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## Effectiveness of Gamma Irradiation and Peracetic Acid treatment on chemical, microbial and sensory attributes of refrigerated Spiny Eel (*Mastacembelidae*)

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Spiny eel (*Mastacembelidae*) had good nutritional value. As fatty fish, spiny eel could not be stored for long time under cool storage. It became spoilage quickly not only by lipid oxidation but also microbial invasion. Hurdle effect by combining physical technique and chemical agent could be considered as an emerging alternative to overcome these matters. This research evaluated the feasibility of gamma irradiation and peracetic acid to form a synergistic effect in prevention against rancidity and microorganism proliferation on spiny eel. The fish was irradiated with 0÷10 kGy, peracetic acid with 10÷30 ppm and kept under refrigerated temperature at 4°C for 20 days. In 5 day-interval, samples were taken to analyze the total volatile base nitrogen (TVB-N), trimethyl amine nitrogen (TMA-N), thiobarbituric acid reactive substances (TBARS), total plate count (TPC) and overall acceptance. Results showed that A combination of gamma irradiation at 5÷10 kGy and peracetic acid at 10÷30 ppm created a synergistic effect to extend fish quality and stability for long-term consumption in acceptable limit.

**Keywords:** Gamma irradiation, microorganism, peracetic acid, rancidity, synergistic, spiny eel

### INTRODUCTION

Rancidity was a serious problem in oily fish storage. In fact, the stability of frozen oily fish normally ended with the onset of rancid flavors. Volatile components derived from the breakdown of lipid hydroperoxides were responsible for rancid flavors and aromas. An increase in free fatty acid lipolysis resulting from the enzymatic hydrolysis of esterified lipids happened in fish tissue post-mortem (Bremner, 2002). The rate of hydroperoxide formation correlated to lipid oxidation in its early stages. Aldehydes, ketones and secondary compounds were created by hydroperoxide reaction which would be determined by using the thiobarbituric acid test (Rodriguez-Turienzo et al. 2011). Oxidative

rancidity could happen even in low-fat fishes, depending on the fatty acid composition. It also occurred in raw, refrigerated and frozen storage (Monteiro et al. 2012; Indergard et al. 2014; Qiu et al. 2014).

Gamma irradiation was a physical treatment involving direct exposure to electron or electromagnetic rays (Muhammad and Hesih, 2017). DNA molecules underwent swelling and broke alongside the chain, preventing them from functioning normally (Lacroix and Ouattara, 2000). It had been proven as non-thermal process not only satisfying the food safety but also extending its shelf-life in inactivating pathogens without any degradation in product quality (Mahapatra et al. 2005; Ozden and Erkan, 2010). The combined

effect of low dose irradiation (1 and 3 kGy) and refrigeration on the shelf-life of vacuum-packed sea bream (*Sparusaurata*) fillets was identified by monitoring microbiological, chemical, and sensory changes of control and irradiated samples (Chouliara et al. 2005). It's demonstrated as an effective alternative to prolong the shelf life of fish commodities of fish by limiting microbial proliferation qualitatively and quantitatively (Arvanitoyannis and Stratakos, 2010). The effect of gamma radiation (1, 3 and 5 kGy) on microbial quality of farmed rainbow trout (*Oncorhynchusmykiss*) fillets was studied (Oraei et al. 2011). Sea bass (*Dicentrarchuslabrax* L.) irradiated up to 3 kGy and stored at 1°C was protected from degradation of membrane lipids (Cheou, 2014).

Peracetic acid (C<sub>2</sub>H<sub>4</sub>O<sub>3</sub>) was an aqueous combination of acetic acid and hydrogen peroxide. It's a promising sanitizer to replace chlorine. Peracetic acid reacted quickly leaving minor residue and relatively harmless to naturally-occurring elements (Evans, 2000). Mechanism of its disinfection was worked on oxidizing the H-S and S-S bonds of the cell wall and outer cell membrane of vegetative bacterial cells, endospores, yeast and mold spores. Microorganisms are unable to function and die rapidly (Gawande et al. 2013). It was demonstrated to be useful emerging candidate superior to ozone as well as a powerful oxidant capacity in removing biofilms beneficial for water treatment (John et al. 2018).

Spiny eel (*Mastacembelidae*) was a natural fish species locating at the bottoms in the fresh water rivers of Southeast Asia, including the Mekong, Chao Phraya, and Mae Klong. Its flesh had excellent nutrients due to feeding insects, crustaceans, and worms in wild life. Its maximum length could achieve 30 centimetres (Tyson, 1986). Spiny eel (*Mastacembelidae*) was distinguished from all other congeners by the following specific properties: lack of rostral tooth plates, dorsal-fin spines 15-19, dark spots like imperfect ocelli along the base of dorsal soft branched fin rays 7-11, dark blotches at the mid-lateral sides of body 22- 27, dorsal fin rays with two rows of parallel greyish streaks, caudal fin rays with 4-6 striated greyish streaks and body width 59.0- 67.4% of its depth (Arunkumar, 2016). The genetic difference of spiny eel (*Mastacembelidae*) was affected by immigration and isolation events as well as by surrounding variables (Takagi et al. 2011). One study verified the processing of spot fin spiny eel into the

curcumin-dry-salted product by salting and drying method. By 0.75% of curcumin supplementation, drying at 50°C in 4 hours, preserving under vacuum at 4°C, the curcumin-dry-salted spotfin spiny eel products had the good physicochemical, microbiological and sensory characteristics. Product shelf life could be lasted for 12 months without any deterioration (Minh et al. 2018). Minh and Nghia (2019) studied the feasibility of chitosan coating in preservation of dried spiny eel. They concluded that the incorporation of 2.5% w/w chitosan could control microbial spoilage and lipid oxidation for 12 months. In order to prolong shelf-life and improve quality of this fatty fish during refrigerated storage, our study investigated the possibility of gamma irradiation and peracetic acid in combination to create a synergistic effect in control of rancidity and microorganism proliferation on spiny eel during refrigerated storage..

## MATERIALS AND METHODS

### Material

Spiny eel (*Mastacembelidae*) fishes were naturally collected from HauGiang province, Vietnam. After collecting, they must be preserved in flake ice and quickly move to laboratory for experiments. They were washed and sanitized by peracetic acid under washing tank with a support of air bubble blowing to remove foreign matters. Chemical reagents were all analytical grade.

### Researching method

Spiny eel (*Mastacembelidae*) fishes were irradiated with 0÷10 kGy as well as peracetic acid with 10÷30 ppm. The treated fishes were refrigerated at 4°C for 20 days. In 5 day-interval, the fishes were sampled to analyze the total volatile base nitrogen (TVB-N), trimethyl amine nitrogen (TMA-N), thiobarbituric acid reactive substances (TBARS), total plate count (TPC) and overall acceptance.

### Chemical, microbial and sensory evaluation

The total volatile base nitrogen (TVB-N, mg N/100g) and Trimethyl amine nitrogen (TMA-N, mg N/100g) content were estimated by the Conway micro-diffusion method described by Manjanaik et al. (2018). The thiobarbituric acid reactive substances (TBARS, mg malonaldehyde/kg) was measured by method described by Raghavan and Hultin (2005). Total plate count (TPC) expressed as the number of viable bacterial colonies per gram of fish (log

CFU/g) was measured by 3M-Petriefilm. Acceptability (sensory score) was evaluated by a group of panelists using 9 point-Hedonic scale.

### Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean  $\pm$  standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI

## RESULTS AND DISCUSSION

Lipid oxidation and proteolytic activities were responsible for major changes in spiny eel (Minh and Nghia, 2019). The combined total amounts of ammonia and trimethylamine (TMA) in fish was measured as the total volatile base (TVB-N) nitrogen content of the fish. TVB-N was commonly used as an estimate of spoilage. With the increase of spoilage bacteria after death in fish, a subsequent increase in trimethylamine oxide (TMAO) reduction to trimethylamine (TMA) took place. The increase in the TVB-N was mostly created by the formation of TMA, which was prevalent in spoiled fish (Heising et al. 2014). The effect of gamma irradiation (kGy) and peracetic acid (ppm) on TVB-N (mg N/ 100g) of refrigerated spiny eel during 20 days of storage was clearly presented in table 1. During refrigerated storage the TVB-N value of spiny eel was significantly higher in the non-treated samples than in the treated ones. It could be explained by the elimination of the microbial density (Venugopal et al. 1999). By gamma irradiation and peracetic acid sterilization, TVB-N values of refrigerated spiny eel were in acceptable limit not over 35 mg N/ 100 g (Huss, 1988). Mbarki et al. (2009) mentioned that TVB-N concentrations in horse mackerel irradiated with a dose of 1 and 2 KGy lower than the control group. El-Ghafour and Zakar (2017) reported that TVB-N values significant increased but still within the permissible level after 12 days of storage of treated tilapia samples. The untreated samples reached to onset of spoilage after 8 days of storage.

TMA-N was a valuable parameter to define the fish quality because of its rapid accumulation in the muscle under refrigerated conditions (Gokodlu et al. 1998). Under enzymatic reactions and microbial activities, nitrogen components like trimethylamine oxide were decomposed to ammonia, formaldehyde and trimethylamine (measured as TMA-N). These might cause protein aggregation, thus limiting the capability of protein to bind water (Barraza et al. 2015). In the current

study, the TMA-N levels increased in all the samples during 20 days of storage. Fortunately, the TMA-N values of treated spiny eel were significantly lower than the non-treated ones (table 2). Ahmed et al. (1997) concluded that the reduction of TMA-N and TVB-N emission was recorded in the irradiated fish compared with the non-irradiated samples. The radiation sensitivity of microorganisms was responsible for the degradation of trimethylamine oxide (Manjanaik et al. 2018). TMA-N values should be below 10 mg N/100 g of fish muscle to meet customer requirement. In the current research, all spiny eel samples treated by gamma irradiation (5-10 kGy) or peracetic acid (10-30 ppm) had the TMA-N in acceptable limit. Mbarki et al. (2009) mentioned that TMA-N concentrations in horse mackerel irradiated with a dose of 1 and 2 KGy lower than the control group. El-Ghafour and Zakar (2017) reported that TMA-N values significant increased but still within the permissible level after 12 days of storage of treated tilapia samples. The untreated samples reached to onset of spoilage after 8 days of storage.

Malondialdehyde was a secondary product from lipid oxidation causing a great risk of dyslipidemia, insulin resistance and high blood pressure (Zaki et al. 2014; Carlos et al. 2016). Low temperature alone could not effectively control lipid oxidation due to the action of endogenous lipoxygenases even under frozen conditions (Karlsdottir et al. 2014). In the current study, the TBARS levels increased in all the samples during 20 days of storage. Fortunately, the TBARS values of treated spiny eel were significantly lower than the non-treated ones (table 3). The ideal TBARS value should be < 3 mg malonaldehyde/kg (Connell, 1990). Our results were contrary to finding by Manjanaik et al. (2018), TBARS values of the irradiated samples were higher than the control group due to lipid oxidation under gamma irradiation. It might be the positive effect of peracetic acid in prevention against lipid oxidation, decomposition of the peroxides, formation of carbonyls, and the interaction compounds with nucleophilic molecules (Aubourg et al. 2004). El-Ghafour and Zakar (2017) reported that TBARS values significant increased but still within the permissible level after 12 days of storage of treated tilapia samples. The untreated samples reached to onset of spoilage after 8 days of storage (Aubourg et al. 2004).

**Table 1: Effect of gamma irradiation (kGy) and peracetic acid (ppm) on TVB-N (mg N/ 100g) of refrigerated spiny eel**

Gamma irradiation (kGy)	Peracetic acid (ppm)	Storage (days)				
		1	5	10	15	20
0	10	4.22±0.17 <sup>a</sup>	6.17±0.09 <sup>a</sup>	8.45±0.14 <sup>a</sup>	11.89±0.30 <sup>a</sup>	17.43±0.25 <sup>a</sup>
	20	3.15±0.09 <sup>b</sup>	5.46±0.15 <sup>b</sup>	6.73±0.19 <sup>b</sup>	8.47±0.21 <sup>cd</sup>	13.71±0.14 <sup>b</sup>
	30	2.07±0.12 <sup>c</sup>	4.93±0.24 <sup>c</sup>	5.61±0.07 <sup>cd</sup>	6.85±0.15 <sup>de</sup>	10.39±0.09 <sup>c</sup>
5	10	3.64±0.23 <sup>ab</sup>	5.68±0.11 <sup>ab</sup>	7.20±0.36 <sup>ab</sup>	10.33±0.33 <sup>b</sup>	14.25±0.13 <sup>ab</sup>
	20	2.73±0.38 <sup>bc</sup>	5.04±0.08 <sup>bc</sup>	6.04±0.15 <sup>c</sup>	7.49±0.16 <sup>d</sup>	10.80±0.27 <sup>c</sup>
	30	1.61±0.41 <sup>cd</sup>	4.21±0.20 <sup>cd</sup>	5.13±0.08 <sup>d</sup>	6.02±0.24 <sup>e</sup>	8.69±0.34 <sup>cd</sup>
10	10	2.87±0.25 <sup>bc</sup>	5.07±0.16 <sup>bc</sup>	6.49±0.11 <sup>bc</sup>	8.95±0.13 <sup>c</sup>	11.36±0.16 <sup>bc</sup>
	20	1.95±0.34 <sup>c</sup>	4.34±0.30 <sup>cd</sup>	5.07±0.26 <sup>d</sup>	6.73±0.11 <sup>de</sup>	8.94±0.19 <sup>cd</sup>
	30	0.74±0.11 <sup>d</sup>	3.81±0.13 <sup>d</sup>	4.26±0.12 <sup>e</sup>	5.11±0.09 <sup>f</sup>	7.29±0.21 <sup>d</sup>

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ( $\alpha = 5\%$ ).

**Table 2: Effect of gamma irradiation (kGy) and peracetic acid (ppm) on TMA-N (mg N/ 100g) of refrigerated spiny eel**

Gamma irradiation (kGy)	Peracetic acid (ppm)	Storage (days)				
		1	5	10	15	20
0	10	2.95±0.24 <sup>a</sup>	4.92±0.13 <sup>a</sup>	7.51±0.17 <sup>a</sup>	9.35±0.23 <sup>a</sup>	12.69±0.12 <sup>a</sup>
	20	2.03±0.15 <sup>b</sup>	4.30±0.07 <sup>ab</sup>	6.17±0.36 <sup>b</sup>	8.22±0.19 <sup>b</sup>	10.44±0.27 <sup>b</sup>
	30	1.44±0.08 <sup>bc</sup>	3.97±0.21 <sup>b</sup>	5.55±0.28 <sup>c</sup>	7.19±0.06 <sup>c</sup>	9.15±0.05 <sup>c</sup>
5	10	2.27±0.37 <sup>ab</sup>	3.85±0.19 <sup>b</sup>	5.99±0.15 <sup>bc</sup>	7.46±0.14 <sup>bc</sup>	9.36±0.21 <sup>c</sup>
	20	1.49±0.14 <sup>bc</sup>	3.06±0.30 <sup>bc</sup>	4.75±0.09 <sup>d</sup>	6.30±0.22 <sup>cd</sup>	8.23±0.09 <sup>cd</sup>
	30	0.82±0.22 <sup>c</sup>	1.93±0.19 <sup>cd</sup>	3.41±0.14 <sup>ef</sup>	5.61±0.08 <sup>de</sup>	7.14±0.11 <sup>d</sup>
10	10	1.53±0.36 <sup>bc</sup>	3.01±0.08 <sup>bc</sup>	4.84±0.33 <sup>cd</sup>	6.07±0.21 <sup>d</sup>	8.07±0.17 <sup>cd</sup>
	20	0.79±0.21 <sup>c</sup>	2.24±0.15 <sup>c</sup>	3.66±0.18 <sup>e</sup>	4.81±0.17 <sup>e</sup>	6.62±0.38 <sup>de</sup>
	30	0.17±0.07 <sup>d</sup>	0.96±0.09 <sup>d</sup>	2.89±0.16 <sup>f</sup>	3.75±0.31 <sup>f</sup>	5.39±0.20 <sup>e</sup>

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ( $\alpha = 5\%$ ).

**Table 3: Effect of gamma irradiation (kGy) and peracetic acid (ppm) on TBARS (mg malonaldehyde/kg) of refrigerated spiny eel**

Gamma irradiation (kGy)	Peracetic acid (ppm)	Storage (days)				
		1	5	10	15	20
0	10	4.87±0.08 <sup>a</sup>	7.33±0.11 <sup>a</sup>	13.49±0.06 <sup>a</sup>	18.70±0.15 <sup>a</sup>	25.96±0.11 <sup>a</sup>
	20	3.17±0.12 <sup>bc</sup>	5.41±0.06 <sup>bc</sup>	9.25±0.12 <sup>b</sup>	13.42±0.27 <sup>b</sup>	18.39±0.36 <sup>b</sup>
	30	2.63±0.21 <sup>c</sup>	3.86±0.17 <sup>d</sup>	6.87±0.24 <sup>d</sup>	9.67±0.09 <sup>d</sup>	13.24±0.22 <sup>c</sup>
5	10	3.75±0.13 <sup>b</sup>	5.79±0.24 <sup>b</sup>	8.14±0.19 <sup>c</sup>	11.53±0.12 <sup>c</sup>	12.90±0.07 <sup>d</sup>
	20	2.31±0.09 <sup>cd</sup>	4.67±0.13 <sup>c</sup>	6.45±0.35 <sup>de</sup>	8.79±0.06 <sup>e</sup>	10.16±0.25 <sup>ef</sup>
	30	1.83±0.18 <sup>de</sup>	2.55±0.07 <sup>f</sup>	4.91±0.08 <sup>e</sup>	6.12±0.24 <sup>f</sup>	7.05±0.19 <sup>g</sup>
10	10	2.09±0.24 <sup>d</sup>	3.69±0.05 <sup>de</sup>	6.86±0.23 <sup>d</sup>	9.04±0.19 <sup>de</sup>	10.33±0.33 <sup>e</sup>
	20	1.15±0.16 <sup>e</sup>	2.83±0.29 <sup>e</sup>	4.57±0.14 <sup>ef</sup>	7.21±0.30 <sup>ef</sup>	8.74±0.26 <sup>f</sup>
	30	0.37±0.05 <sup>f</sup>	1.06±0.34 <sup>f</sup>	2.63±0.09 <sup>f</sup>	3.95±0.27 <sup>g</sup>	5.11±0.11 <sup>h</sup>

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ( $\alpha = 5\%$ ).

**Table 4: Effect of gamma irradiation (kGy) and peracetic acid (ppm) on total plate count (log CFU/g) of refrigerated spiny eel**

Gamma irradiation (kGy)	Peracetic acid (ppm)	Storage (days)				
		1	5	10	15	20
0	10	2.59±0.27 <sup>a</sup>	4.73±0.14 <sup>a</sup>	6.87±0.22 <sup>a</sup>	8.45±0.07 <sup>a</sup>	9.69±0.24 <sup>a</sup>
	20	2.03±0.35 <sup>ab</sup>	3.95±0.09 <sup>ab</sup>	5.13±0.17 <sup>bc</sup>	6.73±0.36 <sup>bc</sup>	8.06±0.16 <sup>bc</sup>
	30	1.70±0.19 <sup>b</sup>	2.88±0.30 <sup>b</sup>	4.21±0.18 <sup>d</sup>	5.39±0.19 <sup>cd</sup>	6.85±0.08 <sup>cd</sup>
5	10	2.07±0.08 <sup>ab</sup>	3.94±0.14 <sup>ab</sup>	5.69±0.26 <sup>b</sup>	7.15±0.26 <sup>b</sup>	8.41±0.14 <sup>b</sup>
	20	1.42±0.27 <sup>bc</sup>	2.92±0.05 <sup>b</sup>	4.58±0.15 <sup>cd</sup>	5.98±0.13 <sup>c</sup>	7.03±0.19 <sup>c</sup>
	30	0.95±0.16 <sup>c</sup>	2.03±0.23 <sup>bc</sup>	3.64±0.29 <sup>de</sup>	4.69±0.09 <sup>d</sup>	5.47±0.23 <sup>de</sup>
10	10	1.63±0.19 <sup>b</sup>	2.84±0.17 <sup>b</sup>	4.97±0.13 <sup>c</sup>	6.06±0.18 <sup>c</sup>	7.14±0.07 <sup>c</sup>
	20	1.01±0.34 <sup>c</sup>	1.65±0.08 <sup>c</sup>	3.22±0.24 <sup>e</sup>	4.73±0.12 <sup>d</sup>	6.01±0.20 <sup>d</sup>
	30	0.17±0.22 <sup>d</sup>	0.59±0.16 <sup>d</sup>	1.98±0.17 <sup>f</sup>	3.05±0.31 <sup>e</sup>	4.72±0.16 <sup>e</sup>

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ( $\alpha = 5\%$ ).

**Table 5: Effect of gamma irradiation (kGy) and peracetic acid (ppm) on overall acceptance (sensory score) of refrigerated spiny eel**

Gamma irradiation (kGy)	Peracetic acid (ppm)	Storage (days)				
		1	5	10	15	20
0	10	7.04±0.06 <sup>d</sup>	6.88±0.00 <sup>d</sup>	6.53±0.05 <sup>d</sup>	6.24±0.02 <sup>d</sup>	5.33±0.03 <sup>e</sup>
	20	7.82±0.02 <sup>c</sup>	7.54±0.04 <sup>cd</sup>	7.21±0.03 <sup>cd</sup>	7.03±0.01 <sup>cd</sup>	6.54±0.00 <sup>d</sup>
	30	8.16±0.03 <sup>b</sup>	8.03±0.01 <sup>b</sup>	7.82±0.02 <sup>b</sup>	7.42±0.00 <sup>c</sup>	7.16±0.02 <sup>bc</sup>
5	10	7.89±0.07 <sup>c</sup>	7.66±0.03 <sup>c</sup>	7.34±0.00 <sup>c</sup>	7.01±0.03 <sup>cd</sup>	6.89±0.04 <sup>cd</sup>
	20	8.03±0.04 <sup>bc</sup>	7.93±0.02 <sup>bc</sup>	7.65±0.01 <sup>bc</sup>	7.39±0.05 <sup>c</sup>	7.11±0.01 <sup>bc</sup>
	30	8.35±0.01 <sup>ab</sup>	8.22±0.06 <sup>ab</sup>	8.01±0.03 <sup>ab</sup>	7.78±0.02 <sup>b</sup>	7.48±0.00 <sup>ab</sup>
10	10	8.01±0.02 <sup>bc</sup>	7.94±0.04 <sup>bc</sup>	7.81±0.04 <sup>b</sup>	7.63±0.01 <sup>bc</sup>	7.03±0.03 <sup>c</sup>
	20	8.14±0.00 <sup>b</sup>	8.09±0.03 <sup>b</sup>	7.95±0.01 <sup>ab</sup>	7.84±0.02 <sup>ab</sup>	7.32±0.00 <sup>b</sup>
	30	8.57±0.03 <sup>a</sup>	8.39±0.01 <sup>a</sup>	8.13±0.00 <sup>a</sup>	8.01±0.03 <sup>a</sup>	7.65±0.01 <sup>a</sup>

Note: the values were expressed as the mean of twenty two samples; the same characters (denoted above), the difference between them was not significant ( $\alpha = 5\%$ ).

Surendra et al. (2018) reported that thiobarbituric acid levels in tilapia muscle increased up to the 28<sup>th</sup> day of storage, and then underwent reductions by low-dose gamma irradiation.

In the current study, the microbial load increased in all the samples during 20 days of storage. Generally, the total plate count of treated spiny eel were significantly lower than the non-treated ones (table 4). Gamma irradiation and peracetic acid created a synergistic effect to kill microorganism. Chen et al. (1996) and Mendes et al. (2005) showed that the mesophilic bacterial counts of irradiated shrimp, crab, and fish were lower than those in the non- irradiated samples during storage at 4°C. Abreu et al. (2009) confirmed that 6 kGy dose was highly efficient in inhibiting *V. cholerae* O1 and *S. enteritidis* and in decreasing lipid oxidation in shrimps compared

with the nonirradiated product. Manjanaik et al. (2018) proved that irradiation doses of 3 and 5 kGy produced an immediate reduction of 2 and 3 log units of aerobic plate counts in squid. Peracetic acid probably reduced the pH of fish to cause an adverse effect for microorganism growth and proliferation (Tajkarimi and Ibrahim, 2011; In et al. 2013). A reduction 0.4÷1.4 log CFU/g of *Escherichia coli* Pangasius fish after sanitizing with peracetic acid solution 10÷150 ppm in 10÷240 seconds (Anh et al. 2015). Peracetic acid was superior to sodium hypochlorite in eliminating *L. monocytogenes* (Lizziane and Martinis, 2015). Surendra et al. (2018) reported that *coliform* on tilapia muscle stored at 0°C was eliminated by 1 kGy irradiation.

In the current study, the overall acceptance decreased in all the samples during 20 days of storage. It's clearly notice that the acceptability of

treated spiny eel were significantly higher than the non-treated ones (table 5). A fish irradiation dose ranging from 1 to 5 kGy has been suggested for shelf life extension (Venugopal et al. 1999; Jo et al. 2004). Minh (2020) showed that 75ppm peracetic acid was appropriate to maintain physicochemical, microbial and sensory characteristics of fresh *Pangasius* fillet during storage. Surendra et al. (2018) confirmed that shelf-life of 3 kGy irradiated Tilapia was extended to 70 days, and 1 kGy irradiated tilapia had a shelf-life of 56 days. Meanwhile, control samples had a shelf-life of 7 days. Gamma irradiation at dose 0.5, 1.0 and 2.0 kGy and cold storage at 4°C was adequate to extend the shelf-life of *Scylla serrate* for 14 days (Arshad et al. 2015).

### CONCLUSION

By perfect nutritional benefits, there was a great demand of spiny eel consumption. As one kind of fatty fish, spiny eel was highly sensitive to lipid oxidation during preservation. Gamma irradiation utilized field of high energy radiation to be directly to inactivate pathogenic bacteria so as to keep the freshness, quality and nutritional fish. A combination of gamma irradiation at 5÷10 kGy and peracetic acid at 10÷30 ppm created a synergistic effect on the limitation of TVB-N, TMA-N, TBARS, microbial load and enhancement of overall acceptance during refrigerated storage of spiny eel for 20 days. Hurdle effect derived from irradiation and low acidity provided better improvement to control lipid oxidation, bacterial proliferation in fish processing and preservation..

### CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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### AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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### REFERENCES

- Abreu V. K. G., J. F. F. Zapata, E. A. T. Figueiredo, D. S. Garruti, E. R. Freitas, A. L. F. Pereira, A. R. C. Braga (2009). Gamma irradiation on frozen and packaged headed shrimp. *Journal of Food Quality* 32: 425-435.
- Ahmed I. O., M. D. Alur, A. S. Kamat, J. R. Bandekar, P. Thomas (1997). Influence of processing on the extension of shelf life of Nagli fish (*Sillagosihama*) by gamma radiation. *International Journal of Food Science and Technology* 32: 325-332.
- Anh N. T. T., I. Sampers, S. V. Haute, S. Samapundo, B. L. Nguyen, M. Heyndrickx, F. Devlieghere (2015). Decontamination of *Pangasius* fish (*Pangasiushypophthalmus*) with chlorine or peracetic acid in the laboratory and in a Vietnamese processing company. *International Journal of Food Microbiology* 208: 93-101.
- Arshad K., K. Sudha, A. A. M. Hatha, G. Anilkumar (2015): Combined effect of gamma irradiation and cold temperature storage on the sensory properties of edible estuarine crab *Scylla serrata*. *International Food Research Journal* 22: 2253-2258.
- Arunkumar L. (2016). *Macrogathussiangensis*, a new spiny eel from Brahmaputra basin, Arunachal Pradesh, Northeast India (Teleostei: Synbranchiformes). *Journal of Research in Biology*, 6: 2003-2012.
- Arvanitoyannis I. S. and A. C. Stratakos (2010). Effect of irradiation on fish and seafood. In *Irradiation of Food Commodities*, p. 287–365, London: Academic Press.
- Aubourg S. P., F. Perez-alonso, J. M. Gallardo (2004). Studies on rancidity inhibition in frozen horse mackerel (*Trachurus trachurus*) by citric and ascorbic acids. *European Journal of Lipid Science and Technology* 106: 232-240.
- Barraza F. A. A., R. A. Q. Leon, P. X. L. Alvarez (2015). Kinetics of protein and textural changes in Atlantic salmon under frozen storage. *Food Chemistry* 182: 120–127.
- Bremner A. H. (2002). Safety and quality issues in fish processing (1<sup>th</sup>ed.). Boca Raton: Woodhead Publishing.

- Carlos F. M. G., T. M. Eliane, M. L. G. Monteiro, M. Lemos, S. B. Mano, C. A. C. Junior (2016). The chemical quality of frozen Vietnamese *Pangasius hypophthalmus* fillets. *Food Sci Nutr* 4: 398–408.
- Chen Y. P., L. S. Andrews, R. M. Grodner (1996). Sensory and microbial quality of irradiated crab meat products. *Journal of Food Science* 61: 1239-1242.
- Cheour F. (2014). Gamma irradiation prolongs the sea bass (*Dicentrarchus labrax*.L) storage and delays the lipid membrane degradation. *International Journal of Nutrition and Food Sciences* 3: 326-332.
- Chouliara I., I. N. Savvaidis, K. Riganakos (2005). Shelf-life extension of vacuum-packaged sea bream (*Sparus aurata*) fillets by combined  $\gamma$ -irradiation and refrigeration: microbiological, chemical and sensory changes. *Journal of the Science of Food and Agriculture* 85: 779-784.
- Connell J. J. (1990). Methods of assessing and selecting for quality. In Control of fish quality. London: Fishing News Books Ltd.
- El-Ghafour S.A and A. H. Zakar (2017). Impact of gamma irradiation on the quality of tilapia fish (*Oreochromis niloticus*) fillets stored under refrigerated condition. *International Journal of ChemTech Research* 10: 573-581.
- Evans D. A. (2000). Disinfectants. *Wiley Encyclopedia of Food Science and Technology* 1: 501-509.
- Gokodlu N., O. Ozden, N. Erkan (1998). Physical, chemical and sensory analysis of freshly harvested sardines (*Sardina pilchardus*) stored at 4°C. *Journal of Aquatic Food Products Technology* 7: 5-15.
- Heising J. K., M. A. J. S. Van Boekel, M. Dekker (2014). Mathematical models for the trimethylamine (TMA) formation on packed cod fish fillets at different temperatures. *Food Research International* 56: 272–278.
- Huss H. H. (1988). Fresh fish quantity and quality changes. FAO Fisheries, Series No. 29, Rome: Danish International Development Agency.
- In Y. W., J. J. Kim, H. J. Kim, S. W. Oh (2013). Antimicrobial activities of acetic acid, citric acid and lactic acid against *Shigella* species. *Journal of Food Safety* 33: 79-85.
- Indergard E., I. Tolstorebrov, H. Larsen, T. M. Eikevik (2014). The influence of long-term storage, temperature and type of packaging materials on the quality characteristics of frozen farmed Atlantic salmon (*Salmo Salar*). *Int. J. Refrig* 41: 27–36.
- Jo C., N. Y. Lee, S. P. Hon, Y. H. Kim, M. W. Byun (2004). Microbial contamination of the food materials for manufacturing Korean laver rolls (Kimbab) and the effect of gamma irradiation. *Journal of Food Science and Nutrition* 9: 236-239.
- John D., S. Summerfelt, D. L. Straus, K. K. Schrader, C. Good (2018). Evaluating the effects of prolonged peracetic acid dosing on water quality and rainbow trout *Oncorhynchus mykiss* performance in recirculation aquaculture systems. *Aquacultural Engineering* 84: 117-127.
- Karlsdottir M. G., K. Sveinsdottir, H. G. Kristinsson, D. Villot, B. D. Craft, S. Arason (2014). Effects of temperature during frozen storage on lipid deterioration of saithe (*Pollachius virens*) and hoki (*Macruronus novaezelandiae*) muscles. *Food Chem.* 156: 234–242.
- Lacroix M. and B. Ouattara (2000). Combined industrial processes with irradiation to assure innocuity and preservation of food products - A review. *Food Research International* 33: 719-724.
- Lizziane K. W. and E. C. P. Martinis (2015). Different methods to quantify *Listeria monocytogenes* biofilms cells showed different profile in their viability. *Braz J Microbiol.* 46: 231–235.
- Mahapatra A. K., K. Muthukumarappan, J. L. Julson (2005). Applications of ozone, bacteriocins and irradiation in food processing: A review. *Critical Reviews in Food Science and Nutrition* 45: 447-461.
- Manjanaik B., N. Kavya, V. Shetty, H. Somashekarappa, P. Rajashekar (2018). Influence of gamma irradiation and low temperature storage on the quality and shelf life of squid (*Doryteuthis sibogae*). *Food Research* 2: 39 – 45.
- Mbarki R., S. Sadok, I. Barkallah (2009). Quality changes of the mediterranean horse mackerel (*Trachurus mediterraneus*) during chilled storage: The effect of low-dose gamma irradiation. *Radiation Physics and Chemistry* 78: 288-292.
- Mendes R., H. A. Silva, M. L. Nunes, J. M. A. Empis (2005). Effect of low-dose irradiation and refrigeration on the microflora, sensory characteristic and biogenic amines of Atlantic horse mackerel

- (*Trachurus trachurus*). *European Food Research Technology* 21: 329-335.
- Minh N. P. (2020). Effectiveness of peroxyacetic acid as disinfectant to physicochemical, microbial and organoleptic characteristics of fresh *Pangasius fillet* during chilling storage. *Journal of Global Pharma Technology* 12: 318-322.
- Minh N. P. and H. T. Nghia (2019). Implementation of chitosan coating for preservation of dried spiny eel (*Mastacembelidae*). *Plant Archives* 19: 232-236.
- Minh N. P., H. T. T. Kieu, V. T. B. Lieu (2018). Production of curcumin- dry- salted spot-fin spiny eel (*Macragnathussiamenis*). *Journal of Global Pharma Technology* 10: 489-495.
- Monteiro M. L. G., E. T. Marsico, C. E. Teixeira, S. B. Mano, C. A. Conte Junior, H. C. Vital (2012). Validade comercial de filés de tilápia do Nilo (*Oreochromis niloticus*) resfriados e embalados em atmosfera modificada e irradiados. *Ciência Rural*. 42: 737–743.
- Muhammad H. and P. Hesih (2017). Gamma irradiation technology to preservation of foodstuff as an effort to maintain quality and acquaint the significant role of nuclear on food production to Indonesia society: A review. *Energy Procedia* 127: 302-309.
- Oraei M., A. A. Motalebi, E. Hoseini, S. Javan (2011). Effect of gamma irradiation and frozen storage on microbial quality of rainbow trout (*Oncorhynchus mykiss*) fillet. *Iranian Journal of Fisheries Sciences* 10: 75-84.
- Ozden O. and N. Erkan (2010). Impacts of gamma radiation on nutritional components of minimal processed cultured sea bass (*Dicentrarchus labrax*). *Iranian Journal of Fisheries Sciences* 9: 265-278.
- Qiu X., S. Chen, G. Liu, Q. Yang (2014). Quality enhancement in the Japanese sea bass (*Lateolabrax japonicus*) fillets stored at 4°C by chitosan coating incorporated with citric acid or licorice extract. *Food Chem.* 162: 156–160.
- Raghavan S. and H. O. Hultin (2005). Model system for testing the efficacy of antioxidants in muscle foods. *Journal of Agriculture Food Chemistry* 53: 4572- 4577.
- Rodriguez-Turienzo L., A. Cobos, V. Moreno, A. Caride, J. M. Vieites, O. Diaz (2011). Whey protein-based coatings on frozen Atlantic salmon (*Salmo salar*): Influence of the plasticiser and the moment of coating on quality preservation. *Food Chemistry* 128: 187–194.
- Surendra I. H. W., E. M. R. K. B. Edirisinghe, R. M. N. P. Rathnayake (2018). Effect of low-dose gamma irradiation on the quality of tilapia fish muscle with storage at 0°C. *American Journal of Food Science and Technology* 6: 237-246.
- Tajkarimi M. and S. A. Ibrahim (2011). Antimicrobial activity of ascorbic acid alone or in combination with lactic acid on *Escherichia coli* O157: H7 in laboratory medium and carrot juice. *Food Control* 22: 801-804.
- Takagi A. P., S. Ishikawa, T. Nao, S. L. Song, S. Hort, K. Thammavong, B. Saphakdy, A. Phomsouvanhm, M. Nishida, H. Kurokura (2011). Genetic differentiation of *Macragnathussiamensis* within the Mekong River between Laos and Cambodia. *Journal of Applied Ichthyology*, 27: 1150-1154
- Tyson R. R. (1986) Systematic review of the *Mastacembelidae* or spiny eels of Burma and Thailand, with description of two new species of *Macragnathus*. *Japanese Journal of Ichthyology* 3: 95-109.
- Venugopal V., S. N. Doke, P. Thomas (1999). Radiation processing to improve the quality of fishery products. *Critical Review in Food Science and Nutrition* 39: 391-440.
- Zaki M. E., H. El-Bassyouni, S. Kamal, M. El-Gammal, E. Youness (2014). Association of serum paraoxonase enzyme activity and oxidative stress markers with dyslipidemia in obese adolescents. *Indian J. Endocrinol. Metab.* 18: 340–344.