e ISSN-2231-6426

Volume 6 | Issue 1 | June, 2015 | 6-13

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International Journal of Processing and Post Harvest Technology

RESEARCH PAPER

DOI: 10.15740/HAS/IJPPHT/6.1/6-13

Storage characteristics of restructured ready-to-cook imitation shrimp fingers under cold storage (-18°C)

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Research chronicle : Received : 12.02.2014; **Revised :** 03.04.2015; **Accepted :** 17.04.2015

SUMMARY :

The frozen storage behaviour of imitation shrimp fingers (ISF) prepared from fresh and one day iced *Nemipterus bleekeri* were studied for 120 days at -18°C. During storage, quality characteristics *viz.*, proximate composition, biochemical, microbial and sensory characteristics were investigated and shelf-life also studied. Salt (NaCl) 1 per cent, sucrose 1.5 per cent and setting process at 40°C for 20 min duration were found to be optimum for good gel formation. The moisture, protein, fat and ash contents were almost unchanged throughout the storage period. pH slightly decreased while TMA-N and TVB-N contents increased during storage period. Bacterial counts *viz.*, total plate count, staphylococcal count, psychrophilic counts, decreased significantly while *E. coli* counts was in loss detection level. Anaerobes growth faster in vacuum packs than air packs. Organoleptic evaluation revealed that the frozen stored ISF had the shelf-life of more there 120 days and also it needs further investigation for determining the maximum shelf-life.

KEY WORDS : ISF, Setting, Cryoprotectants, Gel formation, Quality characteristics, Organoleptic evaluation

How to cite this paper : Alamelu, V., Shanmugam, S.A., Rajagopalsamy, C.B.T. and Velayutham, P. (2015). Storage characteristics of restructured ready-to-cook imitation shrimp fingers under cold storage (-18°C). *Internat. J. Proc. & Post Harvest Technol.,* **6** (1) : 6-13.

Surimi is used as intermediate in processing several value added products with simulated texture, flavour and appearance such as shrimp, lobster tail, scallop meat and crab leg. Surimi is actually a wet concentrate of the myofibrillar proteins in the fish muscle, which give the fish its fibre-like structure and muscular activity (Lee, 1984). Fibreized products are the greatest in demand among the surimi based simulated shellfish products. In this paper, storage behaviour and shelf-life of cold stored ISF prepared from *N. bleekeri* stored at -18°C are reported. Studies were also carried out 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.

At present the world fish production is around 122.3 million tonnes which comprises of 86.03 million tonnes of marine production and 29.50 million tonnes of inland production. The total fish production in India is about 5.96 million tonnes with a potential of 8.4 million tonnes. 67 per cent of the exports in value are accounted by prawns. Fishermen in India throw away the by-catches of fish which are of no use to them. If Surimi production units are established in the country, the unwanted fish catch which is being thrown away can be processed into Surimi. Americans are using surimi processing technique in a big way. Surimi is the Japanese term for minced fish. Eighties have seen a sudden spurt in the surimi industry due to the following :

– In surimi production underutilised and less utilised species can be used successfully as raw materials.
– A variety of surimi based products can be prepared by altering the appearance and eating quality through application of various processing technologies and ingredients.
– Current technology permits mass production with consistent quality.
– Increasing demand of surimi products in international markets.

Scope for surimi production in India :

India is the largest country in the Indian ocean and is having a long coastline of about 7500 kms with over 200 varieties of commercially important fishes and shell fishes. The estimated potential yield of fish at various depth zones is given below :

Pelagic resources :

The important pelagic fishes constituting the total potential yield of 7.42 lakh tonnes in the 50-200 m. depth zone are the anchovies, carangids, ribbon fishes, tunas and sharks. Among these fishes the carangids and the ribbon fishes could be effectively utilised for surimi production in our country. The potential yield of the above varieties from the 0-200 m depth region of our continental shelf is given below :

Species	Potential yield 000 tonnes
Carangids	231
Ribbon fishes	266

These varieties are rarely utilised in the domestic market, due to their low unit value realisation

Demersal resources :

The demersal resources of the 50-200 m zone is estimated as 6.25 lakh tonnes of which 4.23 lakh tonnes can be caught from the 50-100 m. zone and the rest 2.02 lakh tonnes from the 100-200 m. region. A few varieties of this zone are known to produce high quality surimi and can be effectively utilised for value addition into surimi products. The potential source of such raw material varieties are given under :

Species/ group	Potential yield upto 50-200 m. depth (in'000 tonnes)
Thread fin bream	110.6
Bull's eye	54.8
Perches	14.6
Mackerels	62.2
Ribbon fishes	23.3
Trevally	17.1
Lizard fish	20.9
Barracuda	3.2
Clupeids	14.3

EXPERIMENTAL METHODS

Threadfin bream *N. bleekeri* brought from Thoothukudi fishing harbour to the laboratory and divided into two lots. First lot was used for the preparation of ISF immediately and the second lot was immediately kept in flake ice at the ratio of 1:1 for 24 hr and then processed into imitation shrimp fingers were prepared based on the earlier method (Lee, 1984a and 1986b) with some modifications and stored under cold store temperature (-18°C). 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 dewatered. Then, the washed fish mince was mixed with cryoprotectants, such as sucrose 1 per cent, salt 1.5 per cent and sodium tripolyphosphate 0.25 per cent and subjected to setting process in water bath at 40°C for 20 min. After setting the mince was ground to paste for 20 min in a grinder. At the end of grinding, 2 per cent synthetic shrimp flavour (imported from UK) was added. After which the fish paste was cooked for 20 min at 90 ± 2°C without developing pressure in pressure cooker. Then, the cooked paste was cut into fingers of 1cm thickness and 5 cm length and packed in air pack (without vacuum) and vacuum pack (made of multilayer nylon barrier). Vacuum sealing machine was used for vacuum packing of ISF

(Alfa level: Quick 2004, Germany) and stored in a deep freezer (-18°C).

Proximate composition of ISF such as protein, moisture and ash contents were estimated by the method of AOAC (1995) and fat content by Bligh and Dyer (1959). Biochemical parameters such as TMA-N and TVB-N were estimated by the conway micro-diffusion method (Beatty and Gibbons, 1937). Microbiological parameters *viz.*, 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). Organoleptic evaluation was carried by a panel of 5 members using a five point hedonic scale (very good-5; good-4; poor-2; very poor-1).

EXPERIMENTAL FINDINGS AND ANALYSIS

Imitation products are prepared by altering the texture of the fish meat with many additives and made it into different forms. Sodium chloride plays a important role in surimi based product development. Addition of sodium chloride in surimi increase the ionic strength of meat, thereby solubilizing actomyosin, which is the main component for gel formation. Out of several concentration tested (0.25%, 0.5%, 1.0% and 2.0%), 1.5 per cent and 2 per cent were found good gel formation. Gel formation was very good in 2 per cent NaCl concentration. However, NaCl concentration of 1.5 per cent was determined as optimum because both gel formation and the product taste was good. According to sensory panel judgement the product with 2 per cent salt was excess salt taste. From this study sucrose concentration at 1 per cent level (w/w) was found optimum, beyond which it gives more sweetness to the products. Sucrose is added not only as a sweetener, but also more importantly as a cryoprotectant to protect fish proteins during frozen storage (Matsuda, 1979). Artificial shrimp flavour at 2 per cent concentration (v/w) was found sufficient to impart shrimp flavour to washed fish mince. Similar level has been recommended earlier by Lanier and Lee (1992).

The most important issue to conditioning the mince was setting, which is used for the preparation of analog products. High temperature setting is widely used to improve the gel property of surimi because a shorter processing time is required. Setting the washed fish mince at 40°C for 20 min resulted in better gel formation when compared to lower temperatures (20°C and 30°C) with same time period. Present study suggested that the setting process at 40ºC with 20 min duration was good for gel formation in fish mince obtained from *N. bleekeri*. The optimum temperature for setting among species may be determined by the heat stability of myosin (Benjakul *et al*., 2004). They have also suggested that setting at 25°C for an appropriate time should be a promising means to improve gelling properties of surimi produced from tropical fish.

Proximate composition of imitation shrimp fingers did not change significantly throughout the storage period. However, moisture content showed neither an increasing trend nor a decreasing trend during storage. Invariably in all the samples, the moisture content was in the range of 82.49 per cent - 82.91 per cent. Similarly the protein contents also did not vary during storage of ISF. Protein content was found to be around 13.5 per cent in all the samples. The fat content of ISF was found to be 0.66 per cent to 0.70 in all the ISF packs prepared from fresh and iced fish.

Table 1 : Changes in pH of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	7.07 ± 0.01	7.07 ± 0.01	7.02 ± 0.02	7.02 ± 0.02
15	6.69 ± 0.01	6.98 ± 0.01	7.06 ± 0.01	7.03 ± 0.01
30	6.82 ± 0.02	6.91 ± 0.01	7.00 ± 0.01	7.00 ± 0.02
45	6.90 ± 0.01	7.00 ± 0.02	6.85 ± 0.01	6.87 ± 0.01
60	6.99 ± 0.01	7.05 ± 0.01	6.88 ± 0.01	6.86 ± 0.01
75	6.98 ± 0.02	6.96 ± 0.01	6.88 ± 0.01	6.86 ± 0.01
90	6.99 ± 0.01	6.98 ± 0.01	6.89 ± 0.01	6.89 ± 0.02
105	6.82 ± 0.01	7.01 ± 0.02	6.92 ± 0.01	6.92 ± 0.02
120	6.86 ± 0.01	6.98 ± 0.02	6.96 ± 0.01	6.96 ± 0.01

During storage, pH decreased from above neutral to slightly below neutral (Table 1). Yoon *et al.* (1988) have reported that there was no changes in pH of imitation crab during storage at below 10^0 C. Changes in pH of the product are mainly attributed to the bacterial flora associated with the products. TMA-N and TVB-N contents were increased slightly in all the samples (Table 2 and 3). TMA-N content was found to be higher in air packed samples than in vacuum packed samples. 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 (Hebard *et al*., 1982). Yoon *et al*. (1988)

Table 2: Changes in TMA -N contents (mg %) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	0.00	0.00	0.84 ± 0.01	0.84 ± 0.01
15	1.96 ± 0.01	0.84 ± 0.01	1.96 ± 0.02	1.96 ± 0.02
30	1.96 ± 0.02	1.96 ± 0.02	1.96 ± 0.02	0.84 ± 0.02
45	1.96 ± 0.02	1.96 ± 0.02	2.10 ± 0.01	1.96 ± 0.02
60	1.96 ± 0.02	2.56 ± 0.01	3.48 ± 0.02	1.96 ± 0.02
75	3.42 ± 0.02	2.56 ± 0.03	4.48 ± 0.02	1.96 ± 0.02
90	3.42 ± 0.01	2.56 ± 0.01	5.42 ± 0.02	2.86 ± 0.01
105	3.42 ± 0.02	2.86 ± 0.01	5.42 ± 0.02	3.01 ± 0.01
120	3.42 ± 0.02	2.86 ± 0.02	5.42 ± 0.02	3.46 ± 0.02

Table 3: Changes in TVB –N contents (mg %) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	1.96 ± 0.02	1.96 ± 0.02	2.56 ± 0.01	2.56 ± 0.01
15	2.56 ± 0.01	1.96 ± 0.02	3.06 ± 0.04	2.56 ± 0.01
30	2.87 ± 0.01	2.56 ± 0.02	3.06 ± 0.04	2.96 ± 0.02
45	2.87 ± 0.01	2.96 ± 0.02	4.48 ± 0.01	3.06 ± 0.02
60	2.91 ± 0.01	2.96 ± 0.02	4.48 ± 0.02	2.96 ± 0.02
75	4.26 ± 0.04	3.32 ± 0.03	5.01 ± 0.08	3.06 ± 0.04
90	5.61 ±0.11	4.26 ± 0.06	5.61 ± 0.16	4.26 ± 0.06
105	6.92 ± 0.10	5.61 ± 0.16	5.61 ± 0.16	5.61 ± 0.16
120	6.92 ± 0.09	5.61 ± 0.16	6.92 ± 0.30	5.61± 0.16

Table 4 : Changes in total plate counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	6.40×10^3	6.40×10^3	9.60×10^3	9.60×10^3
15	1.70×10^3	1.20×10^3	2.20×10^3	3.11×10^3
30	3.33×10^3	3.00×10^2	7.10×10^2	1.00×10^3
45	1.00×10^2	3.00×10^2	3.00×10^2	8.00×10^2
60	4.00×10^2	4.00×10^2	6.00×10^2	3.00×10^2
75	4.00×10^2	$< 1.00 \times 10^2$	7.00×10^2	$< 1.00 \times 10^2$
90	6.00×10^2	$< 1.00 \times 10^2$	6.00×10^2	$< 1.00 \times 10^2$
105	2.00×10^2	$< 1.00 \times 10^2$	2.00×10^2	$< 1.00 \times 10^2$
120	2.00×10^2	$< 1.00 \times 10^2$	2.00×10^2	$< 1.00 \times 10^2$

reported that the TVB-N level was 4.5 mg per cent 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 per cent even when the samples were considered as spoiled.

Upon cold storage, the TPC was found to decrease in all the samples. The reduction was faster in vacuum packed samples than in air packed samples. Generally, more than one log unit reduction was observed in all the samples (Table 4).

The staphylococcal counts were initially found at the level of 10^2 cfu/g (Table 5). The counts in all the samples decreased to <10^2 cfu/g. Reduction was still faster in vacuum packed ISF. However,

Table 5 : Changes in psychrophilic counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	1.33×10^3	1.33×10^3	3.33×10^3	3.33×10^3
15	1.33×10^3	1.33×10^3	2.00×10^3	1.00×10^3
30	6.66×10^2	6.66×10^2	2.66×10^2	4.00×10^2
45	5.66×10^2	1.33×10^2	3.33×10^2	1.00×10^2
60	4.33×10^2	$< 1.00 \times 10^2$	2.00×10^2	$< 1.00 \times 10^2$
75	1.33×10^2	$< 1.00 \times 10^2$	1.33×10^2	$< 1.00 \times 10^2$
90	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
105	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
120	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$

Table 6 : Changes in spore formers counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

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
15	2.00×10^2	8.00×10^2	2.00×10^2	2.00×10^2
30	1.00×10^2	5.00×10^2	1.00×10^2	1.00×10^2
45	2.00×10^2	8.00×10^2	1.00×10^2	1.00×10^2
60	1.00×10^2	1.00×10^2	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
75	1.00×10^2	2.00×10^2	1.33×10^2	2.33×10^2
90	1.00×10^2	2.00×10^2	1.33×10^2	1.33×10^2
105	1.33×10^2	1.00×10^2	$1. 33 \times 10^2$	1.00×10^2
120	1.68×10^2	$< 1.00 \times 10^2$	1.00×10^2	1.00×10^2

Table 7 : Changes in anaerobes counts (MPN/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

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
15	4.5	9.5	9.5	4.5
30	6.5	6.5	6.5	4.5
45	6.5	4.0	2.0	6.5
60	6.5	4.5	3.0	4.5
75	3.0	4.5	3.0	4.5
90	4.0	2.0	4.0	7.5
105	2.0	3.0	2.0	6.5
120	3.0	3.0	3.5	6.5

investigation of Shanmugam *et al.* (2000) also witnessed the ability of *Staphylococcus aureus* to grow in sardines in refrigerated storage. Low levels of spore former counts were recorded in both fresh fish and iced fish ISF on initial sampling (Table 6). The counts remained almost at the same level throughout the storage in all the samples. Yoon *et al*. (1988) reported the presence of aerobic spore former *Bacillus* spp. in crab analog products at higher percentage (85 %) composition.

Psychrophilic count reduced significantly in all the samples (Table 7). Reduction in psychrophilic bacterial count was faster particularly in vacuum packs. Psychrotrophic bacteria are the major groups of micro-organisms responsible for spoilage of seafood (Adams *et al*., 1964). *E. coli* counts were less detection level ($<1.00 \times 10^2$) in all the samples of ISF from initial

Table 8 : Changes in staphylococcal counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

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	2.00×10^2	2.00×10^2
15	2.20×10^2	4.00×10^2	1.80×10^2	2.00×10^2
30	7.33×10^2	$< 1.00 \times 10^2$	1.40×10^2	3.33×10^2
45	1.33×10^2	$< 1.00 \times 10^2$	2.00×10^2	3.16×10^2
60	1.33×10^2	$< 1.00 \times 10^2$	1.00×10^2	$< 1.00 \times 10^2$
75	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	1.00×10^2	$< 1.00 \times 10^1$
90	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	1.00×10^2	$< 1.00 \times 10^2$
105	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
120	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$

Table 9 : Changes in *E. coli* counts (cfu/g) of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
15	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
30	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
45	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
60	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
75	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
90	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
105	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$
120	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$	$< 1.00 \times 10^2$

Table 10 : Changes in sensory characteristics of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18îC)

Storage days	ISF from fresh fish		ISF from iced fish	
	Air pack	Vacuum pack	Air pack	Vacuum pack
0	4.91	4.91	4.89	4.89
15	4.90	4.90	4.80	4.85
30	4.85	4.89	4.76	4.81
45	4.62	4.69	4.52	4.61
60	4.52	4.61	4.46	4.49
75	4.35	4.40	4.25	4.31
90	4.26	4.32	4.10	4.19
105	4.11	4.26	3.96	3.99
120	3.85	4.10	3.75	3.86

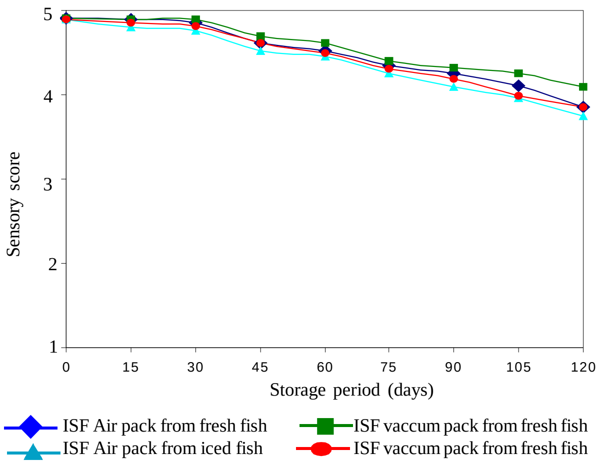

Fig. 1 : Changes in sensory scores of imitation shrimp fingers (ISF) prepared from fresh fish and iced fish during storage at cold store temperature (-18^{0}C)

sampling (Table 8). Upon storage, *E. coli* did not turn to detection limit at any point of storage time. The anaerobes counts were reduced gradually in air and vacuum packed ISF prepared from fresh and iced fish (Table 9). Zhuang *et al*. (1996) reported that the anaerobic bacterial growth is associated with spoilage of vacuum packed seafood. Changes in organoleptic scores presented in Fig.1. During frozen storage, the surface of ISF showed the dryness. Generally, the storage stability of fish and fishery products is highly dependent on the freshness of raw materials used. Upon storage slight change was observed in colour, chewiness / rubberiness, sweetness and flavour. At present study, the cold stored ISF samples did not spoiled upto 120 days and it needs further investigation to determine the maximum shelf-life.

In general, the cold store temperature could effectively reduce the bacterial population and thereby prolong the shelf-life of the products to a great extent. Due to ever increasing seafood consumer popularity, there is a big gab between the demand and supply at present and the situation will still intensity in future. Under these circumstances, consumers could be forced to take up under utilized or low value fishes. Preparation of analog products like imitation shrimp product will be very much possible from underutilized fishes.

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