

PART II

SCIENTIFIC AND TECHNICAL

DIVERSIFICATION IN UTILISATION OF
TRASH FISH BY GAMMA IRRADIATION

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Radiation pasteurisation enhances the shelf stability of trash fish varieties and enables the grading of fish depending upon the freshness quality. As against the ice-chilled fish which spoils within 8-10 days, exposure to 100 Krad and storage at ice temperature helps in maintaining the quality in Grade I, II or III up to 10, 20 or 25 days respectively. The improvement in quality thus provides scope for greater utilisation of trash fish for various secondary products.

INTRODUCTION

In recent years, there is a growing awareness for effective utilisation of low priced fish varieties, generally termed as 'trash fish'. It is realised that as trash fish varieties will continue to form a major component of the total catch in the mechanised trawlers, the economics of fishing schedules will largely depend on the potential market for trash fish. Recognising the magnitude of this problem, several laboratories in India (Combined workshop meeting, I. C. A. R. 1972, 1973) and elsewhere (King & Carver, 1970; Crawford *et al.* 1972; Anderson & Mendelsohn, 1971) are engaged in processing of trash fish for the development of secondary products. These include a wide

range of products suitable for human consumption, poultry and cattle feed and constituents of biological media. A review of the progress made in India and the scope for future programmes were highlighted at the Workshop meetings of the Indian Council of Agricultural Research held in 1972 and 1973.

One major problem, in the formulation of secondary products on large scale from trash fish, is the maintenance of uniformity in the quality of the products. Variation in the quality is to be expected to occur from differences in the degree of bacterial contamination during handling and storage of trash fish prior to processing. The composition of trash fish will also vary with the species constituting each batch.

These factors are required to be carefully controlled in order to obtain sustained consumer response, especially, where the secondary products have not yet established themselves in the market. It would be also difficult to adhere to specifications which are critical for maintenance of bacteriological standards of peptones derived from trash fish. The potential application of gamma irradiation for shelf life extension and quality improvement of sea-foods have been extensively reviewed. (Kumta & Sreenivasad 1966, 1970; Tozawa, 1968, Kumta *et. al.* 1973). Radurization (radiation pasteurization) offers the dual advantages of minimising the spoilage rates (Kumta *et. al.* 1971) and staggering the shelf life of fish (Kumta *et. al.* 1973).

This paper essentially forms an extension of our studies on the application of gamma radiation first initiated for conservation of Bombay duck (Sawant *et. al.* 1967) and later followed up for other fish varieties of economic significance (Kumta *et. al.* 1970; Kamat *et. al.* 1972; Kumta & Madhavan, 1973, Venugopal *et. al.* 1973). From the physico-chemical (Madhavan & Kumta, 1973; Kamat & Kumta 1972) and microbiological (Mavinkurve *et. al.* 1967, Kumta & Mavinkurve 1971, Alur *et. al.* 1971) aspects, a radiation dose of 100 Krad seems to be optimum dose. In this paper amenability and storage properties of two commercially important and nine trash fish varieties subjected to a dose of 100 Krad are described. Special emphasis is given to quality attributes and minimum requirements of packaging that would be adequate prior to the development of secondary products from trash fish. A brief discussion on the multiple uses and advantages of radurized trash fish which will provide scope for diversification in products formulations is included.

MATERIALS & METHODS

Nine different varieties of trash fish, two commercially important fish species (as given in Table 1) and shark were brought from Sasson Dock, Bombay, in iced condition.

Processing

The fish were beheaded, eviscerated and washed thoroughly. Each fish variety was separately packed in polyethylene bags (300 gauge) and heat sealed. The net weight of each bag ranged between 250-500 g. in case of small and medium sized fish varieties and about one Kg. in case of seer fish.

With a view to enable packaging of fish as rapidly as possible for large scale operation, a part of the fish after washing and evisceration were packed in polyethylene pouches without any additional sealing. For easy transportation the unsealed end of the pouches was tied with thread.

The sealed as well as the unsealed bags containing fish were exposed to a radiation dose 100 Krad in a Co 60 package irradiator (1,00,000 curies), at 0-2°C.

Storage

All the redurized samples along with the respective unirradiated batches were stored at 0-2°C. The samples were assessed for keeping quality at regular intervals during storage.

Assessment of quality

The stored samples were analysed for organoleptic score (O.S), total viable bacterial count (TBC), total volatile basic nitrogen (TVBN) and trimethylamine nitrogen (TMA-N) according to the methods described in our earlier communication. (Gore & Kumta, 1970).

TABLE I

Shelf life and spoilage rate of trash fish and other varieties of fish stored at 0–2°C. in sealed and unsealed conditions.

Species	Sealed				Unsealed			
	Shelf life days		Spoilage unit per day		Shelf life days		Spoilage unit per day	
	Control	100 Krad	Control	100 Krad	Control	100 Krad	Control	100 Krad
Cat fish (<i>Tachysurus</i> spp)	5	22	-1.17	-0.16	4	19	-1.75	-0.22
Croaker (<i>Johnius dissimulieri</i>)	3	20	-1.5	-0.17	3	17	-1.75	-0.22
Ribbon fish (<i>Trichurus</i> spp)	4	20	-1.5	-0.16	3	19	-1.5	-0.22
Anchovies (<i>Thrissoles</i> spp)	4	17	-1.5	-0.17	3	15	-1.75	-0.34
Sole (<i>Cynoglossus</i> spp)	4	19	-1.5	-0.17	3	15	-1.5	-0.34
Lactarius <i>Lactarius laclarius</i>	4	17	-1.17	-0.17	3	15	-1.5	-0.34
Silver bar (<i>Chlorocentrus dorab</i>)	5	20	-1.17	-0.17	5	19	-1.17	-0.22
Bombay duck (<i>Harpodon nehereus</i>)	5	25	-1.17	-0.13	5	20	-1.17	-0.17
Horse Mackerel (<i>Caranx</i>)	5	23	-1.17	-0.16	5	19	-1.17	-0.21
Seer fish (<i>Scomberomorous guttatus</i>)	5	23	-1.17	-0.16	5	18	-1.17	-0.30
Hilsa (<i>Hilsa Ilisha</i>)	5	25	-1.17	-0.13	5	17	-1.17	-0.22
Shark	4	10	-1.75	-1.17	3	9	-1.75	-0.17

Spoilage units

Spoilage rates of the samples in terms of organoleptic ratings were determined by the least-square method as described by Spencer and Baines (1964).

Oxidative changes

Extent of oxidative changes in muscle tissue due to lipid peroxidation was assessed on the basis of thiobarbituric acid reacting substances (TBARS) as described by Kamat and Kumta (1972).

TABLE II
Retention of organoleptic score in irradiated and unirradiated
mixed catch containing nine trash fish varieties*

Packing condition	Treatment	Storage days	Organoleptic score
Unsealed	Ice chilled	5	3.2 ± 2.6^1
	Ice chilled	5	7.5 ± 0.99
	+ 100 Krad	10	6.6 ± 0.95
		15	5.5 ± 0.99
		20	2.7 ± 1.83^1
Sealed	Ice chilled	5	3.6 ± 2.4^1
	Ice chilled	5	7.7 ± 0.85
	+ 100 Krad	10	6.7 ± 0.84
		15	6.1 ± 0.22
		20	5.6 ± 0.62
		24	2.5 ± 1.91

* As shown in the upper part of Table I.

1. The standard deviation was computed from the O. S. data obtained for 9 different varieties of trash fish. The higher values for standard deviation for ice chilled or ice chilled and radurized fish samples denote the differences in the spoilage rate during terminal storage.

RESULTS

Selection of radiation dose

The process parameters viz. a dose of 100 Krad and storage temperature in the range 0-3°C are stipulated to meet the requirements in preventing the outgrowth of *Clostridium botulinum* (Eklund & Poysky, 1970). As processing of trash fish should be commensurate with its availability in fairly large quantities, higher radiation doses may reduce the throughput of the irradiated products in the plant. In addition, higher doses may decrease the quality attributes relating to texture, flavour and colour. The choice of radiation dose in radurization process has been adequately emphasized (Kutma *et al.* 1973)

Based on organoleptic score of 5 on a 10-point scale of Miyauchi *et al.* (1964) the shelf life extension resulting from irradiation and storage of fish at ice temperature can be computed. These results are summarized in Table I. It is seen that with the exception of shark, irradiation offers almost 4-5 fold extension in shelf life over the ice stored fish when packed in polyethylene bags. However, if the packaging, which is one of the requirements of the radurization process, is omitted and polyethylene bags are used without sealing them, irradiated fish stored under these conditions show shelf life extension of about 3-4 fold over the unirradiated fish, similarly stored.

TABLE III
Anticipated shelf life and spoilage rate of mixed catch of
nine trash fish varieties*

Packaging condition	Treatment	Shelf life (days)	Spoilage unit/day (Organoleptic score)
Unsealed	Ice chilled	3.84 ± 1.49	1.47 ± 0.027
	Ice chilled + 100 Krad	17.5 ± 3.0	0.25 ± 0.003
Sealed	Ice chilled	4.4 ± 1.08	1.31 ± 0.026
	Ice chilled + 100 Krad	20.3 ± 5.0	0.16 ± 0.003

* As shown in the upper part of Table I.

The spoilage units calculated according to Spencer and Baines (1964) for organoleptic score are given in Table I for each variety of fish. It can be seen that in sealed or unsealed condition, the spoilage units for unirradiated fish are almost four to eight fold higher than for the corresponding fish samples subjected to 100 Krad.

Since the fish varieties given in Table I showed almost similar trends in their storage properties, calculations were made for 9 trash fish varieties assuming each variety contributing equally in a mixed catch. These values given in Table II show that fall in O. S. was rapid and was almost similar in the conventional ice chilled sealed or unsealed fish. Irradiation, however, enabled retention of O. S. almost to the same extent and above acceptable score for 10 days for sealed or unsealed fish. Thereafter, the unsealed samples registered lower O. S. These differences in the packaging condition and processing treatments are also seen in Table III for shelf life and spoilage units for mixed catch.

It can be seen from Table I that shark fillets do not seem to be amenable to radiation treatment as the shelf life extension is not of the same order as for other fish varieties. Studies now in progress indicate that by suitable pre-treatments ammonia odour in shark fish can be minimized resulting in shelf life extension as for other fish varieties. These results will be published elsewhere.

Freshness indices of ice-stored and radurized trash fish

For determining the freshness indices and the degree of oxidative changes of ice stored and radurized trash fish only four varieties were considered as a representative of the groups differing in the lipid content. Since the parameters examined to denote the quality showed rapid changes in ice stored fish compared to corresponding irradiated fish, the data on ice stored fish are presented in the inserts for fig. 1-4.

It can be seen from Figs. 1 and 2, that in fish samples subjected to 100 Krad, the initial bacterial load is reduced by

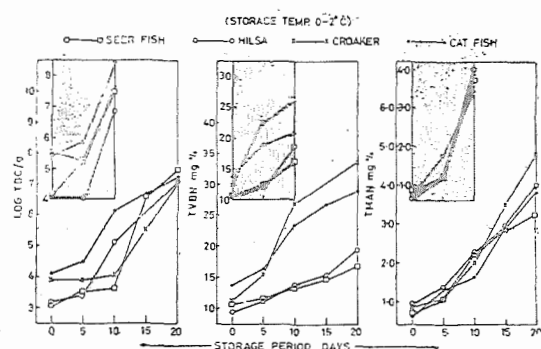


Fig. 1: Freshness indices of fish species held at ice temperature and sealed in polyethylene bag. TBC was determined in duplicate at different intervals of time using pour plate technique. TMAN and TVBN were obtained from TCA extracts as described previously. (Gore and Kumta, 1970)

1-2 log cycles. Beyond 10 days, the redurized samples exhibited rise in TBC values concurrent with the rise in TVBN and TMAN values. By the end of 10 days, the samples had TVBN values ranging from 16-26 mg%. Irradiation delayed increase in the TMAN values, but at the terminal spoilage the values of TMAN compared with unirradiated counterparts. Rise in TMAN values

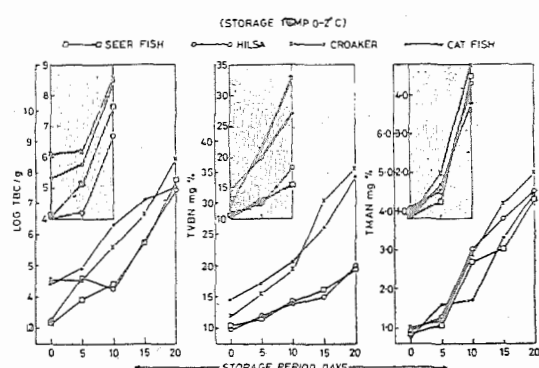


Fig. 2: Freshness indices of fish species held at ice temperature and tied in polyethylene bag. Details of enumeration of TBC and estimations of TMAN and TVBN are as per Fig. 1.

were of the same magnitude in all the irradiated and unirradiated samples.

Quality attributes during minimum packaging

When the fish species were tied in polyethylene bags and stored in ice temperature, the storage behaviour of unirradiated and irradiated fish was almost similar to the samples sealed in polyethylene bags. The results for TBC, TMAN and TVBN are given in Fig. 2.

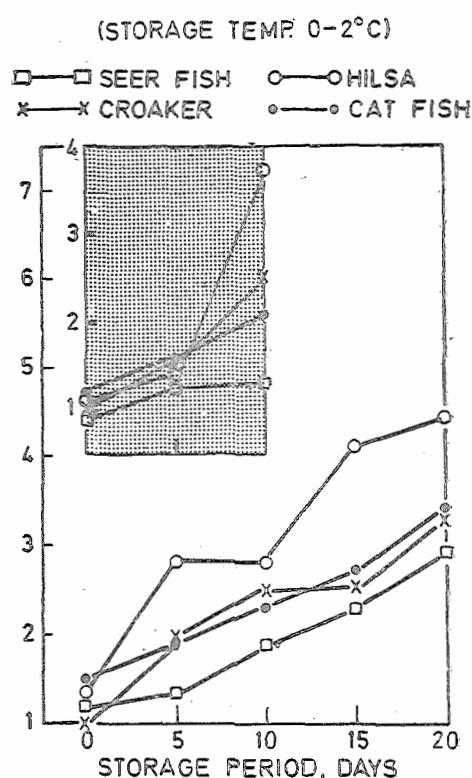


Fig. 3: TBARS formation in four varieties of fish. Storage temperature and packaging conditions as for Fig. 1.

Oxidative changes

The results given in Fig. 3 and 4 show that among the fish varieties tested, hilsa exhibited increased formation of TBA reacting substance (TBARS). However, the rise in TBARS was not sufficient to cause oxidative rancidity in the fish.

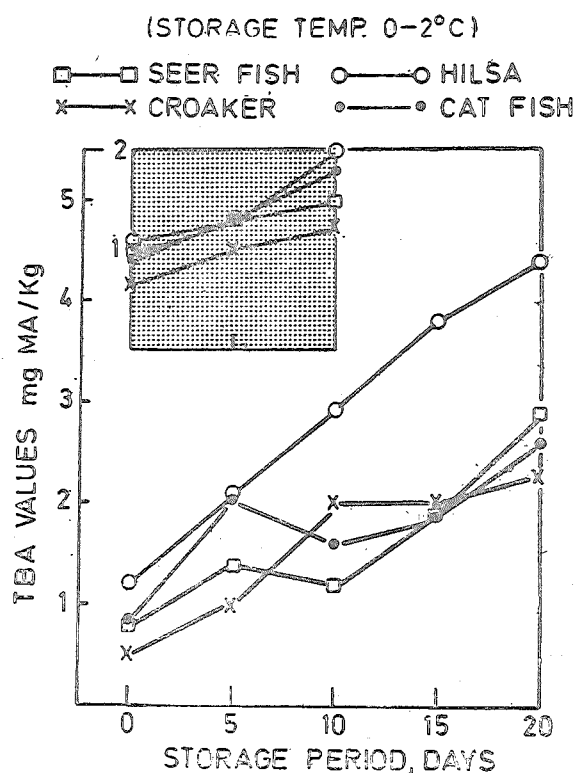


Fig. 4: TBARS formation in four varieties of fish. Storage temperature and packaging conditions as for Fig. 2.

DISCUSSION

From the statistical data provided by the Export Promotion Council, India, it is apparent that there is increasing trend in the available trash fish. During 1971-72 trash fish formed 30-35% of the total catch. Currently, most of the trash fish varieties are converted to fish meal, cattle feed and organic manure and, as such, they are not being carefully handled. The bacterial contamination and the accompanying biochemical putrefactive reactions would greatly reduce the quality of the raw products. This, in turn, would reflect on the quality of the secondary products. With growing malnutrition and protein inadequacy, the utilization of trash fish varieties in the preparation of reconstituted fillets from deboned meat, fish protein concentrate, protein hydrolysate and other food formulati-

ons is receiving greater attention (Combined Workshop meeting, ICAR1972, 1973). These efforts will also help in enhancing the commercial value of the trash fish varieties to a greater extent.

Two key factors which are responsible for the loss in quality of fishery products are the initial bacterial load and the temperature of storage. For radurization process initial bacterial load up to 10^5 - 10^6 could be tolerated but storage temperature must be critically maintained at 0-3°C. These exact requirements will therefore help in transforming the prevailing practices of handling, processing and storage to prerequisites which are necessary in order to obtain maximum benefit from the radurization process.

As demonstrated in the present studies, irradiation at 100 Krad extends the shelf life of the fish in 'as is' form. Thus by decreasing the rapid spoilage rate and consequently staggering the shelf life of trash fish, utility of this commodity can be expanded considerably.

It is known that fish species vary in their composition. Hence, oxidative changes in lipids during storage may contribute to differences in the quality of trash fish varieties. Our present studies show that

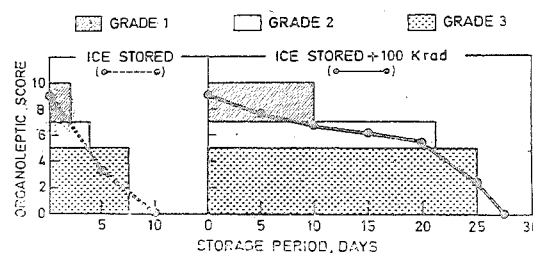


Fig. 5 Expansion in utility of trash fish by gamma irradiation.

Grade 1 : O.S. = 7-10 Grade 2 : O.S. = 5-7; Grade 3 : O.S. < 5

formation of TBARS ranges between 0.5 to 4.5 mg MA/Kg on irradiation. Higher radiation doses which may bring about differential responses in fish species in their oxidative rancidity cannot be adopted for the treatment of fish. Further, in terms of higher throughput requirement, doses above 100 Krad do not offer any specific advantages.

From the point of quality control, the radurized trash fish can be stored out species-wise or graded into categories depending upon the type of products to be prepared. Thus, products will qualify for Grade 1 during storage when organoleptic score lies between 7-10. This quality of irradiated fish can be marketed either as such or as products for human consumption or diverted for isolation of fish protein concentrate. Grade 2 products would have organoleptic score between 7 to 5; this grade of irradiated trash fish would be still suitable for preparation of protein hydrolysates, ensilage and peptones. Subsequently, during the terminal stage when the organoleptic score decreases to less than 5 and irradiated or unirradiated samples are not fit for human consumption, the fish together with offal and other waste materials collected as a part of the processing could be converted into manure. The irradiated trash fish, as a raw material, thus provides almost 20 days for product development in contrast to unirradiated fish which rapidly loses its quality attributes. In the conventional ice storage, therefore, it becomes mandatory to complete product development within the short span of 2-3 days.

The approach presented above would help in the diversification of products, depending upon the market needs and demands. The advantages of irradiated trash fish in terms of qualifying them

into distinct grades depending on the quality are shown in Fig. 5.

SUMMARY

The potential application of radurization for the extension in shelf life and quality retention in twelve fish varieties has been examined. The fish varieties include nine trash fish species, hilsa, seer fish and shark fish. The keeping qualities have been examined with reference to packaging conditions applicable to large scale handling.

The studies indicate merits of radurization process for development of secondary products from trash fish varieties.

REFERENCES

- Alur, M. D., N. F. Lewis and U. S. Kumta. 1971. *Indian J. Exptl. Biol.*, 9:48.
- Anderson, M. L. and J. M. Mendelsohn. 1971. Report from U. S. Dept. of Commerce, Technical Assistant Pro. No. 01 - 6-09131, Washington, D.C.
- Combined Workshop on All India Coordinated Research Projects on Transportation of Fresh Fish and Utilisation of Trash Fish, I.C.A.R. 1972.
- Combined Workshop on All India Coordinated Research Project on Transportation of Fresh Fish and Utilisation of Trash Fish, I.C.A.R. 1973.
- Crawford, D. L., D. K. Law, J. K. Babitt and L. S. Mc Gill. 1972. *J. Food Sci.*, 37 : 551.
- Eklund, M. D. and F. T. Poysky. 1970. In 'Preservation of Fish by Irradiation' Proc. Panel, Vienna 1969, IAEA, Vienna, P 125.
- Gore, M. S. and U. S. Kumta. 1970. *Food Technol.*, 24 : 286.
- Kamat S. V. and U. S. Kumta. 1972. *Fish. Technol.*, 9 : 8.

- Kamat, S. V., S. G. Gaonkar and U. S. Kumta. 1972. *Fish. Technol.*, **9**:25.
- King, F. L. and J. H. Carver. 1970. *Comm. Fish. Rev.*, **32** : 12.
- Kumta, U. S. and A. Sreenivasan. 1966. In 'Food Irradiation', Proc. Symp. Karlsruhe Sponsored by FAO/IAEA, Vienna, 785.
- Kumta, U. S. and A. Sreenivasan. 1970. 'Preservation of Fish by Irradiation' (Proc. Panel, Vienna, 1969) IAEA, Vienna, 75.
- Kumta, U. S., S. S. Mavinkurve, M. S. Gore, P. L. Sawant, S. V. Gangal and A. Sreenivasan. 1970. *J. Food. Sci.*, **35** : 360.
- Kumta, U. S. and S. S. Mavinkurve. 1971. *J. Food Sci.*, **36** : 63.
- Kumta, U. S., M. D. Alur, S. S. Mavinkurve and N. F. Lewis. 1971. *J. Food Sci.*, **36** : 831.
- Kumta, U. S., K. A. Savagaon, S. V. Ghadi, S. N. Doke, M. S. Gore, V. Venugopal, V. N. Madhavan and A. Sreenivasan. 1973. In 'Radiation Preservation of Food., IAEA, Vienna, P 403.
- Kumta, U. S. and V. N. Madhavan. 1973. *Acta Alimentaria.*, **2** : 467.
- Madhavan, V. N. and U. S. Kumta. 1973. *Acta Alimentaria.*, **2** : 445.
- Mavinkurve, S. S., S. V. Gangal, P. L. Sawant and U. S. Kumta. 1967. *J. Food Sci.*, **32** : 711.
- Miyauchi, D., M. Eklund, J. Spinelli and N. Stoll. 1964. *Food Technol.*, **18** : 928.
- Sawant, P. L., S. S. Mavinkurve, S. Saroja, K. A. Savagaon, and U. S. Kumta, 1967. *Food Technol.*, **21** : 444.
- Spencer, R. and C. R. Bains. 1964. *Food Technol.*, **18** : 769.
- Venugopal, V., K. A. Savagaon, U. S. Kumta and A. Sreenivasan. 1973. *J. Fish. Res. Bd. Can.*, **30** : 305.
- Tozawa, H. 1968. *Bull. Jap. Soc. Sci. Fish.*, **34** : 740.