The amount of nitrogen was estimated after titration with 0.2 N

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

HCl and then multiplied by the coefficient 6.25.

Fat was extracted according to the acid hydrolysis method described by Weilmeier & Regenstein (2004). Clean aluminum pans were weighed after drying at 105°C for about 2 h. Approximately 2–2.5 g of ground or finely chopped fresh fish muscle were weighed into a 100 ml beaker. After adding 2 ml H_2O and 2 ml concentrated HCl it was mashed. Then 6 ml HCl were added was and the mixture was placed on a hot plate (about 80°C) for about 90 min tobe digested. The mixture was then transferred into a flask, followed by rinsing the beaker with 7 ml ethanol and 25 ml diethyl ether. The tightly capped flask was shaken vigorously. An additional 25 ml of petroleum ether was added to the flask and the flask was shaken again. The mixture was allowed to separate until the layers were visibly separated (about 20 min), and the ether layer was poured into the aluminum pan. The pan was placed on a hot plate until the ether evaporated (Rotavapor 2-3000, Buchi Labortechnic, Switzerland). Two more extractions with 15 mL each of both diethyl and petroleum ether was performed, always adding the upper ether layer into the same pan. Once all the ether had been evaporated from the pans, the pans were dried for at least 20 min in an oven (FN 500, Nüve, Turkey), allowed to cool, and re-weighed. Fat content was calculated according to the following equation:

Fat (%) = (weight of A1 pan after oven – weight of A1 pan before oven)/weight of sample

The carbohydrate content of fish was determined (Carbohydrate%=100-(moisture %+ Ash %+ Fat %+ Protein %)) by Merril & Watt (1973) method.

In order to analyze amino acid, 10 vacuum packaged fillets were removed randomly from frozen storage (-40°C), well extracted and hydrolyzed in 6 N HCl at 110ºC for 24 h. The hydrolyzed solution was analyzed by Ultrakit WRK-146 Amino acids of amino acids in HPLC (AOAC (1998c). The linear gradient system with buffer A (40 mM Na_2HPO_4, pH 7.8) and buffer B (ACN: MeOH: Water (45:45:10, v/v/v), respectively, allowed separation of the amino acids using a Agilent Zorbax SB-C 18 4.6x75 mm column and the detection was carried out by measurement of the absorbance at 338 nm for primary amino acid and 262 nm for secondary amino acid.

The lipids for fatty acid analysis were extracted of minced fillets using the petroleum diethyl ether extraction procedure of Özden *et al.,* (2002). Fatty acid composition was determined after methylation by gas chromatography (Termoquest Trace GC/Milan, Italy) using a SP- 2330 Fused Silica Capillary Column (30 m-0.25 mm ID-0.20 µm film). The chromatographic conditions were as follows: injection volume: 0.5 µl; injection temperature: 240°C; Air: 350 ml/min; H_2: 35 ml/min; Make-up: He, 30 ml/min; Range: 1; Carrier: 0.5 ml/min; Split Flow: 75 ml/min; Split Ratio: 1/150; Detector and detector temperature: FID, 250°C; Column temperature, 120°C for 2 min, programmed at 5 °C/min up to 220°C 8 min. Fatty acids were identified by comparison of their retention time with those of authentic standard (Sigma Cod No: 189-19) and their contents were

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

calculated on a weight percentage basis (IUPAC Standard Method, 1979). The descriptive statistics (mean, standard deviation,) and one–way analysis of variance (ANOVA) were conducted using the Microsoft Office Excel 2003 software. Significance was established at $P<0.05$ with Tukey test (Sümbüloğlu & Sümbüloğlu 2002).

Results

The concentrations of the constituents in sea bass used in these experiments and their standard deviations were as follows: moisture 70.26%, total protein 20.35%, total fat 6.13%, ash 1.63% and carbohydrate 1.64% (Table 1). The total amino acid content in non irradiated and irradiated (2.5 and 5 kGy) sea bass were determined as 20318.26 mg/100g, 20453.92 mg/100g and 22450.86 mg/100g, respectively (Table 2). Amino acid composition of sea bass showed a general increase ($P<0.05$) after irradiation.

Table 1: Proximate composition of non- irradiated and irradiated sea bass

Proximate composition (%)	Control	2.5 kGy	5 kGy
Moisture	$70.26^{a}\pm0.99$	$66.20^{b}\pm0.42$	$65.22^{b}\pm0.43$
Protein	$20.34^{a}\pm0.41$	$20.41^{a}\pm0.23$	$20.65^{a}\pm0.85$
Fat	$6.13^{a}\pm0.44$	$7.66^{b}\pm0.55$	$8.48^{c}\pm0.75$
Ash	$1.63^{a}\pm0.04$	$1.70^{a}\pm0.08$	$1.73^{b}\pm0.01$
Carbohydrate	$1.64^{ab}\pm0.47$	$4.03^{b}\pm0,32$	$3.92^{b}\pm0,51$
Energy (Kcal/100g)	179.56^{a}	203.81^{b}	212.52^{c}

All values are the mean ± standard deviation (n =3). Different letters (^{a,b,c}) in the same line indicate significant differences ($P<0.05$)

In case of irradiation dose 2.5 kGy, a significant increase ($P<0.05$) was found in aspartic acid, serin, histidine, glycine, treonine, cystine, methionine and hydroxyproline (Table 2), while the decrease in glutamic acid, asparagine, tyrosine, leucine, lysine, proline was significant ($P<0.05$). Glutamic acid, asparagine, serine, histidine, glycine, treonine, alanine, tyrosine, leucine and proline content of 5 kGy irradiated sea bass were found lower than control groups samples. Some essential amino acids including arginine, valine, tryptophan, phenylalanine and lysine significantly ($P<0.05$) increased after irradiation at 5 kGy. Fatty acid composition in non-irradiated and 2.5-5 kGy irradiated muscle of sea bass were shown in Table 3.

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

Table 2: Amino acid composition of non- irradiated and irradiated sea bass

Amino acid (mg/100g)	Control	2.5 kGy	5 kGy
Aspartic acid**	3698.855 [a] ±0.072	5750.563 [b] ±0.215	5296.785 [c] ±0.136
Glutamic acid**	5925.768 [a] ±0.280	4028.643 [b] ±0.354	5660.688 [c] ±0.170
Asparagine**	347.735 [a] ±0.352	311.775 [b] ±0.095	323.648 [c] ±0.165
Serine**	3587.870 [a] ±0.072	3646.628 [b] ±0.372	3492.755 [c] ±0.140
Histidine*	72.818 [a] ±0.163	78.570 [b] ±0.376	68.720 [c] ±0.210
Glycine**	234.875 [a] ±0.083	385.658 [b] ±0.221	224.633 [c] ±0.135
Threonine*	348.613 [a] ±0.332	364.585 [b] ±0.307	324.783 [c] ±0.179
Arginine*	200.758 [a] ±0.244	289.558 [b] ±0.184	419.773 [c] ±0.162
Alanine**	360.795 [a] ±0.153	256.570 [b] ±0.252	212.620 [c] ±0.398
Tyrosine**	40.825 [a] ±0.171	29.720 [b] ±0.104	34.723 [c] ±0.115
Cystine**	48.783 [a] ±0.191	57.538 [b] ±0.208	47.785 [c] ±0.125
Valine*	449.775 [a] ±0.317	468.630 [b] ±0.300	483.708 [c] ±0.207
Methionine*	106.545 [a] ±0.324	583.698 [b] ±0.318	112.555 [c] ±0.291
Tryptophan*	29.840 [a] ±0.070	41.765 [b] ± 0.215	45.615 [c] ±0.285
Phenylalanine**	305.820 [a] ±0.189	313.735 [b] ±0.204	316.650 [c] ±0.220
Isoleucine*	305.800 [a] ±0.111	312.655 [b] ±0.200	317.585 [c] ±0.401
Leucine*	563.810 [a] ±0.170	446.640 [b] ±0.325	464.625 [c] ±0.391
Lysine*	3494.793 [a] ±0.067	3078.715 [b] ±0.226	4937.575 [c] ±0.260
Hydroxyproline**	135.678 [a] ±0.382	257.595 [b] ±0.293	212.593 [c] ±0.397
Proline**	58.498 [a] ±0.193	50.683 [b] ±0.221	55.630 [c] ±0.275
Total	**20318.26**	**20453.92**	**22450.86**

***essential amino acid ** non-essential amino acid**

All values are the mean ± standard deviation (n =3). Different letters ([a,b,c]) in the same line indicate significant differences (*P*<0.05)

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

Table 3: Fatty acid composition of non- irradiated and irradiated sea bass

Total fatty acid (%)	Control	2.5 kGy	5 kGy
Butyric acid $C_{4:0}$	**0.497**^{a} ±0.076	**0.477**^{a} ±0.042	**0.537**^{a} ±0.083
Caproic acid $C_{6:0}$	**1.777**^{a} ±0.073	**1.146**^{b} ±0.008	**0.275**^{c} ±0.009
Capryloic $C_{8:0}$	**0.700**^{a} ±0.013	**0.085**^{b} ±0.002	**0.045**^{c} ±0.001
Lauric acid $C_{12:0}$	**0.036**^{a} ±0.001	**0.040**^{b} ±0.001	**0.043**^{b} ±0.001
Tridecanoic acid $C_{13:0}$	**0.033**^{a} ±0.001	**0.036**^{b} ±0.001	**0.038**^{b} ±0.001
Myristic acid $C_{14:0}$	**3.867**^{a} ±0.049	**4.236**^{b} ±0.003	**4.396**^{c} ±0.033
Pentadecanoic acid C $_{15:0}$	**0.625**^{a} ±0.034	**0.663**^{b} ±0.011	**0.672**^{b} ±0.004
Cis-10-Pentadecanoic acid $C_{15:0}$	**0.111**^{a} ±0.005	**0.146**^{b} ±0.009	**0.152**^{b} ±0.004
Palmitic acid $C_{16:0}$	**15.938**^{a} ±0.038	**16.650**^{b} ±0.118	**17.929**^{c} ±0.034
Heptadecanoik acid $C_{17:0}$	**0.904**^{a} ±0.019	**0.993**^{b} ±0.006	**1.053**^{c} ±0.010
cis-10-Heptadecanoik acid $C_{17:0}$	**0.488**^{a} ±0.008	**0.514**^{b} ±0.002	**0.53**^{c} ±0.003
Stearic acid $C_{18:0}$	**2.777**^{a} ±0.003	**2.954**^{b} ±0.016	**3.145**^{c} ±0.005
Arachidic acid $C_{20:0}$	**0.072**^{a} ±0.010	**0.069**^{a} ±0.007	**0.089**^{b} ±0.004
Henicosanoic acid $C_{21:0}$	**0.043**^{a} ±0.007	**0.048**^{a} ±0.014	**0.044**^{a} ±0.006
Behenic acid $C_{22:0}$	**0.042**^{a} ±0.004	**0.055**^{a} ±0.012	**0.051**^{a} ±0.006
Lignoceric acid $C_{24:0}$	**0.063**^{a} ±0.001	**0.066**^{b} ±0.001	**0.078**^{c} ±0.001
Total saturated	**27.97**	**28.18**	**29.08**
Myristoleic acid $C_{14:1}$	**0.071**^{a} ±0.008	**0.071**^{a} ±0.008	**0.080**^{a} ±0.010
Palimiteloic acid $C_{16:1}$	**4.935**^{a} ±0.058	**5.185**^{b} ±0.016	**5.507**^{c} ±0.003
cis Oleic acid $C_{18:1\ \omega-9}$	**17.603**^{a} ±0.175	**18.243**^{b} ±0.060	**20.454**^{c} ±0.040
cis-11-Eicosenoic acid $C_{20:1\ \omega-9}$	**1.276**^{a} ±0.024	**1.379**^{b} ±0.009	**1.510**^{c} ±0.013
Erucic acid $C_{22:1\ \omega-9}$	**0.154**^{a} ±0.004	**0.177**^{b} ±0.001	**0.205**^{c} ±0.013
Nervonic acid $C_{24:1\ \omega-9}$	**0.685**^{a} ±0.002	**0.695**^{b} ±0.003	**0.788**^{c} ±0.004
Total MUFA	**24.724**	**25.75**	**28.544**
trans Linoleadic acid $C_{18:2\ \omega-6}$	**0.086**^{a} ±0.013	**0.081**^{a} ±0.004	**0.081**^{a} ±0.002
cis Linoleic acid $C_{18:2\ \omega-6}$	**7.017**^{a} ±0.029	**8.225**^{b} ±0.048	**8.538**^{c} ±0.025
Gamma-Linolenic acid $C_{18:3\ \omega-6}$	**0.152**^{a} ±0.007	**0.171**^{b} ±0.006	**0.173**^{b} ±0.004
alpha-Linolenic acid $C_{18:3\ \omega-3}$	**1.309**^{a} ±0.012	**1.477**^{b} ±0.007	**1.509**^{c} ±0.002
cis 11,14 Eicosadienoic $C_{20:2}$	**0.486**^{a} ±0.001	**0.547**^{b} ±0.012	**0.537**^{c} ±0.010
cis11,14,17Eicosatrienoic $C_{20:3\ \omega-3}$	**0.080**^{a} ±0.010	**0.103**^{b} ±0.002	**0.098**^{b} ±0.010
Arachidonoic acid $C_{20:4\ \omega-6}$	**0.685**^{a} ±0.008	**0.731**^{b} ±0.004	**0.779**^{c} ±0.001
cis 5,8,11,14,14Eicosapentaenoic $C_{20:5\ \omega-3}$	**5.564**^{a} ±0.007	**5.988**^{b} ±0.017	**6.103**^{c} ±0.002
Docosadienoic acid $C_{22:2}$	**0.053**^{a} ±0.009	**0.065**^{a} ±0.023	**0.060**^{a} ±0.010
Cis 4,7,10,13,16,19 Docosahexaenoic $C_{22:6\ \omega-3}$	**11.225**^{a} ±0.028	**13.268**^{b} ±0.021	**12.276**^{c} ±0.026
Total PUFA	**26.66**	**30.66**	**30.154**
Not detected	**20.65** ±0.267	**15.41** ±0.378	**12.234** ±0.100

All values are the mean ± standard deviation (n =3). Different letters (^{a,b,c}) in the same line indicate significant differences ($P<0.05$)

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

The contents of total saturated fatty acids in the muscle of non-irradiated sea bass was 27.97%, respectively, lower than in 2.5-5 kGy irradiated sea bass (28.18-29.08%). In both non-irradiated and irradiated fish the dominant saturated fatty acid (SFA) was myristic acid $C_{14:0}$, palmitic acid $C_{16:0}$ and stearic acid $C_{18:0}$ and were significantly different from one another ($P<0.05$). Significant difference ($P<0.05$) was found in the content of total mono unsaturated fatty acids (MUFA) between 2.5 kGy (25.75%) and 5 kGy (28.54%) irradiated sea bass. In this study, there was significant difference in the content of MUFAs between non-irradiated and irradiated fish ($P<0.05$). The major fatty acids in muscle of sea bass were Palmitoleic acid ($C_{16:1}$) and cis Oleic acid ($C_{18:1\ \omega-9}$). The content of fatty acids had statistically significant $P<0.05$ differences between control and irradiated samples. The content of polyunsaturated fatty acids (PUFAs) in the muscle of non-irradiated, 2.5 and 5 kGy irradiated sea bass were 26.66%, 30.66% and 30.15%, respectively. Initial average value of cis Linoleic acid $C_{18:2\ \omega-6}$ was found 7.02% muscle for sea bass whereas after irradiation values of cis Linoleic acid $C_{18:2\ \omega-6}$ were 8.23% (2.5 kGy) and 8.54% (5 kGy). Cis Linoleic acid $C_{18:2\ \omega-6}$ contents showed significant ($P<0.05$) increase among all groups after irradiation. Content of alpha-Linolenic acid $C_{18:3\ \omega-3}$ was significantly different between non irradiated and irradiation group ($P<0.05$). The $C_{20:5\ \omega-3}$ and $C_{22:6\ \omega-3}$ content were 5.56 % and 11.23 % for non-irradiated sea bass. At the end of the irradiation process, $C_{20:5\ \omega-3}$, contents reached 5.99 % for 2. 5 kGy irradiated sea bass, 6.10 % for 5 kGy irradiated samples respectively. The end of irradiation, the $C_{22:6\ \omega-3}$ content was found 13.27 % for 2.5 kGy and 12.28 % for 5 kGy irradiated sea bass muscle.

Discussion

Grigorakis *et al.,* (2004) found summer samples of sea bass 74.4% water, 20.39% protein, 3.90% fat and 1.30% ash. Erkan & Özden, (2006) determined sea bass samples 70.43% water, 21.26% protein, 5.60% fat, 2.05% ash. Proximate compositions (70.71% moisture, 20.35% protein, 6.10% fat and 1.66% ash) have been reported by Erkan & Özden (2007a) for aqua cultured sea bass. Similar proximate compositions (76.72% moisture, 19.43% protein 4.81% fat and 1.23% ash,) have been reported by Kyrana & Lougovois, (2002) for sea bass. It is known that variations in the chemical composition of marine fishes is closely related to nutrition, living area, fish size, catching season, seasonal and sexual variations as well as other environmental conditions (Ludorff & Meyer 1973)**.**Moisture content (non-irradiated fish, 70.26%) was reduced in irradiated fish (66.20% for 2.5 kGy, 65.22% for 5 kGy). Fat (7.66- 8.48%), carbohydrate (4.03- 3.92%) and ash (1.70 and 1.73 %) contents in irradiated fish were higher than those in non-irradiated fish. Similar moisture content (75.15% and 74.85%) has been reported by Von Amin *et al.,* (1978) for non-irradiated and irradiated fresh water fish. Parallel of decreasing water ratio changed of ash, protein, fat, and carbohydrate value. Aspartic acid, glutamic acid and lysine were found as the major amino acids in sea food products (Özden, 2005). Aspartic

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

acid and glutamic acid play important roles as general acids in enzyme active centers, as well as in maintaining the solubility and ionic character of proteins. The essential amino acids are arginine, lysine, histidine, isoleucine, phenylalanine, leucine, methionine, tryptophan, threonine and valine (Sikorski *et al.,* 1990; Belitz *et al.,* 2001). Rosa & Nunes (2004) stated that arginine, lysine and leucine are the major essential amino acids in aquatic organisms, and aqua cultural products are therefore known as high quality protein sources. Nene *et al.,* (1975) and Hassan (1990) reported an increase in free amino acids of red gram and chicken immediately after irradiation treatment. Al-Kahtani *et al.,* (1998) found increase in the arginine, decrease in aspartic acid, glycine and alanine of irradiated (1.5, 3, 4.5, 6 and 10 kGy) tilapia. These authors determined in the isoleucine, leucine, phenylalnine, lysine, histidine, glutamic acid, glycine, alanine a significant increase and in treonine, methionine, tryptophan, arginine significant decrease of 3 and 4.5 kGy irradiated Spanish mackerel.Amino acids have also been used as quality indices for various fish and crustacean species. The amino acids tyrosine, arginine and lysine are very important during fish spoilage, since these amino acids can produce biogenic amines by decarboxylation (tyramine, agmatine and cadaverine respectively), which are very important from the toxicity point of view and as quality control indices for fish spoilage. Amino acids have also been used as quality indices for various fish and crustacean species (Ruiz-Capillas & Moral, 2001). Arginine, tryptophan and lysine content of 5 kGy irradiated sea bass were found higher ($P<0.05$) than non-irradiated and 2.5 kGy irradiated sea bass samples. Biogenic amines by decarboxylation of the amino acid can affect quality and safety of fish. Many amino acids, such as glutamic acid, aspartic acid, alanine and glycine, are responsible for flavour and taste. These amino acids are important because they give fish their characteristic taste and flavour (Ruiz-Capillas & Moral, 2004). Irradiation treatment can changed flavor and taste of fish. Glutamic acid, asparagine content of 5 kGy irradiated sea bass samples determined higher that 2.5 kGy irradiated sea bass samples. After irradiation process, glycine and alanine of 2.5 kGy irradiated sea bass samples were determined significantly ($P<0.05$) higher than 5 kGy irradiated samples. Similar results have been reported by Erkan & Özden (2007b) for 2.5 kGy and 5 kGy irradiated sea bream.Researches on meat irradiation and its effect on lipids have been done in the last decades. Researches done on chicken by Rady *et al.,* (1987) showed no significant difference in total saturated and unsaturated fatty acids between irradiated (1, 3, 6 kGy) and non-irradiated frozen chicken muscle. Katta *et al.,* (1991) found significant decrease in amount of palmitic acid and increase in oleic acid as irradiation dose level increased (0.5 to 3 kGy) in chicken meat. These authors determined levels of other fatty acids notably polyunsaturated fatty acid (linoleic and arachidonic acid) did not change. Irradiation did not affect hydrolysis of triglycerides in Indian mackerel. There was a progressive decrease in the initial content of

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

triglycerides with an increase in free fatty acids during refrigerated storage of both non-irradiated and irradiated fish (Rao & Bandyopathyay 1982). Hau & Liew (1993) examined the effect of irradiation at 10 kGy on the linoleic and linolenic acid contents of grass prawns. Irradiation caused a 16% decrease in linoleic acid content, whereas linolenic acid was not affected significantly. Armstrong *et al.,* (1994) reported no changes in fatty acid compositions of two species of Australian marine fish irradiated at doses up to 6.0 kGy. Yılmaz & Geçgel (2007) have been reported total saturated (53.98, 53.71 and 53.42%), total monounsaturated (42.40, 42.78 and 42.96%) and total polyunsaturated fatty acid (3.62, 3.51 and 3.62 %) of non – irradiated and 3-5 kGy irradiated ground beef. These study results generally agreed that irradiation of fishery items had only marginal effects on the lipids, including essential fatty acids (cis Linoleic acid $C_{18:2\ \omega\text{-}6}$). The effects of 2.5 and 5 kGy irradiation on chemical composition, fatty and amino acid composition of sea bass were studied. Overall results of this study was determined after irradiation treatment significantly ($P<0.05$) changes the chemical composition of sea bass.

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

Acknowledgement

This study was supported by the Research Fund of the University of Istanbul (Project No: BYP-711/07062006 and UDP-813/10072006). We wish to thank Director Dr. Hasan ALKAN, GAMMAPAK Company, Çerkezköy, Turkey for performed the irradiation.

References

Al-Kahtani, H.A., Abu-Tarboush, M.H., Atia, M., Bajaber, A.S., Ahemd, M.A., El-Mojaddidi, M.A. 1998. Amino acid and protein changes in Tilapia and Spanish mackerel after irradiation and storage. Radiation Physics and Chemistry, 51**(1),**107-114.

AOAC, 1998a. Official Method 938.08, Ash of Seafood. Chapter 35, p.6. Fish and Other Marine Products, James M. Hungerford, Chapter Editor. Official Methods of Analysis of AOAC International, Edited by Patrica Cunniff. ISBN 0-935584-54-4 and ISSN 1080-0344.

AOAC, 1998b. Official Method 955.04, Nitrogen (Total) in Seafood. Chapter 35, p.6. Fish and Other Marine Products, James M. Hungerford, Chapter Editor. Official Methods of Analysis of AOAC International, Edited by Patrica Cunniff. ISBN 0-935584-54-4 and ISSN 1080-0344.

AOAC, 1998c. Official Method 994.12 Amino Acids in feeds. Chapter 4, p.4-12. Animal Feed, William, R. Windham, Chapter Editor. Official Methods of Analysis of AOAC International, Edited by Patrica Cunniff. ISBN 0-935584-54-4 and ISSN 1080-0344.

Armstrong, S. G., Wyllie, S. G., Leach, D. N. 1994. Effects of preservation by gamma-irradiation on the nutritional quality of Australian fish. Food Chemistry, **50:** 351–357.

Belitz, H.D., Grosch, W., Schieberle, P. 2001. Lehrbuch der Lebensmittelchemie, ISBN.3-540-41096-1, 5. Aufl. Springer Verlag.Berlin Heidelberg New York pp. 75-85.

Erkan, N. & Özden, Ö. (2006). Gutted and Un-Gutted Sea bass (*Dicentrarchus labrax*) stored in ice: Influence on fish quality and shelf life. International Journal of Food Properties, 9(**2**), 331-334.

Erkan, N. & Özden, Ö. 2007a. Proximate composition and mineral contents in aqua cultured sea bass (*Dicentrarchus labrax)*, sea bream (*Sparus aurata*) analyzed by ICP-MS. Food Chemistry, 102(**3**): 721-725.

Erkan, N. & Özden, Ö. 2007b. The changes of fatty acid and amino acid compositions in sea bream (*Sparus aurata*) during irradiation processing. Radiation Physics and Chemistry, 76(**10**), 1636-1641.

Gram, L., & Huss, H.H. 1996. Microbial spoilage of fish and fish products. International Journal of Food Microbiology, **33**:121-137.

Grigorakis, K., Alexis, M., Gialamas, I., Nikolopoulou, D., 2004. Sensory, microbiological, and chemical spoilage of cultured common sea bass (*Dicentrarchus labrax*) stored in ice: a seasonal differentiation. European

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

Food Research and Technology, **219**: 584-587.

Hassan, M.I. 1990. Electrophoretic analysis of proteins from chicken after irradiaton and during cold storage. Food Chemistry, **35:**263-276.

Hau, L.B. & Liew, M. S. 1993. Effects of gamma irradiation and cooking on vitamin B_6 and B_{12} in grass prawns (*Penaeus monodon*). Radiation Physics and Chemistry, **42**: 297-300.

ISO/ASTM 51205, 2002. Standard Practice for Use of a Ceric-Cerous Sulfate Dosimetry System. International Organization for Standardization/ASTM International 01-Oct-2002, 11 P.

ISO/ASTM 51276, 2002 . Standart Practice for use of a polymethylmethacrylate dosimetery system. 01-Oct-2002 pp. 49-55.

IUPAC, (1979). International Union of pure and applied chemistry applied chemistry division commission on oils, fats and derivates. Standard methods for the Analysis of Oils, Fats and Derivates, 6th Edition (Part 1, section I and II) p.96-102. Pergamon Press, Oxford.

Jeevanandam, K., Kakatkar, A., Doke, S.N., Bongirwar, D.R., Venugopal, V., 2001. Influence of salting and gamma irradiation on the shelf –life extension of threadfin bream in ice. Food Research International, **34:** 739-746.

Katta, S.R., Rao, D.R., Sunki, G.R., Chawan, C.B. (1991). Effects of gamma irradiation of whole chicken carcasses on bacterial loads and fatty acids. Journal Food Science, **56:** 371-372.

Kyrana, V.R. & Lougovois, V.P., 2002. Sensory, chemical and microbiological assessment of farm-raised European sea bass (*Dicentrarchus labrax*) stored in melting ice. International Journal of Food Science and Technology, **37:** 319-328.

Lakshmanan, R., Venugopal, V., Venketashvaran, K., Bongirwar, D.R., 1999. Bulk preservation of small pelagic fish by gamma irradiation: studies on a model storage system using Anchovies. Food Research International, **32:** 707-713.

Ludorff, W. & Meyer, V., 1973. Fische und Fischerzeugnisse. Verlag Paul Parey in Hamburg und Berlin. ISBN: 3 489 71914 X, p.155-157.

Mahapatra, A.K., Muthukumarappan, K., Julson, J.L., 2005. Applications of ozone, bacteriocins and irradiation in food processing: A review. Critical Reviews in Food Science and Nutrition, **45:** 447-461.

Mattissek, R., Schnepel, M.F., Steiner, G., 1992. Lebensmittelanalytik, Grundzüge. Methoden. Anwendungen. ISBN: 3-540-54684-7 Zweite, korrigierte Auflage. Springer Berlin Heidelberg New York, p. 11-13.

Mendes, R., Silva, H.A., Nunes, M. L., Empis, J.M.A.E., (2005). Effect of low-dose irradiation and refrigeration on the microflora, sensory characteristics and biogenic amines of Atlantic horse mackerel (*Trachurus*

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

trachurus). European Food Research and Technology, **221:** 329–335.

Merril, A.L. & Watt, B.K., (1973). Energy value of Foods, basis and derivation. Agriculture research service. United States Department of Agriculture. Agriculture handbook No:74, p. 2.

Nene, S.P., Vakil, U.K., Sreenivasan, A., 1975. Effect of gamma irradiation on red gram (*Cajanus cajan*) protein. Journal Food Science, **40:** 815-819.

O' Bryan, C.A., Crandall, P.G., Ricke, S.C., Olson, D.G., 2008. Impact of irradiation on the safety and quality of poultry and meat products: a review. Critical Reviews in Food Science and Nutrition, **48:** 442-457.

Özden, Ö., 2005. Changes in amino acid and fatty acid composition during shelf life of marinated fish. Journal of the Science of Food and Agriculture, **85:**2015-2020.

Özden, Ö., Inugur, M., Erkan, N., 2007a. Preservation of iced refrigerated sea bream (*Sparus aurata*) by irradiation: microbiological, chemical and sensory attributes. European Food Research and Technology, 225(**5-6**), 797-805.

Özden, Ö., Inugur, M., Erkan, N., 2007b. Effect of different dose gamma radiation and refrigeration on the chemical and sensory properties and microbiological status of aqua cultured sea bass (*Dicentrarchus labrax*). Radiation Physics and Chemistry, 76(**7**), 1169-1178.

Özden, Ö., Kruse, R., Erkan, N., 2002. Bestimmung von Organochlor-Pestiziden und Polychlorierten Biphenylen in Miesmuscheln. Deutsche Lebensmittel-Rundschau, 98(**6**), 215-220.

Rady, A.H., Maxwell, J., Wiebicki, E., Phillips, J.G., 1987. Effect of gamma radiation at various temperatures and packaging conditions on chicken tissues. I. Fatty acid profiles of neutral and polar lipids separated from muscle irradiation at -20 ºC. Radiation Physics and Chemistry, **31**: 195-202.

Rao, B.Y.K. & Bandyopathyay, C., 1982. Changes in lipid composition of radurized Indian mackerel (*Rastrelliger kanagurta*) during refrigerated storage, Fleischwirtschaft, **62:** 194-197.

Rosa, R. & Nunes, M.L., 2004. Nutritional quality of red shrimp, *Aristeus antennatus* (Risso), pink shrimp, *Parapenaeus longirostris* (Lucas), and Norway lobster, *Nephrops norvegicus* (Linnaeus). Journal of the Science of Food and Agriculture, **84:** 89–94.

Ruiz-Capillas C. & Moral A., 2001. Changes in free amino acids during chilled storage of hake (*Merluccius merluccius*, L.) in controlled atmospheres and their use as a quality control index. European Food Research and Technology, **212:** 302-307.

Ruiz-Capillas, C. & Moral, A., 2004. Free amino acids in muscle of Norway lobster (*Nephrops novergicus* (L.) in controlled and modified atmospheres during chilled storage. Food Chemistry, **86:** 85-91.

Sikorski, Z.E., Kolakowska, A., Pan, B.S., 1990. The nutritive composition of the major groups of marine food

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]

organisms. In "Resources Nutritional Composition and Preservation". Edt. Sikorski, CRC Press-Inc. Boca Raton Florida pp.30-52..

Sümbüloğlu, K. & Sümbüloğlu, V., 2002. Biyoistatistik. Hatipoğlu Basım ve Yayım San. Tic. Ltd. Şti. ISBN: 975-7527-12-2. 10. Baskı, Ankara.

Venugopal, V., Doke, S.N., Thomas, P., 1999. Radiation processing to improve the quality of fishery products. Critical Reviews in Food Science and Nutrition, **39:** 391-440.

Von Amin, M.H., Qureshi, M.J., Haq, I., Chaudhry, M.A., 1978. Radurization of fresh water Rahu fish (*Labeo rohita*). *Archiv für Lebensmittelhygiene,* 29(**2**), 54-56.

Weilmeier, D.M. and REGENSTEIN J.M., 2004. Cooking Enhances the Antioxidant Properties of Polyphosphates. Journal of Food Science, **69:** 16-23.

Yılmaz, I. & Geçgel, U., 2007. Effects of gamma irradiation on trans fatty acid composition in ground beef. Food Control, 18(**6**), 635-638.

[Downloaded from jifro.ir on 2024-04-20]

[DOR: 20.1001.1.15622916.2010.9.2.7.1]