Studies on the Quality Changes of Frozen Fish in Retail Cold Stores

P. T. LAKSHMANAN, P. R. G. VARMA and T. S. G. IYER
Central Institute of Fisheries Technology, Kochi- 682029

The changes in the quality of five commercially important fishes, namely, black pomfret *(Parastromateus niger)*, white pomfret *(Pampus argenteus)*, seer fish *(Scomberomorus* sp.), mullet *(Mugil cephalus)* and pearlspot *(Etroplus suratensis)*, quick frozen at -40°C and kept in five selected retail cold stores having average temperatures of -11.2, -4.43, -10.4, -11.25 and -4.55°C and a control stored at -18°C were studied and shelf life evaluated. The keeping quality of the fish was studied by following sensory, biochemical and microbiological changes. The study showed that the above fishes could be kept in good quality upto 10-12 weeks if the temperature is maintained below -10°C. Fluctuating and high temperature in the cold stores are the limiting factors in the quality of frozen fish from retail outlets.

Frozen fish has, over the years, become more and more important especially among the urban population of the country. As consumer preference increases for frozen fish, the need for supplying safe and wholesome products is also growing. However, in the domestic trade no attempt has been made so far in evaluating the quality and shelf life of frozen fish although much data is available on dried/cured fish (Sreenivasan & Joseph, 1966; Mathen, 1970; Valsan *et al.*, 1985; Joseph *et al.*, 1983; 1986 and 1988) and wet fish (Lakshmanan *et al.*, 1984; Iyer *et al.*, 1986). The major quality problem in the retail net work is the slow freezing process and the high and fluctuating temperature in the cold stores. The objectives of the present study were to monitor the changes in the quality of fishes kept in retail cold stores, variations in temperature conditions and to evaluate their shelf life.

Materials and Methods

The fishes used for the study were: three species of marine fish, black pomfret (*Parastromateus niger*), white pomfret (*Pampus argenteus*), seer fish (Scomberomorus sp.) and two brackish water species, pearl spot (Etroplus suratensis) and mullet (Mugil cephalus). The fishes were procured from a local market in very fresh condition. The experiment was conducted in two stages. In the first phase seer fish, black pomfret and pearlspot were used and in the second phase mullet and white pomfret were taken. Seer fish was cut as chunks (weighing about 500 g), washed and wrapped in polythene films and frozen individually. The other fishes were frozen as blocks of 500-600 g. All fishes were frozen in contact plate freezer at -40°C. The frozen fishes were packed in 5 ply corrugated fibre board cartons and kept in different cold stores in the city. Selected cold stores in the city, arbiterarily designated as I, II, III, IV and V and the average temperatures were -11.2, -4.43, -10.4, -11.25 and -4.55°C respectively. Control samples were kept in the cold store of the Institute maintained at -18°C (Fig. 1). In all cases, one species was kept in two retail cold stores and the control cold store. Two trials had been carried out in each case.

The temperature of the cold stores were monitored at 3 or 4 days interval using a freezer temperature monitor.

Quality evaluation of the samples were carried out by drawing samples from different cold stores at almost fortnightly intervals for over 3 months. After aseptically taking the muscle for bacteriological analysis, the samples were thawed in sealed airtight covers in running water. The thawed fishes were filleted and one portion from each sample was steamed for 10 min and presented to a trained taste panel consisting of 6 members for assessment of texture, flavour and overall quality on a 10 point hedonic scale; excellent = 8 to 10; very good = 7 to 8; good = 6 to 7; moderately good = 5 to 6; neither good nor poor = 4 to 5 and poor < 4. A portion of the muscle finely chopped and homogenised in a mincer was used for all the biochemical analysis.

Moisture and pH were determinee by the methods specified by Curran *et al.*, (1980). Total volatile base nitrogen (TVB - N) and trimethylamine nitrogen (TMAN) were determined by the microdiffusion method of Conway (1962) using TCA extract of the muscle. Hypoxanthine (HX) content was measured by the method of Jones *et al.* (1964). Thiobarbituric acid value (TBA) was determined according to Tarladgis *et al.*, (1960).

Total bacterial count (TPC), *E. coli* and coagulase positive staphylococci were estimated by the FDA (1978) method. Faecal streptococci was determined by the method of Kenner *et al.*, (1961).

Results and Discussion

The results of the study are given in Tables 1 to 5 and Fig. 1. The variations in temperatures of different cold stores are presented in Fig. 1.

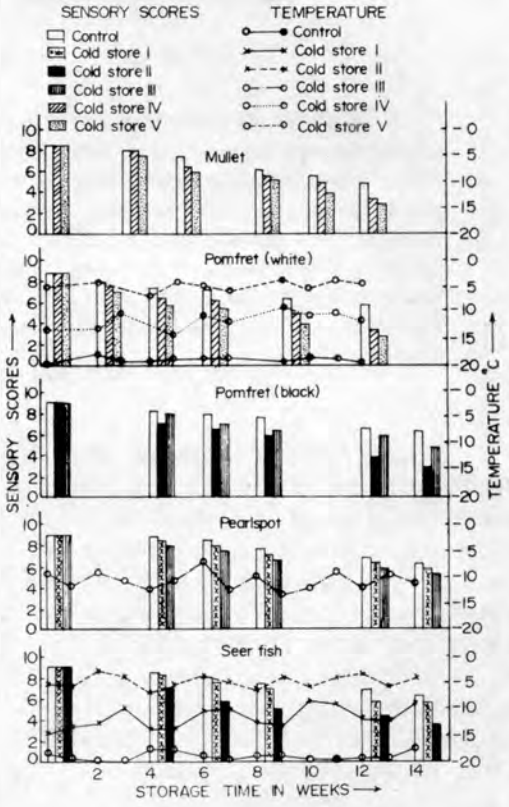

Fig. 1. Changes in the overall acceptability of frozen fishes during storage in different cold stores

Table 1. *Changes in the chemical indices and total bacterial count of frozen seer fish during storage at different cold stores*

Storage time weeks	Moisture %	TVN mg/100g	TMAN mg/100g	HX μ moles/g	TBA mg/100g	TPC x 10^2 (count/g)
Cold Store I (-11.2°C)						
4	77.5	15.4	2.8	0.82	0.34	27.1
6	77.6	18.9	2.8	1.45	0.55	16.6
8	77.1	21.4	4.2	1.91	0.73	37.6
12	76.8	26.8	5.6	2.82	1.60	2.05
14	76.2	28.7	5.2	3.65	2.40	2.10
Cold Store II (-4.43°C)						
4	77.5	18.9	2.4	0.89	1.21	27.0
6	76.3	23.8	3.2	2.30	2.80	12.5
8	76.1	26.2	5.6	3.35	3.85	13.6
12	75.6	25.4	4.8	5.60	6.70	15.9
14	74.5	33.8	7.2	7.12	10.21	63.8
Cold Store, Control (-18°C)						
0	78.5	10.4	Nil	0.12	Nil	81.0
4	77.8	8.4	Nil	0.68	0.14	62.4
6	77.6	14.6	1.4	1.30	0.35	9.43
8	77.1	16.8	2.8	1.48	0.56	1.70
12	75.7	18.7	2.8	2.10	0.78	1.43
14	76.9	23.5	4.2	2.60	0.73	2.32

Table 2. *Canges in the chemical indices and bacterial counts (TPC) of frozen pearl spot during storage at different cold stores*

Storage time, weeks	Moisture %	TVN mg%	TMAN mg%	HX µ moles/g	TBA mg/100g	TPC x 10^2 (count/g)
Cold Store I (-11.2°C)						
4	78.8	11.9	2.8	0.39	0.20	32.0
6	79.4	16.3	1.4	0.72	0.46	20.5
8	78.9	18.2	2.8	0.92	0.42	38.2
12	77.6	23.3	2.8	1.23	0.53	12.8
14	77.4	26.1	3.4	1.60	0.67	23.6
Cold Store II (-4.43°C)						
4	79.9	16.1	Nil	0.32	0.14	50.0
6	79.7	18.9	2.4	0.54	0.30	65.0
8	80.3	18.4	3.6	0.74	0.54	25.4
12	78.6	22.8	3.8	1.47	0.78	53.1
14	79.1	23.6	4.2	2.38	1.43	21.4
Cold Store, Control (-18°C)						
0	79.4	6.3	Nil	0.21	Nil	63.0
4	78.8	12.4	Nil	0.32	Nil	41.4
6	79.7	16.8	2.4	0.53	0.23	31.6
8	78.6	15.9	2.4	0.78	0.42	14.2
12	78.4	18.6	3.1	0.86	0.44	105.0
14	78.1	17.5	2.4	1.12	0.58	28.7

Table 3. *Changes in the chemical indices and total bacterial count of frozen pomfret (block) during storage at different cold stores*

Storage time, weeks	Moisture %	TVN mg%	TMAN mg%	HX μ moles/g	TBA mg/100g	TPC x 10^2 (count/g)
Cold Store II (-4.43°C)						
4	76.5	23.30	4.2	2.1	3.62	40.6
6	78.0	25.20	3.6	2.45	5.45	53.2
8	76.8	28.60	5.2	3.20	12.68	25.0
12	76.3	35.43	6.5	4.70	15.70	191.0
14	76.1	45.24	7.2	5.83	21.25	2760.0
Cold Store II (-10.4°C)						
4	77.3	14.68	1.6	0.92	2.14	30.6
6	77.0	18.25	2.4	0.51	3.80	12.4
8	76.8	19.60	2.4	1.48	5.95	17.3
12	76.4	24.52	4.8	2.25	7.86	3.45
14	75.8	22.70	4.8	3.17	11.20	11.50
Cold Store, Control (-18°C)						
0	75.8	10.38	0.6	0.21	0.32	60.0
4	76.5	12.20	1.2	0.35	0.65	34.2
6	76.2	16.10	2.4	0.64	0.72	15.3
8	76.5	20.21	2.4	0.94	1.68	22.4
12	76.1	19.30	4.2	1.45	2.10	18.6
14	77.3	21.40	4.2	1.80	2.83	16.2

Table 4. *Changes in the physico-chemical indices, total bacterial count and sensory characteristics of frozen silver pomfret during storage at different cold stores*

Storage time, weeks	Moisture %	TVN mg%	TMAN mg%	HX μ moles/g	TBA mg/100g	TPC x 10^2 (count/g)
Cold Store I (-11.24°C)						
2	76.1	15.4	Nil	0.85	0.450	442
4	74.8	14.0	2.4	1.68	2.21	47
6	75.1	18.2	3.6	1.74	3.52	33.1
9	73.9	23.5	4.2	2.80	5.94	56.8
12	72.4	2.40	5.6	3.83	9.50	281.0
Cold Store II (-4.43°C)						
2	75.2	9.8	1.4	0.76	0.78	14300
4	73.5	14.0	1.4	2.85	3.69	9100
6	74.1	17.6	2.8	3.62	9.80	880
9	73.4	23.5	4.2	5.82	12.56	1250
Cold Store, Control (-18°C)						
0	76.3	7.2	Nil	0.30	0.35	5900
4	74.8	12.6	1.4	0.76	0.78	576
6	75.3	16.8	2.8	1.09	1.55	62
8	74.6	15.4	3.2	1.34	1.80	280
9	73.5	18.2	2.8	1.30	2.42	392
12	73.3	21.2	2.8	1.50	2.80	1940

Table 5. *Canges in the chemical indices and bacterial counts (TPC) of frozen pearl spot during storage at different cold stores*

Storage time, weeks	Moisture %	TVN mg%	TMAN mg%	HX μ moles/g	TBA mg/100g	TPC x 10^2 (count/g)
Cold Store IV (-11.25°C)						
3	74.1	14.0	Nil	1.03	0.34	534
5	73.4	16.8	Nil	1.17	0.90	260
8	71.5	16.8	Nil	2.16	2.80	340
10	72.3	14.9	Nil	2.24	3.92	158
12	71.5	16.8	2.8	2.60	7.60	430
Cold Store V (-4.55°C)						
3	72.6	16.8	2.8	1.37	0.70	746
5	72.5	12.6	Nil	1.56	0.85	970
8	72.1	14.3	Nil	3.40	2.68	240
10	71.7	16.2	Nil	4.80	5.50	576
12	72.3	18.4	2.4	5.23	10.60	432
Cold Store, Control (-18°C)						
0	75.6	6.90	Nil	0.24	Nil	590
3	74.4	14.0	1.4	0.79	0.35	301
5	76.8	9.80	Nil	1.51	0.78	152
8	74.6	15.90	Nil	1.72	1.25	245
10	73.8	17.3	2.8	2.08	2.50	362
12	73.5	16.8	1.4	2.13	3.75	395

Sensory assessment showed that there was significant variations in the overall acceptability scores for the same species kept in different cold stores (Fig. 1). Upto 6 weeks of storage fish in all the retail cold stores remained in good condition except in II. Seer fish remained in good to fair condition for 8 weeks in cold store I while it was very good to good quality in control and it was in the limit of acceptability in cold store II. In cold store I seer fish developed slight rancidity by 12 weeks storage.

Black pomfret kept in cold store II became moderately good, developed rancid taste and slightly tough texture by 6 weeks storage. The intensity of rancidity increased and at 8 weeks the sample was rated moderately good to poor (Fig. 1). In II, the temperature conditions were fairly high and varied from-2.8 to-4.5°C. In cold store III upto 8 weeks of storage the sample retained good quality and by 12 weeks storage it developed rancid taste.

The pearlspot kept in III was rated good to moderately good upto 12 weeks and is comparable to the shelf life of pearlspot in I. The temperature of I and III were similar with average values-11.2 and-10.4°C respectively. The sensory characteristics of all the three species kept in the control store was good upto 12 weeks storage.

White pomfret and mullet were kept in cold stores IV and V along with control. By 4 weeks storage, white pomfret in V developed slight rancid odour and flavour. After 12 and 8 weeks storage in cold stores IV and V respectively, white pomfret became highly rancid and unacceptable. Control sample was good upto 12 weeks. The mullet after 10 weeks in IV was moderately good with slight rancid odour, flavour and tough texture whereas sample in V was not acceptable due to intense rancid taste and brown discolouration. Thus, intense rancidity, brown discolouration and tough texture reduced the eating quality of mullet from retail cold stores. Control mullet also developed the problem to a lesser extend after 10 weeks storage.

Mullet after a few weeks storage developed sour taste and tough texture. Toughness in white pomfret was also noticed. Texture score decreased with increase in time of storage for all samples. The increase in texture toughness with decrease in muscle pH has been observed by Kelly (1969).

In general water content in these samples also varied slightly and decreased by 2 to 4 units in all the cold stores.

The objective indices used to assess and compare the sensory quality in the study were hypoxanthine content and TBA values. The flavour changes were mainly caused by degradation of nucleotides as well as by the development of rancidity. The TBA values increased steadily in four species kept in different cold stores, in varying degrees. However, the TBA values in pearlspot was low in all the three cold stores including control. No rancid odour or flavour was developed in this species during the experimental period. However, in all other fatty fishes the TBA values increased with intensity of rancid flavour. The magnitude of variation in TBA values in the various species and sensory characteristics can be seen from Tables 1 to 5. The results indicated that TBA values increased fast in black pomfret and seer fish kept in II and white pomfret and mullet kept in V. This can be explained as a consequence of high temperature in these stores and must have accelerated fat oxidation. The sensory characteristics, especially the flavour, rancidity is found to be the major cause of quality deterioration.

The hypoxanthine content in these samples also increased with length of storage time and increased temperature conditions. The variations in hypoxanthine levels are given in Tables 1 to 5. The sensory scores of the product were very much dependent on the hypoxanthine content. It appears that samples having hypoxanthine levels > 2.04 moles/g are rated moderately good to poor.

The rate of increase of HX was fast in samples kept in II and V. Correlation tests with overall acceptability scores and HX content or TBA values marked significant negative correlation ($p< 0.0001$) in all the species.

The TVBN values also indicated an increase with storage period and the values were high in samples kept at elevated temperatures. It is observed that the level of TVBN did not increase in mullet during storage and remained at 14-16 mg% (Table 5.)

The sensory charcteristics and chemical indices used in the study clearly indicated that the quality deterioration was rapid in samples kept in cold stores II and IV where the average temperatures during the period were -4.43 and -4.55°C respectively. In other three cold stores, the average temperatures were below -10°C and the frozen fishes were kept upto 10 to 12 weeks in good to moderately good quality.

The bacteriological safety of the product is also evaluated (Tables 1 to 5). All the samples were free from pathogenic organisms. In general, the samples were not contaminated by *E. coli,* coliforms, faecal streptococci, coagulase positive staphylococci, salmonella and *Vibrio cholerae.* Total bacterial count in these samples were low and generally ranged from 10^2 to 10^4 per gram of muscle. TPC values decreased with storage period in most cases except in samples kept in cold stores II and V where the total count showed an increase. This increase in bacterial count is related to the high temperatures of the products.

The study, in general, indicated that fluctating and high temperature conditions of cold storages are the limiting factors in the quality and shelf-life of frozen fish from retail outlets.

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References

Conway, E. J. (1962) *Microdiffusion Analysis and Volumetric Error.* 5th edn., Parch Crosbey and Lockwood and Sons Ltd., London, p.467

Curran, C. A., Nicolaides, L., Poulter, R. G. & Pors, J. (1980) *Trop. Sci.* **22,** 367

FDA (1978) *Bacteriological Analytical Manual,* Food and Drug Administration of the U. S. Association of Official Analytical Chemists (Pub.) Washington, D. C.

Iyer. T. S. G., Damle, S. P., Garg, D. K., Nambiar, V. N. & Vasu, N. M. (1986) *Fish Technol.* **23,** 78

Jones, N. R., Murray, J., Livingstone, E. I. & Murray, C. K. (1963) *J. Sci. Food Agric.* **15,** 763

Joseph, K. G., Muraleedharan, V. & Nair, T. S. U. (1983) *Fish. Technol.* **20,** 118

Joseph, K. G., Muraleedharan, V., Kalaimani, N. & Nair, T. S. U. (1986) *Fish. Technol.* **23,** 63

Joseph, K. G. Muraleedharan, V. Nair, T. S. U. & Kalaimani, N. (1988) *Fish. Technol.* **25,** 120

Kelly, K. G. (1969) in *Freezing and Irradiation of Fish* (Kreuzer, R., Ed.) p.528, Fishing News (Books) Ltd., London

Kenner, B. A., Clark, H. F. & Kabler, P. W. (1961) *Appl. Microbiol.* **9,** 15

Lakshmanan, P. T., Mathen, C., Varma, P. R. G. & Iyer, T. S. G. (1984) *Fish. Technol.* **21,** 98

Mathen, C. (1970) *Fish. Technol.* **7,** 213

Sreenivasan, R. & Joseph, K. C. (1966) *Fish. Technol.* 3, 103

Tarladgis, B. G., Walts, B. M., Margaret, T. Y. & Dungan, L. (1960) *J. Am. Oil Chem. Soc.* **37,** 44

Valsan, A. P., Nambiar, V. N., Damle, S. P., Garg, D. K. Iyer, T. S. G. & Vasu, N. M. (1985) in *Harvest and Post-harvest Technology of Fish,* Society of Fisheries Technologists (India), Cochin, p.661