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# Impact of Gamma Irradiation on the Quality of Tilapia Fish(*Oreochromis niloticus*) Fillets Stored under Refrigerated Condition

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**Abstract :** The present study was conducted to evaluate the effect of low-dose of gamma irradiation (0, 1,2 and 3KGy) on physicochemical,microbial and sensory attributes of Tilapia fish fillets stored at4±1°C periodically at2days intervals for12days.The results showed that slightly decrease of TVB-N, TMA-N and PH values of treated samples with 1,2and3KGy doses.While the thiobarbituric acid value showed slightlyincrease in the same samples. During storage period the TVB–N, TMA-N, TBA and pH parameters showed significant increase but were these values still within the permissible level after 12days of storage of treated samples.The untreated samples reached to onset of spoilage after 8 days of storage. All doses (1,2 and 3 KGy) were enough to reduce the microbial loads and extend the shelf- life of treated Tilapia fish fillets without adverse effect on the acceptability of these samples. It could be concluded that the treatment by 3KGydose showed thehighest values of all quality parameters.
**Keywords**: Irradiation, Tilapia Fish, Physicochemical, Microbial, Sensory Evaluation.

## Introduction

Fish is one of the most important sources of animal protein in the tropics and has been widely accepted as a good source of protein and other elements for the maintenance of healthy body. Fish is a perishable food which needs processing or storage. Okonta and Ekelemu [1].Food irradiated is a process that has proven to be successful, not only in ensuring the safety but also in extending the shelf- life of fresh meat because of its high effectiveness in inactivating pathogenic without deteriorating product quality Mahapatra,*et al.*,[2]. In order to control hygienic quality of fish and fish product and to prolong the duration of protection, radiation has beenlegally allowed in Canada in 1973, Holland in 1985 and Thailand in 1986 Öztasiran, *et al*[3]; IAEA,[4]. Food irradiation is a technology to protect food quality, to provide hygiene and to extend of shelf- life. This technology is physical practice such as pasteurization, canning and freezing methods carried out by utilizing the heat energy. The difference between the methods mentioned is that, the energy used in irradiation is not the heat energy but “ionizing energy” TAEK,[5].

Irradiation effects on the sensory characteristics depend on type of the food that is being irradiated. Dose-dependent gamma irradiation with doses ranging from 1.0 to 5.0 kGy was not induced any unacceptable flavor, texture and odor in Sweetlips*(Lethrinus miniatus)*, red emperor *(Lutjanus sebae)*, mackerel *(Scomberomorus commerson)*, whiting *(Sillago ciliate)*, mullet *(Mugil cephalus)*, barramundi *(Lates calcalifer)* and sand crab *(Portunus pelagicus)* (Poole *et al*., [6]). When the irradiation technology is applied in combination with the processing methods suchas smoking, chilling,freezing etc., better results can be obtained Bengunur and Nilgun [7]. Shelf-life of sea bass stored in ice was found to be 13days whereas it were 15 and 17 days of irradiated sea bass at 2,5 and 5 KGy respectively Özden,*et al*[8].On the basis of sensorial evaluation, a shelf-life of 27-28 days was obtained at 1 or 3 KGy, compared to a shelf- life of 14-15 days for the non – irradiated salted sea bream fish. The chemical indicators of spoilagesshowed that TVB-N andTMA-NValues in non – irradiated, salted sea bream were higher than irradiated samples. While TBA values in irradiated samples were higher than respective untreated samplesChouliaraa, *et al*[9].

The application gamma irradiation at dose 0.5,1,0 and 2,0KGy and cold storage at 4°C on mud crab, *Scylla Serrate* would be helpful to extend the shelf-life of *Scylla serrate* by maintaining fairly good sensory quality for maximum duration of 14 days. While on seventh day, the non-irradiated sample showed mild ammoniacal odor, discoloration, softening and declined to the level of 5,35 of both carapace and sternum Arshad *et al*., [10].

Combination of gamma radiation (3,5 and 8 KGy) with low temperature (-20°C) storage of degutted fresh pampus chinensis was reduced the bacterial load at the beginning of storage to $2x10^2$ at 3KGy while at 5 and 8 KGy the samples were completely sterilized resulting in no bacterial growth and the samples remain acceptable after 90 days at -20°C. In addition TVB-N in irradiated at 3,5 and 8 KGy was lower than non – irradiated sample. During storage period, TVB-N values were increase gradually but within the permissible level Ahmed *et al*.,[11]. Irradiation accelerates free radical reaction resulting in the possibility of color changes, lipid oxidation and odor generation, which may generate negative consumer responses Ahn *et al*., [12]; Du *et al*., [13]; Jo and Ahn, [14]. Thiobarbturic acid values of sime-dried shrimp which ware irradiated at 4KGy dose are higher than that of irradiated at 2 KGy IAEA, [4]. Although TVB-N and TMA-N concentrations increased in all groups in Mediterranean horse mackerel that was irradiated with a dose of 1 and 2 KGy during storage, the irradiated samples have less these values according to the control group Mbarki *et al*.,[15].

## Materials and Methods

Atotal of 12Kg(*Oreochromis niloticus*)bought from khafer Elshikh fishery farm during January2017. The average weight and length of the fish were,350±30 gm. and 23±3cm respectively.Each fish was washed carefully by tab water,backed in ice box with icebags /fish weight ratio 2:1 then fish were transported within4 hour 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, skinned and divided into two fillets by a sterile scalpel and washed again(about85-90gm. each).Each fillet was separately placed in polyethylene bag.The fillets were divided into four lots (18 fillets in each).Fish fillet lots treated by 0KGy(control),1,2 and3KGy Gamma radiation, respectively. Packed samples were delivered to the radiation plant in ice box with icebags/fillets weight ratio 2:1.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 of about 6 KGy/ hour at the time of experiments (this means that the fillets were exposed to 1KGy every10 minutes). After irradiation,irradiated and non-irradiated fillets were transported to the Fish ProcessingTechnology Laboratory in insulated icebox with ice bags/fillets weight ratio to 2:1.Then samples were kept in a chilling storage at 4±1°C.Samples were analyzed for physicochemical, microbiologicaland sensory attributes at the 0,2,4,6,8,10 and12days.

### PhysicochemicalParameters

Total volatile basic nitrogen (TVB-N) was determined by the Macro distillation method proposed by Pearson [16].Trimethylamine nitrogen (TMA-N) was determined using the standardmethod as described by the A.O.A.C [17].Thiobarbituric acid values (TBA) were determined by Pearson’s description[16]. TBA content was expressed as mg of malonaldehyde (MDA)/kg sample. The pH value was measured by using standard methods, AOAC [18].

**Microbiological Analysis**

For the microbiological analysis 10 g of Tilapia fish fillet was removed with a sterile scalpel and minced under aseptic conditions. Then it was homogenized for 2 minutes with 90 ml of 0.1% (w/v) sterile peptone water. Subsequent dilutions were prepared by mixing a 1-ml sample with 9 ml of sterile peptone water. All analyses were carried out in duplicate. For determination of total bacterial count, 1 ml of appropriate dilutions were poured-plated with melted plate count agar and then were incubated at 35-37°C for 48 h. For the numeration of total coliforms, 1 ml of appropriate dilutions were poured-plated with melted violet red bile agar (VRBA); plates were incubated at 37°C for 48 h. Total yeasts and molds were enumerated on potato dextrose agar after incubation at 25° C for 3–5 days according to.FDA[19]. The results were expressed as log10cfu/g of sample.

**Sensory Evaluation**

The organoleptic quality attributes (appearance ,flavor,texture and overall acceptability) of fried untreatedand treated fishfillets by deep-frying in sunflower oil at 160°C for 5 min. (Frying was carried out immediately during evaluation) were evaluated at zero time and periodically every twodays according to the procedure of Fey and Regenstein,[20] using the following numerical system: excellent 8.5> 10,very good 7.5> 8.5, good 6.5> 7.5, accepted 5.0 > 6.5, poor 4.5 >5.0 and very poor 0>4.0.

**Statistical Analysis**:

All data were subjected to malty varianceanalysisby Duncan's multiple range test ($P$<0.05) to evaluate the effect of irradiation at different applied doses and storage condition in this study on physicochemical, microbial and sensory attributes of Tilapia fish fillets stored at 4±1 °C periodically at 2 days intervals for 12 days.. SPSS version 20.0 was used for statistical analysis.

## Results and Discussion

**Physico-chemical Quality Parameter**

TVB-N,TMA-N,TBAand pHvalues of non-irradiated and 1,2,and3KGy irradiated Tilapia fish fillets stored at 4±1 °C are showed in Table(1). TVB-N data showed no-significant differences between treated and untreated samples which recorded11.9 mg/100 gfor control sample and 11.7,11.6and11.5 mg/100g after irradiated by 1,2 and3KGy samples,respectively.However,TVB-N values increased with the progress of storage period.This may be attributed to the breakdown of protein as the result of microbial and proteolytic enzymes activity. At the end of cold storage period after 12 days this value reached to28.7,27.9 and27.6mg/100g for samples irradiated by 1,2 and3 KGy respectively, while control samples reached to permissible level recommended by Elbassuony [21] and Connell [22] after8days from cold storage.This may be attributed to the role of irradiated on microbial population and bacterial growth. Similarly results reported byAhmed et al[11]; Asli*et al*[23],Oraei, *et al*[24] andNur.,*et al*[25]revealed that the production of TVB-N was retarded considerably in the irradiated fish stored under low temperature as compared to control samples and increased applied dose decreased the rate of TVB-N formation during storage by reducing the initial levels of the common spoilage bacteria.

TMA-N is considered as a valuable tool in the evaluation of fish quality because of its rapid accumulation in muscle under refrigerated conditionGokodlu,*et al.*,[26].In this study, the initial TMA-N value was 5.5 mg/100g flesh for non-irradiated Tilapia fish fillets and5.2,5.1 and4.9 for irradiated samples, by 1,2 and 3KGy respectively.TMA-N levels increased in all samples but the values in the irradiated Tilapia fish fillets remained lower than that in the non-irradiated samples during storage period at4±1°C as shown in (Table 1).

TMA-N values at the end of cold storage period (12 days) recorded 9.7, 9.5and 9.3 mg/100g for irradiated samples at 1, 2 and 3 KGy respectively, while control sample after 8 days increased than (10mg/100g) permissible level recommended by Egyptian standards [27]. However, Similarly results reported by Chouliara *et al.* [28]; Ahmed *et al.* [11]; Aslı, *et al.* [23] and Nur., *et al.*[25]revealed that the statistical analysis of TMA–N showed that significant differences (p<0.05) were found between control and each irradiated fish stored at -20°C. Finally, the obtained results indicated that the TVB-N and TMA-N formation is lower in irradiated and cold storage Tilapia fish fillets than non-irradiated fish. These results clearly showed that irradiated has an important effect of lessening volatile amine contents, which may be explained by the diminished total viable count and the account of surviving flora of the irradiated fish in generally non-proteolytic. Therefore, the production of free volatile amines is reduced relative to that of non-irradiated fish.

**Table 1 "Effect of Gamma irradiation on physicochemical parameter of Tilapia fish fillets during refrigeration storage period"**

| Dose (KGy) | Storage Period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | 8 | 10 | 12 |
| **TVB - N** | | | | | | | |
| **0** | 11.90±0.2$^{a}$ | 12.30±0.3$^{a}$ | 16.70±0.6$^{b}$ | 19.40±0.4$^{c}$ | 29.80±0.2$^{d}$ | R | R |
| **1** | 11.70±0.10$^{a}$ | 12.10±0.3$^{a}$ | 15.30±0.1$^{b}$ | 17.80±0.5$^{b}$ | 21.10±0.2$^{c}$ | 23.2±0.5$^{c}$ | 28.70±0.3$^{d}$ |
| **2** | 11.60±0.2$^{a}$ | 11.80±0.4$^{a}$ | 14.80±0.6$^{b}$ | 16.70±0.6$^{b}$ | 20.70±0.4$^{c}$ | 22.40±0.3$^{c}$ | 27.90±0.5$^{d}$ |
| **3** | 11.50±0.2$^{a}$ | 11.70±0.4$^{a}$ | 14.20±0.3$^{b}$ | 15.30±0.2$^{b}$ | 19.30±0.3$^{c}$ | 21.80±0.3$^{c}$ | 27.60±0.3$^{d}$ |
| **TMA-N** | | | | | | | |
| **0** | 5.50±0.2 $^{a}$ | 5.7±0.1 $^{a}$ | 6.20±0.1 $^{b}$ | 8.30±0.1 $^{c}$ | 12.40±0.2$^{d}$ | R | R |
| **1** | 5.20±0.1 $^{a}$ | 5.40±0.1 $^{a}$ | 5.70±0.2$^{a}$ | 7.20±0.1 $^{b}$ | 8.60±0.3$^{c}$ | 9.10±0.2 $^{c}$ | 9.70±0.1 $^{c}$ |
| **2** | 5.10±0.06 $^{a}$ | 5.30±0.1$^{a}$ | 5.40±0.1$^{a}$ | 7.30±0.2 $^{b}$ | 8.30±0.2 $^{c}$ | 9.10±0.3$^{c}$ | 9.50±0.2 $^{c}$ |
| **3** | 4.90±0.2 $^{a}$ | 5.10±0.2$^{a}$ | 5.90±0.3 $^{a}$ | 6.30±0.1 $^{b}$ | 7.90±0.2 $^{b}$ | 8.60±0.1 $^{c}$ | 9.30±0.1$^{c}$ |
| **TBA** | | | | | | | |
| **0** | 0.31±0.02$^{a}$ | 0.35±0.02$^{a}$ | 0.7±0.03$^{b}$ | 1.63±0.03$^{c}$ | 1.86±0.06$^{c}$ | R | R |
| **1** | 0.36±0.02 $^{a}$ | 0.42±0.02$^{a}$ | 0.85±0.03$^{b}$ | 1.20±0.08$^{c}$ | 1.35±0.5 $^{c}$ | 1.27±0.02$^{c}$ | 1.68±0.1 $^{c}$ |
| **2** | 0.45±0.02$^{b}$ | 0.53±0.02$^{b}$ | 0.97±0.02$^{b}$ | 1.35±0.02$^{c}$ | 1.28±0.02$^{c}$ | 1.40±0.03$^{c}$ | 1.79±0.2 $^{c}$ |
| **3** | 0.53±0.02$^{b}$ | 0.62±0.02$^{b}$ | 0.79±0.03$^{b}$ | 1.46±0.02$^{c}$ | 1.53±0.03$^{c}$ | 1.65±0.03$^{c}$ | 1.94±0.1 $^{d}$ |
| **pH** | | | | | | | |
| **0** | 6.20±0.07 $^{a}$ | 6.30±0.07$^{a}$ | 6.40±0.07$^{b}$ | 6.60±0.071$^{b}$ | 6.80±0.071$^{c}$ | R | R |
| **1** | 6.10±0.0 $^{a}$ | 6.10±0.0 $^{a}$ | 6.30±0.07$^{a}$ | 6. 40±0.07 $^{b}$ | 6.70±0. 07$^{c}$ | 6.80±0.0 $^{c}$ | 6.90±0.0$^{d}$ |
| **2** | 6.10±0.0 $^{a}$ | 6.20±0.0 $^{a}$ | 6.20±0.0 $^{a}$ | 6.30±0.071$^{a}$ | 6.60±0.07 $^{b}$ | 6.70±0.07$^{c}$ | 6.80±0.07$^{c}$ |
| **3** | 6.0±0.07 $^{a}$ | 6.10±0.0$^{a}$ | 6.20±0.0 $^{a}$ | 6.40±0.07$^{b}$ | 6.50±0.071$^{b}$ | 6.50±0.0 $^{b}$ | 6.70±0.0 $^{c}$ |

Data are presented as means ± standard deviation (SD).Means followed by different letters in each columnfor dose levels and row for storage days are significantly (P<0.05) different.

- ∗ R: Rejected

TBA values were initiated by Gamma irradiation and the TBA values of Tilapia fish fillets increased indirect proportion to the irradiation dose. The influence of Gamma irradiation on TBA values of Tilapia fish fillets during cold storage at 4±1°C for 12 days was investigated. The obtained results are shown in Table (1). At zero time of storage there were significant (p<0.05) differences between the control and irradiated samples at 2 and 3KGy while no-significant (p<0.05) differences between the control and irradiated sample at 1KGy. Both irradiated and non-irradiated samples were within the permissible level (less than 3mg malonaldehyde/kg) according to Connel,[29].The highest TBA values 1.86mg/kg after 8 days of storage at 4±1 °C recorded for control sample, while compared with irradiated samples, the highest TBA value 1.94mg/kg showed in sample irradiated by 3 KGy and the lowest TBA value 1.68mg/kgshowed in sample irradiated by 1KGy.These variation can be explained as a result of the different phases of decomposition of peroxides, formation of carbonyls and the interaction compounds with nucleophilic molecules present in the fish Aubourg, *et al*[30]similar results have been reported for irradiated Sea bass,anchovy and treated fin breamÖzden ,*et al*[31];Lakshmanan ,*et al.,*[32];Jeevanandam,*et al*[33];Chouliara,*et al*[9].Irradiated fish produce higher TBA valuethan non-irradiated samples and the amount of TBA showed positive correlation with the applied dose. Similar results were reported by(Aslı,*et al*[23]; Oraei,*etal.,*[24]; Gunsen, *et al.,*[34]; Moini *et al*.,[35];Mohamed, *et al*.,[36].

The pH of the muscle tissue of live fish is close to the value of 7.0; however, post-mortem pH can vary from 6.0 to 7.1 depending on species, season and other factors (Castillo- Yáňez et al., [37]). In this study, the pH values of irradiated (1, 2 and 3 kGy) and non-irradiated Tilapia fish fillets increased during storage period. The increasing in pH indicates the accumulation of alkaline and volatile base compounds such as ammonia and trimethylamine as well as the other biogenic amines, mainly derived from microbial action (Özden *et al.*, [31]; Moini *et al.*, [35]. At beginning of storage the highest and lowest pH value were notice in control and irradiated Tilapia fish fillets at 3KGy respectively. These findings were obtained byOraei, et al [24] and Mohamed, *et al.*, [36].They reported that the pH value gradually decreased as the dose of irradiation increased. The pH values increasing during storage period of non-irradiated and irradiated Tilapia fish fillets. This findings are in agreement with Chouliara *etal*, [9]; Moini *et al*, [35] Özden *etal*,[31]; and Reale *et al*,[38]; for Gamma irradiation of different species during storage.

**Microbiological Evaluation**

The values of total plate count, molds and yeasts count and coliforms count of non-irradiated (control) and irradiated (1, 2 and 3 kGy) Tilapia fish fillets during cold storage(4°C±1) are shown in Table(2).

The results of microbiological analysis showed that microbial load of irradiated samples at 1, 2 and 3 kGy samples were lower than control samples throughout the storage period. Coliforms were most sensitive to gamma radiation. Their destruction leads to a significant increase in the acceptable shelf life. Total plate counts immediately after irradiation treatment decreased as irradiation dose increased. The total bacterial count above day 8 in non-irradiated samples was rejected (The fish was considered unacceptable when the total bacterial count is $10^7$ cfu/g EOSQC [27])while irradiated samples at 1, 2 and 3 KGy within permissible level this may be attributed to the sensitivity to radiation ( Grant et al.,) [39]. Total coliform count increased in non-irradiated samples while in irradiated samples below the detection level until the end of the storage. The total mold and yeast count increased during storage, but it was lower in irradiated samples. The study revealed that irradiation (1, 2 and 3 kGy) and storage at low temperature had a significant reduction effect on microbial loads of Tilapia fish fillets. These findings indicated that food spoilage microorganisms are generally very susceptible to irradiation; a 90% reduction of most vegetative cells can be accomplished with 1–1.5 kGy (Brewer, [40]). Fallah et al. [41] reported that the irradiation dose of 1.5 kGy reduced the initial counts of yeasts and molds by 2 Log units, while at 3 kGy yeasts and molds were below the detection levels during 6 days of storage. Moini et al., [35] reported that coliforms have a very low resistance to radiation. In addition, the current study showed the synergistic effect of two preservation methods, food irradiation and cold storage temperature on extending the shelf-life of Tilapia fish fillets by reducing the microorganism's load.

**Table 2 "Effect of Gamma irradiation on total plate count, coli form and, mold and yeast count of Tilapia fish fillets during refrigeration storage period"**

| Dose (KGy) | Storage Period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | 8 | 10 | 12 |
| **Total plate count (log10 CFU/g)** | | | | | | | |
| 0 | 3.69±1.85[a] | 3.98±1.85[a] | 4.53±2.85[a] | 5.62±3.85[b] | 5.95±4.85[c] | R | R |
| 1 | 1.92±0.45[a] | 2.23±0.85[a] | 2.94±1.15[a] | 3.43±1.85[a] | 3.98±1.85[a] | 5.81±4.15[b] | 5.93±3.85[b] |
| 2 | < 10[a] | 1.79±0.33[a] | 2.20±0.85[a] | 2.99±1.33[a] | 3.86±2.15[a] | 5.72±4.15[b] | 5.90±4.33[b] |
| 3 | < 10[a] | < 10[a] | 1.83±0.33[a] | 2.59±1.15[a] | 3.79±1.85[a] | 4.93±3.15[a] | 5.88±3.85[b] |
| **Total coli form (log10 CFU/g)** | | | | | | | |
| 0 | < 10[a] | 1.51±0.15[a] | 1.93±0.63[b] | 2.08±0.55[b] | 2.26±0.85[c] | R | R |
| 1 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| 2 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| 3 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| **Total mold and yeast count (log10 CFU/g)** | | | | | | | |
| 0 | 2.86±1.15[a] | 2.97±1.33[a] | 3.79±1.85[b] | 4.49±2.85[c] | 4.91±3.15[d] | R | R |
| 1 | 1.15±0.15[a] | 1.87±0.45[a] | 2.45±0.85[a] | 2.81±1.15[a] | 2.99±1.15[a] | 3.73±1.85[b] | 4.56±2.85[c] |
| 2 | No [a] | No [a] | 1.41±0.15[a] | 1.72±0.33[a] | 2.57±0.85[a] | 3.34±2.15[a] | 3.76±1.85[a] |
| 3 | No [a] | No [a] | No [a] | No [a] | 1.15±0.15[a] | 1.62±0.33[a] | 3.56±2.15[a] |

Data are presented as means ± standard deviation (SD).Means followed by different letters in each columnfor dose levels and row for storage days are significantly ($P<0.05$) different.

* R: Rejected

### Sensory Evaluation

The results of sensory analysis are one of the most important quality criteria used for determination of shelf life of fish.The sensory scores of irradiated and non-irradiatedsamples of the Tilapia fish fillets under the coldstorage at 4°C±1for different duration are representedin Table(3).

At the beginning of cold storage period no- significant difference in sensory evaluation between irradiated (1, 2 and 3 KGy) and non-irradiated Tilapia fish fillets and recorded excellent scores for all samples. Initial sensory attributes scores of Tilapia fish fillets gradually decreased with the progress of storage period in control and irradiated samples at 1, 2 and 3 KGy. The sensory score of Tilapia fish fillets stored at 4±1°C, the shelf-life reached to 8 days for non-irradiated samples and to 12 days of all irradiated samples. It is worth indicated that the decomposition accurse in non-irradiated samples was higher than irradiated samples, received

**Table 3 "Effect of Gamma irradiation on Sensory Characteristics of Tilapia fish fillets during refrigeration storage period"**

| Organoleptic Quality Criteria | Dose (KGy | Storage Period (days) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 2 | 4 | 6 | 8 | 10 | 12 |
| Appearance | 0 | **9.5**±0.12$^{a}$ | **8.9**±0.35 | **7.3**±0.36 | **6.8**±0.33 b | **5.3**±0.22$^{c}$ | **R** | **R** |
| | 1 | **9.5**±0.17 $^{a}$ | **9.2**±0.39 a | **8.9**±0.45 a | **7.8**±0.18 a | **6.5**±0.34$^{b}$ | **5.7**±0.41$^{b}$ | **5.1**±0.03$^{c}$ |
| | 2 | **9.4**±0.1 $^{a}$ | **9.1**±0.2 $^{a}$ | **8.7**±0.37 a | **8.1**±0.39 a | **7.6**±0.09$^{a}$ | **6.4**±0.2$^{b}$ | **5.2**±0.1 c |
| | 3 | **9.3**±0.2 a | **9.0**±0.41 a | **8.4**±0.51 a | **7.7**±0.45 a | **6.9**±0.54$^{b}$ | **5.8**±0.33$^{b}$ | **5.3**±0.25 c |
| Flavor | 0 | **9.4**±0.21 a | **8.3**±0.38 a | **6.9**±0.27 b | **6.3**±0.22 b | **5.1**±0.1$^{c}$ | **R** | **R** |
| | 1 | **9.4**±0.13 a | **8.7**±0.2 $^{a}$ | **8.1**±0.13 a | **7.6**±0.1 $^{a}$ | **7.1**±0.09 b | **6.4**±0.25 $^{b}$ | **5.2**±0.45 c |
| | 2 | **9.3**±0.45 a | **8.6**±0.1 a | **8.2**±0.47 a | **7.9**±0.29 a | **7.3**±0.35 b | **6.3**±0.2$^{b}$ | **0.28**$^{c}$ **5.3**± |
| | 3 | **9.2**±0.33 a | **8.9**±0.15 a | **8.2**±0.1 a | **7.9**±0.16 a | **7.4**±0.48 b | **6.6**±0.1 $^{b}$ | **5.4**±0.16 c |
| Texture | 0 | **9.4** ±0.09 a | **8.5**±0.3 a | **7.6**±0.16 a | **6.5**±0.46 b | **5.0**±0.18$^{c}$ | **R** | **R** |
| | 1 | **9.3**±0.12 a | **8.3**±0.55 a | **7.9**±0.1 $^{a}$ | **7.1**±0.1 $^{b}$ | **6.7**±0.2 $^{b}$ | **5.5**±0.31c | **5.0**±0.09 c |
| | 2 | **9.2**±0.22 a | **8.1**±0.11 a | **7.8**±0.2 $^{a}$ | **7.2**±0.1 $^{b}$ | **6.5**±0.42 b | **5.7**±0.1$^{b}$ | **5.1**±0.1 c |
| | 3 | **9.1**±0.1 $^{a}$ | **8.2** a ±0.28 | **7.9**±0.18 a | **7.4**±0.53 b | **6.8**±0.14 b | **5.9**±0.18 $^{b}$ | **5.3**±0.22 c |
| Overall Acceptability | 0 | **94**±0.06$^{a}$ | **8.6**±0.31$^{a}$ | **7.3**±0.35$^{b}$ | **6.5**±0.25$^{b}$ | **5.1**±0.15$^{c}$ | **R** | **R** |
| | 1 | **9.4**±0.1$^{a}$ | **8.7**±0.45$^{a}$ | **8.3**±0.53$^{a}$ | **7.5**±0.15$^{a}$ | **6.8**±0.31$^{b}$ | **5.9**±0.47$^{b}$ | **5.1**±0.1$^{c}$ |
| | 2 | **9.3**±0.1$^{a}$ | **8.6**±0.5$^{a}$ | **8.2**±0.45$^{a}$ | **7.7**±0.47$^{a}$ | **7.1**±0.57$^{b}$ | **6.1**±0.38b | **5.2**±0.1$^{c}$ |
| | 3 | **9.2**±0.1$^{a}$ | **8.7**±0.44$^{a}$ | **8.2**±0.23$^{a}$ | **7.7**±0.25$^{a}$ | **7.0**±0.32$^{b}$ | **6.1**±0.44$^{b}$ | **5.3**±0.06$^{c}$ |

Data are presented as means ± standard deviation (SD).Means followed by different letters in each columnfor dose levels and row for storage days are significantly (P<0.05) different.

- R: Rejected

all irradiationdoses and stored at4°C±1.Arshad etal.[10]reported that the irradiated samples of *Scylla serrate* at1KGy and 2KGy is the reliable dosage to improve sensory properties and thereby shelf-life by 14daysfor storage at 4°C.Ahmed *et al.*[11] reported that the organolepticscores of non-irradiated fish samples decreased graduallywith the progress of storage period whereas irradiatedsamples showed the acceptable score up to 90 days.Özden et al. [31] reported that acceptabilityscores for odor, taste and texture of cooked sea bassdecreased with the storage time. According to thesensory scores of sea bass stored in ice (4°C) theshelf life of 13, 15 and 17 days was determined for non-irradiatedand irradiated samples at 2.5 and 5 KGy, respectively.

## Conclusion

All the results from physicochemical, microbial and sensory attributes in this study indicates that low dose gamma irradiation can be applied to improve biochemical safety indices and to extend the shelf life of Tilapia fish fillets up to twelve days at ± 4°C without adverse effects on the quality and acceptability. Gamma irradiation at3KGy was the best treatment because recorded the highest values of all quality parameters. In addition, the current study showed the synergistic effect of the two preservation methods, food irradiation and cold storage, on extending the shelf life of Tilapia fish fillets.

## References


1. Okonta, A. A. and. Ekelemu, J. K. ( 2005):"A preliminary study of microorganisms associated with fish spoilage in Asab, Southern Nigeria," in Proceeding of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON), Port Harcourt, pp. 557-560.
2. Mahapatra, A. K.; Muthukumarappan, K. and Julson, J. L.( 2005.): "Applications of ozone, bacteriocins and irradiation in food processing: A review," Critical Reviews in Food Science and Nutrition vol. 45, pp. 447 – 461,
3. Öztasiran,I;Siyakus,G.;Ersen,S.;Kutsal,O.Ve andMutluer,B.(1992):Isinlanmis Hamsi BallĝÎinin Toksikolojik Yönden Güvenirliginin Ratlar Üzerinde Denenmesi.DoĝaTr.J. of veterinary and Animal Sciences,16:233-244.
4. IAEA,2010.http://www.iaca.org/icgfi(March 27,2010).
5. TAEK,2010.http://www.tack.gov.tr/(Febraury 12,2010).
6. Poole, S. E., Mitchell, G. E. and Mayze, J. L. 1994. Low dose irradiation affects microbiological and sensory quality of sub-tropical seafood. Journal of Food Science 59(1): 85–87. Bengünur, ÇoRAPCI and Nilgün, KABA( 2011): Irradiation Technology in sea products. yunns Arastirma Bülteni (4):22-27.
7. Bengünur ÇoRAPCI and Nilgün KABA( 2011):Irradiation Technology in sea products. yunnsArastirmaBülteni (4):22-27.
8. Özden, Ö.;İnuğur, M. and Erkan, N.( 2007): Effect of different dose gamma radiation and refrigeration on the chemical and sensory properties and microbiological status of aqua cultured sea bass (*Dicentrarchusl labrax*). Radiation Physics and Chemistry 76(7): 1169–1178
9. Chouliara, I.; Savvaidis, I. N.; Panagiotakis, N. and Kontominas, M. G.( 2004): Preservation of salted, vacuum-packaged, refrigerated sea bream (*Sparus aurata*) fillets by irradiation: microbiological, chemical and sensory attributes. Food Microbiology, 21, 351–359.
10. Arshad, K.;Sudha, K.; Hatha, A. A. M. and Anilkumar, G.(2015): Combined effect of gamma irradiation and cold temperature storage on the sensory properties of edible estuarine crab *Scyllaserrata* International Food Research Journal 22(6): 2253-2258.
11. Ahmed, K.;Hasan, M.; Alam, J.;Ahsan, N.; Islam, M. and Akter, M. S.(2009): The effect of Gamma Radiation in Combination with Low Temperature Refrigeration on the Chemical, Microbiological and Organoleptic Changes in Pampus chinensis (Euphrasen, 1788). World Journal of Zoology, 4(1), 9-13.
12. Ahn,D.U.;Sell,J.L.;Jeffery,M.,Jo.,C.;Chen,X.;Wu,C.andLee,J.L.(1997):Dietary vitamin E affects lipid oxidation and total volatiles of irradiated raw turkey meat .Journal of Food Science.62.954-958.
13. Du,M.,Ahn,D.U.,Nam,K.C., andSell,JL.2000.Influence of dietary conjugated linolenic acid on volatile profiles, color and lipid oxidation of irradiated chicken meat. Meat Science.56.387-395.
14. Jo,C.andAhn,D.U(.2000):Volatiles and oxidative changes in irradiated pork sausage with different fatty acid composition and tocopherol content.J.Food Sci.,65.270-275.
15. Mbarki,R.;Sadok,S.and Barkallah,I.(2009):QualityChangesoftheMediterraneanHorseMackerel(*Trachurusmediterraneus*)DuringChilledStorage:TheEffect of Low-dose Gamma Irradiation. Radiation Physics and Chemistry, 78:288-292.
16. Pearson, D. (1991): The Chemical Analysis of Food. Churchill, New York, London, PP: 374 - 410.

17. AOAC ( 2002): Association of official analytical methods. Official Methods of Analysis, 16th ed. Arlington, Virginia, USA
18. AOAC (2006): Official Methods of Analysis. Association of Official Analytical Chemists, Washington, D.C.
19. FDA "Food and Drug Administration" (2001) U. S. Department of health and human services Public Health Service Food and Drug Administration. College Park, MD 20740.
20. Fey, M. S. and Regenstein, J. M., (1982): Extending shelf life of fresh wet Red Hake and salmon using CO2-O2 modified atmosphere and potassium sorbete ice at 1Co. J. Food Sci., 47:1048-1054.
21. Elbassuony, R. (2002) :Quality evaluation of some fatty fishes during freeze storage. Ph.D. Thesis. Vet. Med. Cairo Univ.
22. Connell, J. J. (1975) :Control of Fish Quality, 1st ed. fishing news books. Torry Research Station of U.K. Ministry of Agriculture.
23. Aslı Hocaoĝlu; Ahmet Sükrü Demirci ; Tuncay Gümüs and Mehmet Demirci.( 2012): Effects of gamma irradiation on chemical, microbial quality and shelf life of shrimp. Radiation Physics and Chemistry 81:1923–1929
24. Oraei, M.;Motalebi, A.A.; Hoseini, E. and Javan, S. (2012): Effect of gamma irradiation and frozen storage on chemical and sensory characteristics of rainbow trout (*Oncorhynchusmykiss*) fillet. International Journal of Food Science and Technology 47, 977–984.
25. Nur-A-Sayed;Zahangir Alam; Mahmudur Rahman Khan; Saima Sharif Nilla and Ghulam Mustafa.( 2013): Biochemical Sensory and Chemical Changes at -20°C in Gamma Irradiated Two Types of Stinging Catfish, *Heteropneustes fossilis*. World Journal of Zoology 8 (2): 225-233.
26. Gökodlu, N.; Özden, Ö.and Erkan, N.(1998):Physical, chemical and sensory analyses of freshly harvested sardines (*Sardinapilchardus*) stored at 4 1C. J. Aquatic. Food Prod. Technol. 7, 5–15.
27. Egyptian Organization for Standardization and Quality Control (2005): EOSQC.889-2/2005 for frozen fish, part 2 fish portions.
28. Chouliara, I.;Savvaidis, L.N.; Riganakos, K.and Kontaminas, M.G.( 2005): Shelf-life extension of vacuum-packaged sea bream (*Sparus aurata*) fillets by combined g-irradiation and refrigeration: microbiological, chemical and sensory changes. J. Sci. Food Agric. 85, 779–784.
29. Connell, J.J.(1990): Methods of assessing and selecting for quality. In: Connell, J.J. (Ed.), Control of fish quality. Fishing News Books. Oxford, UK, pp. 122–150.
30. Aubourg, S.;Perez-Alonzo, F.and Gallardo, J.M.(2004): Studies on rancidity inhibition in frozen horse mackerel (*Trachurus trachurus*) by citric and ascorbic acids.Eur. J. Lipid Sci. Technol. 106, 232–240.
31. Özden, O.; Inugur, M.and Erkan, N.( 2007): Preservation of iced refrigerated sea bream (*Sparus aurata*) by irradiation: microbiological, chemical and sensory attributes. Eur. Food Res. Technol. 225, 797–805.
32. Lakshmanan,R.; Venugopal, V.; Venketashvaran, K.and Bongiwar, D.R.(1999): Bulk preservation of small pelagic fish by gamma irradiation: studies on a model storage system using Anchovies. Food Res. Int. 32, 707–713.
33. Jeevanandam, K.; Kakatkar, A.; Doke, S.N.;Bongiwar, V.and Venugopal, V.( 2001): Influence of salting and gamma irradiation on the shelf life extension o threadfin bream in ice. Food Res. Int. 34, 739–746.
34. Gunsen, U.;Ozcan, A.and Aydin, A. (2010): The Effect of modified atmosphere packaging on extending shelf-life's of cold storage marinated seafood salad. Journal of Animal and Veterinary Advances, 9, 2017–2024.
35. Moini, S.; Tahergorabi, R.and Seyed Vali, H. (2009): Effect of gamma radiation on the quality and shelf life of refrigerated rainbow trout (*Oncorhynchus mykiss*) fillets. Journal of food protection, 72, 1419–1426.
36. Mohamed, W. S.; EL-Mossalami, E. I. and Nosier, Sh. M.(2009): Evaluation of Sanitary Status of Imported Frozen Fish Fillets and its Improvement by Gamma Radiation. J. Rad. Res. Appl. Sci., Vol. 2, No.5, pp. 921 – 931.
37. Castillo-Yáňez, F.J.; Pacheco-Aguilar, R.; Márquez-Rìos, E.; Lugo- Sánchez, M.E.and Lozano-Taylor, J. (2007):Freshness loss in sierra fish (*Scomberomorus Sierra*) muscle stored in ice as affected by postcapture handling practices. Journal of Food Biochemistry, 31, 56–67.
38. Reale, A.;Sorrentino, E.and Iaffaldano, N. (2008): Effects of ionizing radiation and modified atmosphere packaging on the shelf life of aqua-cultured sea bass (*Dicentrarchus labrax*). World Journal of Microbiology and Biotechnology, 24, 2757–2765.

39. Grant, M.A.;Frazier,W.C. and Westhoff,D.C.(1998):Chapter10.preservation by radiation .In Food Microbiology(4 th Ed.)McGraw-Hill.New York.NY.
40. Brewen,M.S.(2009):Irradiation effects on meat flavor :A review. Meat Science.81,1-14.
41. Fallah,A.A.; Tajik, H.; Razavi Rohani, M. and Rahnama, M. (2008):Microbial and sensory characteristics of camel meat during refrigerated storage as affected by gamma irradiation. Pakistan Journal of Biological Sciences, 11, 894–899.

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