

Storage Characteristics of Restructured Ready-to-Cook Imitation Shrimp Fingers under Refrigerated Storage at 4°C

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The imitation shrimp fingers (ISF) prepared from *Nemipterus bleekeri* were packed in air pack and vacuum pack and stored at 4°C. Quality characteristics viz. proximate composition, biochemical, microbial and sensory characteristics were investigated and shelf life determined. Salt (NaCl) concentration of 1.5% with sucrose concentration of 1% and setting process at 40°C with 20 min duration were found to be optimum for good gel formation. The moisture, protein, fat and ash contents remained almost unchanged during storage. pH gradually decreased while TMA-N and TVB-N contents increased during storage period. Microbial parameters such as total plate count, staphylococcal count and psychrophilic counts also increased significantly. Organoleptic evaluation revealed that the air packed samples had the storage life of 15 days while vacuum packed samples had the shelf life of 18 days. One day icing of fish before processing did not affect the quality of ISF under same experimental conditions.

Key words : Imitation shrimp fingers, refrigerated storage, shelf life, quality characteristics

Surimi processing plays an important role in increasing the consumption of fish and fishery products by effectively using underutilized / undersized fish species. There is vast scope for increasing the fish consumption in the country by the development of ready to cook seafood analog products. Surimi is a myofibrillar protein concentrate produced by repeated washing of fish mince in order to remove water soluble proteins, flavour compounds and to enhance gel forming capacity of the structural proteins (Lee, 1984). Surimi is used as a base material for the preparation of seafood analogs that possess acceptable texture and flavour of natural product. In this paper, storage behaviour and shelf life of refrigerated ISF prepared from *N. bleekeri* stored at 4°C are reported. Attempts were also made to assess whether or not the raw material condition (fresh fish and iced fish) and packaging style

(air packing and vacuum packing) affect the quality and storage life of ISF.

Materials and Methods

Fresh threadfin bream *N. bleekeri* (16 ± 2 cm size) procured from Thoothukudi fishing harbour was brought to the laboratory and divided into two lots. First lot was used for the preparation of ISF immediately. Second lot was immediately kept in flake ice (1:1 ratio) for 24 hr and then processed into Imitation shrimp fingers based on the earlier method (Lee, 1984 & 1986) with some modifications and stored under refrigerated temperature (4°C). Briefly, fish mince was obtained from thoroughly washed fish by mechanical deboner (Baader/601, Germany). The mince was washed with chill water (8-10°C) at the ratio of 1:3 (mince: water) for 3 times and drained. The washed fish mince was mixed with salt 1.5% and cryoprotectants

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such as sucrose 1%, and sodium tripolyphosphate 0.25% and subjected to setting process at water bath at 40°C for 20 min. The mince was ground to paste for 20 min in a grinder. At the end of grinding, synthetic shrimp flavour (food grade) was added at 2% concentration (v/w). The fish paste was stuffed in a stainless steel rectangular container (15 cm x 10 cm x 3cm) to the thickness of 2 cm and then it was placed in a pressure cooker and steam cooked for 20 min. at 90 ± 2°C without pressure. After cooking, it was allowed to cool at room temperature. Finally, the cooked paste was cut into fingers of 1 cm thickness and 5 cm length and packed in air pack (without vacuum) and vacuum pack (made of multilayer nylon barrier film). Vacuum packing was done (-1 bar pressure) by using vacuum sealing machine (Alfa Level; Quick 200A, Germany) and stored in a refrigerator at 4°C.

Proximate composition viz. protein, moisture and ash contents were estimated by the method of AOAC (1995) and fat content by the method of Bligh & Dyer (1959). Biochemical indices such as TMA-N and TVB-N were estimated by the Conway microdiffusion method (Beatty & Gibbons, 1937). 5 g sample was ground well and diluted in 25 ml of distilled water and the

pH was tested in a digital pH meter (Systronics, India 335). ISF samples were analyzed for total plate count, psychrophilic bacterial count, anaerobic bacterial count, staphylococcal count, spore formers and *E. coli* counts according to the standard methods recommended by Speck (APHA, 1976). Sensory characteristics such as appearance, colour, texture, taste and flavour were evaluated by a panel of 5 trained persons and scored on a five point hedonic scale (very good - 5; good - 4; fair - 3; poor - 2; very poor - 1) individually and the mean scores were calculated. The texture of the product (gel formation) was evaluated by folding test. The sample was cut into 3 mm slices and the cut piece was held between thumb and forefinger and folded to observe the way it breaks. Score was made on 5 point scale (no crack as folded in four - 5; no crack as folded in two - 4; slow cracking as folded in two - 3; rapid cracking as folded in two - 2; collapse by a fingers press - 1).

Results and Discussion

The restructured fishery products are prepared by altering the texture of the fish meat with many additives and made it into different forms. Addition of sodium chloride plays a vital role in surimi based

Table 1. Changes in pH of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	7.05 ± 0.05	7.05 ± 0.05	6.89 ± 0.02	6.89 ± 0.02
3	6.71 ± 0.01	7.02 ± 0.04	6.85 ± 0.02	6.71 ± 0.02
6	6.95 ± 0.02	6.93 ± 0.02	6.88 ± 0.01	7.02 ± 0.02
9	6.94 ± 0.02	6.91 ± 0.02	6.70 ± 0.01	6.76 ± 0.02
12	6.92 ± 0.02	6.90 ± 0.01	6.71 ± 0.01	6.92 ± 0.01
15	6.81 ± 0.01	6.83 ± 0.01	6.67 ± 0.02	6.91 ± 0.01
18	6.91 ± 0.01	6.72 ± 0.01	6.85 ± 0.01	6.91 ± 0.01
21	6.92 ± 0.02	6.86 ± 0.01	6.72 ± 0.01	6.88 ± 0.01

Table 2. Changes in TMA -N contents (mg%) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	2.81 ± 0.12	2.81 ± 0.12	4.21 ± 0.12	4.21 ± 0.12
3	2.86 ± 0.12	3.93 ± 0.16	3.97 ± 0.12	3.95 ± 0.08
6	3.94 ± 0.01	4.26 ± 0.16	4.23 ± 0.12	4.21 ± 0.12
9	4.18 ± 0.12	4.35 ± 0.08	4.17 ± 0.12	4.27± 0.16
12	4.70 ± 0.09	5.19 ± 0.12	4.90 ± 0.05	5.46 ± 0.12
15	4.94 ± 0.12	5.44 ± 0.16	5.07 ± 0.09	5.74 ± 0.08
18	5.18 ± 0.12	5.67 ± 0.16	5.76 ± 0.08	5.92± 0.12
21	5.64± 0.12	5.66 ± 0.12	6.11± 0.04	6.24 ± 0.14

product development. Sodium chloride is added to the surimi to increase the ionic strength of meat, thereby solubilizing actomyosin, which is the main component for gel formation. Out of several concentrations tested (0.25%, 0.5%, 0.75%, 1.0%, 1.5% and 2.0%), 1.5% and 2.0% were found good in forming the gel. Gel formation in the ground fish mince was very good in 2% NaCl concentration. However, NaCl concentration of 1.5% was determined as optimum because both gel formation and the product taste were good. On the other hand, the product added with 2% salt had excess salt taste according to the sensory panel judgement. In

the present study, sucrose concentration at 1% level (w/w) was found optimum, beyond which it gives excess sweetness to the products. Sucrose is added not only as a sweetener, but also as a cryoprotectant to protect fish proteins during frozen storage. Artificial shrimp flavour at 2% concentration (v/w), was sufficient to impart shrimp flavour to washed fish mince.

“Setting” is the most important step in conditioning the fish mince, which is to be used for the preparation of analog products. High temperature setting is widely used to improve the gel property of surimi because

Table 3. Changes in TVB -N contents (mg%) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	3.52 ± 0.08	3.52 ± 0.08	4.56 ± 0.12	4.56 ± 0.12
3	4.49 ± 0.12	4.61 ± 0.05	4.19 ± 0.12	4.65 ± 0.12
6	6.53 ± 0.12	5.91 ± 0.05	5.94 ± 0.12	5.78 ± 0.12
9	7.47 ± 0.16	7.63 ± 0.10	6.81 ± 0.21	6.77 ± 0.12
12	7.74 ± 0.24	7.62 ± 0.14	7.44 ± 0.16	7.38 ± 0.16
15	7.89 ± 0.26	8.57 ± 0.18	8.17 ± 0.12	8.08 ± 0.09
18	8.25 ± 0.26	8.81 ± 0.24	8.70 ± 0.12	8.34 ± 0.08
21	8.28 ± 0.28	8.89 ± 0.30	9.74 ± 0.14	9.89 ± 0.13

Table 4. Changes in Total plate counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	1.50×10^3	1.50×10^3	4.90×10^3	4.90×10^3
3	2.76×10^3	6.50×10^4	3.00×10^4	9.10×10^3
6	3.00×10^3	8.33×10^4	2.00×10^4	1.00×10^4
9	4.60×10^4	9.00×10^4	7.80×10^4	1.80×10^4
12	6.00×10^4	4.60×10^5	4.00×10^4	4.21×10^4
15	9.10×10^4	5.60×10^5	1.07×10^5	7.80×10^4
18	6.00×10^5	7.20×10^5	4.00×10^5	1.10×10^5
21	7.82×10^5	9.15×10^5	6.10×10^5	1.90×10^5

a shorter processing time is required. Setting the washed fish mince at 40°C for 20 min resulted in better gel formation compared to lower temperatures of 20°C and 30°C with same time interval. The present study suggested that the setting process at 40°C with 20 min duration was good for gel formation in fish mince from *N. bleekeri*.

Proximate composition of ISF did not change significantly throughout the study, however slight fluctuation was observed only in moisture content. The moisture content was around 82% and it did not change significantly in the air packed and vacuum packed ISF prepared from fresh and

iced fish. The protein content was 6.88% in ISF prepared from fresh fish whereas in ISF prepared from iced fish, it was slightly lower (6.40%).

The fat content of ISF prepared from fresh fish was slightly higher (0.68%) than ISF prepared from iced fish (0.61%). Ash content was in the level of 1.86% in fresh fish ISF and 1.82% in iced fish ISF.

Upon storage, pH slightly decreased in all the samples (Table I). Yoon *et al.* (1988) have reported that there was no change in pH of imitation crab during storage at a temperature below 10°C. Changes in pH of

Table 5. Changes in Psychrophilic counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	3.00×10^2	3.00×10^2	4.33×10^2	4.33×10^2
3	3.33×10^2	3.00×10^2	2.33×10^2	3.00×10^2
6	5.33×10^2	4.33×10^2	4.66×10^2	4.00×10^2
9	7.66×10^2	6.33×10^2	5.33×10^2	4.66×10^2
12	9.33×10^2	6.66×10^2	4.00×10^3	2.00×10^3
15	2.33×10^3	8.33×10^2	1.33×10^3	3.66×10^3
18	3.00×10^3	1.33×10^3	4.66×10^3	6.33×10^3
21	6.66×10^3	5.33×10^3	9.00×10^3	7.00×10^3

Table 6. Changes in Spore formers (cfu/g) counts of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	4.00×10^2	4.00×10^2	2.00×10^2	2.00×10^2
3	3.00×10^2	3.00×10^2	3.00×10^2	3.00×10^2
6	2.33×10^2	3.00×10^2	3.00×10^2	2.00×10^2
9	3.00×10^2	4.33×10^2	1.00×10^2	2.00×10^2
12	3.00×10^2	2.00×10^2	1.33×10^2	2.33×10^2
15	7.00×10^2	6.00×10^2	2.33×10^2	4.00×10^2
18	2.00×10^2	1.33×10^3	1.00×10^2	2.66×10^2
21	3.33×10^2	2.66×10^2	3.33×10^2	3.00×10^2

Table 7. Changes in Anaerobes counts (MPN/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	4.5	4.5	4.5	4.5
3	6.5	6.5	4.5	4.5
6	6.5	9.5	6.5	9.5
9	6.5	20.0	6.5	30.0
12	7.5	45.0	6.5	30.0
15	7.5	45.0	7.5	45.0
18	7.5	110.0	9.5	45.0
21	7.5	140.0	9.5	110.0

Table 8. Changes in Staphylococcal counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	8.00×10^2	8.00×10^2	7.00×10^2	7.00×10^2
3	7.66×10^2	3.90×10^2	7.00×10^2	5.00×10^2
6	7.66×10^2	8.66×10^2	3.00×10^2	2.33×10^2
9	3.33×10^3	4.80×10^3	4.00×10^3	2.33×10^3
12	6.33×10^3	5.05×10^3	4.00×10^3	8.66×10^3
15	6.43×10^3	1.44×10^3	1.14×10^4	8.00×10^3
18	1.05×10^4	2.34×10^3	3.50×10^4	1.33×10^4
21	3.40×10^4	7.50×10^4	6.30×10^4	2.00×10^4

Table 9. Changes in *E. coli* counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at refrigerated temperature

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	1.00×10^2	1.00×10^2	8.00×10^2	8.00×10^2
3	1.00×10^2	4.00×10^2	1.66×10^2	2.00×10^3
6	3.66×10^2	4.33×10^2	1.33×10^3	3.00×10^2
9	3.00×10^2	7.00×10^2	2.00×10^3	4.00×10^3
12	5.00×10^2	5.33×10^2	3.66×10^3	2.00×10^3
15	6.33×10^2	6.00×10^2	6.66×10^3	4.33×10^3
18	6.00×10^2	7.66×10^2	6.60×10^3	6.00×10^3
21	7.00×10^2	7.00×10^2	7.66×10^3	5.66×10^3

the product are mainly attributed to the bacterial flora associated with the products. TMA-N and TVB-N contents were increased significantly ($P < 0.01$) in all the samples (Table II & III). TMA-N and TVB-N contents were found to be slightly higher in ISF prepared from iced fish than ISF from fresh fish. TMA-N is a product of spoilage and is often used as an index to assess the keeping quality and shelf life of seafood products. Yoon *et al.* (1988) reported that the TVB-N level was 4.5 mg% on initial day storage of crab analog stored at 15°C and this value slowly increased in all the storage temperature (0°C, 5°C and 15°C) but did not exceed 10 mg% even when the samples were considered as spoiled. Results of present study also supported the above investigation.

TPC increased significantly in all the samples ($P < 0.01$) (Table IV). About 3 log unit rise of TPC was found in air packed and vacuum packed samples prepared from both fresh fish and iced fish during storage. Shalini *et al.* (2001) reported 4 log increase of TPC in refrigerated fish fillets. Psychrophilic counts also increased significantly ($P < 0.01$) in all the samples prepared from fresh and iced fish (Table V). The counts

were slightly higher in air packed samples when compared to vacuum packed ISF from fresh and iced fish. Ingram & Potter (1987) reported that aerobic plate counts and psychrophilic counts of samples stored at 5°C and 13°C were initially similar in surimi, but reached higher levels with time.

Invariably in all the samples, staphylococcal counts increased by about 2 log. (Table VI). It could not be fully controlled at refrigeration temperature. Investigation of Shanmugam *et al.* (2000) also witnessed the ability of *Staphylococcus aureus* to grow in sardines in refrigerated storage. Spore count was found to be 10^2 cfu/g initially in all the samples, which remained unchanged invariably in all the samples packed in air pack as well as vacuum pack (Table VII). *E. coli* counts were relatively higher in ISF prepared from iced fish (Table VIII) than fresh fish. During storage about 1 log increase was found in iced fish ISF when compared to fresh fish. *E. coli* counts in air pack was slightly higher when compared to vacuum pack of iced fish. The anaerobic counts increased gradually in vacuum packs but not in air packs (Table IX). Zhuang *et al.* (1996) reported that the anaerobic bacterial growth is associated with spoilage of vacuum

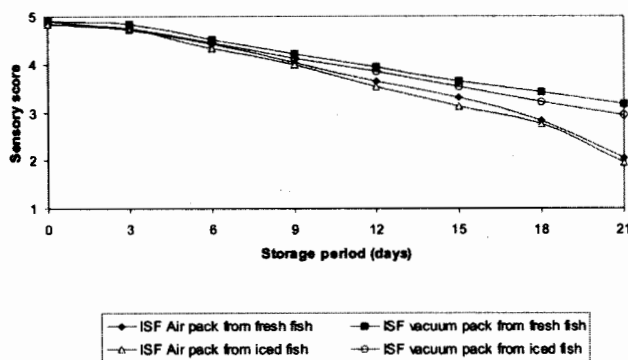


Fig. 1. Changes in sensory scores of imitation shrimp fingers prepared from fresh and iced fish during storage at refrigerated temperature

packed seafood. Changes in organoleptic scores presented in Fig I. During storage, loss of sensory qualities were observed with respect to freshness in appearance, colour, texture, taste and flavour. Upon storage yellow discolouration, loss of chewiness / rubberiness, loss of sweetness and flavour were also noticed. Vacuum packed ISF from fresh and iced fish had better sensory quality characteristics when compared to air packed ISF throughout the storage period. Generally the shelf life of vacuum packed ISF was better than air packed ISF. Air packed samples had the storage life of 15 days while vacuum packed samples had the shelf life of 18 days.

In future, restructured fish products may constitute one of the most rapidly expanding segments all over the world. It is expected that the availability of a greater variety and quality of surimi based products will spur the introduction of many new products for the convenience food market.

REFERENCES

AOAC (1995) *Official Methods of Analysis*, 16th edn., Association of Official Analytical Chemists, Washington, DC, USA.

Beatty, S.A. and Gibbons, N.E. 1937 The measurement of spoilage in fish. *J. Biol. Bd. Can.* 3, pp 77-91.

Bligh, E.G. and Dyer, W.J. 1959 A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol.* 37, pp 911-916

Ingram, C.S. and Potter, N.N., (1987). Microbial growth on surimi and mince made from Atlantic Pollock. *J. Food Protec.*, 50: pp 312-315.

Lee, C.M. (1984) Surimi process technology. *J. Food Technol.* 38, pp 69-80.

Lee, C.M. (1986) Surimi manufacturing and fabrication of surimi based products. *J. Food Technol.* 40, pp 115-124

Shalini, R., Indra Jasmine, G., Shanmugam, S.A. and Ramkumar, K. (2001) Effect of potassium sorbate dip treatment in vacuum packed *Lethrinus lentjen* fillets under refrigerated storage. *J. Food Sci.* 66, pp 12-16.

Shanmugam, S.A., Shalini, R. and Indra Jasmine, G. (2000) Sensory and bacterial characteristics of sodium acetate and potassium sorbate treated vacuum packed *Lethrinus lentjen* fillets. *Indian J. Microbiol.* 40, pp 113-117.

Snedecor, G.N. and Cochran, W.G. (1962) Factorial experiments. In: *Statistical Methods*. PP: 339-380. Oxford and IBH Publishing Co., Calcutta

Speck, M.L. (1976) *Compendium of Methods for the Microbiological Examination of Foods*. American Public Health Association (APHA), Washington, D.C.

Williams, S.K., Martin, R., Brown, W.L. and Bacus, J.N. (1983) Moisture loss in tray

packed fresh fish during eight days of storage at 2°C. *J. Food Sci.* **48**: pp 168-171.

Yoon, I.H., Matches, J.R. and Rasco, B.(1988) Microbiological and chemical changes of surimi based imitation crab during storage. *J. Food Sci.* **53**, pp 1343-1346.

Zhuang, R.Y., Huang Y.W. and Beuchat, L.R. (1996) Quality changes during refrigerated storage of packaged shrimp and cat fish fillets treated with sodium acetate, sodium lactate or propyl gallate. *J. Food Sci.* **61**, pp 241-244.