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Changes of fatty acid profile of mullet fish (*Mugil cephalus*) fillets as influenced by gamma irradiation

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A B S T R A C T

The current study was conducted to assess fatty acids profile of *Mugil cephalus* fillets as affected by low-dose of commercial Gamma ray's irradiation (0, 0.75, 1.5, 2.25 and 3 kGy). The results showed that the palmitic ($c_{16:0}$) and stearic acids ($c_{18:0}$) were predominant saturated fatty acids (SFAs) while, oleic ($c_{18:1}$) and linoleic acids ($c_{18:2}$) were the predominant unsaturated fatty acids (USFAs) in all treated and control samples. The concentration of total saturated (SFAs) and monounsaturated fatty acids (MUFAs) were incremented with increment irradiation dose. Oleic acid ($c_{18:1}$) and Palmitoleic acid ($c_{16:1}$) were major (MUFAs) in all treated and control samples of *Mugil cephalus*. Linoleic ($c_{18:2}$), eicosapentaenoic ($c_{20:5}$) and docosahexaenoic ($c_{22:6}$) acids were predominant polyunsaturated fatty acid (PUFAs) regarding treated in addition to control samples. The Significant difference ($p < 0.0\ 5$) was found between irradiated and non-irradiated *Mugil cephalus* of some PUFAs (Linoleic, Arachidonic and Eicosapentaenoic acid).

Introduction

Food irradiation is treated physically to extend storage period, enhancing the quality criteria and safety ratio (Mahindru, 2005). Electromagnetic γ-rays which similar to light are produce by cobalt- 60 but it has much higher energy. The dose of 10 kGy is authorized for commercially processed food (Lacroix and Ouattara, 2000). Food irradiation is a mechanism of food preservation that has developed since the beginning of considering irradiation as an improve method of meat, poultry and fish preservation has excellent possibilities to meat safety and lengthen the shelf life (Fu et al., 2000; Chawla et al., 2003; Jeevanandam et al., 2001; Mahrour et al., 2003; Chouliara et al., 2004, 2005; Morehouse, 2002).

Ionizing radiation is the reason behind the water radiolysis. During irradiation, the influenced lipids are (PUFAs) with produce free radicals (OH−, H+ and hydrated electron), all of which react with the food constituents Brewer (2009). Myristic, stearic and palmitic are the predominant of (SFAs) but their concentrations are low in fish. The high concentrations of (MUFAs) and (PUFAs) in fish oil are preserve the oil in liquid form (Urairina and Jamaludin, 2012).

Irradiation of grass prawns at 10 kGy causes decrement linoleic, while linolenic was not influenced (Hau and Liew, 1993). Irradiation of some marine fish in Australia at dose up to 6 kGy doesn't influence on fatty acid (Armstrong et al., 1994). Irradiation of tilapia and Spanish mackerel at 1.5–10 kGy was reason behind decreased in palmitic and palmitoleic acids in tow species (Al-Kahtani et al., 1996). A significant ($p < 0.05$) difference in MUFA of treated sea bream with 2.5 kGy and 5 kGy was found but no significant ($p > 0.05$) difference in MUFA between control and treated fish. While PUFAs in irradiated sea bream at 5 kGy has lower than control and 2.5 kGy (Erkan and Özden, 2007). Irradiation of sea bass at dose 2.5 and 5 kGy causes increase in (SFAs) and (MUFAs) contents. A significant ($p < 0.05$) difference in MUFAs between control and treated sea bass, also between 2.5 kGy and 5 kGy was found. While total (PUFAs) for irradiated samples was higher compared to control samples (Özden and Erkan, 2010). Irradiation process and different doses at 1, 3 and 5 kGy for Rainbow trout fillets had no significant ($P > 0.05$) impacts on fatty acid profile (Oraei et al., 2010). SFA and MUFA of beef lipid increased, while PUFA decrease with irradiation (1.13, 2.09, and 3.17 kGy). The ratio of MUFA/SFA did not change but PUFA/SFA decrease. (Chen et al., 2007).

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Recently, research on seafood riched in ω −3 highly PUFAs has useful impacts on human health, to prevent cardiovascular diseases, mortality and neurodevelopment in infants (Kinsella et al., 1990; Hu et al., 2001; Simopoulos, 2002, Okada, and Morrissey, 2007). Low-dose irradiation had no adverse effect on the nutritionally important polyunsaturated fatty acids (PUFAs) of Mediterranean horse mackerel (Mbarki et al., 2009). Due to a great present of (PUFAs) in fish, so it is useful impact on human health but they susceptible to peroxidation damage (Haghparast et al., 2010). The ratio of ω3/ω6 (1:1–1:5) would represent a healthy human diet (Osman et al., 2001). Increasing of ω6/ω3 ratio than permissible level was harmful to human health and may promote cardiovascular diseases (Moreira et al., 2001). Thus, this study assessed changes in the FAs composition of mullet fish (*Mugil cephalus*) fillets as influenced by gamma irradiation at 0.0, 0.75, 1.5, 2.25 and 3.0 kGy.

Materials and methods

Fish sample

A total 5 kg cultured fresh Mullet (*Mugil cephalus*) were obtained from the Chafer Elshikh fishery farm during January 2017. The average (mean ± SD) of fish were, 330 ± 20 gm and 30 ± 2 cm; respectively. Each fish was washed carefully by tap water and packaged in polyethylene bag and transported using ice-box (fish: ice 1:2) within 4 hrs to Fish Processing and Technology Laboratory, El-kanater El-khiria station, National Institute of Oceanography and Fisheries, Ministry of Scientific Research, A.R. E. The fish were eviscerated, beheaded and divided into two fillets by a sterile sharp knife. All fillets were washed and divided to five groups.

Irradiation

Studies samples were delivered to the radiation center in ice box within 2 h. Gamma irradiation was carried out in the National Center for Radiation Research and Technology (N.C.R.R.T). Nasr City, Cairo, Egypt with a ^{60}Co-Gamma Ray source using Russion Facility (CM-20) Gamma cell located at the source giving a dose rate of irradiation about 6 KGy/hour at the time of experiments (this means that the fillets were exposed to 0.75 KGy every7.5 min). After irradiation, treated and untreated fillets were transported to Fish Processing Technology Laboratory in icebox. Then samples were kept by frozen to -20° C until analysis.

Fatty acid composition

Oil was extracted from muscle tissue of *Mugil cephalus* samples and converted to methyl ester according to the procedure described by Anitowska et al. (2016). The obtained methyl ester of fatty acid were separated with a PU 4410 gas chromatography (Philips, UK), using a capillary column RTX-2330 (Restek, USA), 105 m. length, diameter 0.25 mm i.d. and film thickness 0.2 μm. Detector (FID) and injection temperature was 260 °C. Column temperature was 160 °C (30 min.) to180 °C (17 min) at 3 °C/min. and to 220 °C (15mi n) at 5 °C/min. The carrier gas was helium. For data handling system the star chromatography workstation (version 6.6) was used, with software from Varian. The fatty acid composition was expressed as percentage of total fatty acid (AOAC 1995).

Statistical analysis

All results (n = 3) were analyzed using (Duncan's test). Level of significance was set at P < 0.05. SPSS version 20.0 was used for statistical analysis.

Results and discussion

FAs composition of investigated *Mugil cephalus* fillets was shown in Table 1. Total SFAs was 27.12% for control, while samples treated at 0.75, 1.5, 2.25 and 3 kGy were 27.38, 27.64, 27.77 and 28.23%; respectively. The predominant (SFAs) in all samples were palmitic and stearic acids. The highest contents of the total (SFAs) were in treated sample at 3 kGy (28.23%) while, lowest content was observed in control sample (27.12%). Myristic ($c_{14:0}$) and Palmitic acid were significantly (p < 0.0 5) higher in treated *Mugil cephalus* at 3 kGy compared with control sample. While, stearic showed no statistically significant difference (P > 0.05) between irradiated and non- irradiated samples. It could be observed that the total (SFAs) increased slightly with increase irradiation doses. These results parallel with Özden and Erkan (2010), Lakshmanan et al. (1999) Chen et al. (2007). Contrast results have been noticed by Javan and Motallebi (2015), who reported that the lowest value of myristic acid with increasing irradiation doses for Rainbow trout fillets.

Total (MUFAs) in control and irradiated *Mugil cephalus* were 33.42, 33.63, 34.09, 34.50 and 34.86 respectively. The major types of (MUFAs) in all samples were oleic and Palmitoleic acid. The highest contents of the total (MUFAs) were in irradiated sample at 3 kGy (34.86%) while, lowest content was observed in control sample (33.42%). The lowest and highest contents of eicosaenoic and erucic acids were found in control and irradiated samples with 3 kGy. These results are agreement with those of Javan and Motallebi (2015), Özden and Erkan (2010),who reported that total (MUFAs) of irradiated Rainbow trout and sea bass were higher significant than control sample.

The contents of (PUFAs) in control and irradiated *Mugil cephalus* samples were 35.37, 34.68, 34.34, 34.19 and34.51 %; respectively. The predominant (PUFAs) in all samples were linoleic, EPA and DHA. The highest (20.45%) and lowest value (19.79%) of linoleic were obtained for irradiated samples at 0 kGy and 3 kGy. EPA and DHA contents were 3.72 and 5.07% for non-irradiated *Mugil cephalus*. The EPA contents in irradiated samples reached to 3.38, 3.46, 3.51, and 3.32% at doses 0.75, 1.5, 2.25 and 3 kGy respectively. The highest contents of DHA were in irradiated sample at 3 kGy (5.12%) while, lowest content was observed in irradiated sample at 1.5 kGy (4.93%). In this study, there was significantly decrease (P < 0.05) of some (PUFAs) content between control and irradiated *Mugil cephalus*. Parallel results have been noticed by Javan and Motallebi (2015), who reported that the highest and lowest contents of (PUFAs) in control 37.68% and irradiated Rainbow trout fillets at 4.5 kGy 36.46% respectively. Contrast results have been noticed by Özden and Erkan (2010), who reported that the highest value of total (PUFAs) contents with increasing irradiation doses for sea bass. Oraei et al. (2010), found no significant differences (p > 0.05) in fatty acids levels between irradiated Rainbow trout fillets at different doses (1, 3, 5 kGy) and the non-irradiated ones (control).

Results in Table 2 showed that P/S ratio was ranged from 1.3 in control sample to1.22 at 3 kGy.

This ratio is higher than recommended level (0.45) as set by (HMSO, 1994). Concerning ω3/ω6, it was found that ω3/ω6 ratio in all studies samples ranged (0.49–0.51) this ratio is within those (1:1–1:5) as set by (Osman et al., 2001). With regarded to ratio of ω6/ω3 was reached to be 2.0, 2.03, 2.0, 1.95, 1.97 for 0, 0.75, 1.5, 2.25 and 3 kGy; respectively. In this study, ratio of ω6/ω3 was lower than (4.0) as reported by (HMSO, 1994).

Table 3. shows that the ratio of (TUFA/TSFA) and percentage of EPA, DHA of studied Samples. Data showed that (TUFA/TSFA) ratio was recorded 2.54% in control sample and 2.46% at 3 kGy. Also, EPA percentage was slightly decreased with increasing gamma irradiation dose and reached to 3.32% at 3 kGy. Meanwhile, DHA