

Asian Fisheries Science 11(1998):213-222
Asian Fisheries Society, Manila, Philippines

<https://doi.org/10.33997/j.afs.1998.11.3-4.004>

Flexible Packagings for Individually Quick Frozen Shrimp and their Effects on Shelf Life

K.P. ANTONY, P. RAVINDRANATHAN NAIR, T.K. SRINIVASA GOPAL and T.S. GOPALAKRISHNA IYER

Central Institute of Fisheries Technology
Cochin-682 029
India

Abstract

The suitability of different packaging materials used in storing individually quick frozen (IQF) prawns at -20°C is studied. Compared to block frozen shrimp, IQF products are more susceptible to changes during storage as more of their surface area is exposed. As it is one of the more popular IQF export products, the headless shrimp was chosen as the material for the study. Packaging materials used include multilayer films like polyester/low-density polythene (PEST/LDPE) and low-density polythene/nylon/linear low-density polythene (LDPE/Ny/LLDPE), which have very good barrier and strength properties, and single-layer films like low-density polythene, ultra-density polythene (UDPE) and octane-based linear low-density polythene (OBLDPE). IQF prawns packaged using the two mul-tilayer films had a shelf life of 180 d at $-20\pm 2^{\circ}\text{C}$ while the three single-layer films provided only 120-150 d of shelf life at the same temperature. The major limiting factor of the shelf life of the product was dehydration, which marred its appearance, texture and flavor.

Introduction

India's exports of marine products in fiscal year 1995-96 reached 296,377 tons, valued at Rs. 3501 crores. Of the 53 varieties of seafood products exported, shrimp products accounted for 70% of total export value (MPEDA 1996). Shrimp products are either individually quick frozen (IQF), reaching the consumer in the same form, or block frozen, which means that they are mostly reprocessed and repacked. Thus, producers can earn more by shifting from bulk frozen slab-type products to IQF products. In this context, the type of packaging material used plays an important role. However, packaging, to be effective, should provide the necessary barrier properties against dehydration, color, texture, flavor and rancidity changes. Production costs may slightly go up when the traditional single-web polythene film is replaced by multilayer films, but the high costs are more than amply compensated for by the higher returns achieved from properly packed IQF products.

There are certain special problems associated with IQF products' packaging compared to packaging of traditional block frozen shrimp products. IQF shrimps are less protected than glazed block frozen shrimps against dehydration, oxidative rancidity and loss of flavor while in storage. Temperature fluctuations in the storage area aggravates this problem. Dehydration is

particularly worrisome, if extended shelf life is required. Standardization of glaze and barrier properties of packaging materials are important in this context (Dordi 1992).

IQF products weigh from 200 g upwards. The types include products with heads on, headless, peeled and deveined or cooked products (Goran Londahl 1993). Among the more popular products are headless shrimps (MPEDA 1996). Packaging materials for IQF products, besides having excellent barrier properties, should have very good tensile strength, bursting strength, sealing strength and puncture resistance to prevent breaking or opening of the pouches and puncturing of the spine in the tail portion. Even though films of high strength and low permeability are available, the industry continues to use the traditional single-layer films, causing packaging problems. The present study deals with the suitability of the different packaging materials used in the frozen storage of IQF shrimps.

Materials and Methods

Headless shrimp (*Metapaeneus affinis*) in a rigor to post-rigor condition were used. The headless IQF shrimp were prepared in a local factory under commercial operating conditions. There were about 65 pieces of headless shrimp per kg. During the entire process of washing, processing and freezing, 5-10 ppm chlorinated water was used. The shrimp were individually quick frozen in a fluidized bed freezer at -40°C and treated with 5 ppm chilled chlorinated water to obtain a uniform glaze. In previous studies on headless shell on products, the usually acceptable 5-10% glaze was found to be inadequate in preventing product deterioration. However, 15% glaze was found to be quite adequate if the proper packagings were used (Antony and Srinivasa Gopal, unpubl. data). Accordingly, the level of glazing of the IQF products was raised to 15%. The following types of packages were used:

- 12m polyester/37.5m polythene;
- 40m low-density polyethylene/15m nylon/20m linear low-density polyethylene;
- 50m ultra-density polyethylene;
- 80m octane-based linear low-density polyethylene; and
- 62.5m low density-polyethylene.

The last is the film type traditionally used by the industry and, hence, was used as the control packaging material.

Two hundred 50g samples of the IQF headless shrimp were packed in each of the above-

mentioned packages of size 25 x 20 cm, heat sealed, further packed in duplex cartons and 7 ply master cartons, strapped and stored at $-20\pm 2^{\circ}\text{C}$. The process of packaging was done in a chill room.

Initial analysis was conducted immediately after freezing. Periodic analysis of the samples was conducted at 30-day intervals. The IQF products were subjected to biochemical analysis after thawing, peeling and deveining. Bacteriological tests were conducted while the products were in a frozen condition. Moisture content was determined by AOAC (1990) method, fat by petroleum

ether extraction in the soxhlette apparatus, protein (TN x 6.25) by microkjeldahl method (Oser 1971), total volatile base nitrogen by the method of Lea (1952), free alpha amino nitrogen by the method of Pope and Stevens (1959), and salt-soluble nitrogen and water extractable nitrogen by the AOAC (1990) method. The glaze percentage was determined by weighing the frozen material on a 2.8 mm clean sieve dipped three times for three seconds in water with a temperature of 27-30°C and finally drained for 5 minutes and then weighed for percentage loss. Net weight percentage was determined as the percentage of material frozen, after the product was thawed in a waterproof pouch in running water at room temperature and drained and weighed (Cyriac Mathen and Francis Thomas 1986). The suitability of films for food contact application was tested using the methods of BIS (1981) and FDA (1983) and water vapor transmission rate (WVTR) was determined as per ASTM (1975). Tensile strength and elongation at a break in machine and cross direction were determined as per BIS (1984) using 5 x 1.5 cm film specimens. Heat seal strength was determined using a tensile strength machine. Before thawing, the percentage of dehydrated pieces was calculated by visual counting and the percentage expressed based on the total number of pieces. Sensory characteristics of the thawed material was assessed by an expert panel of six members based on dehydration, discoloration, the presence of black spots on shell and meat as well as odor and flavor of the thawed material. One part of the thawed material was cooked in 2% brine for eight minutes and subjected to taste panel studies. Sensory score of the cooked samples was based on odor, texture, sweetness and flavor. The scoring was according to a 1 to 9 hedonic scale and results were analyzed statistically as per ASTM (1968). Total plate count for bacteria, E.coli, coagulase-positive staphylococci, fecal streptococci and salmonella were estimated, according to the methods of IS: 2237 (1997). In all analytical work, triplicate samples were taken and the average value reported.

Results and Discussion

The proximate composition of the IQF shrimp used in the study is given in Table 1.

Initially, the color of the peeled and deveined meat was grayish white. Taste tests showed the cooked meat to have excellent organoleptic qualities.

Table 1. Proximate composition and other chemical parameters of *Metapaeneus affinis*.

Moisture (%)	79.30
Fat (%)	01.23
Crude protein (%)	17.74
Ash (%)	01.52
Glaze (%)	15.86
TVBN (mg/100 g)	19.60
Alpha amino nitrogen (g/100g)	0.212
WEN (g/100g)	0.812
SSN (g/100g)	2.100
TPC (per g)	5.4 x 10 ⁴

TVBN - total volatile base nitrogen; WEN - water extractable nitrogen; SSN - salt-soluble nitrogen; TPC - total plate count.

The different physical properties of the films used in making the pouches used as packagings for the IQF shrimps are presented in Table 2.

The PEST/LDPE and LDPE/Ny/LLDPE laminates had the lowest WVTR and OTR. These have a direct bearing on the minimum reduction rate of glaze on the IQF products and kept the net weight of the material without much change compared to the other three films. This is very much evident from Fig. 1, where glaze percentage was reduced from the original 15.86 to 10.19 in LDPE, 12.48 in OBLDPE and 9.72 in UDPE on the 210th day of storage, whereas the two laminates mentioned above had a reduction rate of glaze of 13.5% and 14.06%, respectively, in the same period. It can also be noticed that both the laminates used in the packaging of IQF products barely changed the net weights, compared to the single webbed films in Fig. 2. Dehydration was noticed in LDPE packed samples after 120 d, with 30% dehydration after 150

Table 2. Physical properties of flexible packaging materials used for packing IQF shrimp.

Physical properties	PEST/LDPE	LDPE/Ny/LLDPE	UDPE	OBLDPE	LDPE
Thickness (m)	12/37.5	40/15/20	50	80	62.5
WVTR ¹	6.0	4.5	12.0	8.6	8.3
OTR ²	110	425	8150	3000	3200
Tensile strength ³					
MD	395	275	250	270	310
CD	275	250	210	230	200
Elongation at break (%)					
MD	100	380	490	860	250
CD	120	540	610	940	440
Heat seal strength ³					
MD	210	210	130	150	220
CD	130	185	110	120	140
Flexibility at -20°C	Flexible	Flexible	Flexible	Flexible	Flexible
Water extractives ⁴	1.86	1.25	3.71	4.12	2.22
Impact strength (g·cm)	9900	28880	18480	33000	6600

¹ $\text{g} \cdot \text{m}^{-2} \cdot 24^{-1}$ h at 37°C and 90% RH.

² $\text{g} \cdot \text{m}^{-2} \cdot 24^{-1}$ h at 1 atmospheric pressure difference.

³ $\text{kg} \cdot \text{cm}^{-2}$.

⁴ $\text{mg} \cdot \text{l}^{-1}$.

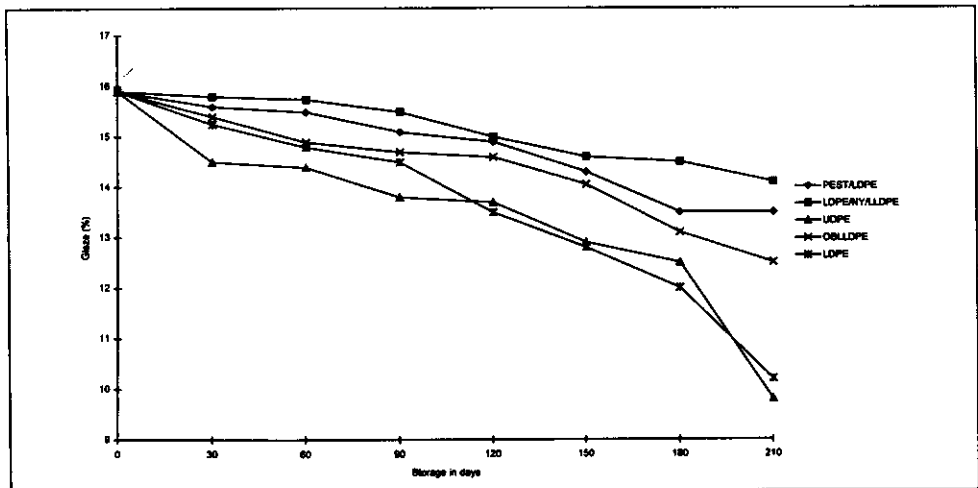


Fig. 1. Changes in glaze of IQF headless, shell on shrimp packed and stored at -20°C.

Table 3. Effects of packaging films on the physical and sensory qualities of IQF headless, shell on shrimp stored at -20±2°C.

Period in days	PEST/LDPE	LDPE/NY/LDPE	UDPE	OBLDPE	LDPE
30	Good texture, flavor color and sweetness 8.43+0.12	Good texture, flavor, color and sweetness 8.43+0.12	Good texture, flavor, color and sweetness 8.43+0.12	Good texture, flavor color and sweetness 8.43+0.12	Good texture, flavor color and sweetness 8.43+0.12
Score					
60	Good texture, flavor, color and sweetness 8.16+0.12	Good texture, flavor, color and sweetness 8.37+0.04	Good-fair texture, flavor and sweetness 7.52+0.41	Good-fair texture, flavor and sweetness 7.06+5.7	Good-fair texture, flavor and sweetness 7.81+0.09
Score					
90	Good texture, flavor, color and sweetness 8.26+0.32	Good texture, flavor, color and sweetness 8.29+0.22	Fair, firm, flavor, color and slightly sweet 6.27+0.61	Good-fair taste, color and sweetness 7.87+0.31	Firm, fair color, flavor and slightly sweet 6.71+0.11
Score					
120	Firm, good flavor and color, reduced sweetness 7.72+0.16	Firm, good flavor and color, reduced sweetness 7.62+0.41	Sweet-bland, chewy but slightly tough, 10% dehydrated pieces, acceptable 4.87+0.06		
Score				6.72+0.62	5.42+0.26
150	Slightly sweet, chewy, firm, fair retention of color and flavor 6.82+0.07	Slightly sweet, chewy, firm, fair retention of color and flavor 6.45+0.64	Bland, tough, dry odor, 25% dehydrated pieces, not acceptable 3.52+0.53	Bland, satisfactory color and flavor, 10% dehydrated pieces, acceptable 5.12+0.13	Bland, 30% dehydrated pieces, tough, dry odor, not acceptable 3.36+0.71
Score					
180	Almost bland taste, slight tough, satisfactory color and flavor, 10% dehydrated pieces, 5.22 + 0.37	Sweet to bland taste, slightly tough, satisfactory color and flavor, 8.5% dehydrated pieces 5.81 + 0.52		Bland taste, flavor changes, loose shell, dry odor, 15% dehydrated pieces, acceptable 3.61 + 0.52	
Score					
210	Bland taste, tough, loose shell, 15% dehydrated pieces, not acceptable 3.82+0.42	Tough texture, bland taste, loose shell, 14% dehydrated pieces, not acceptable 3.67 + 0.27			
Score					

Initial score: 9

days of storage (Table 3). A similar trend was seen with the other single webbed films. According to the ISI standard (1991), dehydration, if it exceeds 20%, should be cause for a frozen packed material to be rejected. Deyhdration happened despite the good operating conditions in the storage area, adversely affecting texture and appearance of the product (Table 3). The number of dehydrated pieces ran up of 10% and 8.5% in polyester laminate and nylon laminate, respectively, after 180 d. In the final stages of storage, it was observed that, in all samples, the glaze sublimed and resolidified on the films. This was probably due to the water vapor pressure difference inside and outside the pack due to temperature fluctuations during storage. It may be seen from Table 2 that the tensile strength and heat seal strength tested in MD and CD could provide the necessary strength and stretch properties. The impact strength of the materials indicated that they could withstand the hazards of handling and transport. All the films used had water extractive values within the limits specified by the FDA (1983) and BIS (1981), i.e., less than 50 mg/l and 60 mg/l, respectively, and hence, safe for food contact applications. WVTR was comparatively high in UDPE, followed by OBLDPE and LDPE. A corresponding percentage loss in glaze was noticed (Fig. 1). Comparative net weight retention of films is shown in Fig. 2. Both glaze and net weight percentages were calculated as percentages of the material frozen. Nylon-based film retained 93.14% net weight after 210 d compared to LDPE film, which retained only 89.56%. Here, the combined effect of WVTR and OTR helped. The moisture content of the products in Fig. 3 also shows a good relationship with these properties. Initially, the total bacterial load in the samples was 5.4×10^4 /g and all the microorganisms of sanitary significance like *E. coli*, *Staphylococci*, *Streptococci* and *Salmonella* were absent. This trend continued throughout the studies, indicating the prime quality of the product and that the process and packaging were carried out under hygienic conditions. Towards the end of the study, TPC was found to have declined in all cases. Fecal bacteria were absent. According to IS (1997), the maximum permissible total bacterial count shall be 5×10^5 for frozen headless shrimp, *E. coli* 20 nos., fecal streptococci 100 nos., coagulase positive staphylococci 100 and *Salmonella* should be absent.

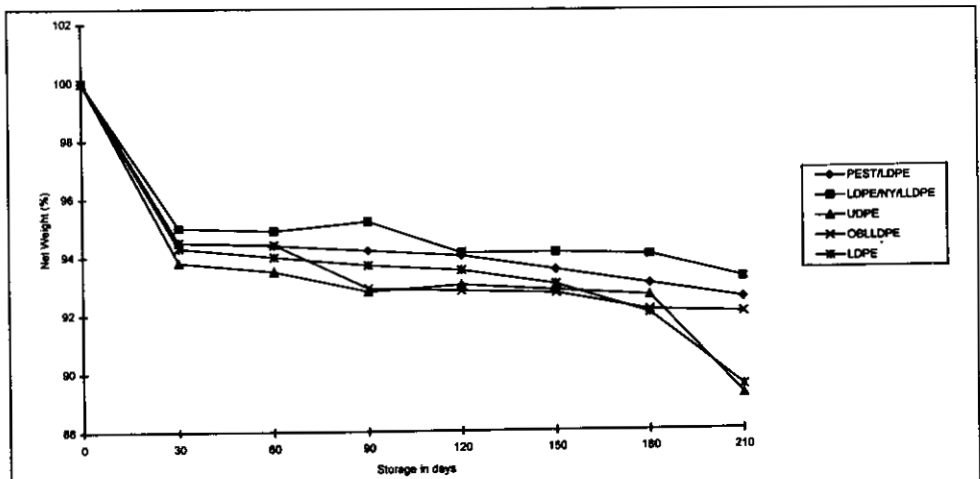


Fig. 2. Changes in net weight of IQF headless, shell on shrimp packed and stored at -20°C .

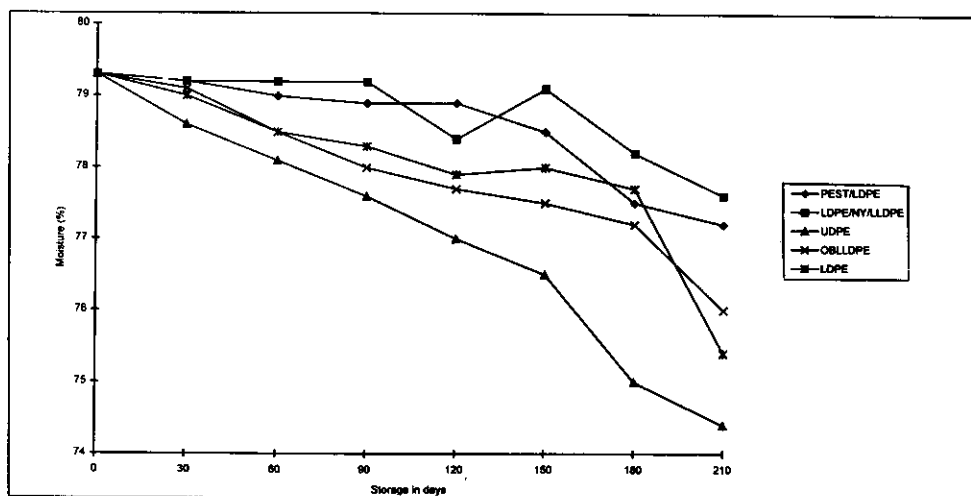


Fig. 3. Changes in moisture content of IQF headless, shell on shrimp packed and stored at -20°C .

Fig. 4 shows the TVBN values of the IQF shrimp during frozen storage. The values were not in full agreement with organoleptic values (Table 3) and did not indicate spoilage. The latter agrees with the findings of Pillai *et al* (1965). However, comparatively high values were obtained at the end of the storage studies. Proteolysis due to proteolytic enzymes was indicated by an increase in TVBN values, which were found to be minimal during the frozen storage of the packed material. As seen from Figs. 5-7, the values for SSN, alpha amino N_2 and WSN for all types of packaging were high during the first 30 days of storage, indicating minimum denaturation and minimum loss of sweetness during this period. The lowest values were obtained after 210 d in the case of UDPE, OBLDPE and LDPE. Bland taste, toughness, flavor loss and dry odor in all cases were related to these values. Proportionately low organoleptic scores were obtained in 120-150 d, except in the case of the polyester-based and nylon-based films, in which cases this happened only after 210 d. The comparatively better properties of WVTR and OTR of the films played a prominent part in minimizing the loss of glaze, thereby preventing

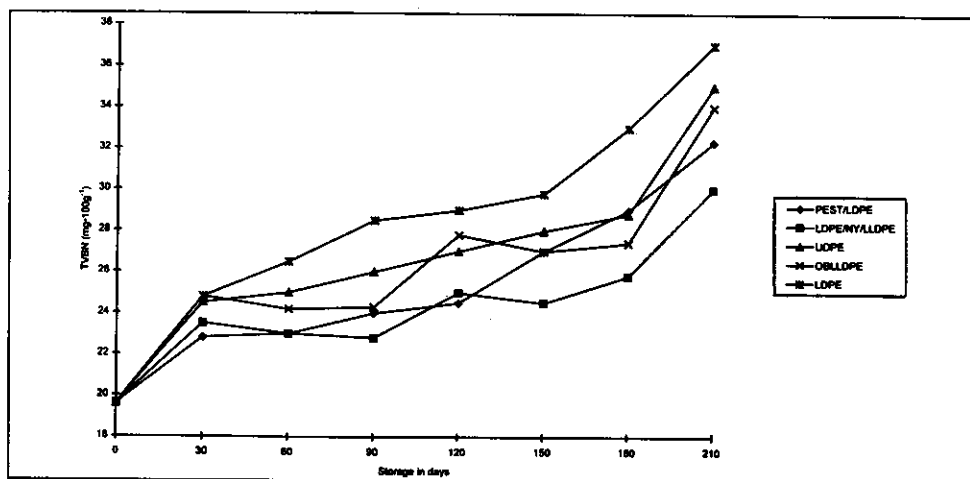


Fig. 4. Changes in TVBN of IQF headless, shell on shrimp packed and stored at -20°C .

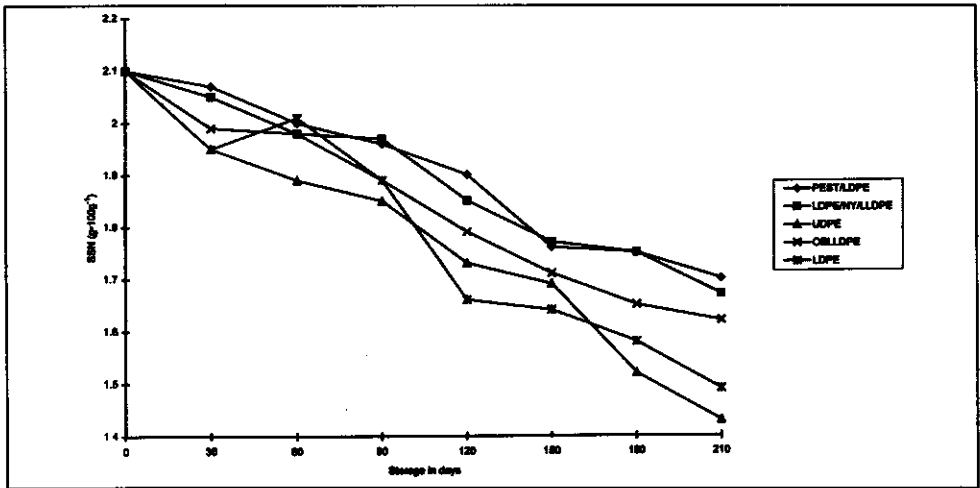


Fig. 5. Changes in SSN of IQF headless, shell on shrimp packed and stored at -20°C.

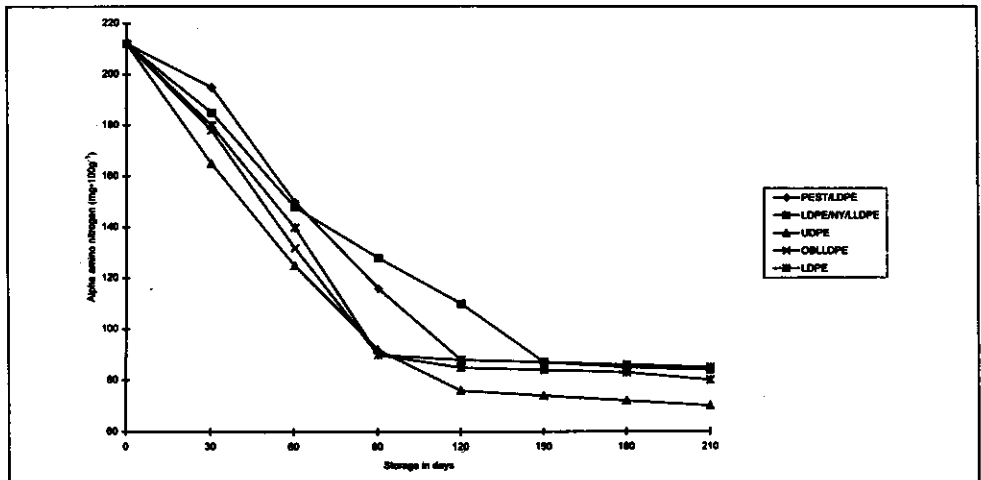


Fig. 6. Changes in alpha amino nitrogen of IQF headless, shell on shrimp packed and stored at -20°C.

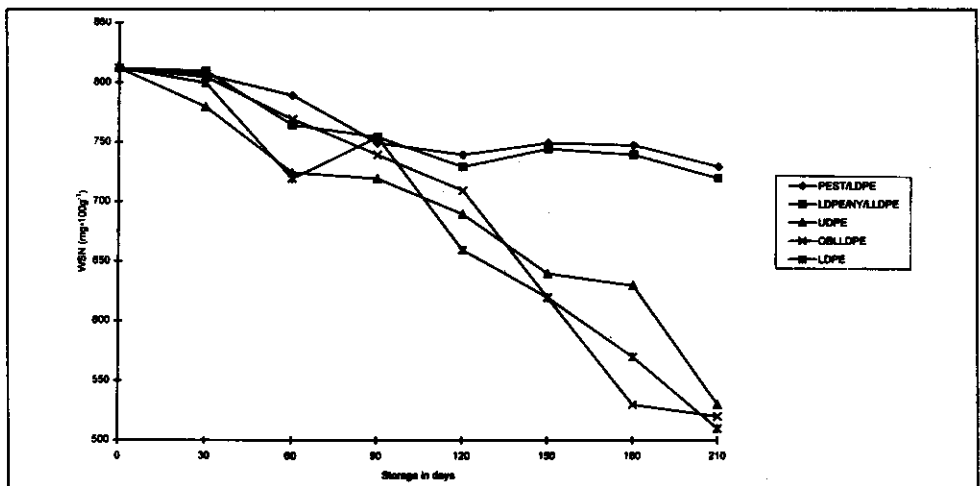


Fig. 7. Changes in WSN of IQF headless, shell on shrimp packed and stored at -20°C.

denaturation (Fig. 1). The organoleptic assessment of the cooked IQF shrimp is shown in Table 3. The samples packed in UDPE and LDPE had a shelf life of only 120 d, with the main reason behind the short shelf life being dehydration. The number of dehydrated pieces increased from 10% to 25% in UDPE and 30% in LDPE during this period. Moreover, the texture became tough, taste became bland and dry odor was felt probably due to dehydration. The samples packed in OBLDPE had only 15% dehydrated pieces after 180 d but because of the hard texture, bland taste, dry odor and loose shells of the thawed pieces, the average score was only 3.61 after 150 d. For IQF samples packed in PEST/LDPE and LDPE/Ny/LLDPE films, the shelf life was for 180 d only. After 210 d, even though the dehydrated pieces were only 15% and 14%, the samples could score only 3.82 and 3.67 upon organoleptic evaluation. The low score resulted from bland taste, dry odor, loose shell and hard texture. It can be concluded from these findings that the IQF products packed in either polyester film or nylon film exhibited good shelf life when stored at $-20\pm 2^{\circ}\text{C}$. One significant advantage of this is the reduction in the degree of dehydration when using these two combination films. Low-cost single-web films can be used when shorter shelf life is desired, the two multilayer films when longer shelf life is needed. To prevent the progressive separation of glaze and dehydration, it is better to raise glaze on IQF products to 15% in all cases.

Acknowledgment

The authors thank Dr. K. Gopakumar, Director, Central Institute of Fisheries Technology, Cochin, India, for permission to publish this paper.

References

- AOAC. 1990. Official methods of analysis. Association of Official Analytical Chemists, Washington, D.C.
- ASTM. 1968. Manual on sensory testing methods, ASTM S.T.P. 434. American Society for Testing Materials, Philadelphia.
- ASTM. 1975. Standard test methods for gas transmission film sheeting, ASTM, D 1434. American Society for Testing Materials, Philadelphia.
- BIS. 1966. Methods of sampling and test for paper and allied products, IS:1060 (Part 2). Bureau of Indian Standards, New Delhi.
- BIS. 1981. Method of analysis of overall migration of constituents of plastics, IS: 9845. Bureau of Indian Standards, New Delhi.
- BIS. 1984. Specifications for low density polyethylene films (second revision), IS:2508. Bureau of Indian Standards, New Delhi.
- Conway, E.J. 1947. Microdiffusion analysis and volumetric error. Crosby and Lockwood Son, London.
- Dordi. 1992. Packaging India, August-September, pp. 17-26.
- Dyer, E.J., M.V. French and J.H. Snow. 1950. Journal of the Fisheries Research Board of Canada 7, 585.
- Export Inspection Agency. 1991. Preshipment Inspection and Quality Control Manual on Frozen fish and Fishery products, Quality Development Centre, Madras, p.64.
- FDA (1983) Resinous and polymeric coating. Code of Federal Regulations. Revised on April 1983, 175: 200, FDA - USA.
- IS:2237. 1997. Specifications for frozen prawns (shrimps) (Third Revision), Bureau of Indian Standards, New Delhi, India.
- Lea, C.H. 1952. Journal of Science and Food Agriculture 3, 586.
- Londahl, G. 1993. Infofish International, No.3, pp. 180-187.

Mathen, C. and F. Thomas. 1986. *Seafood Export Journal* 18(6):1-4.

MPEDA. 1996. *Price indicator of Marine Products Export*, 20/39.

Oser, V.L., Editor. 1971. *Hawks Physiological Chemistry*, 14th ed. Tata McGraw-Hill Publishing Company Ltd., New Delhi.

Pope, C.G. and M.F. Stevens. 1939. *Biochemistry Journal*. 1970.