Fishery Technology
1994, Vol. 31(2) pp : 148-152

Effect of Packaging Materials on the Shelf Life of Frozen Fish Fingers

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A commercially available lean fish, *Sciaena aneus,* was used for making battered and breaded fish fingers. The fish fingers were packed in flexible film pouches of 50μ Low density polyetheylne (LDPE), 62.5μ Low density polyethylene - High density polyethylene (LD/HDPE), 20μ High molecular weight high density polyethylene (HM-HDPE) and 100μ Low density polyethylene-Nylon-Primacore (LDPE/NY/PC), heat sealed and stored at -20°C and storage quality evaluation was conducted in comparison to the control sample which was kept without packaging. Control samples were discarded in 4 weeks time due to rancidity development, tough texture aand colour changes. The samples packed in LD/HDPE and LDPE/NY/PC remained in satisfactory condition up to 28 and 32 weeks, respectively, whereas LDPE and HM-HDPE packed samples remained in satisfactory condition only for 20 weeks.

The fish processing industry in India is mainly export oriented and the major portion of the exported item is block frozen shrimp. But recently individually quick frozen (IQF) shrimp have also become common in exported items. It is felt that diversified products from low cost fish could also be prepared for export and internal market. Many value added and convenience ready-to-eat products such as battered and breaded fish fingers have been prepared from fish mince. Proper packaging of such products is most essential to get long frozen storage life.

Materials and Methods

Fish fingers were prepared from mince of freshly landed Big eye croaker (*Sciaena aneus*). The fish were beheaded, eviscerated and split open. Meat was separated using a hand mincer and salt and sodium polyphosphate were incorporated in the mince at 10 and 5 g kg^{-1}, respectively. Prepared mince was frozen in a contact plate freezer at -40°C. The frozen material was cut into uniform sized fingers of 7x2.5x1 cm, battered and breaded using egg and bread powder, respectively and then refrozen at -40°C.

The films used for packaging the frozen fingers were 50 μ Low density polyethylene (LDPE), 62.5 μ Low density polyethylene/high density polyethylene (LD/HDPE), 20 μ High molecular weight high density polyethylene (HM-HDPE) and 100 μ Low density polyethylene/Nylon/Primacore (LD/NY/PC). Four fish fingers (100 g) were packed in each pouch of 10x12 cm, heat sealed and packed in wax coated duplex cartons which were packed in 5 ply corrugated fibre board cartons as a shipping container and stored at -20°C.

After freezing and packing in pouches the samples were taken for initial analysis. Periodic analyses of the samples were conducted at intervals of two weeks in the beginning and then at every four weeks. Moisture was determined by AOAC (1975) method 24.003, fat by petroleum ether extraction in the soxhlet apparatus, protein (Total Nitrogen x 6.25) by the micro-kjeldahl method (Oser, 1971), total volatile nitrogen by the method of Lea (1952) and peroxide value and free fatty acids (FFA) were determined by AOCS (1946) methods, respectively. The suitability of the films for food contact application was tested as indicated by the methods of BIS (1981) and FDA (1983). Water wapour transmission rates (WVTR) of the packaging films were determined as per BIS (1960). Oxygen transmission rate (OTR) was determined as per ASTM (1975). Tensile strength and elongation at break, in machine and cross directions were determined as per BIS (1984) in 5x1.5 cm film specimens and the heat seal strength was determined using a tensile strength testing machine. Organoleptic evaluation was made by an expert taste panel of six members, after thawing and frying the fish fingers in refined groundnut oil at 175-200°C for 5 min. The acceptability was determined on a hedonic scale ranging from 1 to 9 and the results were analysed statistically as per ASTM (1968).

Results and Discussion

The initial chemical composition of the raw fish fingers before frying is given in Table 1.

Table 1. *Composition of fish fingers from Big eye croaker*

Moisture, %	71.16
Crude protein, % (N x 6.25)	14.82
Fat, %	4.74
Ash, %	3.80

Table 2 shows the different physical properties of the films used for packing the fish fingers. The films LD/NY/PC and LD/HDPE had very low water vapour transmission rate (WVTR) while the other two films HM-HDPE and LDPE had considerably higher WVTR. LD/NY/PC

Table 2. *Physical properties of flexible packaging materials used for packing fish fingers*

		LDPE	LD/HDPE	HM-HDPE	LD/NY/PC
1. Thickness, μ		50	62.5	20	100
2. Water vapour transmission rate, g m^{-2} at 37°C, 24 h and 90% RH		8.8	2.95	8.12	3.38
3. Oxygen transmission rate, cm^3 m^{-2} $24h^{-1}$, atmos. at 20°C and 0% RH		3500	1800	5098	48
4. Tensile strength, kg cm^{-2}	MD	320	168	383	198
	CD	180	156	308	188
5. Elongation at break, %	MD	220	300	375	380
	CD	360	420	425	450
6. Heat seal strength, kg cm^{-2}	MD	200	125	216	120
	CD	128	100	166	115
7. Flexibility at -20°C		Flexible	Flexible	Flexible	Flexible
8. Water extractives, mg l^{-1}		4.16	1.36	3.44	1.4

MD - Machine direction; CD - Cross direction

Table 3. *Effect of packaging films on the physical and organoleptic characteristics of fish fingers during storage at -20°C (Initial score : 9)*

Period of storage, weeks	Control without packaging	LDPE 50 μ	LD/HDPE 62.5 μ	HM-HDPE 20 μ	LD/NY/PC 100 μ
2	Sweet taste lost, slightly tough, colour texture and flavour changes, but acceptable Score : 5.32±0.41	Good Taste, sweet, good texture, flavour and colour Score : 8.18±0.22	Good taste, sweet, good texture and colour Score 8.72±0.03	Good taste, sweet, good flavour and colour Score : 8.41±0.15	Good taste, sweet, good texture, flavour and colour Score : 8.65±0.06
4	Dehydrated, rancid, tough and slight off flavour. Not acceptable Score : 3.00±0.32	Good taste, sweet, good texture, flavour and colour Score : 7.30±0.62	Good taste, sweet, good texture and colour Score : 8.50±0.21	Good taste, sweet, good texture Score : 8.13±0.27	Good taste, sweet, good texture, flavour and colour Score : 8.42±0.15
16	--	Fair taste, colour and flavour. Firm texture Score : 6.84±0.15	Good taste, sweet, good texture & colour Score 7.82±0.79	Good to fair colour and flavour, firm Score 7.12±0.17	Good taste, sweet, good texture and colour Score : 8.25±0.03
20	--	Taste satis-factory, slightly tough but accepta-ble Score : 5.10±0.38	Good to fair taste, not much change in texture and colour Score : 7.23±0.42	Taste satis-factory, slightly tough but accepta-ble Score : 5.12±0.82	Good taste, sweet, good texture and colour Score : 7.88±0.72
24	--	Change in flavour and colour, rancid and tough. Not acceptable Score : 3.3±0.27	Fair taste, slight changes in texture and colour Score : 6.56±0.27	Changes in flavour, bitter, tough. Not acceptable Score : 3.82±0.17	Good to fair taste, colour and texture Score : 7.21±0.31
28	--	--	Taste satis-factory; slightly tough but acceptable Score : 5.72±0.42	--	Fair taste, slight changes in colour and texture Score : 6.87±0.22
32	--	--	Slight off taste, rancid, tough. Not acceptable 3.32±0.12	--	Satisfactory taste, sweetness slightly lost Score : 5.75±0.13
36	--	--	--	--	Original taste lost, bitter, and tough. Not acceptable Score : 3.82±0.12

had the lowest OTR among the four. OTR is very important as far as the rancidity of the product is concerned. The water extractive values of all the four films were within the limits specified by FDA (1983) (50 mg l^{-1}) and BIS (1982) (60 mg l^{-1}) and therefore could be safely used for packing fish fingers. Tensile strength (Table 2) showed that all the films could provide the required breaking strength and stretch. However, duplex cartons and master cartons were provided for better strength and to withstand hazards during transportation. Throughout the storage period all the films remained flexible and without cracking.

The changes in moisture content was pronounced in the control sample resulting in toughness of the product by 4 weeks (Fig. 1; Table 3). Packed fingers had a good moisture retention from the initial stages of the experiment.

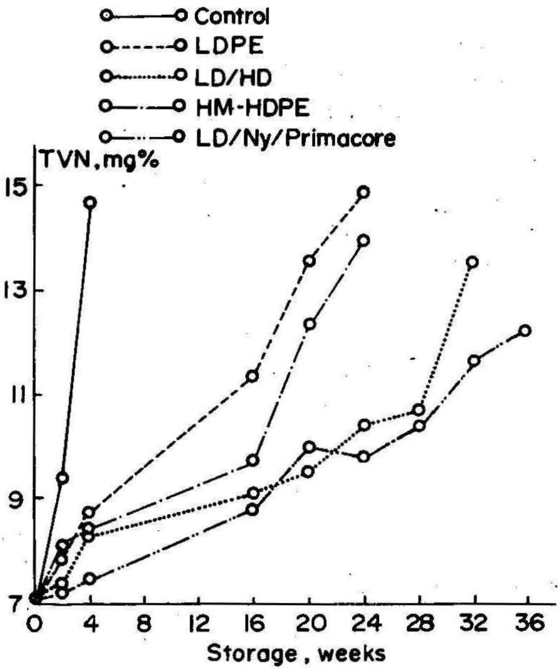

Fig. 2. Changes in total voltaile nitrogen of frozen fish fingers packed in different packaging materials stored at -20°C

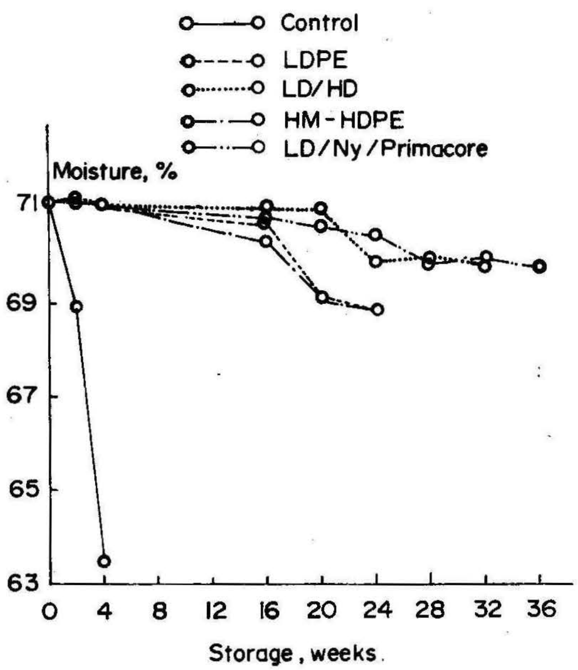

Fig. 1. Moisture changes in frozen fish fingers packed in different packaging materials and stored at -20°C

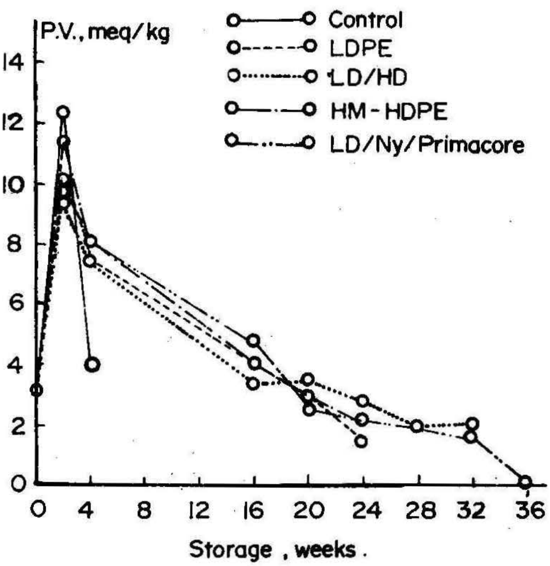

Fig. 3. Changes in peroxide value of frozen fish fingers packed in different packaging materials and stored at -20°C

The TVN values increased slowly and steadily (Fig. 2) within limits during storage period but in the control sample high values were reached in the 4th week thus correlating with the sensory evaluation results. Fig. 3 shows the pattern of increase in peroxide value. It reached a peak in 2nd week and then showed a decreasing trend. This may be because the peroxides being highly reactive undergo decomposition and/or react with proteins. The changes in FFA values (Fig. 4) showed slow but definite increasing trend throughout the study. As may be seen from Table 3, the taste panel scores supported the changes in chemical indices in Figs. 1-4. The organoleptic scores showed steady decrease from the 16th week in all samples. The control sample was rejected in 4th week itself. The longer acceptability as indicated by the taste panel scores (Table 3) was provided by the LD/HDPE and LD/NY/PC compared to thin film packed samples. It was the toughness and flavour changes (Table 3) which finally limited the keeping qualities of the packed frozen fish fingers.

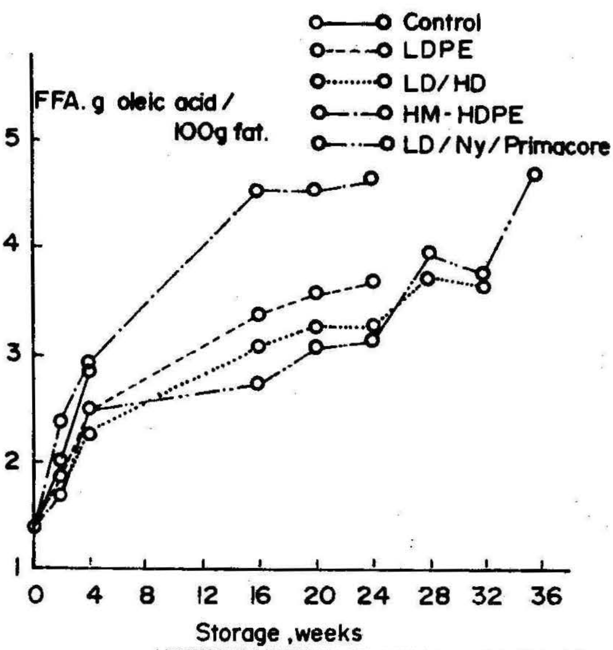

Fig. 4. Changes in free fatty acid content of frozen fish fingers packed in different packaging materials and stored -20°C

It may be concluded that the protective barriers provided by the combination films have manifested themselves in giving better shelf life compared to control sample and samples packed in thinner films. The thin films LDPE and HM-LDPE provided only 20 weeks of satisfactory storage time whereas the multilayer film LD/NY/PC and co-extruded film LD/HDPE gave 32 and 28 weeks of storage life, respectively for the fish fingers during frozen storage. Hence for short term frozen storage, cheaper films like LDPE or HM-HDPE may be used but the other two costly films can be employed when long period of storage life is required.

The authors are thankful to Dr. K. Gopakumar, Director, Central Institute of Fisheries Technology, Cochin for his encouragement and permission to publish this paper.

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