Development and Optimization of Ready to Eat Cobia (*Rachycentron canadum*) fish Fillet Chunks in Curry Medium Packed in Flexible Retort Pouches

ABSTRACT

Cobia fish fillet chunks in curry medium, a famous North Eastern Indian dish, was developed using Cobia (Rachycentron canadum) fish fillet chunks prepared in a traditional culinary style. The present study aims to optimize different F0 values for Cobia fish fillet chunks in curry medium using flexible retortable pouches. The product underwent thermal processing at two distinct lethality levels and heat penetration rates, demonstrating equivalent cooling and heating lag effects. The fh values were 15 and 18.5 minutes for the product processed at F0 values of 9.29 and 8.42 minutes, respectively. The total process times were 39.79 and 38.80 minutes, respectively, for the F0 values of 8.42 and 9.29 minutes. Cook values for the processed product were 86.60 minutes for the F0 value of 8.42 minutes and 92.57 minutes for the F0 value of 9.29 minutes. Based on sensory characteristics, the product processed at an F0 value of 8.42 minutes was rated better over a storage period of 90 days.

Keywords: Cobia, thermal processing, F_0 value, CV, TPT, retort pouch.

1.INTRODUCTION

Ready to eat food products are pre-cooked, packaged, and can be consumed without further preparation to the table. They are commonly made from high-protein rich perishable food like seafood, poultry, and dairy. Among these, the global demand for Ready to eat fish products is growing due to the health benefits of fish. Fish products processed in retortable pouches offer several advantages, such as being cost-effective, shelf-stable for over a year without refrigeration, and convenient for storage. Traditional and ethnic fish products, in particular, are in high demand in this category. [1-3].

The fish Cobia (*Rachycentron canadum*) belongs to the family *Rachycentridae* and is a marine finfish species with developing global potential for mariculture. This fish species has huge potential for aquaculture due to its rapid development, high meat quality and widespread distribution over subtropical and tropical oceans and temperate regions. [4]. Cobia is a large coastal pelagic fish found worldwide in tropical and subtropical waters, and its production was

0.67 tons in 2021 (V). It is well-known for its high-quality meat and is a popular premium food fish in Taiwan and Japan. The white meat of the fish is served in restaurants as raw fish called Sashimi [5].

The concept of thermal processing, which primarily involves in container sterilization of foodstuffs, has come a long way since Bigelow and Ball developed in 1920, the first scientific basis for calculating the minimum safe sterilization process. The concept of in-container sterilization (Canning) involves the application of a high-temperature thermal treatment for a sufficiently long time to destroy microorganisms of public health and spoilage concerns. The hermetic seal maintains an environment in the container that prevents the growth of other microorganisms of higher resistance. Most importantly, it prevents recontamination and pathogens from producing toxins during storage [6].

Thermal processing technique is one of the most effective food preservation procedures and is in high demand. This involves heating food at a given temperature for a set amount of time to eradicate pathogenic microorganisms from food that causes public health risk. Flexible retortable pouches with three or four layers can be used as a packaging alternative to standard metal containers which are more convenient and cost-effective. The very thin layers of these pouches allow for rapid heat penetration, reducing processing time, improving product quality, minimizing nutritional loss and lowering energy requirements. [7-8].
The canning industry is concerned about the impact of high processing temperatures on both nutritional and sensory quality [2,9,10].

Different forms of Cobia value-added products may have become available in the near future to meet consumer demand. Frozen or vacuum-packed cobia fish fillets are currently being sold in Asian markets. The research on the development of ready-to-eat Cobia fish fillets chunks in various filling media packed in flexible retort pouches is limited. Therefore, the present study has been undertaken to develop ready-to-eat Cobia fish fillet chunks in curry medium, packed in retort pouches, and to evaluate the textural, biochemical, and sensory changes that occur during the storage period.

2. MATERIALS AND METHODS

2.1 Materials

The Cobia Fish (*Rachycentron canadum*) were purchased from the Karnataka Fisheries Development Corporation (KFDC) Mangalore, Karnataka, India packed in high-density polyethylene (HDPE) bags with ice (1: 3 ice to fish ratio) and transported aseptically to the laboratory in an insulated styrofoam ice box. The fish were washed with chilled potable water and descaled, gutted, and filleted into 2-3 cm thick chunks. The cleaned Fish chunks were subjected for marination by adding chili powder, turmeric powder and required salt were added and kept for 30 min in refrigerated storage to improve the firmness of fish muscle during thermal processing. Flexible retort pouches (4 ply), consisting of 12 µm polyester (outer layer), 9 aluminium foil, 15 nylon (middle layer) and 70 polypropylene (inner layer) was used to pack the cobia fish curry product. The pouches having dimensions 150 × 200 mm with a capacity of 250±10 g were procured from Floeter India Retort pouches Pvt. Ltd, Haryana. The horizontal over pressure retort unit with a capacity for 25-30 pouches (M/s. Lakshmi Engineering works, Chennai, India), consisting of a retort boiler, control system and air compressor, was used for sterilization and thermal processing studies. All of the chemicals and glassware used in the investigation are AR grade.

2.2 Preparation of Cobia fillets chunks in curry

For the preparation of Cobia fillet chunks in curry medium, the list of ingredients used were presented in Table 1. Cobia fish curry was prepared by following a method as follows. Mustard seed, cumin seed, fenugreek seed, coriander seed, big onion, tomato, garlic, ginger and red chili were fried until colour changes into brown. After frying of all the ingredients, a fine paste was made. Afterwards on a pan, vegetable oil, green chilli, curry leaves, turmeric powder, shallots (small onions), coconut water, turmeric were added and fried in a low flame for few minutes. Curry paste was then added and slowly heated under a low flame till the emergence of the unique aroma. Salt was added to enhance the flavour. Water was added to get the desired consistency of the fish curry. **Figure 1** shows the flow chart and its accompanying illustration.

Sl.No.	Ingredients	Quantity (w/v)
1	Shallots - Small onion	100 g
2	Big onion	200 g
3	Tomato	300 g
4	Garlic	50 g
5	Coriander leaves	25 g
6	Coriander seeds	300 g
7	Turmeric powder	10 g
8	Fenugreek	10 g

9	Red chili small	20 g
10	Chili powder	10 g
11	Curry leaves	10 g
12	Ginger	50 g
13	Mustard seed	15 g
14	Cumin seed	10 g
15	Button red chili	20 g
16	Vegetable oil	150 ml
17	Coconut	1 piece
18	Salt	As required
19	Water	As required

Table 1: Ingredients used for preparation of Cobia fillets chunks in curry

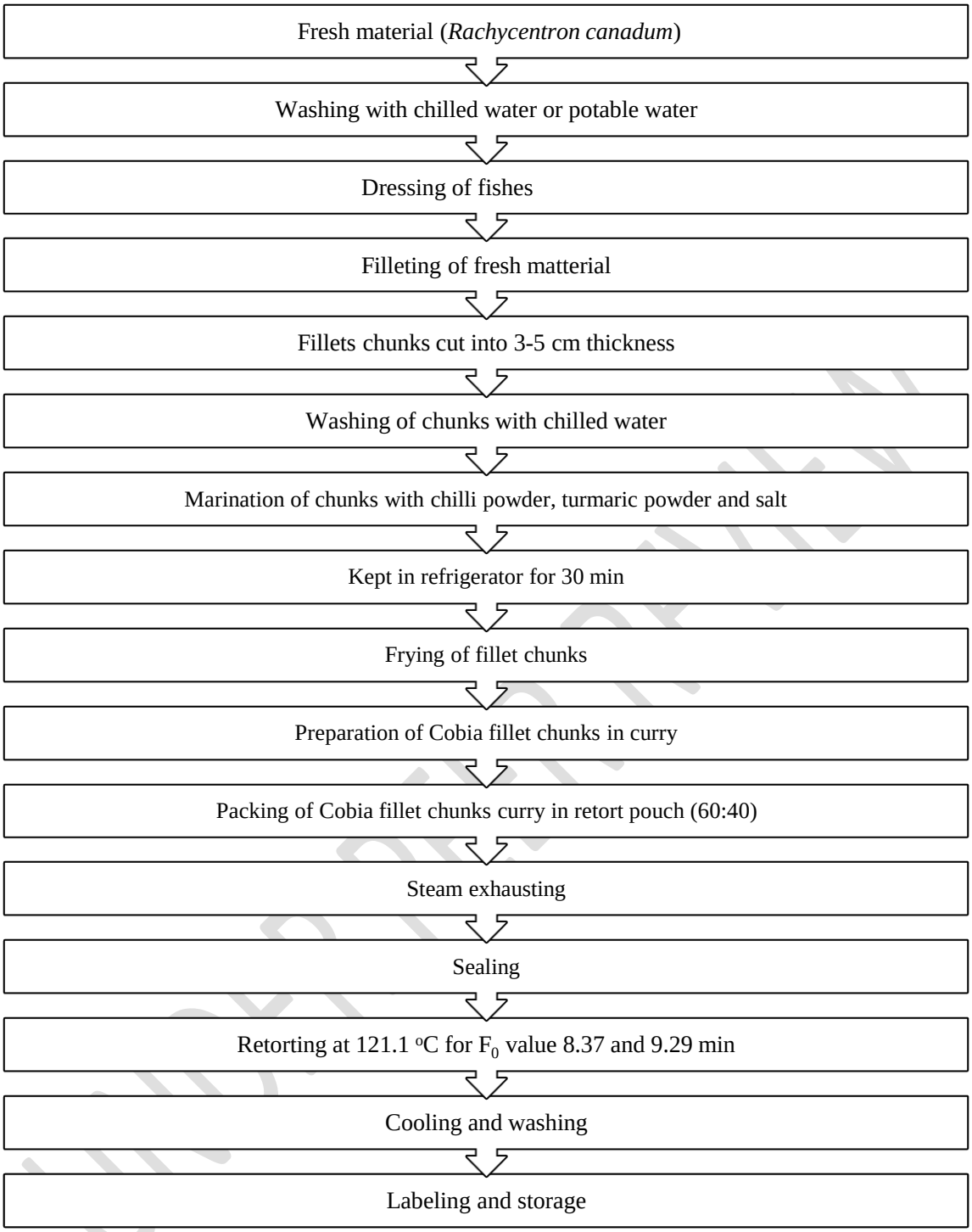

Fig. 1 Flow chart for preparing Cobia fillet chunks in curry.

2.3 Filling and sealing of the retort pouch

About 250 ± 10g Cobia fillet chunks in curry (60:40) chunks to curry was packed in retort pouches in hot condition. During packing, special care was taken to avoid contaminating the seal area of the pouches. Required numbers of pouches were fixed with glands and the tip of the thermocouples were inserted into the fish chunks. The pouches were immediately steam exhausted (injected with steam) mainly to remove any entrapped air and gases in the pouches, followed by sealing with a continuous band sealing machine (M/s. Gemp Pack, Chennai, India). Filled and sealed pouches were put into the overpressure retort and heated to *Fo* values of 8.42 and 9.29.

2.4 Thermal Processing of Cobia fillets chunks in curry

Heat processing of cobia fillet chunks in curry in retortable pouches was monitored to ensure proper heat penetration using Ellab E-val Flex, 4 Channel Thermal Validation System (Cat 21401004, Ellab A/S, Trollesmindealle 25, DK-3400, Denmark) was used in the study. At a predetermined 60-second interval, the core temperature, retort temperature, and F0 value cook value were recorded using a thermocouple (Ellab SSA-TS) and F0 value integrators. The F_0 constants were set at T = 121.1 ^{o}C, Z = 10 ^{o}C and cook value constant at T = 100 ^{o}C and Z-value was 33 ^{o}C. The processing time was computed using Ball's mathematical formula. The lag factor (U), cooling (J_c), the slope of heating curve (f_h), and the lag factor for heating (J_h) were calculated. Mathematical calculation was used to determine the value of f_h/U, final temperature deficit g, processing time B and total process time (TB) was estimated using the methodology by Stumbo (1973). The Cook value (g), which is determined by measuring the amount of cooking and nutritional loss during processing, is a measure of nutrient degradation during processing. [11].

2. QUALITY EVALUATION

2.1 Proximate, biochemical and the microbiological analysis

The proximate composition was analysed for raw fish by AOAC (2010) method. Biochemical parameters such as TVB-N, TMA-N, and TBA-RS analysis for raw and processed cobia fillet chunks was done. TVB-N and TMA-N were determined by Conway's micro diffusion method [12]. The TBA value obtained by following the approach of Raghavan and Hultin [13]. The total plate count (TPC) of raw cobia fish was done using spread plate technique [14].

3.2 The Commercial sterility test

The samples treated at varied F_O values were incubated at 37°C for 15 days and 55°C for a minimum of 5 days. Then incubated pouches were aseptically opened, and 1 to 2 g of the processed sample was inoculated into the sterilized thioglycolate broth. To produce an anaerobic environment, sterilized liquid paraffin was layered on top of the broth and incubated at 37°C for 48 hours and 55°C for 4 days (IS: 2168, 1971).

3.3 Texture profile analysis

The texture of Cobia fish muscle was analysed using a Texture Analyzer (TA XT +, Stable-Micro System, UK). A 75 mm diameter cylindrical probe was used for the loading the cell with a sensor of 50 N. For studying the texture profile analysis (n=3) equal sized blocks of raw Cobia as well as cooked Cobia fillets chunks at different F_0 values (8.42 and 9.29). The texture measurement composed of two consecutive 40 % compression with a trigger force of 0.5 kg and with time and distance of 5 seconds and 6 mm, respectively at a crosshead speed of 12 mm/min and the force by time data was used to calculate by Bourne [15].

3.4 Sensory evaluation

Sensory test was done by the differentiation and characterization of various features like flavor, color, appearance, succulence, chewiness, toughness, and overall acceptability. By the using of 9-point hedonic scale score was given through 25-member panel as per the guidelines by Indian Standards (IS 6273 [II]). Thermally processed Cobia fish curry pouches were randomly picked and heated in boiling water for five minutes. 5 sensory score was taken as an acceptability. The panelists were asked to assign a score of 1-9 (1=dislike extremely; 2=Dislike very much; 3=Dislike moderately; 4=Dislike slightly; 5=neither like or dislike; 6=Like slightly; 7=Like moderately; 8=Like very much; 9=Like extremely).

3.5 Statistical Analysis.

Experimental data was analysed using the Statistical Package, (SPSS, version 21.00 for Windows) software. Results were given as mean ± SD. A one-way ANOVA was used to determine the difference in means, and Duncan's multiple range tests were employed to compare the means at the 5% level of significance.

3. RESULTS AND DISCUSSION

4.1 Thermal process evaluation

The distinct flavor and health benefits of ready-to-eat ethnic Indian food appeal to a wide audience. This study focuses on creating ready to eat cobia fillets chunks in curry medium. The study found that four-layer retort pouches were appropriate for this type of food because they had excellent tensile strength in both the machine and cross directions, which is required to survive the demands of heat processing in an over-pressure retort.

In this study f_h values obtained were 18.5 min for F_o 8. 37 min and 15 min for F_o 9.29 min. The process time (Ball's process time) for the product was discovered to 29.93 min and 31.26 min, respectively, while the total process time or operator's process time were 39.79 min and 38.8 min for F_o 8.37 and *Fo* 9.29, respectively (**Table 2**). The heat penetration characteristics with reference to cook value were found to be 60.95 min for F_o 8. 37 min and 60.61 min for F_o 9.29 min. (**Fig. 2 and Fig. 3**).

Table 2: Heat penetration characteristics of Cobia fillets chunks in curry processed at F_0 8.37 and F_0 9.29 min.

Parameters	***Fo* 8.37**	***Fo* 9.29**
Come-up-time (min)	6 min	8 min
Heating lag factor (J_h)	1.03	0.972
Cooling lag factor (J_c)	1.09	1.087
f_h slope of heating curve (min)	18.5	15
U	8.61	9.50
f_h/U	2.147	1.57
g (^oC)	2.15	1.35
Cook value (min)	60.95	60.61
Ball's process time (min)	29.93	31.26
Total process time (min)	39.79	38.8

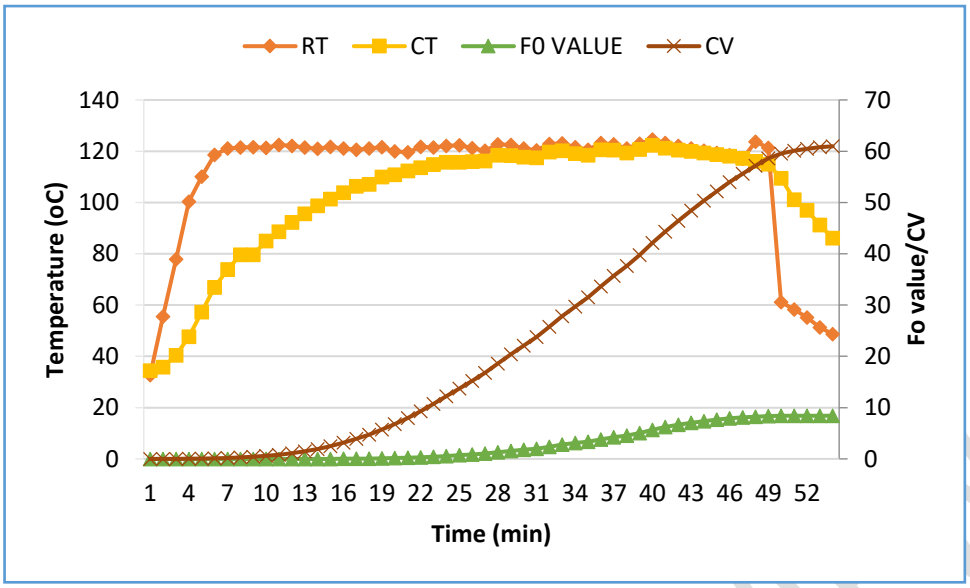

Fig. 2 Heat penetration rate (F_o value and cook value) of Cobia fillets chunks in curry processed at F_0 8.37 min

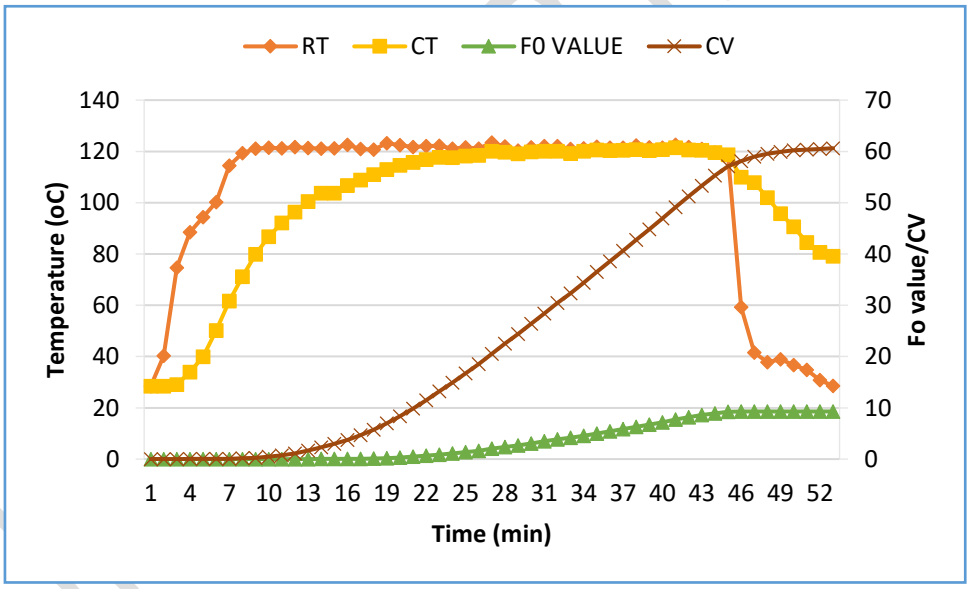

Fig. 3. Heat penetration rate (F_o value and cook value) of Cobia fillets chunks in curry processed at F_0 9.29 min

Several authors conducted similar research and reported on the heat penetration properties of different food packs [3, 15-18].

Lag factor for heating (J_h) and cooling (J_c) during the thermal processing were calculated and values J_h were found to be 1.03 min and 0.972 min for two different F_o 8. 37 min and F_o 9.29, min respectively and J_c values were 1.09 min and 1.087 min respectively. The lag factors

for heating and cooling did not differ significantly in any case, and they were found to be within the range reported [3, 19-23].

The f_h/U and J_c are necessary to calculate the g value during the heat penetration. U value for the heat penetration test for two different F_o values were found to be 8.61 min and 9.50 min, the g value was 2.15 min and 1.35 min and f_h/U value were 2.147 and 1.57 min, respectively. These values were within the range of previous reported works [1, 24-27].

The come-up time obtained were 6 min for F_o 8. 37 and 8 min for F_o 9.29, respectively and it varies on the kind of retort used for the study. Ball's process time was calculated for F_o 8. 37 min as 29.93 min and for F_o 9.29 min 31.26 min whereas Stumbo's process time was calculated as 39.79 min and 38.8 min for F_o 8. 37 min and F_o 9.29 min respectively [3, 24-28]. The cook values achieved for the thermally processed Cobia fillet chunks in curry were 60.95 min and 60.61 min for F_o 8. 37 and F_o 9. 29 min respectively [2, 19].

Table 3: Changes in biochemical parameters of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min.

Parameters	Raw	Days of storage													
		5 days		15 days		30 days		45 days		60 days		75 days		90 days	
		F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29
TVBN (mgN/100g)	3.73±1.62^{k}	13.77±0.06^{j}	13.73±0.15^{j}	15.60±0.26^{i}	15.67±0.15^{i}	17.37±0.15^{h}	18.57±0.15^{g}	19.33±0.28^{f}	20.43±0.15^{e}	20.43±0.31^{e}	22.44±0.39^{c}	21.13±0.09^{d}	23.70±0.27^{b}	22.30±0.31^{c}	25.09±0.02^{a}
TMAN (mgN/100g)	2.80±0.00^{j}	3.61±0.00^{i}	4.73±0.03^{h}	4.42±0.01^{i}	6.66±0.03^{ef}	5.19±0.06^{gh}	8.59±0.03^{d}	6.02±0.02^{f}	9.70±0.16^{c}	6.42±0.52^{f}	10.44±0.57^{c}	6.93±0.97^{ef}	11.48±0.49^{b}	7.40±1.42^{e}	12.66±0.32^{a}
TBARS Malonaidehyde/Kg	1.78±0.14^{c}	1.08±0.93^{d}	1.22±0.10^{d}	1.27±0.93^{d}	1.37±0.10^{d}	1.46±0.93^{d}	1.52±0.10^{d}	1.65±0.93^{d}	1.67±0.10^{d}	1.67±0.83^{b}	1.87±0.12^{d}	1.80±0.88^{b}	1.90±0.10^{d}	1.87±0.90^{a}	1.97±1.00^{d}

Value is expressed as mean ± standard deviation different superscripts in same rows indicated significant difference ($p<0.05$) (n=3).

4.2 Proximate, biochemical and microbiological analysis

There is a decreasing trend in moisture content from 79.13±0.23 % value in the fresh material to about 69.37% in the processed product. This may be attributed to the loss of water holding capacity of the cells due to protein denaturation upon heat treatment [29-30]. Others parameters like crude protein, crude fat and ash content were found to increase in the processed products than that of the fresh material. This result was in agreements with [31-35]. The increasing protein, fat and ash contains in the study may be due to the loss of water from muscle during sterilization. Also adding an oil during curry preparation would also contributes to the increase of fat contents [30-36].

TVB-N, TMA-N and TBA-RS were determined and compared with the fresh material used in the study. For fresh material, the values of TVBN, TMAN and TBARS content 3.37 ± 1.62 mg N/100g, 2.80±0.00 mg N/100g and 1.78±0.14 malonaldehyde/Kg respectively (**Table 3**). For the processed samples, the TVBN content was within the range of 13-25 mg N/100g, TMAN content was 3-12 mg N/100g and TBARS value was 1-1.9 malonaldehyde/Kg during the storage period of 90 days. All the biochemical indices showed on increasing trend with respect to storage days. The increased amount of TVBN and TMAN in the processed sample may be attributed to the degradation of proteins, amino acids, and other nitrogenous chemicals such as TMAO during sterilization [2, 10, 33, 36].

TBARS value is an indication of secondary oxidation. During the storage of processed Cobia fillet chunks in curry packed in flexible retortable pouches TBARS values increased and it was showing a minimal increasing trend. Acceptable limit value of TBARS content is between 7 and 8 mg MDA/kg [37]. However, the rising trend of TBARS in processed samples remained within tolerable limits. The results are followed with finding of various authors [38-39] reported that TBARS values was0.14±0.02 in the product of ready-to-eat “Fish peera”. Some researchers concluded that TVB-N was 2.87±0.43 mg N/100g, TMA-N 1.31±0.18 mg N/100g and TBA was 0.27±0.004 malonaldehyde/Kg [40].

For the Cobia fillet chunks in curry, all biochemical values were within the limit throughout the 90-day preservation period. Pearson (1976) indicated a lower limit of 20 to 30 mg N/100 g for TVBN acceptability in fish, while Kirk and Sawyer (1991) suggested a higher limit of 30 to 40 mg N/100 g. The suggested limit of TMA value for human intake is 10 - 15 mg N/100 g (Connell, 1995). Connell (1995) also claimed that the permissible limits for fish was 30 mg N/100 g. The current study attributes the increasing pattern of TBARS value to lipid

oxidation during sterilization, which disrupts cell structures and inactivates antioxidant enzymes [38].

4.3 Commercial sterility test

The thermal processed Cobia fillet chunks in curry packed in pouches were subjected to commercial sterility. The turbidity which is an indication of growth, was not observed in the thioglycolate media. This revealed that the heat treatment given was sufficient enough to get the commercially sterilize product.

4.4 Texture profile analysis

The instrumental texture profile analysis concluded for raw material and processed Cobia fillet chunks in curry at two different F_o values after 5 days and 90 of days storage at ambient temperatures. The hardness (kgf), springiness (mm), cohesiveness and chewiness (kg.mm) values for the fresh Cobia were found to be 7.56 ± 0.08, 1.53 ± 0.46, 0.44 ± 0.01 and 3.39 ± 0.08 respectively. Instrumental texture profile analysis parameter for female Tench (*Tinca tinca*) were analyzed and found the hardness (N), springiness (mm), cohesiveness and chewiness (kgf.mm) were 9.49 ± 0.6, 0.67 ± 0.01, 0.47 ± 0.02 and 2.85 ± 0.26, respectively (**Table 4**). The lowering of the hardness values upon thermal processing is due to the impact of temperature on the collagen and the resultant softening of the muscle [41].

The hardness for Cobia fillet chunk in curry F_0 8.37 and 9.29 min were 2.31±0.37 and 1.23±0.25 kg respectively. It was noted that the hardness decreases as F_o values increases. After 90 days of storage, the processed fish product's hardness rating dropped as compared to fresh Cobia. The hardness values of the processed samples after 90 days of the storage period showed a decreasing trend with an increase of F_o value. These results were in agreement with findings of some researchers who compared the firmness of mackerel, carps, sweet and sour carp respectively, processed at various temperature and reported that the thermal processing at higher temperature produce firmer products [42-43]. Other parameters like springiness, cohesiveness and cohesiveness followed the same trend as like that of hardness. The springiness values ranged from 0.81±0.46 to 0.50±0.46 for the F_o values of 8.37 and 9.29 min, respectively. Cohesiveness values ranged from 0.34±0.00 to 0.24±0.00 for the F_o values of 8.37 and 9.29 min respectively. As the F_o value increases, textural qualities including hardness, springiness, and cohesiveness and chewiness decreased. Similar trend was reported [20, 42, 44]. The sensory textural parameters and instrumental textural parameter showed very good correlation [28]. The panellists rated the rohu curry prepared at F0 value for 8 minutes as having the highest overall acceptability based on the sum of all sensory characteristics. Shah *et al*. (2017) Concluded acceptable sensory properties. However, the results revealed that all the

sensory attributes showed a declining trend and increase in storage time for all the samples. Putanangadi Dasan [3] stated that among the various F_o values studied initially, F_o 8 and 9 min indicated best sensory quality for ready-to- eat shrimp in masala in retortable pouches. Thermal processing caused a change in the textural attributes of the product with that of the fresh Cobia in the study. Low values of hardness, springiness, cohesiveness and chewiness of the thermally processed Cobia fillet chunks in curry than the fresh Cobia fish. Heat treatments altered the native protein conformation with leads to denaturation of muscle protein results in a change in texture of the products [45].

Table 4: Instrumental texture profile analysis for fresh and thermally processed Cobia fillets chunk in curry processed at F_0 8.37 and F_0 9.29 min.

Attributes	Raw	Days of storage													
		5 days		15 days		30 days		45 days		60 days		75 days		90 days	
		F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29	F_0 8.37	F_0 9.29
Hardness(kg)	7.56 ±0.08^{a}	3.67±0.62^{b}	3.04± 0.07^{bc}	3.14± 0.27^{b}	2.36± 0.55^{d}	3.14± 0.12^{b}	2.28± 0.61^{d}	2.45± 0.41^{cd}	1.93± 0.06^{d}	2.41± 0.44^{cd}	1.87± 0.15^{d}	2.38± 0.39^{d}	1.80± 0.26^{de}	2.31± 0.37^{d}	1.23± 0.25^{e}
Springiness (mm)	1.53 ±0.46^{bc}	1.93±0.05^{a}	1±0.00^{bc}	1.14± 0.16^{bc}	0.73± 0.55^{c}	1.11± 0.21^{bc}	0.67± 0.58^{c}	1.08± 0.11^{bc}	0.63± 0.55^{c}	1.05± 0.05^{bc}	0.60± 0.53^{c}	1±0.00^{bc}	0.53± 0.50^{c}	0.81± 0.46^{bc}	0.50± 0.46^{c}
Cohesiveness	0.44 ±0.01^{ab}	0.47±0.02^{a}	0.38± 0.01^{de}	0.44± 0.02^{abc}	0.38± 0.01^{ef}	0.43± 0.01^{bc}	0.33± 0.01^{gh}	0.41± 0.00^{cd}	0.31± 0.01^{g}	0.38± 0.04^{de}	0.29± 0.01^{de}	0.36± 0.00^{ef}	0.26± 0.00^{h}	0.34± 0.00^{ef}	0.24± 0.00^{h}
Chewiness (kgmm)	3.39 ±0.08^{a}	2.45±0.16^{b}	1.67± 0.35^{c}	1.53± 0.37^{cd}	1.39± 0.09^{cd}	1.29± 0.24^{de}	1.22± 0.27^{def}	1.06± 0.09^{ef}	1.06± 0.13^{ef}	1.00± 0.00^{ef}	0.98± 0.01^{ef}	0.93± 0.03^{f}	0.96± 0.25^{ef}	0.91± 0.02^{f}	0.94± 0.00^{f}

Value is expressed as mean ± standard deviation different superscripts in same rows indicated significant difference ($p<0.05$) (n=3).

4.5 Sensory evaluation of the processed product

The main objective of sensory evaluation test is to measure the intrinsic sensory attributes of a food product by trained panellist's assessors and it is a part of the production process [46]. The sensory scores for the product processed at two F_o 8.37 min and varied from 8.40 to 7.20, for F_o 9.29 min ranged from 8 to 6.8 during the storage at ambient temperature for 90 days. However, the values are in acceptable limit based on 9-point hedonic scale [19, 47-48]. The panellists were asked to provide a score of 1-9 for appearance, colour, flavour, odour, taste, texture, and overall acceptability [47].

The results of sensory analysis of Cobia fillet chunks in curry are represented in **Fig. 4 to Fig. 10**. The sensory scores given by panel for appearance were 6.60, and 6.30, respectively for thermally processed F_0 8.37 and 9.29 min after the storage period of 90 days. The color parameters were 6.90 and 6.60 for F_0 8.37 and 9.28 min, respectively. For flavor, panelists scored 7.10 and 6.80 for processed Cobia fillet chunks in curry at F_0 8.37 and 9.29 min, respectively. It was observed from the above-mentioned result that there was a slight decrease in color and flavor parameters with an increase in F_0 values. It would be because of the increased processing time [3, 48-49].

The total influence of all sensory variables i.e., the overall acceptability was scored the highest by the panellists for the Cobia fillet chunks in curry processed at F_o value of 8. 37 min. With an increase in the F_o value, the colour of the thermally processed Cobia fillet chunks in curry decreased. It would be due to increasing the processing time [3, 28, 49].

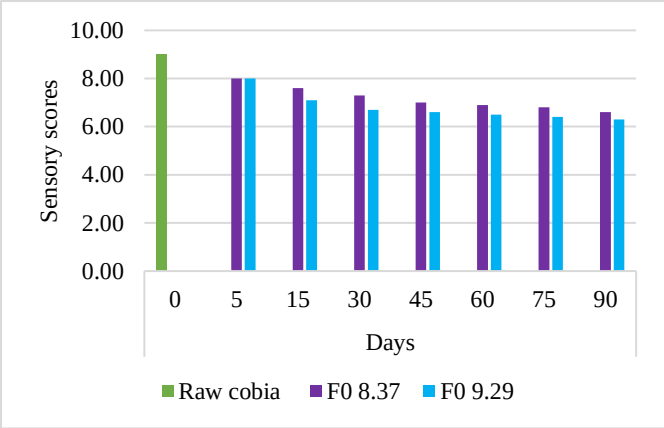

Fig. 4 Appearance of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

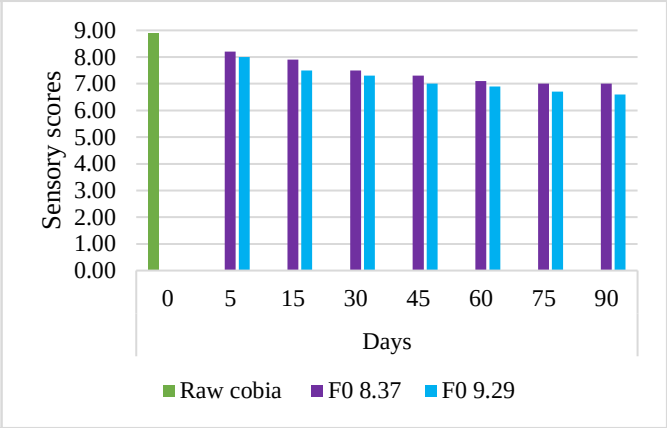

Fig. 5 Color of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

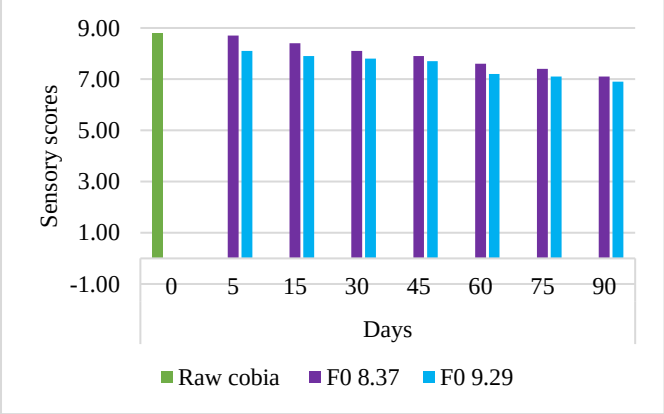

Fig. 6 Flavor of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29

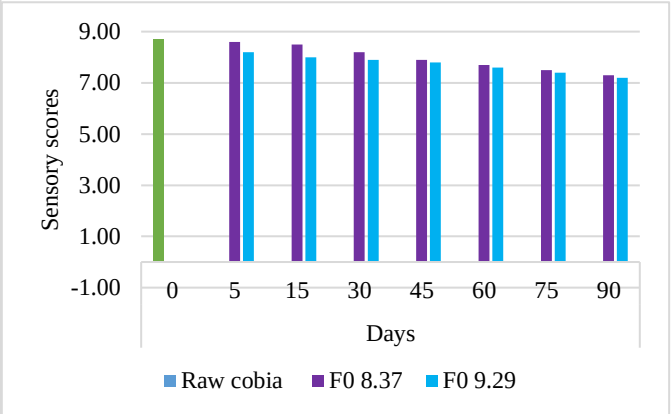

Fig. 7 Firmness of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

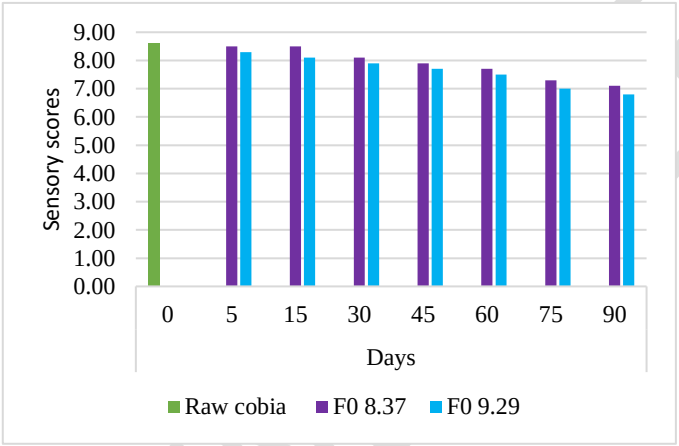

Fig. 8 Succulence of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

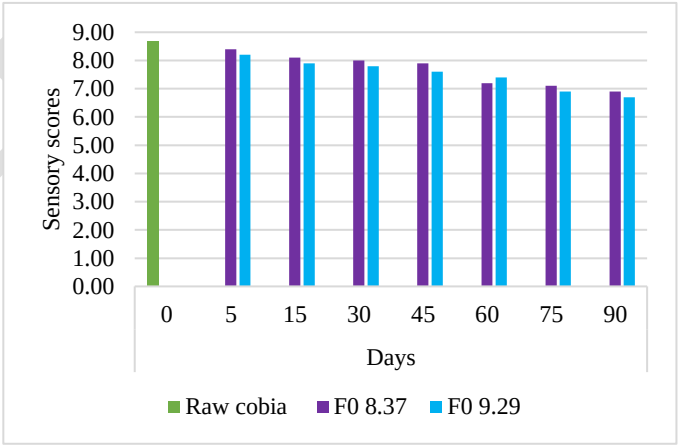

Fig. 9 Toughness of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

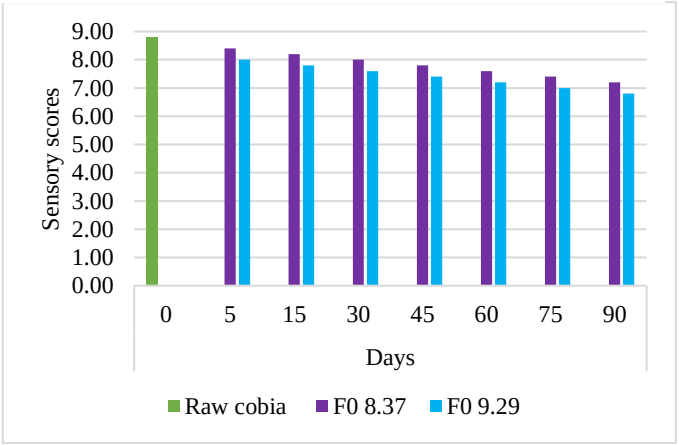

Fig. 10 Overall acceptability of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

CONCLUSIONS

The study successfully optimized the total lethality (F_0) for developing RTE cobia fish fillets chunks in curry using flexible retortable pouches by selecting F_0 values of 8.37 min and 9.29 min based on the evaluation of sensory parameters. Assessment of the heat penetration characteristics and commercial sterility test revealed that both F_0 values satisfied the requirements for commercial sterility. Microbiological, biochemical, and proximate analysis showed that the processed product's parameter levels were within the acceptable limits for the duration of its 90 days storage. The texture profile analysis showed diminishing patterns of texture during the period of storage, which revealed that heat processing had significant effects on the product's texture. The product processed at F_0 8.37 min received higher sensory scores and rated better for its overall quality. The results finally summarize that cobia fish fillets chunks could be an excellent raw material for developing various RTE ethnic dishes and meeting the global demand for fish products.

DISCLAIMER

This article is true as result of pure research without being engineered and doesn't use AI technology

ETHICAL APPROVAL

Not applicable

REFERENCES

1. Bindu, J., Srinivasa Gopal, T.K. And Unnikrishnan Nair, T.S., 2004. Ready-to-eat mussel meat processed in retort pouches for the retail and export market. *Packaging Technology and Science: An International Journal*, 17(3): 113-117. Available: https://doi.org//10.1002/pts.637
2. Mohan, C.O., Ravishankar, C.N., Bindu, J., Geethalakshmi, V. And Srinivasa Gopal, T.K., 2006. Effect of thermal process time on quality of "shrimp kuruma" in retortable pouches and aluminum cans. *Journal of Food Science*, 71(6): S496-S500. Available: https://doi.org/10.1111/j.1750-3841.2006.00099.x
3. Puthanangadi Dasan, G., Bojayanaik, M., Gundubilli, D., Banavath, S.N., Siravati, M.R., Obaliah, M.C. And Alandur, V.S., 2021. Heat penetration characteristics and

quality of ready-to-eat shrimp in masala (*Litopenaeus vannamei*) in flexible retortable pouches. *Journal of Food Processing and Preservation*, 45(5) :15411.Available: https://doi.org/10.1111/jfpp.15411

4. Briggs, John C., 1960. "Fishes of worldwide (circumtropical) distribution." *Copeia* 3: 171-180.Available: https://doi.org/10.2307/1439652
5. MPEDA. 2020. http://mpeda.gov.in/farmers/?page_id=1714
6. Awuah, G.B., Ramaswamy, H.S. And Economides, A., 2007. Thermal processing and quality: Principles and overview. *Chemical Engineering and Processing: Process Intensification*, 46(6), pp: 584-602.
   Available: https://doi.org/10.1016/j.cep.2006.08.004
7. Bindu, J., Mallick, A.K. And Gopal, T.K.S., 2014. Thermal processing of fishery products in flexible and rigid containers. *Fishery Technology*., 51: 137 – 148.
8. Rangarao, G.C.P., 2002. Ready-to-eat Indian foods in retort pouches: the second wave. *Indian Food Industry*, 21(1): 12-20.
   Available: http://ir.cftri.res.in/id/eprint/2864
9. Awuah, G.B., Ramaswamy, H.S. And Economides, A., 2007. Thermal processing and quality: Principles and overview. *Chemical Engineering and Processing: Process Intensification*, 46(6), pp: 584-602.
   Available: https://doi.org/10.1016/j.cep.2006.08.004
10. Chia Ss, Baker Rc, Hotchkiss Jh., 2006. Quality comparison of thermoprocessed fishery products in cans and retortable pouches. *J Food Sci.*, 48:1521–1525.
    Available: https://doi.org/10.1111/j.1365-2621.1983.tb03529.x
11. Ranganna, S., 2000. Handbook of canning and aseptic packaging. Tata McGrew-Hill Publishing Company Limited, New Delhi, pp 1-3.
12. Conway, E. J. (1962). Microdiffusion analysis and volumetric error (5th edn). Crosby: Lockwood and Son Ltd. p. 467.
13. Raghavan, S., & Hultin, H. O. (2005). Model system for testing the efficacy of antioxidants in muscle foods. Journal of Agricultural and Food Chemistry, 53(11), 4572–4577. Available: https://doi.org/10.1021/jf0501387
14. ICMSF. (1986). International commission on microbiological specifications for foods. Sampling plans for fish and shellfish. In ICMSF (Ed.), ICMSF, Microorganisms in foods. Sampling for microbiological analysis: Principles and scientific applications (Vol. 2, 2nd ed.). University of Toronto Press.
15. Bourne, M. C., 1978. Texture Profile analysis. *Food Technology*, 32, 62-66, 72.

16. Santhkumar, G., 2004. Utilization of tilapia by canning. Master's thesis, USA, Bangalore.
17. Pedanna, V. C., 2005. Modified procedure for canning of shrimp and squid in masala. *Master's Thesis,* University of Agriculture Sciences, Bangalore.
18. Gundubilli Devika, 2018, Development of ready-to-eat (RTE) squid ring in masala using flexible retortable pouches, Karnataka veterinary, animal and fisheries sciences university, Bidar.
19. Manju, S., Sonaji, E.R., Leema, J., Gopal, T.K.S., Ravishankar, C.N. And Vijayan, P.K., 2004. Heat penetration characteristics and shelf life studies of seer fish moilee packed in retort pouch. *Fishery Technology*, 41: 37–44.
20. Ali, A., Sudhir, B. And Srinivisa Gopal, T.K. 2005. Effect of heat processing on the texture profile of canned and retort pouch packed oil sardine (*Sardinella longiceps*) in oil medium. *Journal of Food Science*, 70(5): S350-S354.
    Available: https://doi.org/10.1111/j.1365-2621.2005.tb09990.x
21. Mohan, C.O., Ravishankar, C.N., Bindu, J., Geethalakshmi, V. And Srinivasa Gopal, T.K., 2006. Effect of thermal process time on quality of "shrimp kuruma" in retortable pouches and aluminum cans. *Journal of Food Science*, 71(6): S496-S500.
    Available: https://doi.org/10.1111/j.1750-3841.2006.00099.x
22. Bindu, J., Ravishankar, C.N., Dinesh, K., Mallick, A.K. And Gopal, T.K.S., 2011. Heat penetration characteristics and shelf life of ready to serve mahseer curry in opaque retortable pouches. *Fishery Technology*., 48(2): 137 – 148.
23. Xavier, K.M., Ravishankar, C.N., Bindu, J. And Gopal, T.S., 2013. Textural and colour changes of mackerel (*Rastrelliger kanagurta*) thermal processed at different retort temperatures. *Fishery Technology*, 45: 133-138.
24. Bindu, J. Ravishankar, C.N. And Gopal, T.K.S., 2007. Shelf life evaluation of a ready to eat black clam (*Villorita cyprinoides*) product in indigenous retort pouches, *J. Food. Engg*., 78: 995-1000.
    Available: https://doi.org/10.1016/j.jfoodeng.2005.12.040
25. Dhanapal, K., Reddy, G.V.S., Nayak, B.B., Basu, S., Shashidhar, K., Venkateshwarlu, G. And Chouksey, M.K., 2010. Quality of ready to serve tilapia fish curry with PUFA in retortable pouches. *Journal of Food Scienc*., 75(7): S348-S354.
    Available: https://doi.org/10.1111/j.1750-3841.2010.01762.x
26. Hema, K., Velayutham, P., Mohan, C.O., Sukumar, D., Sundaramoorthy, B., Athithan, S., Sugumar, G., Ravishankar, C.N. And Ashok Kumar, K., 2021. Thermal process

evaluation of analogue shrimp product (ASP) from Lizard Fish (*Saurida tumbil*) in retort pouches. *Indian Journal of Animal Research*, 2: 230-235
Avialbel: https://doi.org/10.18805/IJAR.B-3898

27. Shashidhar, K., Biji, K.B., Ravishankar, C.N., Sreenivasagopal, T.K. And Jose, J., 2015. Development of Ready to Drink Iron Fortified Shrimp Soup in Retortable Pouches. *Fishery Technology*, 52: 157 – 163.
28. Majumdar, R.K., Dhar, B., Saha, A., Roy, D., Parhi, J. And Singh, A.S., 2017. Evaluation of textural quality as a parameter to optimize thermal process during retort pouch processing of boneless rohu balls in curry medium. *Journal of Food Processing and Preservation*, 41(3): 12925.
Available: https://doi.org/10.1111/jfpp.12925
29. Castrillón, A.M., Alvarez-Pontes, E., Arias, M.T.G. And Navarro, P., 1996. Influence of Frozen Storage and Defrosting on the Chemical and Nutritional Quality of Sardine (*Clupea pilchardus*). *Journal of the Science of Food and Agriculture*., 70(1): 29-34.
Available:https://doi.org/10.1002/(SICI)1097-0010(199601)70:1%3C29::AID-JSFA461%3E3.0.CO;2-2
30. García-Arias, M.T., Sánchez-Muniz, F.J., Castrillón, A.M. And Navarro, M.P., 1994. White tuna canning, total fat, and fatty acid changes during processing and storage. *Journal of Food Composition and Analysis*, 7: 119-130.
31. Mai, H, Shimp, J., Weilhrauch J, Kinsella Je., 1978. Lipids of fish fillets: changes following cooking by different methods. *J Food Sci*., 43: 1669–1674.
Available: https://doi.org/10.1111/j.1365-2621.1978.tb07384.x
32. Gall Kl, Otwell Ws, Koburger Ja, Appledorf H., 1983. Effects of four cooking methods on proximate, minerals and fatty acid composition of fish fillets. *J Food Sci*., 48: 1068–1074.
Available: https://doi.org/10.1111/j.1365-2621.1983.tb09163.x
33. Gallardo, J.M., Perez-Martin, R.I., Franco, J.M., Aubourg, S. And Sotelo, C.G., 1990. Changes in volatile bases and trimethylamine oxide during the canning of albacore (*Thunnus alalunga*). *International Journal of Food Science and Technology*, 25(1): 78-81.
Available: https://doi.org/10.1111/j.1365-2621.1990.tb01061.x
34. Biji, K.B., Shamseer, R.M., Mohan, C.O., Ravishankar, C.N., Mathew, S. And Gopal, T.K.S., 2015. Effect of thermal processing on the biochemical constituents of green

mussel (*Perna viridis*) in Tin-free-steel cans. *Journal of Food Science and Technology*, 52(10): 6804-6809.
Available: https://doi.org/10.1007/s13197-015-1757-8

35. Shakila, R.J., Raj, B.E. And Felix, N., 2012. Quality and safety of fish curry processed by sous vide cook chilled and hot filled technology process during refrigerated storage. *Food Science and Technology International*, 18(3): 261-269.
Available: https://doi.org/10.1177/1082013211415177
36. Gall Kl, Otwell Ws, Koburger Ja, Appledorf H., 1983. Effects of four cooking methods on proximate, minerals and fatty acid composition of fish fillets. *J Food Sci*., 48: 1068–1074.
37. *Sinnuber RO, Yu TC 1958. 2-Thiobarbituric acid method for the measurement of rancidity in fishery products. II. The quantitative determination of malonaldehyde. Food Technol. 12(2):9–12.*
38. AHN, D.U. And MIN, B. 2005. Mechanism of lipid peroxidation in meat and meat products- A review. *Food Sci. Biotech.*, 14: 152-163.
39. Bindu, J., Ravishankar, C.N., Srinivasa Gopal, T.K. And Mallick, A.K., 2010. Investigation of shelf life and heat penetration attributes of ready-to-eat “fish peera” from anchovy (*stolephorous commersoni*) in retort pouches. *Journal of Food Processing and Preservation*, 34: 207-222.
Available: https://doi.org/10.1111/j.1745-4549.2008.00334.x
40. Shah, M.A., Bosco, S.J.D., Mir, S.A. And Sunooj, K.V., 2017. Evaluation of shelf life of retort pouch packaged Rogan josh, a traditional meat curry of Kashmir, India. *Food Packaging and Shelf Life*, 12: 76-82.
Available: https://doi.org/10.1016/j.fpsl.2017.04.001
41. Vácha, F., Stejskal, V., Vejsada, P., Kouřil, J. And Hlaváč, D., 2014. Texture profile analyses in tench (*Tinca tinca* L., 1758) from extensive and intensive culture. *Acta Veterinaria Brno.*, 82(4): 421-425.
Available: https://doi.org/10.2754/avb201382040421
42. Mallick, A.K., Gopal, T.S., Ravishankar, C.N., Vijayan, P.K. And Geethalakshmi, V., 2010. Changes in instrumental and sensory properties of indian white shrimp in curry medium during retort pouch processing at different F0 values. *Journal of Texture Studies*, 41(5): 611-632.
Available: https://doi.org/10.1111/j.1745-4603.2010.00243.x

43. Tanaka, M., Nagashima, Y. And Taguchi, T., 1985. Quality comparison of canned mackerel with equal lethality, *Bull. Jap. Soc. Sci. Fish*., 51 (10): 1737-1742
44. Sreenath P. G., 2006. Standardization of process parameters for ready to eat fish products in indigenous polymer coated tin free steel cans. Doctoral thesis. Cochin University of Science and Technology.
45. Ma, L.Y., Deng, J.C., Ahmed, E.M. And Adams, J.P., 1983. Canned shrimp texture as a function of its heat history. *Journal of Food Science*, 48(2): 360-363. Available: https://doi.org/10.1111/j.1365-2621.1983.tb10743.x
46. York, R.K. And Sereda, L.M., 1994. Sensory assessment of quality in fish and seafoods. In Seafoods: chemistry, processing technology and quality Edt., Shahidi, F. and Botta, J.R., Chapman and Hall, London., pp: 233-262.
47. Vijayan, P.K., Gopal, T.S., Balachandran, K.K. And Madhavan, P., 1998. Fish curry in retort pouch. Society of Fisheries Technologists (India), Cochin, pp: 233-235.
48. Majumdar, R.K., Dhar, B., Roy, D. And Saha, S., 2015. Study of Instrumental and Sensory Characteristics of Catla in Curry Medium during Retort Pouch Processing to Optimize F_0 Value. *Journal of Food Processing and Preservation*, 39(6):1595-1604. Available: https://doi.org/10.1111/jfpp.12388
49. Akande, G.R., Emokpae, A.O., Towuru, E.T., Ogbonna, C. And Ajayi, A., 1988. Proximate composition, microbiological and sensory evaluation of canned skipjack tuna (*Katsuwonus pelamis*) stored at ambient and accelerated temperatures. *Nigerian Institute for Oceanography and Marine Research*, 1-5.