Food Preservation

Development and Shelf-life Extension of Nutritious RTE Fish Spread using Gamma Irradiation

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Ready-to-eat fish spread

ABSTRACT

Modern lifestyle demands convenient, ready-to-cook (RTC), ready-to-eat (RTE), easily available and nutritious food. A high protein, low fat and no sugar-based spread was developed from readily available fish Bombay Duck *(Harpadonnehereus*). The shelf life of fish spread was extended by 2 months using gamma irradiation (5 kGy) and chilled storage (4 °C). Acceptability of the spread was confirmed based on microbiological, biochemical and organoleptic assessments. No significant change in the nutritional quality between non-irradiated and radiation processed samples was observed. The fish spread is safe for all consumers including diabetics and health conscious.

KEYWORDS: RTE, Fish spread, Nutritious, Shelf-life, *Harpodonnehereus*, Gamma irradiation

Introduction

Consumers' demand for healthy food products is increasing worldwide. Modernization has led to increase in the number of working personnel with higher income, education, better consciousness towards quality, freshness, nutrition, hygiene and health. This has necessitated supply of healthy, wholesome, nutritious diet consisting of low salt, low sugar, high protein and high fiber without compromising the taste. More emphasis is on development of convenient, minimally processed, ready to eat and easily available foods. Muscle food products are an essential component of a balanced diet in the developed countries. Their principal components, besides water, are proteins and fats, with substantial contribution of vitamins and minerals. Muscle proteins are of high nutritional quality due to their high biological value (BV) and bio-availability [1]. Fish is the most nutritious food consisting of proteins, long chain omega 3 fatty acids, vitamin D, selenium and iodine. This awareness has increased the demand for fish amongst the rich and the poor as a cheap and readily available source of nutrition. However, few convenient, RTC/ RTE fish products available in the supermarkets that include fish patties, fish burgers, cutlets, sausages etc. However, the fish-based products are highly perishable. There is a demand for meat-based spreads like fish spread which is not available at present. The Compounded Annual Growth Rate (CGAR) of spreads is expected to reach 23.7 billion by 2022[2]. In the present study, a low cost, easily available fish, Bombay duck (*Harpodon nehereus*) was used to develop a nutritious ready-to -eat (RTE) fish-spread and its shelf-life extension using gamma irradiation under chilled storage 4°C was studied by microbiological, biochemical, organoleptic and nutritional analysis.

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Development of Fish Spread

Fresh beheaded, eviscerated and deboned fish (Bombay duck or Bombil,) was cleaned by chilled water (4°C) and cut into small pieces. The fish was steamed under pressure to soften the fish muscle which makes easier for removal of soft muscular bones and homogenized. This was homogenized with spices and ingredients like finely chopped and sautéed fresh onion (25 %), garlic (2.4%), ginger (1%), green chilies (3%), coriander leaves (3.5%). The samples were packed in polypropylene (PP) containers (Trendplast Pouch Pack Private Limited, Mumbai) of 3.5 mm height x 1.2 mm thickness x 70 mm diameter and sealed using multilayered aluminum foil lid by cup sealer (Aman Engineering Works, Mumbai) set at 250 °C. The developed product is shown in Fig.1.

Fig.1: Ready to eat fish spread.

Irradiation and Storage Studies

Samples were irradiated at a dose of 5 kGy in ice in food package irradiator (Atomic Energy of Canada Ltd, with a ^{60}Co source at a dose rate of 3 kGy/h) while un-irradiated samples served as control. The dose measurements were done using Fricke dosimeter. Both the samples were stored at 4°C and

Table 1: Nutritional Composition of Control and Irradiated (5 kGy) Fish Spread.

	Control	Irradiated
Energy (kcal/100g)	106.61± 2.14ᵃ	108.26±3.36ᵃ
Protein (g/100g)	12.75±0.35ᵃ	13.59±1.01ᵃ
Fat	3.53±0.26ᵃ	3.54±0.37ᵃ
Carbohydrate	5.95±0.51ᵃ	5.49±0.36ᵃ
Sugar	0±0ᵃ	0±0ᵃ
Moisture	76.25±0.31ᵃ	75.73±1.11ᵃ
Ash	1.51±0.08ᵃ	1.63± 0.09ᵃ

Results are expressed as Mean ± SD. The values are average of 3 independent experiments in triplicates (n=9). Values marked by same letter (superscripts) are not significantly different (P ⩾ 0.05).

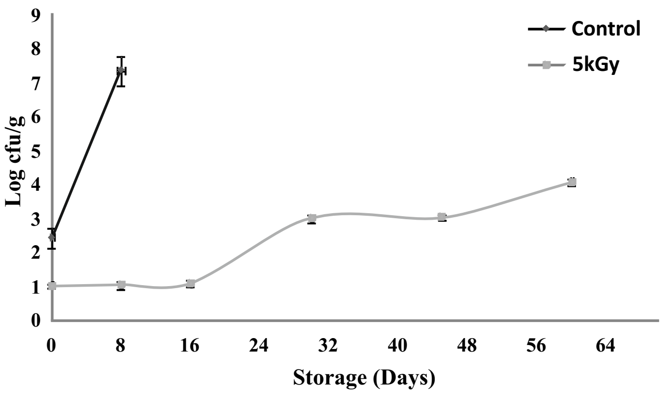

Fig.2: Total bacterial count (TBC) of control and irradiated (5kGy) on storage at 4ºC. The values are average of 3 independent experiments in triplicates (n=9).

analyzed on 0, 8, 16, 30, 45 and 60 days for quality and acceptance by microbiological, biochemical and organoleptic analysis. Nutritional analysis was validated through National Accreditation Board for Testing and Calibration Laboratories (NABL) certified laboratory (Ram Krishna Bajaj CFBP Consumer Education and Testing Center, Mumbai, India). The statistical analyses were performed with DSAASTAT ver, 1.101.

Results and Discussion

Nutritional Composition

Convenient, ready-to-eat, healthy food with high protein, low fat, low sugar is preferred by modern consumers. The market survey showed that the spreads had higher fat, sugar and low protein content. For example, an egg-less sandwich spread had fat content of 38.6%, protein content of 1.6%, sugar content of 8.2% and carbohydrate content of 8.7%; a cucumber carrot sandwich spread had fat content 37.4%, protein 2.0%, sugar content 13.2% and carbohydrate content of 18.2% while tomato onion jalapeno spread was low in fat (1.63%) as well as protein (0.71%) but contained 7% of sugar and 12.71% of carbohydrate. No significant ($p < 0.05$) difference in nutritional composition of control and irradiated fish spread was observed (Table 1). The developed RTE fish spread has a high protein content of 12-14%, low fat (3-4%) and carbohydrate (5-6%) content with low sugar content, making the fish spread a suitable choice for all including special requirement group like diabetics and calorie conscious consumers.

Microbiological Analysis

The initial bacterial load (2.42 ± 0.28 log cfu/g) of fish spread was reduced to 1.01 ± 0.06 log cfu/g in irradiated samples immediately on the zero day. The control samples showed increase in the microbial load on the 8th day of storage (7.35 ± 0.43 log cfu/g) indicating spoilage while, irradiated samples showed a gradual increase to 4.07 ± 0.11 log cfu/g at the end of 60 days of storage at 4ºC (Fig.2). Initially, total mold count was absent in both the samples which increased to 3.97± 0.01 logcfu/g after 8th day with mold growth visible on the control samples, while irradiated samples were free of mold growth till 60 days of storage. Similar results in the reduction of total microbial load and shelf life extension were observed in irradiated Threadfin bream whole fish, Tilapia fillets and Seer steaks on storage at 4ºC [3-5]. The repair mechanism of bacteria is hampered due to various hurdles used in the development of product, which affects their growth and hence, are not able to survive for long [6]. Therefore, irradiation along with refrigerated storage is essential for lower bacterial load and shelf-life extension of the fish spread up to 60 days.

Fish and fishery products are known to be carriers of different food borne pathogens [7]. Therefore, screening for the presence of important food-borne pathogens is essential to ensure safety of fishery products. The fish spread was free of all the food-borne pathogens tested (*Escherichia. coli, Salmonella* spp*, Listeria monocytogenes, Yersinia enterocolitica* and coagulase positive *Staphylococcus aureus*). indicating that the pathogenic bacteria in and around fish may be low or cooking of raw materials may have helped in lowering the microbial load.

Irradiation is the most widely studied decontamination method in fish species and is utilized in fresh, frozen, canned, dried and cured fish and also in ready-to-eat fish products[8]. There are reports of radiation preservation of minced meat-based product (Pâté), produced mainly from a minced mixture of offal (particularly liver), muscle, fat, vegetables, herbs and spices which is cooked at relatively low temperatures[9]. Radiation treatment (2-4 kGy) of many RTE foods like dried meat (beef jerky), uncooked and fermented minced meat products (salami), cooked offal or minced meat products (chicken liver pâté or luncheon sausage), and cooked whole meat products (ham) caused reduction of *Salmonella* spp. or *L. monocytogenes*[10].

Biochemical Indices

The results suggest a positive correlation between increase in the bacterial load and increased TVBN and TMAin fish spread for control samples (Table 2). There was no significant difference ($p < 0.05$) between the TVBN and TMA values of irradiated samples on storage; however, both control and irradiated samples showed the values within the prescribed limits of 35 mg N/100g and 15 mg N/100g respectively indicating a fresh original sample[11]. TVBN (8.4 ± 2.54 to 18.4 ± 2.42 mg N/100g) and TMA (3.51 ± 0.86 to 7.71 ± 0.50 mg N/100g) increased in control samples during storage of 8 days while it remained constant for irradiated samples up to 45 days and increased at the end of storage of 60 days (Table 2).

Both the control and irradiated samples showed increase in the TBA values from 1.67 ± 0.06 µg malondialdehyde/g (MA/g) to 1.95 ± 0.06 µg MA/g during storage of 8 days which are near the upper limit of 2 µg MA/g [11]. However, no significant difference ($p > 0.05$) in TBA values was observed between control and irradiated samples on the same day

Table 2: Biochemical analysis of control and irradiated (5 kGy) fish spread on storage at 4 ºC.

Parameters	Samples	Storage time (days) 0	8	15	30	45	60
TVBN (mg N/100g)	Control	8.4 ± 2.54 ^{b}	18.2 ± 2.42 ^{a}	ND	ND	ND	ND
	Irradiated	8.4 ± 1.19 ^{b}	8.4 ± 1.05 ^{b}	9.8 ± 2.42 ^{b}	9.8 ± 2.42 ^{b}	11.2 ± 2.42 ^{b}	19.8 ± 2.42 ^{a}
TMA (mg N/100g)	Control	3.51 ± 0.86 ^{cd}	7.71 ± 0.50 ^{a}	ND	ND	ND	ND
	Irradiated	2.93 ± 0.24 ^{d}	3.34 ± 0.37 ^{cd}	3.91 ± 0.24 ^{c}	3.42 ± 0.24 ^{cd}	5.60 ± 0.38 ^{b}	7.42 ± 0.24 ^{a}
TBA (µg MA/g)	Control	1.67 ± 0.06 ^{d}	1.95 ± 0.06 ^{c}	ND	ND	ND	ND
	Irradiated	1.74 ± 0.06 ^{d}	1.99 ± 0.06 ^{c}	2.34 ± 0.05 ^{a}	2.02 ± 0.07 ^{c}	2.13 ± 0.04 ^{b}	2.38 ± 0.06 ^{a}

ND= Not done as sample spoiled

Results are expressed as Mean ± SD. The values are average of 3 independent experiments in triplicates(n=9). Different letters (superscripts) in row/ column indicate significant differences (P $\leqslant$ 0.05) for each biochemical analysis.

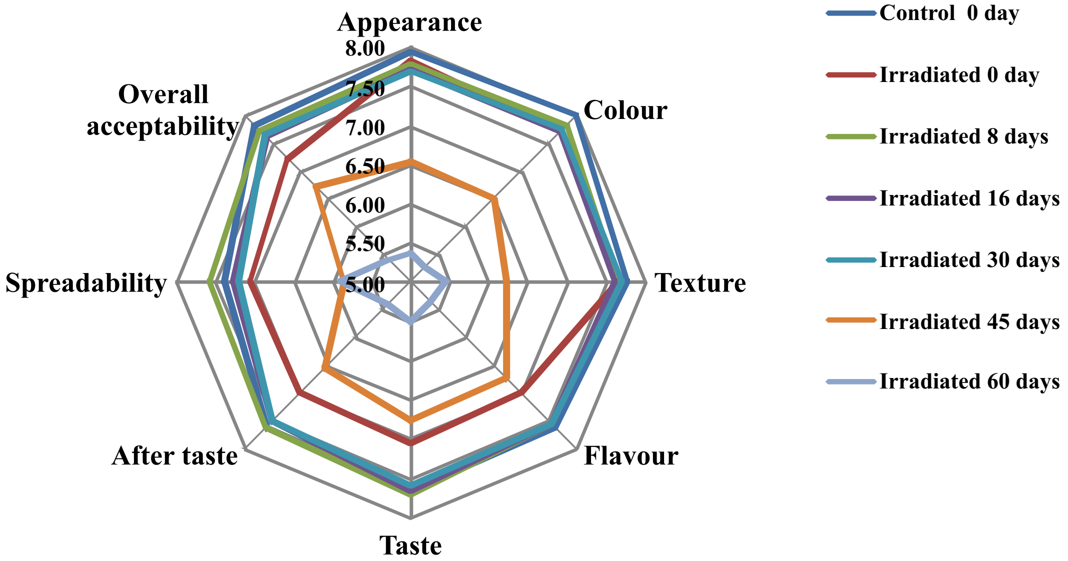

Fig.3: Web diagram showing organoleptic evaluation of control and irradiated fish spread on storage at 4˚C.

(Table 2). This may be due to low fat content of Bombay duck. These results are in accordance with other studies[12, 6].

Organoleptic Analysis

Organoleptic evaluation is the most popular method to assess freshness and acceptability of fish. Organoleptic properties including visual appearance, color, flavor and texture are the important parameters observed by the taste panelists during analysis. Initially, both control and irradiated samples had overall acceptability score of 7.8-7.2 respectively (Fig.3). The sensory web diagram showed no change in the sensory attributes of the irradiated samples on storage up to 30 days. However, on 45th day the overall score decreased to 6.7 (between like moderately and like slightly). On 60th day, score further decreased to 5.4 (between like slightly to neither like nor dislike). Thus, sensory acceptability decreased as the microbial load increased. Similar correlation between sensory scores and microbiological quality was observed previously [13-14].

Conclusion

A nutritious and RTE fish spread was developed with readily available fish, Bombay duck using hurdles like radiation processing (5 kGy) and chilled storage (4°C). The product was microbiologically, biochemically and organoleptically acceptable up to 60 days. Therefore, we suggest a shelf life of 60 days for irradiated RTE fish spread when stored under chilled temperature. The RTE fish spread treated by irradiation with extended shelf-life is pathogen free, protein, PUFA rich, and sugar free, making it suitable for all consumers of different age groups, including infants, elderly, malnourished, calorie conscious people and diabetics. It can be an ideal breakfast bread spread. Regular use of such spreads may provide desired health benefits without additional dietary supplements.

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