STUDIES ON RADIATION PASTEURISATION OF MEDIUM FATTY FISH
III. STORAGE PROPERTIES OF WHITE POMFRET *(STROMATEUS CINEREUS)* FILLETS

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White pomfret fillets packed under aerobic conditions had a limited shelf life of 8 days as against 10 days for samples packed under vacuum and stored at 0-2°C. Irradiation and subsequent storage of the fillets under vacuum at 0-2°C exhibited shelf lives of 30, 50 and 60 days for radiation doses of 0.1, 0.3 and 0.5 Mrad respectively in contrast to aerobically packed fillets which showed only 20, 35 and 50 days of storage life for the same levels of radiation doses and developed yellow discolouration and rancid odours.

INTRODUCTION

White pomfrets *(Stromateus cinereus)*, a choice fish variety, constitute 2-3% of the total marine fish catch in India (Venkataraman *et al* 1968). Serious problems of handling, processing and storage of the fish are encountered during glut seasons. Due to prevailing inadequate facilities for freezing of the fish and transportation of the frozen product, only a small percentage of available white pomfrets are preserved for slack season by freezing. It has been observed, however, that the acceptability of the frozen fish decreases progressively on account of the textural alterations (Sawant and Magar, 1961) and development of a characteristic yellow discolouration on the skin surface (Pawar and Magar, 1966; Kamasastri *et al* 1967). Ice storage is therefore mainly adopted for limited preservation and to meet the consumers' demand. However, due to indifferent methods of handling and processing, besides prevailing unhygienic conditions, the fish stored and transported in ice are prone to rapid microbial spoilage. Reckoning the limitations of the conventional methods, the advantages of radiation pasteurisation process have been examined for augmenting the shelf life of white pomfret in 'as is' form.

Earlier studies (Kamat and Kumta, 1972) have shown that white pomfret provides a system susceptible to radiation-induced oxidative changes, skin tissue being more sensitive than the muscle. Prepackaging under vacuum, however, effectively suppressed the oxidative changes in the fish, both on irradiation and during subsequent storage at 0-2°C.

The present paper describes a radiation pasteurisation process for white pomfret based on control of i) microbial spoilage reactions by low dose irradiation and ii) oxidative changes by maintenance of anaerobic conditions during irradiation and subsequent storage. Storage properties of radio-pasteurised fish have been evaluated in terms of organoleptic, biochemical and microbiological parameters.

EXPERIMENTAL

Preparation of fish samples:

Fresh white pomfrets *(Stromateus cinereus)* available from local market were brought to laboratory in crushed ice. The fish were then washed clean with tap water before and after evisceration, cut into fillets and stored in ice until used.

Experiments relating to the assessment of freshness indices -organoleptic score (O. S.), total bacterial count (TBC), trimethylamine nitrogen (TMAN) and total volatile basic nitrogen (TVBN) - were carried out with three different lots of 10 - 12 fish each. Duplicate samples were used for each assay. The average values on three lots of fish have been reported in the text.

Packaging of fish:

The fish fillets (approx. wt. 50 g; 12.5 cm. × 5.0 cm. × 2.0 cm.) were packed under vacuum in polycel pouches after repeated flushings with nitrogen gas and evacuations. The pouches were further sealed under vacuum in metal cans in order to maintain strict anaerobic condition during storage. Another lot of the fillets packed under aerobic condition served as a control.

Irradiation:

The fish fillets were irradiated with 0.1, 0.3 and 0.5 Mrad at the dose rate of 0.3 Mrad / hr in Food Package Irradiator IR_{11} (100,000 curies, Co^{60} source). During irradiation temperature was maintained at 0-2°C (melting ice). The unirradiated samples served as the controls.

Storage:

All irradiated and unirradiated fish samples were stored at 0-2°C in crushed ice.

Quality evaluation:

Organoleptic score (O. S.): The sensory scoring was done on a reference scale, based on changes in colour, odour and appearance, as adopted by Miyauchi *et al* (1964).

Chemical analysis: The total volatile basic nitrogen (TVBN) and trimethylamine nitrogen (TMAN) were analysed using TCA (8%) extracts of the fish homogenates (10%), according to the methods of Farber and Ferro (1956) and Bethea and Hilling (1965) respectively.

Bacteriological analysis: Total aerobic count was determined by the conventional pour plate technique using TGY - agar (Mavinkurve *et al* 1967). Plates were counted after incubation at 30°C for 48 hr.

RESULTS AND DISCUSSION

Storage characteristics of unirradiated white pomfret fillets:

Table I incorporates data on storage properties, assessed in terms of O. S., TMAN, TVBN and TBC of the unirradiated white pomfret fillets packed under vacuum or aerobic conditions and stored at 0-2°C. The fish fillets packed under aerobic condition had a limited shelf-life of 8 days as against 10 days for the samples packed under vacuum. The terminal spoilage of the unirradiated fish was marked by development of putrid odours coincident with precipitous decline in O. S. and sharp rise in the initial levels of TBC (1×10^5 /g), TMAN (0.5 mg%) and

TABLE I O. S. AND FRESHNESS INDICES OF UNIRRADIATED FILLETS PACKED UNDER VACUUM AND AEROBIC CONDITIONS

Indices	Days	Aerobically packed	Vacuum packed
O. S.	1	10	10
	8	7	10
	12	1 – 2	7
	15	–	3 – 4
TMAN: mg%	1	0.5	0.5
	8	1.9	1.6
	12	6.0	2.3
	15	–	3.6
TVBN: mg%	1	8	8.5
	8	27	9.5
	12	37	18.0
	15	–	28.5
TBC per gm	1	1.5×10^5	1×10^5
	8	2.2×10^7	9×10^5
	12	8.4×10^8	3×10^6
	15	–	6.9×10^7

The unirradiated fillets packed under vacuum and aerobic conditions were stored at 0-2°C. At intervals during storage, the quality of samples was examined in terms of TMAN, TVBN. TBC and O. S.

TVBN (8 mg%). Putrefactive activities due to psychrophilic microorganisms are known to occur in ice stored fish, concomitant with synergistic action between weak and rapid spoilers (Lerke *et al* 1965, Shewan, 1961). The net result of microbial reactions is the formation of putrid odours and undesirable appearance of the fish. Several amines and sulphur compounds have been identified as malodourous in spoiling fish (Tomiyasu and Zenitani, 1957). End products of bacterial metabolism have been examined for their usefulness as freshness indices (Farber, 1961).

Storage characteristics of radiation pasteurised white pomfret fillets:

Evidence obtained from organoleptic, chemical and bacteriological evaluation demonstrates dose dependent storage behaviour of radio-pasteurised white pomfret fillets. Figures 1 and 2 describe the storage properties, assessed in terms of O. S., TMAN, TVBN and TBC values of white pomfret fillets irradiated under aerobic and anaerobic condition respectively and stored at 0-2°C.

Irradiation and subsequent storage under vacuum showed dose dependent extension in shelf-life of the fish fillets without causing any loss in desirable quality of the product. Thus, the fish samples exposed to 0.1, 0.3 and 0.5 Mrad had the shelf-life of 30, 50 and 60 days respectively at 0-2°C. The terminal spoilage patterns of these fillets varied as a function of radiation dose. The fillets irradiated at 0.1 Mrad spoiled with development of putrid odours like the unirradiated

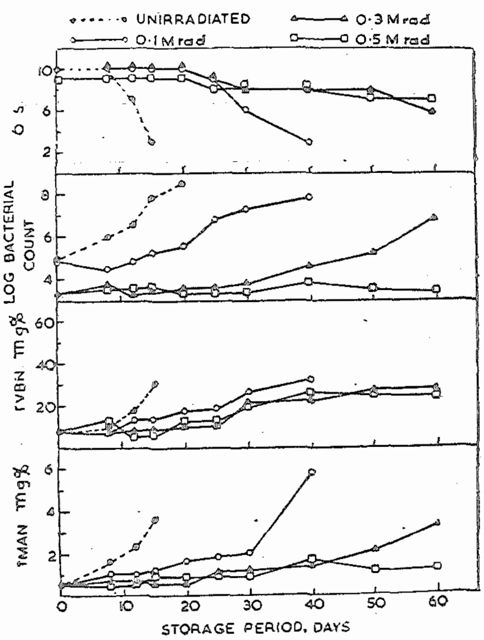

Fig. 1: Freshness indices of aerobically irradiated white pomfret fillets. White pomfret fillets were irradiated at 0.1, 0.3 and 0.5 Mrad under aerobic conditions and stored at 0-2°C. The unirradiated samples served as control At intervals during storage, quality of the fish samples was assessed in terms of O. S. TMAN, TVBN and TBC.

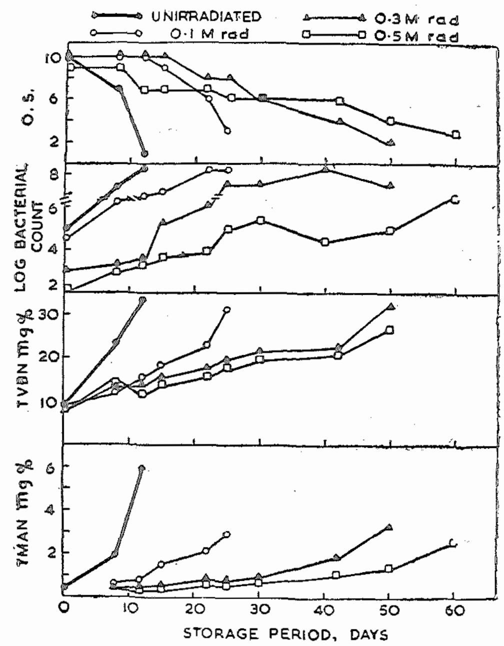

Fig. 2: Influence of vacuum packing on freshness indices of white pomfret fillets. White pomfret fillets pre-packed under vacuum were irradiated at 0.1, 0.3 and 0.5 Mrad and subsequently stored at 0-2°C. Similarly packed unirradiated fillets served as control. At intervals during storage, quality of fish samples were assessed in terms of O. S., TMAN, TVBN and TBC.

fish. The fillets exposed to 0.3 Mrad did not develop putrid odours but were considered to be spoilt when they produced sweetish type of odours. No spoilage could, however, be detected in samples treated with 0.5 Mrad throughout the storage period of 60 days investigated. Pelroy and Eklund (1966) noted that petrale sole fillets irradiated at 0.2, 0.3 and 0.4 Mrad had a spoilage pattern that was significantly different from that of non-irradiated fillets and the fillets exposed to 0.1 Mrad. Treatment of fresh water fish with 0.3 and 0.6 Mrad was also observed to alter the spoilage patterns usually found in untreated fish (Kazanas, 1966; Kazanas *et al* 1966). This was attributed to selection of microbial groups resulting from irradiation.

Fish samples irradiated and stored under vacuum also showed suppression in the levels of TMAN, TVBN and TBC (Fig 2). Significant rise in the levels of TMAN, TVBN and TBC occurred in the fillets irradiated with 0.1 Mrad after a lag period of 8 days while this period was extended to about 20 days for 0.3 and 0.5 Mrad treated fish samples. Low levels of TMAN and TVBN exhibited by white pomfret samples appeared to be due to suppression of microorganisms responsible for the formation of these indices. Some of the predominant microorganisms of fish and meat have been examined for their spoilage potential in terms of their ability to produce VRS, TMAN and TVBN. Studies of Alur *et al* (1970) showed that *P.vulgaris* and *Pseudomonas* species produced large amounts of TMA and TVB in Bombay duck homogenate stored at 10 or 0°C. Mavinkurve *et al* (1967) noted that *Micrococci* species, the major radiation survivor, did not produce TMA from sterilized Bombay duck drip. Inability of certain microorganisms to produce TMA has also been reported from other studies (Castell and Anderson, 1948; Tarr, 1938).

In contrast to vacuum packed fillets, the fish samples packed under aerobic condition were prone to development of rancid odours on irradiation at 0.5 Mrad, while 0.3 and 0.5 Mrad treated samples developed a characteristic yellow discolouration by 20th and 10th day of storage respectively. Aerobically packed fillets exposed to 0.1, 0.3 and 0.5 Mrad showed extended shelf-life of 20, 35 and 50 days respectively (Fig. 1). However, this extension of shelf-life was significantly less than that exhibited by corresponding vacuum packed fish samples. Our results corroborate with the findings of Spinelli *et al* (1965) on petrale sole. Hansen and Jorgensen (1967) and Ampola (1969) observed that vacuum packaging of ocean perch fillets not only inhibits radiation-induced oxidative changes but also enhances the effect of irradiation in extending the shelf-life of fish. Such complementary effects of vacuum packaging have also been reported by Connors *et al* (1964, 1966). Licciardelo (1967) suggested that the low biochemical activity of surviving microorganisms may be due to complementary effect of vacuum packaging.

Selection of radiation dose:

Although the evidence is not precise enough it has been suggested from inoculum pack studies of Eklund *et al* (1969) that radiation doses over 0.3 Mrad may increase potential hazard for *Clostridium botulinum* species in the fish like cod, halibut, English sole, Dover sole and petrale sole fillets stored in the temperature range of 3.3°C to 10°C. It was suggested that at lower doses of radiation where terminal spoilage could be distinguished in terms of putrid odours, the samples could be rejected before toxin production takes place. To define shelf-life from the olfactory rejection of the samples, a radiaton dose of 0.1 Mrad for white pomfret would be more suitable for pasteurisation, since the terminal spoilage pattern of these fish samples was similar to that of the unirradiated fish. At this dose level, under anaerobic condition, extended shelf-life of 35 days for the fish is adequate enough for transportation of the product. Microbial safety as determined by the procedures of Eklund *et al* (1969) based on mouse lethal dose tests have shown (unpublished data) that there was no evidence of toxin formation in the irradiated white pomfret fillets stored at 0-2°C.

SUMMARY

A radiation pasteurisation process integrating low dose irradiation with vacuum packaging is described for white pomfret, based on suppression of oxidative changes in the fish fillets stored at 0-2°C. Organoleptic, chemical and bacteriological analysis indicated that the unirradiated fish fillets packed under aerobic or anaerobic conditions and stored at 0-2°C, spoiled within 8 and 12 days respectively. Dose dependent extension in shelf-life was, however, exhibited by the irradiated fish. Anaerobically packed fish fillets exposed to radiation doses of 0.1, 0.3 and 0.5 Mrad showed extended shelf-life of 35, 50 and 60 days respectively without undergoing any loss in quality attributes of colour, odour or texture. The fish samples packed under aerobic condition were, however, prone to development of rancid odours on irradiation (0.5 Mrad) and yellow discolouration (0.3 and 0.5 Mrad) during storage and also exhibited lesser extension in shelf-life when compared to anaerobically packed fish.

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