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Effects of gamma radiation on nutritional and microbial quality of *Pampus chinensis* (Euphrasen 1788)

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Abstract
To evaluate the efficiency of gamma radiation in combination with low temperature Chinese pomfret, *Pampus chinensis* were preserved by the treatment of different doses of gamma radiation (3, 5 and 8 KGy) at freezing temperature (-20°C) during 90 days of storage period. Quality assessments for fish were carried out at an interval of 15 days during the storage period. Quality assessments were done by organoleptic, chemical (Total Volatile Nitrogen, TVN and Trimethylamine, TMA) and microbiological (Total Bacterial Count, TBC and Total Mould Count, TMC) evaluation. From the analysis of all parameters, maximum shelf-life was observed for irradiated (8 KGy) sample. It remained acceptable up to 75 days and that was the highest duration among 4 types of samples.

Key words: *Pampus chinensis*, Gamma radiation, Nutritional and microbial quality

Introduction

Chinese pomfret, *Pampus chinensis* is very rich in nutritional properties and very popular high valued marine fish species in Bangladesh. Since fish is the main source of our animal protein intake as well as a valuable source of foreign currency, its shelf-life extension is very much needed. Although some protein is removed from the fish during storage, irradiation did not affect the quality of the proteins including myoglobin, as indicate by the spectral characteristics of the melt water. Food irradiation is a process exposing food to ionizing radiations such as gamma rays emitted from the radioisotopes ^{60}Co and ^{137}Cs, or high energy electrons and X-rays produced by machine sources. Depending on the absorbed radiation dose, various effects can be achieved resulting in reduced storage losses, extended shelf life and improved microbiological and parasitological safety of foods. Irradiation of the main commodities such as tuber and bulb crops, stored grains, dried ingredients, meats, poultry and fish, or fruits has an enormous literature evolved during the past 60 years (Molins 2001). Recent research and development directed more on irradiation of minimally processed fresh produce and

cook-chill foods, where our own laboratories are also involved (Farkas 2001a). In the year 2002, the estimated volume of these products treated by irradiation was approximately 90,000 ton (Rubio 2003). Several USDA agencies are collaborating to make irradiated meat and poultry available for use also in the National School Lunch Program of the USA (Murano 2003) and the Food Safety and Inspection Service (FSIS) of the USDA develops an educational program on irradiated meat and poultry. In the above context, the present study was undertaken to determine the effect of radiation on the rate of spoilage of the preserved fish at low temperature (-20°C) and also the feasibility of radiation and consumers acceptance of preserved fish.

Materials and methods

Preparation of samples

All investigations were carried out in the laboratory of Food Processing & Preservation Division, Institute of Food & Radiation Biology (IFRB), Atomic Energy Research Establishment (AERE), Savar, Dhaka. Specimen fish, Chinese pomfret, (*Pampus chinensis*) commonly known in 'Rup Chanda' was selected for the study. Fresh pomfret were collected from the Malibag Bazar, Dhaka. Fishes were divided into the 4 groups: sample A: [control], sample B: irradiated [3KGy], sample C: irradiated [5KGy], sample D: irradiated [8KGy]. All the samples were preserved at -20°C. Sample A was kept at -20°C without irradiation. Sample B, C and D will be subjected to irradiate in 3, 5 and 8 KGy panoramic Co-60 source supplied by the Atomic Energy of Canada Ltd.

Analytical methods

Fishes were first beheaded, degutted, washed and drained. Then only the muscles were collected for biochemical composition. Biochemical composition i.e. protein, lipid, ash and dry matter were determined by the methods described by AOAC (1975). Total volatile nitrogen (TVN) and Trimethyleamine (TMA) were estimated by "Conway dish" technique.

Calcium was determined by precipitating it as calcium oxalate and titrating the solution of oxalate in dilute sulfuric acid against standard potassium permanganate, $KMnO_4$. Phosphorus was estimated by measuring cotorimetric procedure.

Organoleptic analysis

Sensory evaluation for the detection of freshness or shelf-life of the stored fish and consumer's acceptance was performed with high degree of reliability by organoleptic evaluation following the method of Peryam and Pilgrim (1957) and Miyanchui *et al.* (1964). Quality assessment of preserved sample were studied at an interval of 15 days up to 90 days .

Total Bacterial Count (TBC) and Total Mould Count (TMC)

Total bacteria and mould count were estimated by the pour plate technique in petridishes. Viable colonies that developed on the plates after incubation at 37°C and

30°C in an incubator were count by colony counter (Gallenhamp colony counter, England). Finally the bacterial and mould count were obtained multiplying the number of colonies with dilution factor. The count was expressed as cfu/gm.

Results and discussion

Bio-chemical composition

The arerage moisture content of *Pampus chinensis* was 78.08±0.1% (Table 1). Rubbi *et al.*, (1987) stated that the biochemical composition and mineral contents of the fish analyzed on wet-weight basis showed that moisture of fresh fish varied from 72.1 % - 83.6 % with an average 77.64 %, fat content varied from 0.8 % - 15 % with an average 1.95 % and the protein and ash contents varied from 11.9 % - 21.9 % and 0.8 % - 5.11 % respectively (Table 1). The average protein content was determined in this study 15.75±0.4 %. Chandrasheker and Deosthale (1993) observed that a wide variation exist in protein of freshwater fishes and it were 13.5% to 17.3%. Akande *et al.*, (1991) estimated the lipid content of mackerel *(Scomber scombrus)* was 13.2% of fish. Akande *et al.* (1991) estimated the ash content of mackerel *(Scomber scombrus)* which was 1.2 % per gm of fish. The distribution of mineral contents in the ash samples was also found to vary considerably for calcium 7.2-363 mg/100gm, phosphorus 11.9-170 mg/100gm.

In the present study, mineral content such as calcium and phosphorus were 200 mg per 100 gm and 14O mg per 100 gm of fish muscle respectively (Table 1). Rubbi *et al.* (1989) found that calcium content of Chapila *(Gudushia chapra)* was 117.9 mg, Foli *(Notopterus notopterus)* was 220 mg, Koi *(Anabas testudinus)* was 300 mg and Kachki *(Corica suborna)* was 359 mg. According to Rubbi *et al.* (1987) the phosphorus content of Koi *(Anabas testudinus)* was 75.2 mg, Bele *(Glossogobius gaiuris)* was 75.2 mg, Chapila was 143 mg, Foli and Kachki were 153.9 mg and 172.30 mg respectively.

Table 1. Bio-chemical composition of Chinese pomfret, *Pampus chinensis*

Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Calcium (mg/100gm)	Phosphorus (mg/100gm)
77.50	16.79	1.92	4.25	190	160
78.20	14.75	2.15	3.90	210	140
78.56	15.73	1.79	2.76	200	120
Av. 78.08±0.1	Av. 15.75±0.4	Av. 1.95±0.16	Av. 3.63±0.2	Av. 200 ±4.4	Av. 140±4.4

Protein and lipid content at different anatomical position of controlled and irradiated samples shown in (Tables 2, 3) were determined to observe the effect of radiation on protein and lipid. For that reason samples were taken from both dorsal and ventral position.

Table 2. Protein (%) at different anatomical position of fresh *Pampus chinensis*

Position	3KGY	5KGY	8KGY
Dorsal	15.85	16.10	14.45
Ventral	15.25	15.20	15.80
Average	15.55	15.65	15.12

Table 3. Lipid (%) at different anatomical position

Position	3KGY	5KGY	8KGY
Dorsal	6.32	5.66	4.43
Ventral	4.65	5.84	5.12
Average	5.49	5.75	4.77

Organoleptic evaluation

Organoleptic scores of control fish come down 8.49 to 3.20 stored at -20°C respectively. Whereas in the some storage temperature and storage period the organoleptic scores of irradiated fish were come down from 8.74 to 4.00, 8.95 to 5.50 and 9.0 to 6.5, respectively in 3, 5 and 8 KGY (Table 4). Muscle of live fishes is more or less sterilized but after death autolytic, bacterial and other changes occur (Huss 1986). The physical changes could be perceived with sense organs.

The organoleptic scores were gradually decreased with the progress of storage period. Only irradiated samples stored at -20° C temperature showed the acceptable score up to 90 days. The quality of control sample was gradually decreasing during storage. The effect of radiation on fresh fish during 90 days of storage was studied by (Ghaly *et al.* 2000) and no undesirable changes in the sensory properties of the fish compared with control samples were found.

Table 4. Organoleptic scores of *Pampus chinensis* during storage period at -20°C

Storage period (days)	Control	Irradiated 3KGY	Irradiated 5KGY	Irradiated 8KGY
0	8.49	8.74	8.95	9.0
15	8.24	8.41	8.66	8.5
30	7.33	7.66	7.30	8.0
45	6.49	7.48	7.49	8.0
60	4.91	5.91	6.66	7.5
75	3.66	5.00	5.24	7.0
90	3.20	4.00	5.50	6.5

Total Volatile Nitrogen (TVN)

Regarding the shelf-life of control and irradiated Pomfret stored at -20°C, the TVN values were found to increase gradually from the moment of preservation. The initial TVN values for control and irradiated fishes were 4.5 and 3.0 (3 KGY), 2.5 (5 KGY) and 1.5 (8 KGY) mg nitrogen per 100 gm respectively (Table 5). It was observed that TVN value exceeds 30 mg nitrogen per 100 gm of muscle, the fish become unacceptable. Ota (1985) also found that the total volatile nitrogen increased with the increase of time during spoilage and all of them suggested that 30 mg nitrogen per 100 gm of fish muscle should be taken as the upper limit for acceptability.

Table 5. Total Volatile Nitrogen (TVN) (mg N/1OO g) in control and irradiated *Pampus chinensis* during storage period at -20°C

Storage period (days)	Control (mgN/100g)	Irradiated 3KGY	Irradiated 5KGY	Irradiated 8KGY
0	4.5	3.0	2.5	1.5
15	5.6	3.2	2.9	2.0
30	7.5	4.1	3.5	2.7
45	10.6	5.2	3.9	3.1
60	16.8	5.9	4.3	3.5
75	24.6	6.3	4.8	4.2
90	32.5	7.1	5.3	4.9

At the beginning of storage period, TVN value was comparatively higher in control sample than other samples. This value rapidly increased in control sample than irradiated samples which were storage at -40°C. From the present investigation it was found that the fish samples which were stored at -20°C were acceptable almost 90 days in case of irradiated samples. Hossain *et al.* (2001) experimented on effect of radiation on whole and degutted fish *(Rastrelliger kanagurta)* at low temperature (0°C) and found that the acceptable TVN limit of degutted control and irradiated samples were 28 and 35 days respectively. It was lower than the present investigation because of low temperature. At the 0 day he reported the initial TVN value was 2.3 mg nitrogen per 100 gm of fish.

Trimethylamime (TMA)

At the beginning of storage period, TMA value was comparatively higher in control sample 7.5 (Table 6) than other samples. This value rapidly increased in control sample than chemical treated and irradiated samples which were at -20°C. During storage period this value were found to increase gradually as 7.5 mg % to 55 mg % in control, 6 mg % to 45 mg % in irradiated (3 KGY), 5 mg to 27.5 mg % in 5 KGY and 4 mg to 18.7 mg % in 8 KGY sample stored at -20°C.

Table 6. Trimethylamine (TMA) (mg N/lOO gm) in controland irradiated *Pampus chinensis* during storage period at -20° C

Storage period (days)	Control (mgN/lOOgm)	Irradiated 3 KGY	Irradiated 5KGY	Irradiated 8KGY
0	7.5	6.0	5.0	4.0
15	13.0	10.0	7.5	6.0
30	20.0	17.5	10.0	7.5
45	22.5	17.5	14.5	10.5
60	27.5	25.5	20.0	12.7
75	42.0	37.5	22.5	14.3
90	55.0	45.0	27.5	18.7

Hossain *et al.* (2001) reported the effect of irradiation on the shelf-life extension of mackerel and the TMA values of these sample indicated that the increase of TMA values in irradiated sample were significantly less. Hossain *et al.* (2000) also reported on the potassium-sorbet effectiveness on *Labeo rohita* and found that the TMA values of these sample indicated that the acceptable of degutted treated fish was 26 days which was more similar to the present investigation.

Total Bacterial Count (TBC)

At the beginning of storage period total bacterial counts were affected by the radiation. The initial period of storage control sample was shown maximum ($1.3x10^4$ cfu/gm) bacterial colony and irradiated samples were shown minimum (00 cfu/gm) bacterial colony. At 90 days of observation (Table 7) shown that the bacteria were gradually increased as $2.1x10^5$ cfu/gm in control sample stored at -20°C, $2.3x10^4$ cfu/gm in 3 KGY, $6.7x10^3$ cfu/gm in 5KGY and $3.5x10^3$ cfu/gm in 8KGY sample stored at -20°C. Control samples contained more bacteria than those of irradiated samples.

Table 7. Total bacterial count (TBC) (cfu/gm) in control and irradiated *Pampus chinensis* during storage period at -20° C

Storage period (days)	Control	Irradiated 3KGY	Irradiated 5 KGY	Irradiated 8KGY
0	$1.3X10^4$	$2.1X10^2$	00	00
15	$2.5X10^4$	$2.7X10^3$	00	00
30	$3.2X10^4$	$4.1X10^3$	$1.0X10^3$	00
45	$2.9X10^4$	$3.7X10^3$	$2.3X10^2$	$1.5 X10^2$
60	$3.5X10^4$	$1.4X10^4$	$5.4X10^3$	$1.3 X10^3$
75	$3.8X10^4$	$1.8X10^4$	$6.1X10^3$	$2.8 X10^3$
90	$2.1 X 10^5$	$2.3 X10^4$	$6.7 X10^3$	$3.5 X10^3$

Hossain *et al.* (2001) experimented the radiation effect of mackerel fish *(Rastrelliger kanagurta)* at low dose. He found that the irradiated degutted sample remained acceptable upto 29 days at 4°C. In the present investigation, TBC were higher than that of above mentioned findings but this result more supported to the preseent findings. Lee *et al.* (2001) reported that irradiation significantly affected bacterial count at the dose of 5 KGy, shelf life was enhanced effectively by suppression of microbial growth and proliferation.

Total Mould Count (TMC)

At the beginning of storage period, there were no moulds in the irradiated samples. Both control and irradiated samples were examined and total mould counts were affected by the radiation. The initial period of storage, control samples were shown maximum ($1.1x10^3$cfu/g) mould colony and irradiated samples were shown minimum ($1.2x10^2$ cfu/g) mould colony in 8 KGy. At the 90 days observation (Table 8) shown that the mould were tremendously increased as $3.1x10^5$ cfu/g in control samples, $5.3x10^3$ cfu/g in 3 KGY, $3.8x10^4$ cfu/g in 5 KGY and $3.5x10^4$ cfu/g in 8 KGY sample stored at -20°C. Control samples contained more mould than those of irradiated samples.

Table 8. Total mould count (TMC) (cfu/gm) in control, and irradiated Chinese pomfret, *Pampus chinensis* during storage period at -20°C

Storage period (days)	Control	Irradiated 3KGY	Irradiated 5KGY	Irradiated 8KGY
0	$1.1X10^3$	$3.0X10^2$	$2.0X10^2$	$1.2\ X10^2$
15	$1.5X10^3$	$3.2X10^2$	$2.5X10^2$	$1.5\ X10^2$
30	$1.5X10^4$	$3.5X10^3$	$3.1X10^2$	$2.0\ X10^2$
45	$1.9X10^4$	$3.9X10^3$	$3.5X10^3$	$2.5\ X10^3$
60	$2.3X10^4$	$4.5X10^3$	$4.0X10^3$	$3.2\ X10^3$
75	$2.8X10^4$	$4.9X10^3$	$3.5X10^4$	$2.6\ X10^4$
90	$3.1\ X10^5$	$5.3\ X10^3$	$3.8\ X10^4$	$3.5\ X10^4$

Hossain *et al.* (2001) are reported that low temperature and radiation inhibited the rapid organoleptic degradation of fish during the long time preservation. Extension of shelf-life at radiation doses 5 KGy and 8 KGy did not bring about any notification. From the biochemical composition analysis, the contents of moisture, protein, lipid, ash, calcium and phosphorus were estimated as 78 %, 15.75 %, 1.95 %, 3.63 %, 0.20 % and 0.14 % respectively. In this view, Chinese pomfret should be treated as a highly nutritious fish. To extend the shelf-life of selected species, Chinese pomfret, (degutted) were treated with gamma radiation (3, 5 and 8 KGy) and stored at low temperature (-20°C) for 90 days. For determining the shelf-life extension of these fish sample some parameters like organoieplic score, total volatile nitrogen (TVN),

trimethylamine (TMA), total bacterial count (TBC), total mould count (TMC) were used in every 15 days of interval. So, from the present study, it can be concluded that irradiation (8 KGy) in combination with -20°C temperature is the best method for long time preservation of fresh fish.

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