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Comparative Studies on Quality Changes of Air Blast and Plate Frozen Mackerel (*Rastrelliger kanagurta*) During Frozen Storage

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Mackerel (*Rastrelliger kanagurta* Cuvier) frozen in commercial plate and air blast freezers were studied to compare the quality changes during frozen storage (-18°C), The frozen fish were sealed in polythene bags of food grade Linear Low Density Polyethylene (LLDPE), 120 gauge thick conforming to IS: 9845 - 1981) then packed in 5-ply corrugated fiberboard carton and were analyzed for changes in quality during storage at -18°C. The moisture and protein content in air blast frozen samples were decreased ($p<0.05$) at the end. There were no significant difference ($p>0.05$) in PV of both the samples. TBA of air blast frozen samples showed an increasing trend ($p<0.05$) than plate frozen samples. There was an increasing trend in FFA in both the samples but were not significantly different ($p>0.05$). The TMA-N and TVB-N of both the samples showed an increasing trend but air blast frozen samples showed little higher values ($p<0.05$) than plate frozen samples. The total plate count decreased significantly ($p<0.05$) in both the samples, The samples frozen in plate freezer were established to be superior ($p<0.05$) compared to air blast freezer with regard to sensory attributes like appearance, odour etc., and overall acceptability. The present study indicated that plate frozen samples were slightly better than air blast frozen samples in quality because of quick freezing effect but mackerel frozen by both plate and air blast freezer were acceptable even after 3 months of storage at -18°C.

Key words : **Plate freezing, air blast freezing, Indian mackerel, frozen storage, quality**

Processed marine products are of great economic importance. During processing and storage, fish quality may decline due changes in chemical, physical, bacteriological and histological characteristics of the muscle. These quality changes are influenced by many factors, the most important of which is temperature. Low temperature preservation is considered an excellent process, which has been widely used to retain sensory and nutritional properties of fish. (Pigott & Tucker, 1987; Erickson, 1997). But the freezing conditions like type of freezers, time taken to freeze the materials etc., have influence on the quality of the final product. Studies on mackerel (*Rastrelliger kanagurta*) of medium (4%) and high (11%) lipid contents quick frozen individually (IQF) and as blocks (BF) and stored at -23°C showed that block frozen mackerel had higher frozen storage shelf-life than Individually quick frozen samples based on sensory evaluation (Nair *et al.*, 1987).

Presently, a variety of freezers are available in the market, viz., refrigerated contact surface type or drum freezers, immersion or spray freezers, sharp or coil freezers, air blast freezers, fluidized-bed freezers, plate or contact freezers, and liquid nitrogen freezers. Among these, the freezers that are most widely used commercially, are air blast freezer and contact or plate freezer.

The purpose of the present work was to find out the difference in the characteristics of mackerel, a fatty fish of commercial importance, on freezing as IQF plate freezer

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and air blast freezer. Studies were also conducted to find out the effect of freezing equipment and freezing time on the quality characteristics during frozen storage.

Materials and Methods

Mackerel (*Rastrelliger kanagurta*), which were in the early stages of rigor were procured from the fish landing centre, Cochin, India. The average length and weight of the fish were recorded as 20±0.75 cm and 160±1.0 g respectively.

The fish were immediately iced and taken to commercial fish processing plant. The fish were de-iced and washed with water containing 2 ppm chlorine. It was divided into two lots. The first batch was individually quick frozen in Plate freezer (PF) (horizontal type) and the second was individually quick frozen in Air blast freezer (ABF) (batch type). The frozen fish after glazing were packed and sealed in food grade Linear Low Density Polyethylene (LLDPE) sheets of thickness 120 gauge conforming to IS: 9845 - 1981, and then in 5 ply corrugated fiberboard carton and stored in the cold storage at -18°C. The fish were drawn as a representative sample once a month and analyzed to evaluate the quality. The analyses were done in triplicates.

Moisture and total nitrogen were estimated by the AOAC (2000) procedure, Thiobarbituric Acid value was measured by Tarladgis *et al.* (1960) method, and Peroxide value was determined by AOCS, (1999) procedure, Free fatty acid was estimated by the method of Link (1959), Tri-methylamine nitrogen and total volatile base nitrogen were estimated by Conway's micro diffusion method (1950), Total plate count was carried out by the method Hitching *et al.* (1995).

Sensory evaluation for cooked fish was conducted for various sensory characters such as appearance, texture, odour and flavour etc. Score was given based on a 10-point hedonic scale by 10 trained taste panels, as per the guide lines given by IS: 6273(II) – 1971. Scores 9-10, 6-8, 4-5 and 1-3 were taken for excellent, good, fair and poor respectively for each of the sensory characteristic.

The SPSS (2000) Statistical Package was used for analysis of the experimental results. Analysis of variance (ANOVA) was used to calculate significant difference ($p<0.05$) between samples. Mean separations were determined by Duncan multiple range test.

Results and Discussion

Table 1 gives the changes in proximate composition viz., moisture, fat and protein of mackerel frozen as IQF in plate freezer and air blast freezer. During freezing, the plate frozen samples showed 1.65% decrease in moisture and air blast frozen samples showed 1.81% decrease, which are significant and protein content of both the samples

Table 1. Changes in moisture, fat and protein (g %) of *R. kanagurta* during frozen storage at -18 °C

Time (mo.)	MOISTURE (g %) PF**	ABF***	FAT(g %) PF**	ABF***	PROTEIN(g %) PF**	ABF***
Fresh	72.60±0.99 ^{a}		3.44±1.02 ^{a}		23.31±0.05 ^{a}	
0	70.95±1.03^b	70.79±2.31 ^{b}	3.20±0.05 ^{b}	3.13±0.14^b	23.38±0.04 ^{b}	23.51±0.15 ^{b}
1	70.69±1.32 ^{b}	70.74±1.38 ^{b}	3.30±0.02^b	3.30±0.03 ^{b}	22.70±0.12 ^{c}	23.37±0.10 ^{c}
2	70.49±2.31 ^{c}	70.51±1.85 ^{b}	3.54±0.01^a	3.49±0.011 ^{a}	22.44±0.24 ^{c}	22.88±0.11 ^{c}
3	70.38±1.25 ^{d}	70.15±1.66 ^{c}	3.60±0.05^a	3.57±0.09^a	21.91±0.11 ^{c}	21.85±0.12 ^{c}

*Each value is represented by the average ± standard deviation of at least 3 replications.

[a,b,c,d,e] Mean in a column with the same superscript letters are not significantly different ($p>0.05$)

** Plate freezer; *** Air blast freezer.

f.max

also showed significant changes. During frozen storage the changes in moisture, fat and protein were not significant. The decrease in moisture was more in air blast frozen samples, which may be due to dehydration caused by the cold air flow over the samples during freezing.

The Peroxide value (PV) of fish before and after freezing by plate and air blast freezers were found negligible (Fig.1). It increased significantly during storage in both the samples and reached the maximum value in the third month, the increase could be attributed to the peroxidation of PUFA in the presence of atmospheric oxygen.

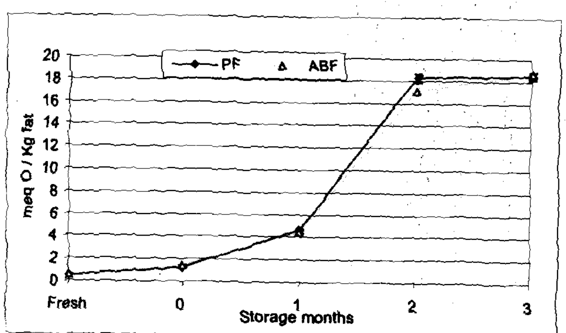

Fig. 1. Changes in peroxide value of *R. kanagurta* during frozen storage at -18°C
*Each value is represented by the average ± standard deviation of at least 3 replications.

The TBA value also showed overall increase during frozen storage for both the samples (Fig. 2). The TBA content was found to increase slightly in air blast frozen samples during frozen storage. At the end of the 3rd month the TBA values were observed to be 5.2 and 6.8 mg of malonaldehyde/kg of fish in plate freezer and air blast freezer respectively, which could be attributed to faster freezing rate and the increased concentration of trace metals in the frozen storage which in turn could lead to non-enzymatic lipid oxidation. The trace metal ions like iron, copper and cobalt which serves in vivo, the bound forms of iron like haeme, non-haeme iron and chelation complexes like histidine-iron may play an important role in catalyzing lipid oxidation. Schonmuller, (1968) reported that maximum level of 5 mg of malonaldehyde/kg of TBA value indicates the good quality of chilled and frozen fish, while the fish may be consumed upto the level of 8 mg of MA/kg of fish. TBA values of both air blast and plate freezers were in acceptable limits during frozen storage.

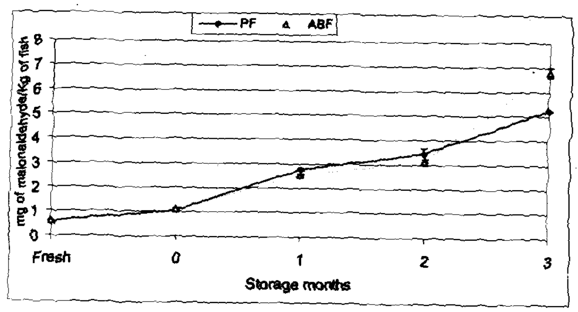

Fig. 2. Changes in thiobarbituric acid value of *R. kanagurta* during frozen storage at -18°C
*Each value is represented by the average ± standard deviation of at least 3 replications.

The FFA levels increased steadily during the storage with no significant difference ($p>0.05$) between samples (Fig.3). Changes in the lipid fraction of fish showed that the lipid slowly underwent hydrolysis that might have increased the FFA content during frozen storage. According to Nair *et al.* (1976), the hydrolytic changes in the lipids of mackerel (*R. kanagurta*) during storage at -18°C indicated that FFA production was mainly associated with the phospholipid hydrolysis.

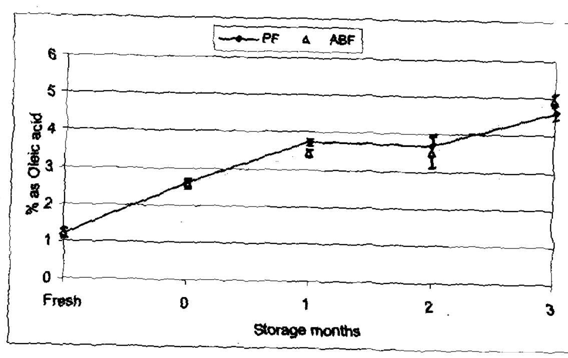

Fig. 3. Changes in free fatty acid value of *R. kanagurta* during frozen storage at -18°C
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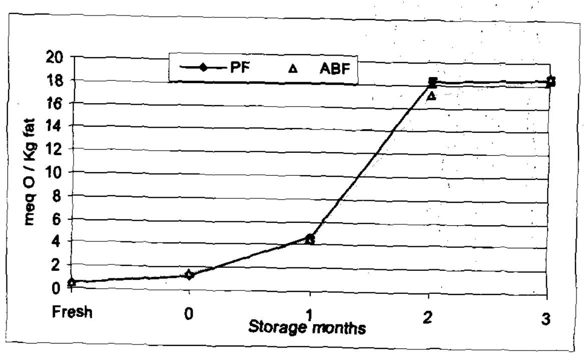

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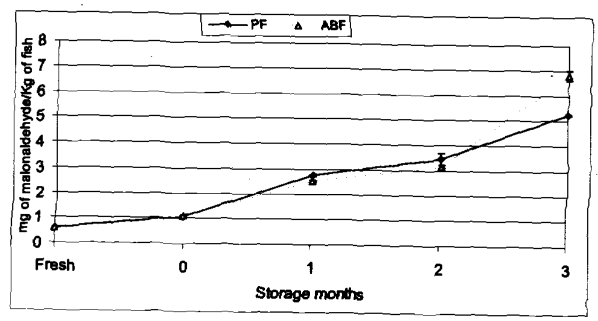

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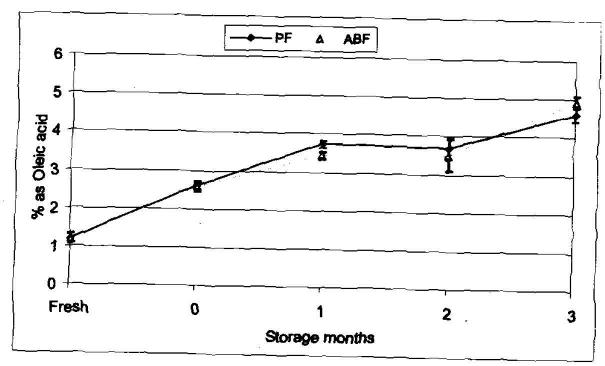

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Table 3. Changes in sensory quality of air blast frozen *R. kanagurta* during frozen storage at -18 °C

Time (mo.)	Appearance	Color	Odor	Taste	Flavor	Texture				Overall acceptability
						Firmness	Fibrous-ness	Succule-nce	Tough-ness	
Fresh	9 ± 0.21^{a}	9.2 ± 0.12^{a}	9 ± 0.25^{a}	8.9 ± 0.11^{a}	9 ± 0.17^{a}	$8.9\pm.0.16^{a}$	$8.8\pm.0.19^{a}$	$9.2\pm.023^{a}$	$8.8\pm.027^{a}$	8.97 ± 0.25^{a}
0	8.6 ± 0.25^{b}	8.7 ± 0.12^{b}	8.5 ± 0.20^{b}	8.8 ± 0.41^{a}	8.2 ± 0.42^{b}	8.5 ± 0.32^{b}	7.9 ± 0.14^{b}	8.5 ± 0.21^{b}	8.0 ± 0.52^{b}	8.41 ± 0.27^{b}
1	8.4 ± 0.12^{b}	8.4 ± 0.45^{bc}	8.0 ± 0.48^{b}	8.4 ± 0.24^{b}	7.8 ± 0.40^{c}	8.1 ± 0.12^{c}	7.5 ± 0.24^{c}	8.0 ± 0.23^{c}	7.6 ± 0.24^{c}	8.02 ± 0.27^{c}
2	7.9 ± 0.32^{c}	8.1 ± 0.59^{c}	7.8 ± 0.52^{b}	6.8 ± 0.42^{c}	7.5 ± 0.19^{d}	7.5 ± 0.15^{d}	7.0 ± 0.21^{d}	7.1 ± 0.21^{d}	6.9 ± 0.19^{d}	7.4 ± 0.18^{d}
3	$7.9\pm0.41b^{c}$	7.5 ± 0.21^{d}	7.0 ± 0.14^{c}	6.0 ± 0.35^{d}	6.7 ± 0.15^{e}	6.6 ± 0.31^{e}	6.5 ± 0.23^{e}	6.5 ± 0.41^{e}	6.3 ± 0.20^{e}	6.7 ± 0.42^{e}

*Each value is represented by the average ± standard deviation of scores given by 10 taste panel members. All traits measured on 10-point scale with 1 being least and 10 being the most.
[a,b,c,d,e] Mean in a column with the same superscript letters are not significantly different ($p > 0.05$)

and texture showed a significant difference when compared to plate frozen samples. This may be attributed to the formation of secondary lipid oxidation products or carbonyl compounds during frozen storage, which are prone to react with proteins and affects both the flavor and texture. Furthermore, the cold air flow that passes over the samples during freezing dehydrates the sample which in turn affects the textural quality. Hence the overall acceptability and sensory quality for the plate frozen samples were judged higher ($p<0.05$) than air blast frozen samples.

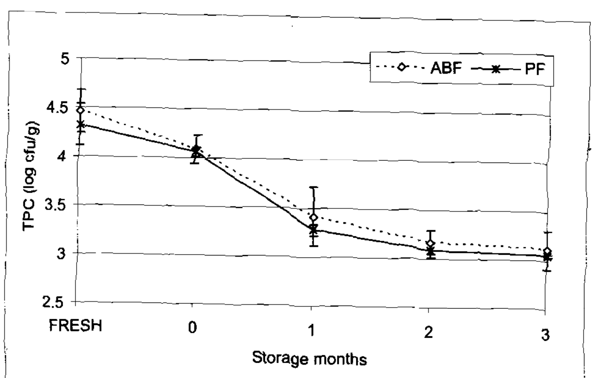

Fig. 6. Changes in total plate count of *R. kanagurta* during frozen storage at -18°C
*Each value is represented by the average ± standard deviation of at least 3 replications.

The present study indicated that plate frozen samples were slightly better than air blast frozen samples in quality, which could be attributed to the faster freezing rate in plate freezer, nevertheless the quality of mackerel (R. *kanagurta*) frozen by both plate and air blast freezer were acceptable even after 3 months of storage at -18°C.

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References

AOAC, (2000). Official methods of analysis. Association of Official Analytical Chemists *International. Maryland, USA.*

AOCS, (1999). Official methods and recommended practices of American Oil Chemists Society-5th Edition. A.O.C.S. Champaign, USA.

Cakli, S., Tokur, B., Celik, U. and Taskaya, L. *(1997). No-froast kosullarda depolanan* sardalya bahklarimin (*Sardina pilchardus*) fiziksel, kimyasal ve duyusal degerlendirilmesi. *In*: B.Hossu. *Akdeniz Baliculik Kongresi,* (9-11Nisan). Bornova – Izmir: E.U. Basimevi. pp. 733-740.

Conway, E.J. (1950). *Microdiffusion Analysis and Volumetric Error*, 5th Edn, Parch Crosbey and Lockwod and Sons Ltd., London., 467 p.

Erickson, M.C. (1997). Lipid oxidation: Flavor and nutritional quality deterioration in frozen foods, in *Quality in frozen foods*, edited by M.C. Erickson and Y. C. Hung, Chapman & Hall, New York, pp. 141-173.

Hitching, A.D., Feng, P., Watkins, W.D., Rippey, S.R., and Chandler, L.A. (1995). Aerobic plate count. In: *Bacteriological Analytical Manual*, 18th Edn., (Tomlinson, L.A., Ed.), PP. 4.01-4.29, AOAC International, USA.

IS: 6273 (II) - (1971). Indian Standard Guide for Sensory Evaluation of Foods (Part II, Methods and Evaluation Cards), Indian Standard Institute, New Delhi, India.

IS: 9845 – (1981). Methods of analysis for the determination of specific and/ or overall migration of constituents of plastic materials, and articles intended to come in to contact with foodstuffs. Indian Standard Institute, New Delhi, India

Joseph, A.C., Surendran, P.K. and Perigreen, P.A. (1989). Delayed freezing on quality and shelf-life of Kalawa (*Epinephelus spp.*). *Fish. Technol.*, 26, pp. 107-110.

Link, W.E. (1959). General methods of analysis of drying oils. *J. Ame. Oil. Chem. Soc.*, 36: pp. 477-483.

Nair, P.G.V., Gopakumar, K., and Rajendranathan, N.M. (1976). Lipid hydrolsis in mackerel (*Rastrelliger kanagurta*) during frozen storage. *Fish. Technol.*, 13, pp. 111-114.

Nair, P.R., Chinnamma G., Nirmala T., perigreen, P.A., and Gopakumar, K. (1987). Studies on Frozen Storage Characteristrics of Individually Quick Frozen and Block Frozen Mackerel, Fish. Technol., 24, pp. 103-107.

Nickelson, I.I.R, Finne, G., Hanna, M.O. and Vanderzant, C. (1980). Minced fish flesh from non-traditional Gulf of Mexico fin fish species. *J. Food. Sci.*, 45, pp. 1321-1326.

Pigott, G.M. and B.W. Tucker (1987). Science opens new horizons for Marine lipids in human nutrition, *Food Rev. Int.* 31, pp. 105-138.

Schonmuller, J. (1968). Handbuch der lebensmittelchemie (Band III/2). Springer Verlag *BerlinHeidelberg- NewYork. pp.* 121-125.

Tarladgis, B.G., Watts, B.M. and Younathan, M.T. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. *J. Ame. Oil. Chem. Soc.*, 37, pp. 44-48.