Processing and storage of restructured surimi stew product in retortable pouches

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Abstract Restructured surimi gel product was prepared using short nosed white tripod (*Triacanthus brevirosterus*) with egg white as additive at 1 %. Heat setting was done initially at 45 °C for 30 min followed by heat processing 90 °C for 45 min. Restructured surimi gel in stew was standardized using four most popular recipes available in local cuisine based on the sensory acceptance and the Kerala fish stew was considered best. Restructured surimi gel in Kerala fish stew was then heat processed in 4 ply laminated retort pouch of dimension 150× 200 mm, at 15 psi gauge pressure for varying time duration and the F_0 values ranged from 13.10 to 22.58 min. Products examined of their organoleptic and microbial qualities showed those processed with F_0 value of 13.10 min was acceptable with excellent eating quality with no fishy flavour and was microbial sterile until the storage period of 6 months.

Keywords White tripod · Restructured surimi gel · Retort pouch · F_0 value · Sterility

Introduction

Short nose white tripod fish (*Triacanthus brevirosterus*) belonging to the family, Triacanthidae is one of the popular fish species available in surplus during certain seasons in Thoothukudi coast of Tamilnadu and are found best suited for the surimi preparation due to their large availability, white

flesh, low cost and less domestic consumption. It is an underutilized fish having silvery colour, dusky body on upper half, with or without darker blotches (Fisher and Bianchi 1983). They are often consumed in several regions bordering the Western Indian Ocean (Fisher and Bianchi 1983).

Surimi based products mainly include restructured analogue or imitation products. Restructured products are prepared mainly by the use of salt to solubilize and extract myofibrillar protein, to form sticky exudate that is responsible for the binding in these kinds of products to form desired shapes (Zimmerman et al. 1998; Ramirez et al. 2007). However, as consumers are demanding healthy foods with light salt to prevent and control adverse blood pressure, several proteins and starch are now being used as binding agents or as additives to improve the mechanical and functional properties of restructured products. Egg white, casein, whey protein concentrate, beef plasma, thrombin and microbial transglutaminase are some of the additives that are being widely used to prepare restructured products (Yetim and Ockerman 1995; Baker et al. 2000; Uresti et al. 2004).

It becomes therefore essential to form low salted restructured surimi gel products using some of the food additives like egg white, casein and corn and their combinations to improve the functional as well as mechanical properties of the resultant surimi product. The textural characteristic of the restructured products are based on the interaction between the myofibrillar proteins and the different additives (Lee and Chung 1989). Thermal processing has been used to achieve long term shelf stability for a wide range of seafood products (Teixeira and Tucker 1997). The main objective of the thermal processing is to produce a safe and high quality seafood product at a price affordable to the consumer (Guntensperger and Escher 1994). Retort pouch packaging have gained importance due to several reasons over metallic cans, as it can withstand thermal processing and has the advantage as flexible packages. Thermal processing of different fish products in retort pouches with good sensory attributes and a shelf life of more than 1 year at ambient temperature have been reported

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by several authors (Gopal et al. 2001; Ravishankar et al. 2002 and 2008; Mohan et al. 2006; Bindu 2009; Dhanapal et al. 2010; Bindu et al. 2011). However, there has been no attempt to process the surimi based products in retortable pouches.

In the present study, it was therefore aimed to prepare restructured surimi gel products from short nose white tripod fish and to process the restructured surimi gel in stew in retortable pouches as a value added product for human consumption. The heat penetration characteristics were determined for the product processed at a standard overhead retort pressure of 15 psi (gauge pressure) to calculate the F_0 values and the products were examined for their consumer acceptance based on organoleptic evaluation and microbial sterility testing.

Materials and methods

Raw materials

Short nose tripod fish (*Triacanthus brevirosterus*) belonging to the family, Triacanthidae caught by the trawl net was procured fresh from the Fishing Harbour, Thoothukudi and brought to the laboratory in chilled condition with the ice to fish ratio (1:1) in insulated containers. The average length and weight of the fish were 28 cm and 330 g, respectively. The 3ply laminated pouches of dimension 200×200 mm consisting of polyethylene, nylon and co-polyethylene under vacuum were used for heat setting of the surimi gel product (Sealed Air India Ltd, Bangalore, India.) Four ply laminated retort pouches of dimension 150×200 mm, consisting of polyester, aluminium foil, nylon and polypropylene with the WVTR – 10.18, OTR – 0.24 were used to pack restructured surimi gel cubes in fish stew (Pradeep laminators Pvt. Ltd. Pune. Maharashtra, India).

Restructured surimi gel product

The raw fish were washed with potable water to clean the dust, dirt, sand and other extraneous matter and dressed manually to remove the head, entrails and fins. The dressed fish were again washed thoroughly in chilled potable water. The temperature during all the processing steps was maintained between 5 and 10 °C by using flaked ice and fed into mechanical deboner/mincer (Baader/601, Berlin, Germany). To prepare surimi, the minced meat was washed with cold water (5 °C) at a mince/water ratio of 1:3 (w/v). The mixture was stirred gently for 4 min and the washed fish mince was then filtered with a nylon screen having a pore size of 0.2 mm. The washing process was repeated thrice. For the third washing, cold 0.5 % NaCl solution (5 °C) was used. To the washed minced fish, 4 % sucrose, 0.25 % sodium tripolyphosphate 4 %

sorbitol and 2.5 % sodium chloride were added and mixed well to obtain surimi.

The moisture content of the surimi should be around 80 % to prepare the restructured surimi gel product (Lee and Chung 1989). Egg white at 1 % level was added as an additive to the surimi and mixed thoroughly for 30 min using a blender (National Super Mixer Grinder, Matsushita Appliances Co, Japan, India). The mixture was then placed in laminated pouches and flattened on the top with a wooden roller. The pouches were then evacuated in a vacuum sealer (Sevana's Quick Seal Vac, Kochi, India) and heat set at 40 °C for 30 min in an incubator (Secor, New Delhi) to form the gel. Then, the pouches were heated in steam at 90 °C for 45 min in an electric steam cooker (Salzer, Chennai, India) to obtain the restructured surimi gel product. The gel product was then gel cut into cubes of 2 cm thickness for preparing the fish stew.

Standardization of restructured surimi gel in stew

Four different recipes of fish stew popular in India were used to standardize the preparation of restructured surimi gel in stew. The recipes of Kerala, Chettinad, Goa and West Bengal fish stew are described in Table 1. Sensory attributes were formulated for the evaluation of restructured surimi gel in stew based on the appearance, color, texture, flavor and taste (Table 2). A panel of 30 experts organoleptically evaluated the restructured surimi gel in stew based on the sensory scores 0- bad, 1- fair, 2- good, 3- very good. The best recipe identified by the panelists was further chosen for the processing of restructured surimi gel in retortable pouches.

Processing of restructured surimi gel in fish stew in retortable pouches

Restructured surimi gel in fish stew was packed in retortable pouches with the solid pack weight of 60 % to a net weight of 200 g. Utmost care was taken to avoid the contamination of seal area in the pouches prior to filling. Three copper/cupronickel thermocouple probes of the length 50 mm and diameter of 1.2 mm (Ellab SSA – 12050 – G700 – TS stainless steel electrode) were fixed at the geometric centre of 4-ply laminated food grade retortable pouches (outer polyester 12 µ; middle aluminum foil 9 µ; nylon layer 15 µ; inner cast polypropylene 70 µ supplied by Pradeep Laminates Pvt. Ltd., Pune, India) to measure the product core temperature. The tip of the thermocouple was inserted into the restructured surimi gel pieces to accurately measure the core temperature. Another three thermocouples were left in the retort to measure the retort temperature during processing. The pouches were sealed using a vacuum sealing machine (Sevana's Quick Seal Vac, Kochi, India) to remove the air present in the head space. The pouches were again sealed airtight to ensure additional safety using the impulse sealing machine (Sunray Industries,

Table 1 Recipes of the different fish curries for restructured surimi gel products

Kerala fish curry		Chettinad fish curry		Goa fish curry		West Bengal fish curry	
Ingredients	Qty (g)	Ingredients	Qty (g)	Ingredients	Qty (g)	Ingredients	Qty (g)
Restructured surimi	1,000	Restructured surimi	1,000	Restructured surimi	1,000	Restructured surimi	1,000
Onion	60	Red chilli powder	28	Ginger	13	Mustard seeds	14
Tomato	500	Coriander seeds	1	Grated coconut	60	Jalapenos	10
Ginger paste	13	Fennel saunf	14	Garlic	25	Panch foran	2
Green chillies	25	Poppy seeds	1	Green chillies	25	Turmeric	0.5
Fenugreek	1	Oil	50 ml	Teffal berry	0.8	Oil	50 ml
Tamarind	50	Mustard	2	Kukum	50	Water	1.5 L
Turmeric powder	2.5	Black gram	0.5	Turmeric powder	5		
Red chilli powder	28	Fenugreek	0.5	Red chilly powder	20		
Coriander powder	20	Garlic	3	Coriander	20		
Oil	50 ml	Curry leaves	2	Water	1.5 L		
Water – Salt	1.5 L	Onion	60	Salt	To taste		
	To taste	Tomatoes	60				
		Tamarind extract	To taste				
		Water	1.5 L				
		Salt	To taste				
Procedure		Procedure		Procedure		Procedure	
Ripe tomatoes were ground, onions were peeled and chopped separately. Chopped onions were fried in oil until it turns to pale brown colour. Ground tomatoes were added to it and seasoned for 20 min. Other ingredients like coriander powder, red chilly powder, turmeric powder, ginger and green chillies were seasoned separately in low flame and added to it. Required amount of water and salt were added. Restructured surimi products were finally added and cooked for 3 min.		Mustard, black gram, fenugreek and curry leaves were seasoned in little oil in low flame. Ingredients such as chilly powder, coriander powder, fennel saunf and poppy seeds were ground in a mixer. Garlic, onion, tomatoes, tamarind and ground masala were added to above and seasoned for few min. Required amount of water and salt were added. Restructured surimi products were finally added and cooked for 3 min.		Red chilly powder, grated coconut, garlic, ginger and coriander powder were mixed well and made into a paste with water. Crushed teffal berry skin, green chillies and kukum were added to the paste and boiled for 10 min. Required amount of water and salt were added. Restructured surimi products were finally added and cooked for 3 min.		Mustard seeds, jalapenos and panch foran were grated and made into a paste. This paste was seasoned in hot oil for 5 min. Required amount of water, salt and turmeric were added. Restructured products of surimi was finally added to it and cooked for 3 min.	

Mysore, India) to withstand high pressure processing. The pouches were then thermally processed in the overhead pressure retort (Lakshmi Engineering Works, Chennai, India) set at 15 psi pressure. Twenty five pouches were processed at a time for each of the time durations viz. 20, 22.5, 25, 27.5 and 30 min. The whole experiment was repeated twice to get concurrent results. After thermal processing, the pouches were cooled rapidly by spraying water under pressure in the retort. The time temperature data were measured using an Ellab data recorder (Ellab CTF 9004, Version 5.0, Roedovre, Denmark)

and F_0 values were calculated by the Patashnik method (1953).

Time – temperature data were recorded for every minute of processing. The process time, F_0 was calculated by the general method (Patashnik 1953) from the product of the sum of lethal rates and time interval (1 min). The lethal rate was calculated using the following formula:

$$LR = \frac{\log^{-1}(CT-RT)}{Z}$$

Table 2 Sensory evaluation of restructured surimi curry

Appearance	Colour	Flavour	Taste	Texture	Scores
Very good, juicy and appealing	Deep red to golden brown	Slightly spicy green chilly, ginger	Mouth watering, slightly chilly and sour	Texture very soft	03
Good, Slightly liquid and appealing	Slightly red to brown	Less spicy, red chilly, peppery	More chilly, less sour, spicy	Texture neither soft nor hard	02
Fair, Semi-solid and not very appealing	Slightly red to orange	More spicy, No flavour	Less spicy, less sour, more spicy	Texture is slightly hard	01
Bad, solid and not appealing	Light orange to yellow	Extremely spicy	Raw spicy, flavour, Bland taste	Texture is very hard	00

Where, CT = Can centre temperature; RT = Reference temperature, 121.1 °C; Z = Z value, 10 °C, Process value (F_0) = Lethal rate $\times$ Sum of time intervals.

The cook value, C_g is a measure of heat treatment with respect to nutrient degradation and textural changes that occur during processing (Ranganna 2000).

$$\text{Cook value}(C_g) = \text{Log}^{-1} \frac{(CT-RT)}{Z}$$

Where, CT = Can centre temperature; RT = Reference temperature, 100 °C; Z = Z value, 33 °C.

Microbial sterility testing

The pouches processed at different F_0 values were stored at ambient temperature (32 ± 2 °C) for periodic organoleptic and microbial evaluation up to a storage period of 6 months. The commercial sterility test was performed by 8 tube technique as per the standard method (IS: 2168 1971). The pouches processed at different F_0 values were incubated at 37 °C for 14 days and 55 °C for 5 days prior to analysis. The incubated pouches were aseptically opened and 1–2 g of the samples were taken by a sterilized forceps and inoculated into the sterilized fluid thioglycollate broth (4 tubes) and glucose tryptone broth (4 tubes). Sterilized liquid paraffin was put on to the top of the thioglycollate broth to create anaerobic condition. Half of the tubes were incubated at 37 °C for 48 h and another half at 55 °C for 4 days, to observe the growth of mesophilic and thermophilic microorganisms. To examine the spore and non spore formers, one set of test tubes were heated at 100 °C in a boiling water bath for 15 min. Change of color from violet to yellow in glucose tryptone broth and disappearance of pink color in thioglycollate broth along with the turbidity indicated the presence of the respective bacteria.

Organoleptic evaluation

Restructured surimi gel in stew processed at different process times were randomly selected for the organoleptic evaluation based on the sensory attributes formulated based on the appearance, color, texture, flavor and taste, for their evaluation (Table 2). A panel of 20 experts organoleptically evaluated the restructured surimi gel in stew during their storage for a period of 5 months at ambient temperature.

Results and discussion

Yield

The average dressing, minced meat and surimi yields obtained by processing the short nose tripod fish are given in Table 3.

Table 3 Average dressing, minced meat and surimi yields of short nosed tripod fish (*Triacanthus brevirosterus*)

Parameters	R1	R2	R3	MEAN $\pm$ S.D
Dressing yield (%)	48.57	49.50	44.24	47.43 $\pm$ 2.29
Minced meat yield in terms of dressed weight (%)	58.80	50.50	56.00	55.10 $\pm$ 3.44
Minced meat yield in terms of total weight (%)	28.57	25.00	24.77	26.11 $\pm$ 3.00
Surimi yield in terms of minced meat weight (%)	70.00	72.00	71.42	71.14 $\pm$ 0.82
Surimi yield in terms of dressed weight (%)	41.17	36.36	40.00	39.17 $\pm$ 2.05
Surimi yield in terms of whole weight (%)	17.14	18.00	17.69	17.61 $\pm$ 0.36

R1, R2 and R3 are the yields of three batches of fish

Earlier, Revankar et al. (1981) had obtained dressing yields of 50–52 % and 34–50 % from croaker and pink perch, respectively, quite similar to our results. The dressing yield of freshwater fish, silver carp (*Hypophthalmichthys molitrix*) was found to be quite high with 59.28 % (Siddaiah 1994). The dressing yield varies with the fish species and it is directly related to the size of fish. The white tripod fish was slightly smaller with an average size of 28 cm and has tough skin as well as large spines which might have contributed to the decrease.

Further, deskinning and deboning processes by the machine removed the muscle portion from the frames. The frames constituted the skin, scales, fins, and bones of the fish, which accounted for 45 % of the dressed weight. The average yield of minced meat was therefore 55 %, in terms of dressed weight and 26 %, in terms of whole weight. The minced meat or deboned meat yields obtained from different fish also varied considerably with species. Minced meat yields of 40 % and 45 % were reported from Pacific hake and cod, respectively (Crawford et al. 1972); 44 to 46 % from threadfin bream (Joseph et al. 1980) and 41 to 45 % from silver carp (Gleman and Benjamin 1989) in terms of dressed weight have been reported by earlier workers. Compared to these results, the minced yield obtained from white tripod fish was higher (55 %) which could be due better deboning operation performed by the mechanical machine. Siddaiah (1994) obtained 24.62 % yield from silver carp (*Hypophthalmichthys molitrix*) and Sankar (2000) reported yields in the range of 30–35 % from calbasu. The yield obtained from white tripod fish was thus comparable with the other fish species. In general, the yield of minced meat depends on method of processing and the machine used for picking (Crawford et al. 1972; Venugopal and Shahidi 1995). The surimi prepared from minced meat after repeated washing resulted in a loss of 29 % and the average yield was around 18 %, in terms of whole weight.

Restructured surimi gel in fish stew standardization

The restructured surimi gel product prepared with egg white had white colour with good gel strength and hence chosen for the preparation of restructured surimi gel in fish stew. Overall sensory scores of the restructured surimi gel prepared with four famous fish stew recipes of Kerala, Chettinad, Goa and West Bengal are tabulated in Table 4. With respect to the appearance of the restructured surimi gel in fish stew, the Kerala recipe was judged well due to the pleasing mouth watering consistency with deep red colour, and got the highest score of 2.6 out of 3.0, followed by Chettinad and West Bengal recipes. On the other hand, the colour of Chettinad and Kerala recipes scored high with 2.21 and 2.16, respectively due to their deep red colour. The same was the judgement in respect of the flavour of these two products that exhibited chilly sour flavour. The taste score was high in the product prepared with Kerala recipe than others. On contrary to the other attributes, the texture was considered best in West Bengal fish curry recipe, as the gel product was very soft. The Goa fish curry recipe got the least average scores for all the attributes. Overall acceptability was decided based on the average scores of each attribute and the Kerala fish stew recipe obtained the highest average overall score of 2.10 out of 3.00, and hence used for further processing in retortable pouches.

Thermal process determination

To examine the process value (F_0) for processing the restructured surimi gel in fish stew, thermal evaluation studies were carried out processing the retortable pouches at 15 psi pressure at five different total process time durations. The average retort temperature obtained at 15 psi pressure ranged from 120.1 to 120.9 °C. The average F_0 values and cook values obtained for different total process times at 15 psi pressure were given in Table 5. The average F_0 value obtained for the restructured surimi gel in fish stew processed with the total process time of 20 min at 15 psi pressure was 12.95 min, while that processed with the total process time of 30 min was 22.58 min. The products processed between these time durations showed intermediate F_0 values. The F_0 value recommended for fish products was in general range from 5 to

Table 5 F_0 values and cook values of the restructured surimi curry processed in retort pouches

Total process time (min)	F_0 value	Cook value
20.0	12.95±0.13	100.08±1.2
22.5	15.33±0.72	112.24±1.5
25.0	15.54±0.50	114.81±2.3
27.5	21.42±0.44	132.78±1.8
30.0	22.58±0.96	139.59±1.2

20 min, according to Frott and Lewis (1994). The process employed for restructured surimi gel in fish stew was thus within the prescribed F_0 values for fish products.

Earlier, Gopal et al. (2001) standardised the traditional kerala style fish stew in indigenous retortable pouch with a F_0 value of 8.43 min as acceptable for fish products. Ravishankar et al. (2002) also reported a slightly higher F_0 value of 11.5 min for seer fish stew processed in retortable pouches. On the other hand, Manju et al. (2004) found a F_0 value of 8.15 min as sufficient process value for the seer fish moilee, a traditional fish based product of Kerala in retortable pouch at ambient temperature (27±10 °C) up to 18 months.

Heat penetration studies on the fish stew processed in retortable pouches were examined by several authors along with cook value, total process time and processing temperatures. Mallick et al. (2006) reported a F_0 value of 8.79 min and cook value of 102 min at 121 °C for ready-to-eat rohu fish stew processed in North Indian style and the product was found to be acceptable even after 6 months of storage at room temperature. However, for a total process time of 44 min at 121 °C, a F_0 value of 9 min and cook value of 99 min were obtained for the ready-to-eat black clam product in indigenous retortable pouches (Bindu et al. 2007). These products were acceptable for one year at ambient temperature (28±2 °C). In yet another study, Bindu et al. (2011) reported that a F_0 value of 8.5 min with the cook value of 76 min as suitable for mahseer fish stew processed at 121 °C with the total process time was 38 min. Much lower F_0 value of 6.94 min and cook value of 107.24 min at a total process time of 50.24 min at 116 °C was reported by Dhanapal et al. (2010) for tilapia fish stew processed in retortable pouches based on the sensory evaluation, commercial sterility, colour and texture profile analysis. The cook values of the restructured surimi gel products ranged from 100 min at a total process time of 20 min at 121 °C to 139 min at a process time of 30 min. The cook values of the product with total process times between 20 and 25 min were found similar to the earlier reports.

In most of the above studies, F_0 values achieved by the researchers were between 8 to 11 min, irrespective of the process temperatures and process times. However, the process time employed was found to be high ranging from 38 to 44 min at 121 °C; and 50 min at 116 °C to achieve these F_0 values. In this

Table 4 Sensory scores of the restructured surimi curry

Parameters	Kerala	Chettinad	Goa	West Bengal
Appearance	2.60±0.79	2.26±0.69	1.91±0.76	2.21±0.81
Colour	2.16±0.96	2.21±0.77	1.60±1.01	1.76±0.93
Flavour	2.00±0.87	2.05±0.86	1.80±1.05	1.90±0.74
Taste	1.86±0.76	1.81±1.15	1.60±0.97	1.79±0.72
Texture	2.01±0.71	2.00±0.86	1.68±0.49	2.11±0.77
Average score	2.10±0.08	2.06±0.15	1.70±0.20	1.90±0.07

study, the process times employed were between 20 to 30 min at 121 °C, but the F_0 values achieved for the restructured surimi curry were greater than the reported values with similar process times. Within a minimum process time of 20 min, a F_0 value of 13 min could be achieved for the restructured surimi gel in fish stew processed in retortable pouches. The higher F_0 values achieved within shorter process time was mainly because of the soft consistency of the product with only 60 % pack weight as well as the smaller size of the over head retort with high heating efficiency employed for the process. Thus, a desirable F_0 value could be achieved for restructured surimi gel in fish stew in a minimum total process time of 20 min at 121 °C.

Microbial sterility test

The microbial sterility of the restructured surimi gel in fish stew processed at different total process time durations were evaluated at periodic intervals during their storage at ambient temperature and the results are given in Table 6. There was a total absence of aerobic and anaerobic, mesophilic and thermophilic, as well as spore and non-spore forming bacteria in all the restructured surimi gel products processed at different total process time durations having different F_0 values. Bindu (2009) have also reported that the tuna in oil, brine and dry pack processed in retortable pouches at 121 °C with F_0 value of 10 min were safe. Dhanapal et al. (2010) examined the tilapia fish stew processed at 116 °C with F_0 value of 7.0 min and found the products were safe for consumption even after a year of storage. The study thus indicated that the thermal process given with the F_0 value of 13 min for the restructured surimi gel in fish stew processed in retortable pouches was sufficient

to attain commercial microbial sterility up to 6 months storage period and hence found safe for human consumption.

Organoleptic evaluation

The results on the organoleptic evaluation of restructured surimi gel in fish stew processed in retortable pouches processed for 20 min at 121 °C are given in Fig. 1. All the products obtained an overall score of above 2.09 even after 5 months of storage at ambient temperature and were graded good by the panellists. Although the products processed at 22.5, 25.0, 27.5 and 30 min at 121 °C did showed some changes in the sensory scores, they were not statistically significant ($P>0.05$) and hence, the results were not given. However, the product processed for 20 min with F_0 value of 13.10 min showed slightly higher sensory scores, which was also evident from their low cook value. This product was in general good in taste with retention of deep red colour and chilly sour flavour. There was a constant reduction in the flavour and taste of the restructured surimi gel products processed for longer time duration throughout the storage period. The restructured surimi gel products processed for 30 min with F_0 value of 22.28 min had slightly hardened texture with an average score of 1.82 than the other products that had the average scores above 2.23. Sensory scores of thermally processed fish stew processed in retortable pouches were reported by many authors (Gopal et al. 2001; Mallick et al. 2006; Ravishankar et al. 2008) and they found the overall sensory scores decreased during storage, as noticed in the present study. Bindu (2009) used a 10 point hedonic scale to evaluate the retort pouch products with scores below 4 as an unacceptable limit. They reported that the scores decreased from 7.0 to 6.1 in the tuna processed in oil, brine and dry packs in retortable pouches at ambient and accelerated temperatures. However, Dhanapal et al. (2010) reported that the tilapia fish stew processed in retortable pouch for a storage period of 1 year was good. Bindu et al. (2011) on examination of the mahseer fish stew in Mughalai style in retortable pouch observed that the textural parameters like succulence,

Table 6 Commercial sterility of the restructured surimi curry processed in retort pouches

Time (min)	Fo value (min)	At 37 °C				At 55 °C			
		Aerobic		Anaerobic		Aerobic		Anaerobic	
		P	UP	P	UP	P	UP	P	UP
Immediately after retort processing									
20.0	13.10±0.13	—	—	—	—	—	—	—	—
22.5	15.57±0.72	—	—	—	—	—	—	—	—
25.0	17.88±0.50	—	—	—	—	—	—	—	—
27.5	21.42±0.44	—	—	—	—	—	—	—	—
30.0	22.58±0.96	—	—	—	—	—	—	—	—
After incubation at 37 °C for 14 days and 55 °C for 5 days									
20.0	13.10±0.13	—	—	—	—	—	—	—	—
22.5	15.57±0.72	—	—	—	—	—	—	—	—
25.0	17.88±0.50	—	—	—	—	—	—	—	—
27.5	21.42±0.44	—	—	—	—	—	—	—	—
30.0	22.58±0.96	—	—	—	—	—	—	—	—

Fig. 1 Organoleptic evaluation of the restructured surimi gel curry processed in retort pouches at different process times

toughness, and fibrosity decreased on storage with the score reducing to 7.05 from 8.52 after 12 months of storage at ambient storage. In this study, the restructured surimi gel in fish stew processed in retortable pouches for longer duration of 30 min with the F_0 value of 22.28 min although showed slight loss in flavour, taste and texture, the overall quality was judged good until 6 months of storage.

Conclusion

This study inferred that restructured surimi gel product prepared from the low valued short tripod fish was found suitable for processing in retortable pouches. The product processed in fish stew with F_0 value of 13.10 min at 15 psi pressure was found sensorially acceptable up to 6 months at ambient temperature with lack of fish flavour, soft texture, hot chilli and sour taste. The absence of aerobic and anaerobic bacteria provided them total microbial sterility to the products. As these restructured surimi gel products lack fishy odour and resemble like milk paneer with soft texture, they would serve as a new ready to eat fish product with good nutritive value and long shelf life.

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References

- Baker K, Lanier T, Green D (2000) Cold restructuring of seafoods using transglutaminase mediated binding. Seafoods IFT Annual Meeting Book of Abstracts. 164 : 75–76
- Bindu J (2009) Thermal Processing of Smoked Yellowfin Tuna (*Thunnus albacares*) in Flexible Pouches. In: partial fulfillment of the requirements for the degree of doctor of philosophy, Faculty of Marine Sciences, CIFT, Cochin
- Bindu J, Ravishankar CN, Srinivasa Gopal TK (2007) Shelf life evaluation of a ready-to-eat black clam (*Villorita cyprinoides*) product in indigenous retort pouches. J Food Eng 78:995–1000
- Bindu J, Ravishankar CN, Dinesh K, Mallick AK, Gopal TKS (2011) Heat penetration characteristics and shelf life of ready to mahseer curry in opaque retortable pouches. Fish Technol 48:141–148
- Crawford DL, Law DK, Babbitt K (1972) Yield and acceptability of machine separated minced flesh from some marine food fish. J Food Sci 37:551–553
- Dhanapal K, Reddy GVS, Nayak BB, Basu S, Shashidhar K, Venkateshwarlu G, Chouksey MK (2010) Quality of ready to serve tilapia fish curry with PUFA in retortable pouches. J Food Sci 75: 348–354
- Fisher W, Bianchi G (1983) FAO species Identification sheets for fishery purposes Fishing area 51, Food and Agricultural organization of the united Nations, Rome. Vol. IV
- Frott R, Lewis AS (1994) In: Frott R, Lewis AS (eds) Canning of meat and fish products. Chapman and Hall, London, pp 200–202
- Gleman A, Benjamin E (1989) Characteristic of mince from pond breed silver carp (*Hypophthalmichthys molitrix*) and preliminary experiment on its uses in sausages. J Sci Food Agric 47:225–241
- Gopal TKS, Vijayan PK, Balachandran KK, Madhavan P, Iyer TGS (2001) Traditional Kerala style fish curry in indigenous retort pouch. Food Control 12:523–527
- Gutensperger B, Escher FE (1994) Thermal processing retortable plastic containers with metal lids in steam and water with comparison to metal cans. J Food Sci 53(6):1877–1886
- IS: 2168 (1971) Specification for Pomfret canned in oil. New Delhi, India: Indian Standard Institute
- Joseph J, Perigreen PA, George G, Govindan TK (1980) Iced and frozen storage characteristic of cultured *Chanos chanos*. Fish Technol 17: 21–25
- Lee CM, Chung KH (1989) Analysis of surimi gel properties by compression and penetration tests. J Texture Stud 20:363–377
- Mallick AK, Srinivasa Gopal TK, Ravishankar CN, Vijayan PK (2006) Canning of rohu (*Labeo rohita*) in north Indian style curry medium using polyester coated Tin Free steel cans. Food Sci Tech Int 12(6): 539–545
- Manju S, Sonaji ER, Leema J, Gopal TKS, Ravishankar CN, Vijayan PK (2004) Heat penetration characteristics and shelf life studies of seer fish moilee packed in retort pouch. Fishery Technol 41(1):37–44
- Mohan CO, Ravishankar CN, Bindu J, Geethalakshmi V, Gopal TKS (2006) Effect of thermal process time on quality of “shrimp kuruma” in retortable pouches and aluminum cans. J Food Sci 71(2):496–500
- Patashnik M (1953) A simplified procedures for thermal process evaluation. Food Technol 7:1–6
- Ramirez JA, Del Angel A, Uresti RM, Velazquez G, Vazquez M (2007) Low-salt restructured fish products using low-value fish species from the Gulf of Mexico. Int J Food Sci Technol 42:1039–1045
- Ranganna S (2000) Handbook of canning and aseptic packaging. Tata McGraw-Hill Publishing Co. Ltd, New Delhi, pp 507–508
- Ravishankar CN, Bindu J, Gopal TKS (2008) Ready to serve mackerel curry (*Goan style*) in retortable pouches. Fish Technol 45:171–180
- Ravishankar CN, Gopal TKS, Vijayan PK (2002) Studies on heat processing and storage of seer fish curry in retort pouches. Packag Technol Sci 15:3–7
- Revankar GD, Keshava N, Naidu AK, Baliga BL (1981) Fish mince -preparation and composition. Indian food Packer. 20–24
- Sankar TV (2000) Biochemical and storage characteristics of myofibrillar protein concentrate (surimi) from Indian major carps, Ph.D Thesis, Cochin University of Science and Technology, Cochin
- Siddaiah D (1994) Stability of minced meat of fresh water fish (Silver carp *Hypophthalmichthys molitrix*) at lower temperature and its suitability to prepare paste products, [M.F.Sc. thesis], Univ. of Agricultural Sciences, Bangalore, Kamataka. 42–95
- Teixeira AA, Tucker GS (1997) Online retort control in thermal sterilization of canned foods. Food Control 6:13–20
- Uresti R, Tellez-Luis S, Ramirez J, Vazquez M (2004) Use of dairy proteins and microbial transglutaminase to obtain low-salt fish products from filleting waste form silver carp (*Hypophthalmichthys molitrix*). Food Chem 86:257–262
- Venugopal G, Shahidi F (1995) Value added products from underutilized fish species, CRC. Crit Rev in Food sci Nutr 35:431
- Yetim H, Ockerman W (1995) The effects of egg white, tumbling and storage time on proximate composition and protein fractions of restructured fish product. J Aquat Food Product Technol 4:65–67
- Zimmerman PA, Bissel HM, McIntosh GS (1998) Arctic Alaska Seafoods Inc, issued on December 8, 1998. Method of processing salmonoid fish, U.S. patent 5, p.846, 594