PRELIMINARY STUDIES ON THE EFFECT OF IRRADIATION AS A MEANS OF PRESERVATION OF FISH AND SHELLFISH

R. VENKATARAMAN, M. K. KANDORAN, K. K. SOLANKI AND C. R. RAJE
Central Institute of Fisheries Technology, Sub-station, Veraval, Gujarat.

Preliminary investigations on the effect of irradiation on commercially important fish and shell fish like silver pomfret. Bombay duck and prawns were conducted. Irradiated samples had an extended storage life compared to their respective controls even though yellowish or brownish discoloration occurred earlier in irradiated fish. Irradiation enhanced the rate of drip formation. Brine treatment prior to irradiation retarded this rate. Pre-blanching was found to further extend the storage life of irradiated fish.

INTRODUCTION

Irradiation is a new field of study for preserving fish and fishery products particularly in India. Even though no fish is irradiated and preserved for future marketing in India so far the trend prevails that this type of preservation may play an important role in the field of fish preservation in the years to come. There are reports of work on irradiation in developed countries recommending it as a new technique for fish processing supported by scientific data. In India also work on this line has already been started (Sawant et al, 1967). This Institute has conducted the study on preservation of commercially important fish and shell fish by irradiation with a view to finding out how far this method could be adopted either alone or in combination process in our country. As a pilot study the investigation was carried out on prawns, Bombay duck and silver pomfret. Arrangements were made with the Bhabha Atomic Research Centre, Bombay, for irradiation of absolutely fresh iced fish despatched from Veraval.

MATERIALS AND METHODS

Absolutely fresh prawns, Bombay duck and silver pomfret were procured after icing in the fishing ground itself and despatched in special insulated boxes to the Bhabha Atomic Research Centre, Bombay, by rail. The materials after packing in polythene bags were irradiated at the dosage of 0.25 Mrad from a source of Cobalt-60 and returned to Veraval at the earliest possible moment. Bombay duck could be irradiated after three days

of ice storage and prawns and silver pomfrets after four days. Systematic observation and analysis of these materials were carried out along with the unirradiated controls during ice storage. In case of prawns, headless (shell-on), pealed and deveined (P&D) and also P&D cooked samples were taken up for the investigation. Regarding Bombay duck and silver pomfret both whole and gutted fish were used. Samples were periodically analysed for salt, TVBN, TMAN, ∝-amino nitrogen and total bacterial count apart from the physical observation. The drip formed in different cases were also noted.

Salt was estimated by the method of AOAC (1960). TVBN and TMAN were estimated by Conway's Micro Diffusion method (1947). Pope and Steven's (1939) method was followed for determining ∝-amino nitrogen. Total bacterial count was found out by sea-water agar medium. For taste panel study the material was cooked in 3% brine for 10 minutes and tasted without adding any ingredients which might mask the original taste of fish.

Results and discussion

Tables I, II and III give the physical observation and analytical data for headless (shell-on), P&D and P&D cooked prawns respectively. Irradiated headless prawn retained its quality for 15 days while control showed spoilage symptoms after 7 days. Eventhough black spots appeared in both control and irradiated samples taste panel study clearly indicated that irradiated prawns did not give any significant off taste and were edible upto 15 days of storage. In the case of P&D prawns the storage life of irradiated sample was 17 days as against 8 days for the respective control. Regarding P&D cooked prawn a storage life of 23 days and 9 days were observed for irradiated and control samples respectively. This clearly indicated that storage life of irradiated prawns could be significantly extended by inactivating enzymes by pre-blanching.

Tables IV and V present the data for whole and gutted Bombay duck respectively. Storage periods of 15 days and 22 days were observed for irradiated whole and gutted Bombay duck respectively in ice storage while controls in both cases spoiled within 6 to 9 days. Regarding drip formation, irradiated fish in both cases gave a significantly higher quantity than the unirradiated controls. In all cases quantity of drip increased as the ice storage period increased.

Tables VI and VII represent the data for whole and gutted (headless) silver pomfret respectively. It indicates that the control samples of whole and gutted fish could remain in good condition only for 7 days while a storage period of 14 days could be secured by irradiation. Compared to controls discoloration developed early on the dorsal region of irradiated fish with slight rancid odor. The intensity of discoloration was found to have enhanced by the presence of head or gut or both. Among all the samples, gutted and irradiated silver pomfret was found to be the best in quality in extended storage.

It was generally observed that bacterial count was definitely reduced by irradiation particularly at the earlier stages of storage in all the species tried under different conditions. This difference in bacterial counts narrowed as the storage period increased. Spoilage indices like TVBN and TMAN contents were higher in controls, but these figures gave only a rough idea because in both control and irradiated samples a considerable quantity of these compounds might have leached out along with the drip. Still the faster spoilage of control samples could be made out from the physical observation and taste panel study. Regarding taste it was

TABLE I PHYSICAL OBSERVATION AND CHEMICAL ANALYSIS OF HEADLESS PRAWN (SHELL-ON)

Ice storage period in days	Sample	TMAN mg %	TVBN mg %	∝-amino nitrogen mg %	Drip %	Total Bact. count per g.	Appearance	Odour	Texture	Taste	Remarks
7	Irradiated (0.25 Mrad)	1.395	12.56	89.45	nil	8.87×10^3	DPB	Ir	firm	CPS Ir	fair
	Control	2.650	23.35	77.62	nil	6.15×10^5	SYPB	SA	moderately soft	ACP	satisfactory
11	Irradiated	2.003	19.74	118.7	nil	1.94×10^4	DPB	SIr	firm	Good	above fair
	Control	5.78	33.80	104.50	nil	8.22×10^5	YMB	A	soft	off	poor
15	Irradiated	1.792	25.94	162.7	2.4	3.07×10^4	APB	SIrSA	moderately soft	satis-factory	fair
	Control	10 26	39.47	128.7	0.3	1.22×10^6	DB	St.A	very soft	spoiled	very poor
20	Irradiated	1 60	25.62	243.8	6.9	3.49×10^6	-do-	SO	soft	-do-	poor
	Control	27.96	69.87	194.5	1.6	3.91×10^8	-do-	putrid	soft & sticky	-do-	spoiled

DPB = Dull Pink-Black spots
Ir = Irradiated
CPSIr = Characteristic pleasant slight Irradiated
SYPB = slight yellowish pink-Black spots
SA = Slight Ammonical
ACP = Absence of Characteristic pleasant taste
SIr = Slight irradiated
YMB = Yellowish muscle Black spots
A = Ammoniacal
APB = Absence of pink colour-Black spots
St A = Strong Ammonical
DB = Dark brown
SO = Slightly off

TABLE II PHYSICAL OBSERVATION AND ANALYTICAL DATA OF PRAWNS (P & D)

Ice storage period in days	Sample	TMAN mg %	TVBN mg %	∝-amino-nitrogen mg %	Drip %	Total Bact. count per g.	Appearance	Odour	Texture	Taste	Remarks
8	Irradiated (0.25 Mrad)	1.445	10.73	63.51	nil	8.65×10^3	yellowish pink, dull	chacteristic pleasant but with slight irr.	firm	characteristic pleasant, but slight irr.	good
	Control	3.25	18.09	78.40	nil	6.73×10^5	bright pink	slight ammoniacal	slightly soft	fresh taste lost	satisfactory
12	Irradiated	2.64	11.08	84.55	nil	1.25×10^4	dull, pinkish, some black spots noted	slight irr. fresh odour lost	not so firm	slight irr. but good	above fair
	Control	6.78	26.87	65.75	2.65	1.72×10^6	pinkish, but no black spots	strong ammoniacal	soft	slightly spoiled	poor
17	Irradiated	3.09	12.28	115.2	nil	1.86×10^4	slight pinkish, slight black spot	very slight amm. no irr.	moderately soft	irr. taste lost, still acceptable	fair
	Control	11.64	31.46	120.5	6.2	6.34×10^6	sligth pinkish with black spots	strong ammo.	very soft	spoiled	very poor
21	Irradiated	5.60	14.0	142.8	nil	4.78×10^4	black spots increased	-do-	soft	not edible	below-satisfactory
	Control	15.4	39.2	135.5	5.8	8.46×10^7	black spots and slime on the surface	spoiled	very soft	spoiled	very poor

TABLE III PHYSICAL OBSERVATION AND CHEMICAL ANALYSIS OF P & D COOKED PRAWNS

Ice storage peroid in days	Sample	TMAN mg %	TVBN mg %	∝-amino-nitrogen mg %	Drip %	Total Bact. count/g	Appearance	Odour	Texture	Taste	Remarks
9	Irradiated (0.25 Mrad)	1.0	7.183	41.31	nil	6.93×10^3	yellowish pink	slight irr.	firm	characteristic, but slight irr.	good
	Control	1.20	9.024	93.07	nil	1.53×10^4	–do–	slight ammoniacal	–do–	characteristic taste lost	above satisfactory
15	Irradiated	2.601	12.35	97.55	nil	$9\ 04 \times 10^3$	–do– with slight black discoloration	very slight irr.	slight rubbery	fairy good	above fair
	Control	4.065	30.80	80.25	nil	1.18×10^6	–do–	ammoniacal	–do–	slight ammo.	below satisfactory
23	Irradiated	3.21	21.69	132.1	nil	1.32×10^4	dull pink color with slight discoloration	irr. odour lost. Very slight amm.	–do–	satisfactory	above satisfactory
	Control	6.541	50.54	98.83	nil	2.03×10^7	–do–	strong ammo	soft, slight sticky	spoiled	poor

TABLE IV PHYSICAL OBSERVATION AND ANALYTICAL DATA OF BOMBAY DUCK (WHOLE)

Ice storage period in days	Sample	TMAN mg %	TVBN mg %	∝-amino-nitrogen mg %	Drip %	Total Bact. count/g	Appearance	Odour	Texture	Taste	Remarks
6	Irradiated (0.25 Mrad)	1.882	9.47	90.22	10.63	1.806×10^4	dull pinkish white	slight irr.	firm	characteristic pleasant but irr.	good
	Control	2.375	11.50	95.00	8.15	3.77×10^5	slight pinkish white	characteristic	moderately soft	fresh taste lost	fair
11	Irradiated	2.570	10.97	72.10	14.78	5.632×10^4	slight yellowish white	slight irr.	less firm	slight irr.	above fair
	Control	3.150	13.55	41.74	13.34	4.23×10^6	slight dull yellowish white	slight off	soft	slight off	poor
15	Irradiated	5.268	19.95	142.4	22.40	9.83×10^4	slight dull greyish white	characteristic odor lost, but not off	slightly soft	fresh & irr. taste lost	fair
	Control	7.386	29.84	286.2	13.80	1.96×10^7	very dull greyish white	off	very soft	spoiled	poor
21	Irradiated	11.06	29.49	183.4	9.2	5.57×10^6	dull greyish white	slight off	–do–	slight off	below satisfactory
	Control	9.75	30.47	108.3	10.0	21.24×10^7	very dull	spoiled	–do–	spoiled	very poor

TABLE V PHYSICAL OBSERVATION AND ANALYTICAL DATA OF BOMBAY DUCK FILLETS

Ice storage period in days	Sample	TMAN mg%	TVBN mg%	∝amino-nitrogen mg%	Drip %	Total Bact count/g	Appearance	Odour	Texture	Taste	Remarks
5	Irradiated (0.25 Mrad)	1.434	9.22	86.93	9.775	2.38×10^3	dull pinkish grey	characte-ristic fresh & irr.	firm	fresh & irr	good
	Control	1.963	9.82	69.87	4.983	1.64×10^5	pinkish grey	fregh odor lost	modera-tely soft	fresh taste lost	above fair
12	Irradiated	2.761	16.44	43.69	12 33	1.61×10^4	dull grey	slight irr	firm	fresh & irr	above fair
	Control	8.10	28.8	75.73	7.20	4.88×10^5	pale pink	slight off.	soft	slight off	below fair
17	Irradiated	3.88	20.75	50 94	12 80	2.95×10^4	vesy slight yellowish grey	fresh odor lost slight irr.	modera-tely soft soft	fresh & irr taste lost	fair
	Control	10.03	33.91	94.15	8.05	6.35×10^5	dull grey	off	very soft	off	poor
22	Irradiated	9.81	35.03	140.4	15.7	4.79×10^4	slight yello-wish grey	irr. odor lost, slight off	modera-tely soft	very slight off	satis-factory
	Control	13.90	45.55	100.27	8.5	9.97×10^5	dull grey	strong off	very soft	spoiled	very poor
30	Irradiated	15.07	52.20	20.17	16.92	2.93×10^5	yellowish white	off	soft	consi-derable off	poor
	Control	18.66	30.85	143.9	10.10	$2\ 1 \times 10^7$	slightly yellowish sticky	very strong off	very soft	spoiled	very poor

TABLE VI PHYSICAL OBSERVATION AND ANALYTICAL DATA OF SILVER POMFRET (WHOLE)

Ice storage period in days	Sample	TMAN mg %	TVBN mg %	∝-amino-nitrogen mg %	Drip %	Total bact count/g	Appearance	Odour	Texture	Taste	Remarks
6	Irradiated (0.25 Mrad)	1.70	26.54	34.29	6.197	2.78 x 10^4	dull eyes, slightly reddish gill	slight irr.	firm	characteristic but irr.	good
	Control	1.999	26.04	42.54	0.88	2.36 x 10^5	–do–	very slight off	moderately soft	fresh taste lost	fair
10	Irradiated	2.05	30.42	37.69	6.56	9.46 x 10^4	slightly dull apearance	slight irr	less firm	slight irr.	fair
	Control	2.474	34.63	38.91	2.21	6.65 x 10^5	–do–	considerable off	soft finger prints noted	slight off	above poor
14	Irradiated	2.512	21.77	29.14	6.98	1.6 x 10^5	yellowish patches	very slight rancid irr. odor lost	moderately soft, slight finger prints	irr. taste lost no off	satisfactory
	Control	2.772	21.26	31.81	2.98	5.38 x 10^6	very dull but no yellowish patches	strong off	soft finger prints	off	poor
17	Irradiated	2.414	35.73	45.96	7.44	1.604 x 10^6	dull and yellowish	considerable off and rancid	–do–	slight off	poor
	Control	4.335	34.67	59.39	...	3.059 x 10^6	very dull	strong off	very soft	spoiled	very poor
21	Irradiated	2.044	18.4	49.46	7.87	6.37 x 10^6	more yellowish discoloration	rancid and off	–do–	off	very poor
	Control	Sample discarded									

TABLE VII PHYSICAL OBSERVATION AND ANALYTICAL DATA OF SILVER POMFRET
(Gutted and Headless)

Ice storage period in days	Sample	TMAN mg %	TVBN mg %	∝-amino-nitrogen mg %	Total Bact count/g	Appearance	Odour	Texture	Taste	Remarks
6	Irradiated (0.25 Mrad)	1.465	22.71	14.65	9.46×10^4	grey white	fresh and irr.	firm	fresh and irr.	good
	Control	1.635	27.48	32.97	4.39×10^5	–do–	fresh odor lost	modera-tely soft	fresh taste lost	fair
10	Irradiated	1.393	28.56	38.72	3.99×10^4	slightly dull	slight irr.	less firm	slight irr.	fair
	Control	2.206	35.30	30.00	1.61×10^6	–do–	considerable off.	soft, finger prints noted	slight off	above poor
14	Irradiated	1.673	19.26	28.14	3.98×10^5	slight yellowish patches	slight rancid	–do–	irr. taste lost, no off	satis-factory
	Control	2.393	18.35	25.22	9.01×10^5	very dull, but no yellowish patches	strong off.	–do–	off	poor
17	Irradiated	3 351	36.19	43.96	9.10×10^5	dull and yellowish	rancid and off	–do–	slight off	poor
	Control		discarded							
21	Irradiated	2.333	17.5	46.0	9.49×10^6	–do–	–do–	–do–	spoiled	very poor
	Control		discarded							

generally noted that control samples were preferrrd during the first 5-6 days of storage. During this period irradiated fish gave its typical irradiation taste. But this was not significant during the later stages of storage when the control failed to retain its prime quality.

Among all the samples tried it was generally noted that drip formation was maximum in Bombay Duck and minimum in prawns. There was no drip in P & D cooked prawns. It was also generally seen that rate of drip formation was enhanced by irradiation. This rate could be considerably retarded by brine treatment prior to irradiation. However, as they are insufficient for presentation, data on this point are not given here.

Yellowing or blackening was generally found to be slightly more intense in irradiated fish. One of the reasons for this type of discolouration in fish and fishery products is the action of enzymes which are supposed to be highly resistant to irradiation. So the suggestion of a combination process by heat treatment (cooking) and irradiation of fish has been widely accepted. Here the enzymes are inactivated by the former while bacterial multiplication is effectively controlled by the latter proeess. But it is to be pointed out that discoloration of fish and fish products need not be necessarily prevented by heat treatment and further irradiation alone. In fish the discoloration by direct oxidation of oil without the help of enzymes is known. Moreover the possibility of enzyme formation, by the surviving bacteria after irradiation, is always there. Maillard reaction in the presence of amino acids and sugars causing browning discoloration is another possibility. Formation of a higher content of α-amino nitrogen was noted in irradiated fish as given in various tables presented here. The possibility of a more intense discoloration in irradiated fish, as observed in this study due to the presence of a higher content of amino nitrogen cannot be ruled out. However, all these factors have to be studied in detail before any definite conclusion can be drawn.

Finaly it has to be mentioned that in all the species under this study irradiation could be effected only after 3 or 4 days of ice storage even though they were iced in the fishing ground itself and stored carefully during this period. Therefore a higher period of storage is likely to be achieved if the species are irradiated immediately after landing or if they can be irradiated on board the vessel itself. Work is in progress to establish the effect of various factors such as time lag between catch and irradiaton, concentration of fat, sugar, aminoacid contents etc. on irradiated fish and its shelf life.

The factors like odor, flavour and texture of the irradiated fish were taken for fixing the limit of their storage life. As the standards of consumer acceptability widely vary particularly for irradiated fish due to their characteristic odor and flavour it has to be pointed out that the conclusion made on the limit of storage life of different species of irradiated fish mentioned in this paper may, perhaps, slightly differ from that of other workers.

SUMMARY

Commercially important fishes and shell fish like prawn, Bombay duck and silver pomfret were irradiated at The Bhabha Atomic Research Centre at the dosage of 0.25 Mrad. from a source of Cobalt-60. The changes in bacterial load and the consequent effect on the qualities of these irradiated fish were studied on the basis of chemical and organoleptic data collected systematically during ice storage and compared with those of control samples.

(a) Headless (shell-on), (b) Peeled and deveined and (c) Peeled and deveined samples after blanching could be stored in good condition in ice for 15, 17 and 23 days respectively after irradiation while unirradiated samples spoiled earlier. The total bacterial counts in the above irradiated fish were 3.071×10^4, 1.859×10^4 and 1.32×10^4 per gram in the above order whereas fairly high counts were recorded in the control samples.

The shelf life in ice storage of irradiated whole and gutted (headless) Bombay duck were found to be 15 and 22 days with total bacterial counts of 9.832×10^4 and 4.789×10^4 per gram respectively. It was also noted that brine treatment prior to rradiation considerably reduced the drip loss during ice storage period of Bombay duck.

Irradiated silver pomfret could be stored for at least 14 days in good condition with a total bacterial count of 1.592×10^5 per gram. However slight rancid odor and discoloration developed in the fish at the later stages of storage.

In general the taste of control samples was preferred only during the initial stages of ice storage. The retention of taste qualities of these species during ice storage was found to have a direct relationship with the bacterial load.

ACKNOWLEDGEMENT

The authors wish to express their sincere thanks to Dr. A. Sreenivasan, Head of the Food Technology & Biochemistry Department and Dr. U. S. Kumta of Bhabha Atomic Research Centre, for their valuable guidance and facilities extended for irradiating the samples at the Bhabha Atomic Research Centre.

RRFERENCES

A. O. A. C. 1960 Official Methods of Analysis (Association of Official Agricultural Chemists) 9th Edn.

Conway, E. J. 1947 Micro-Diffusion Analysis and Volumetric error-Crosby Lockwood and Sons, London.

Pope C. G. and Stevens, M. F. 1939 Biochem. J., 33, 1070,

Sawant, P. L., S. S. Mavinkurve, S. Saroja, K. A. Savagoan and U. S. Kumta 1967, Food Technol, *21*, 444.