Optimizing the Use of Flexible Retort Pouches for Production of Ready to Eat Cobia (*Rachycentron canadum*) Fish Chunks in Curry Medium

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Cobia fish chunks in curry medium, a famous North Eastern Indian dish, was developed using Cobia (*Rachycentron canadum*) fish chunks prepared in a traditional culinary style. The present study was aimed to optimize F_0 values for Cobia fish chunks in curry medium using flexible

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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 F_0 values of 9.29 and 8.42 minutes, respectively. The total process times were 39.79 and 38.80 minutes, respectively, for the F_0 values of 8.42 and 9.29 minutes. Cook values for the processed product were 86.60 minutes for the F_0 value of 8.42 minutes and 92.57 minutes for the F_0 value of 9.29 minutes. Based on sensory characteristics, the product processed at an F_0 value of 8.42 minutes was rated better over a storage period of 90 days.

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 (Bindu J et al, 2004, Mohan CO et al, 2006, Puthanangadi Dasan G et al, 2021).

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 (Briggs JC, 1960). 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 (MPEDA. 2020).

The concept of thermal processing, which primarily involves 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 (Awuah GB, 2007).

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 (Bindu J et al, 2014, Rangarao GCP, 2002).

The canning industry is concerned about the impact of high processing temperatures on both nutritional and sensory quality (Mohan CO et al, 2006, Awuah GB and Ramaswamy HS, 2007, Chia SS et al, 2006).

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 procured 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 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. Fig. 1 shows the flow chart and its accompanying illustration.

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 contam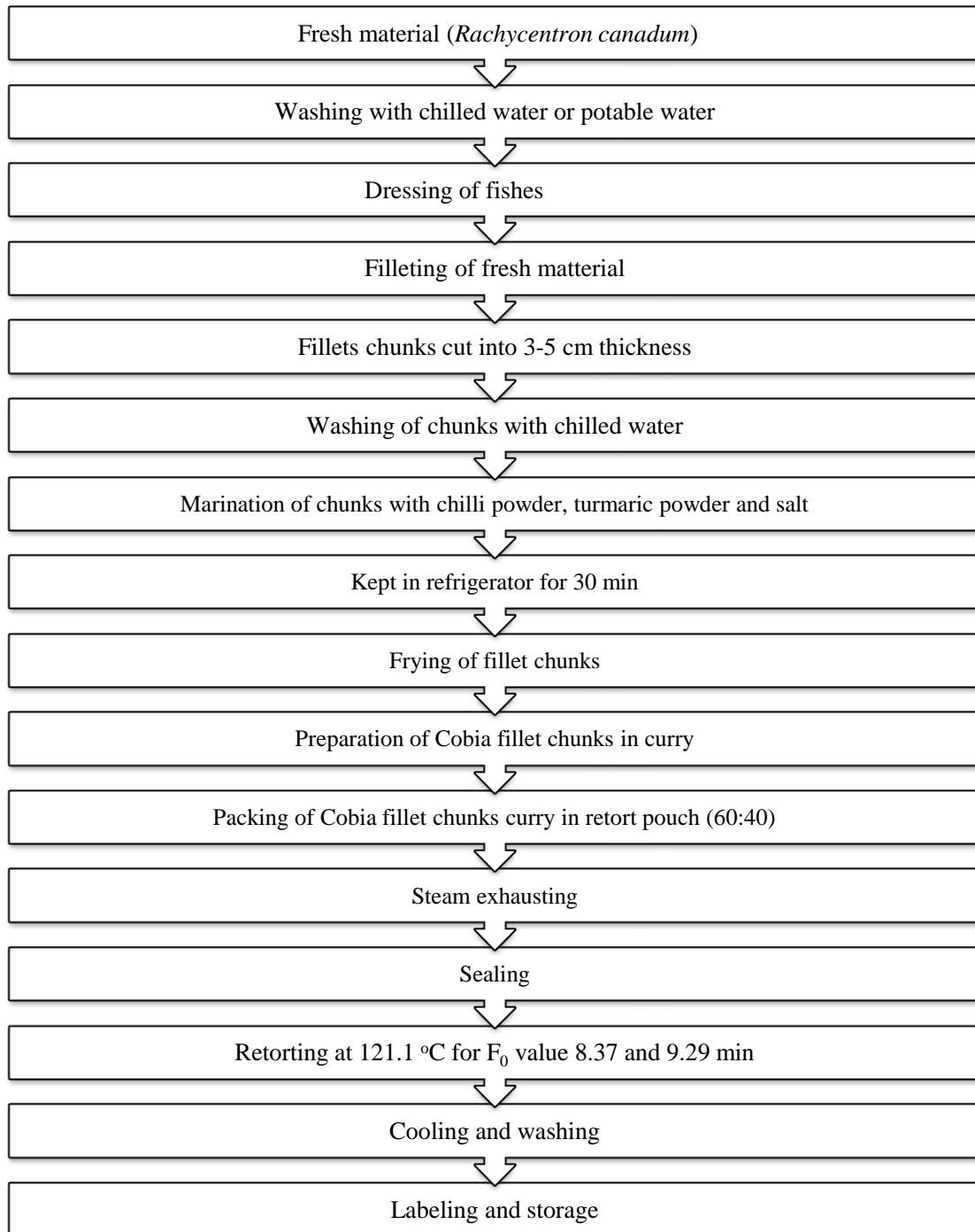inating the seal area of the pouches. Required numbers of pouches were fixed with glands and the tip of the thermocouples were inserted into the fish chunks. The pouches were immediately steam exhausted (injected with steam) mainly to remove any entrapped air and gases in the pouches, followed by sealing 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.

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

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

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 °C, Z = 10 °C and cook value constant at T = 100 °C and Z-value was 33 °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 (Stumbo CR, 2013). 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 (Ranganna S, 2000).

Fresh material (*Rachycentron canadum*)

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Washing with chilled water or potable water

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Dressing of fishes

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Filleting of fresh matterial

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Fillets chunks cut into 3-5 cm thickness

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Washing of chunks with chilled water

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Marination of chunks with chilli powder, turmaric powder and salt

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Kept in refrigerator for 30 min

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Frying of fillet chunks

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Preparation of Cobia fillet chunks in curry

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Packing of Cobia fillet chunks curry in retort pouch (60:40)

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Steam exhausting

↓

Sealing

↓

Retorting at 121.1 °C for F_0 value 8.37 and 9.29 min

↓

Cooling and washing

↓

Labeling and storage

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

2.5 Quality Evaluation

2.5.1 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 (Conway EJ, 1962). The TBA value obtained by following the approach of Raghavan and Hultin (2005). The total plate count (TPC) of raw cobia fish was done using spread plate technique (ICMSF,1986).

2.5.2 The commercial sterility test

The samples treated at varied F_O values were incubated at 37°C for 15 days and 55°C for 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 (IS 2168, 1971).

2.5.3 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 (Bourne MC,1978).

2.5.4 Sensory evaluation

Sensory evaluation was done based on the different attributes such as flavor, color, appearance, succulence, chewiness, toughness, and overall acceptability. The score was given based on the 9-point hedonic scale (5 = limit of acceptability) by a 25-member panel as per the guidelines given by Peryam and Pilgrim (1957). To assign the score, thermally processed pouches were heated in boiling water for 5 minutes and served warm to panellists. 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). Sensory analysis was carried out for the product before thermal processing as a control and the thermally processed product after an interval of 15 days for a period of 90 days of storage at ambient temperature.

2.6 Statistical Analysis

Experimental data was analysed using the Statistical Package, (SPSS, version 21.00 for Windows) software. Results were given as mean ± SD. 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 (p< 0.05).

3. RESULTS AND DISCUSSION

3.1 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 F_o 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).

Several authors conducted similar research and reported on the heat penetration properties of different food packs (Puthanangadi Dasan G et al, 2021, Bourne MC ,1978, Peryam DR and Pilgrim FJ, 1957, Santhkumar G, 2004).

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 (Bourne MC, 1978, Peryam DR and Pilgrim FJ, 1957, Pedanna VC, 2005, Gundubilli Devika, 2018, Manju S et al, 2004, Ali A et al, 2005).

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

Table 2. Heat penetration characteristics of Cobia chunks in curry medium processed at F_0 8.37 and F_0 9.29 minutes

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 (°C)	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
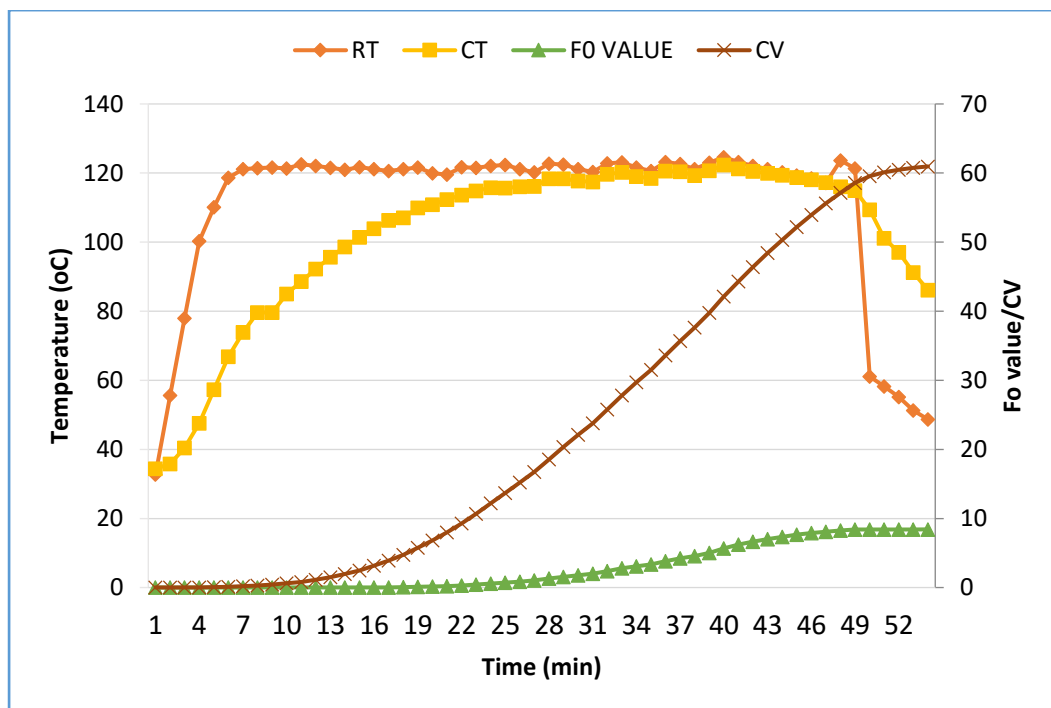
RT-Retort temperature, CT- Core temperature, CV- Cook Value

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

were 2.147 and 1.57 min, respectively. These values were within the range of previous reported works (Bindu J et al, 2004 Mohan CO et al;, 2006, Bindu J et al, 2011, Xavier KM et al, 2013, Bindu J et al, 2007, Dhanapal K et al, 2010, Hema K et al, 2021).

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 (Puthanangadi Dasan G et al, 2021, Bindu J et al, 2007, Dhanapal K et al, 2010, Hema K et al, 2021, Shashidhar K et al, 2015, Majumdar RK et al, 2017). 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 (Mohan CO et al, 2006, Manju S, 2004).

3.2 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 (Castrillón AM et al, 1996, García-Arias MT et al, 1994). 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 (Mai H et al, 1978, Gall KL et al, 1983). 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 (García-Arias MT et al, 1994, Mai H et al, 1978, Gall KL et al, 1983, Gallardo JM et al, 1990, Biji KB et al, 2015, Shakila RJ et al, 2012, Gall KL et al, 1983).

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 (Briggs JC, 1960, Chia SS et al, 2006, Gallardo JM et al, 1990, Gall KL et al, 1983).

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 (Sinnuber RO et al, 1958). However, the rising trend of TBARS in processed samples remained within tolerable limits. The results are followed with finding of various authors (Ahn DU and Min B, 2005, Bindu J et al, 2010) 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 (Shah MA et al, 2017).

For the Cobia fillet chunks in curry, all biochemical values were within the limit throughout the 90-day preservation period. The current study attributes the increasing pattern of TBARS value to lipid oxidation during sterilization, which disrupts cell structures and inactivates antioxidant enzymes (Ahn DU and Min B, 2005).

3.3 Commercial Sterility Test

The commercial sterility of thermally processed chunks in curry was examined, and no growth was observed in the medium. This suggests that the total lethality given to the product was sufficient to achieve commercial sterility. Thermal processed Cobia chunks curry pouches processed at F_0 8.37 and F_0 9.29 minutes were subjected to a commercial sterility test. The sample was incubated in thioglycolate broth tubes for 48 hours at 37 °C and for five days at 55°C. The tubes showed no signs of turbidity. The study was carried out throughout the study period of 90 days and there was no growth of any thermal resistance bacteria. This indicates that both F_0 values were good enough to reach the commercial sterility of the product.

3.4 Texture Profile Analysis

The instrumental texture profile analysis concluded for raw material and processed Cobia fillet chunks in curry at two different F_0 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 (Vácha F et al, 2014).
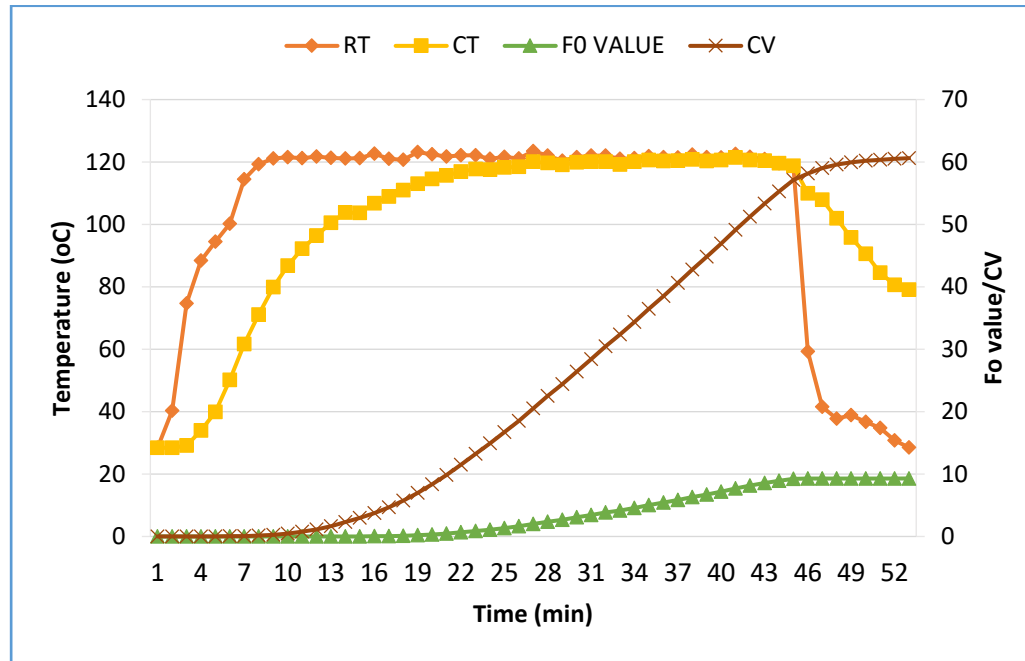
RT-Retort temperature, CT- Core temperature, CV- Cook Value

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

Table 3. Changes in biochemical parameters of raw and thermally processed Cobia chunks in curry processed at F_o 8.37 and F_o 9.29 minutes

| Parameters	Raw	Processed product													
		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)

Table 4. Texture profile analysis for raw and thermally processed Cobia chunk in curry processed at F$_0$ 8.37 and F$_0$ 9.29 minutes

| Attributes	Raw	Processed product												
		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)
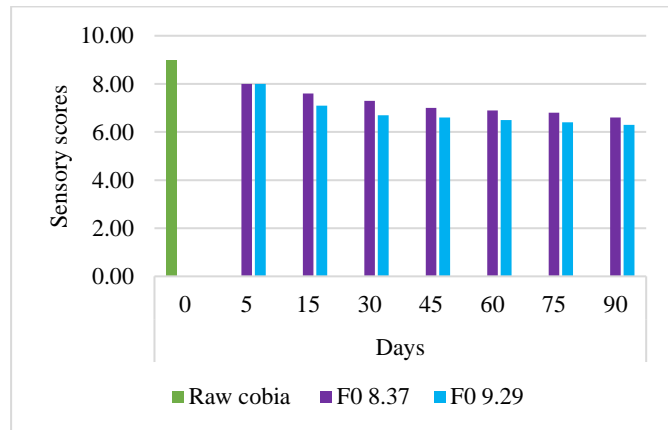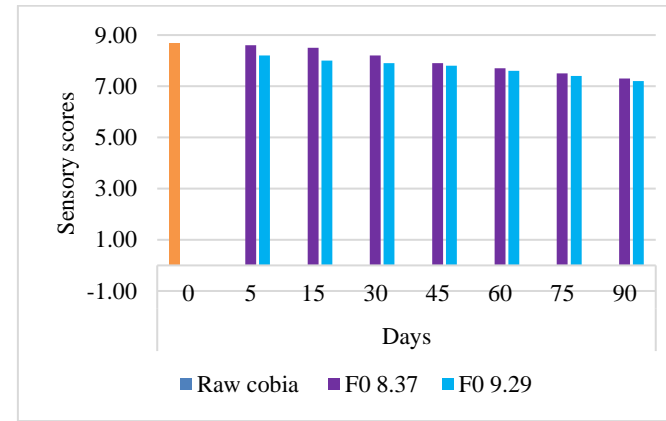

Fig. 4. Appearance of fresh and thermally processed Cobia fillets chunks in curry processed at *F$_o$* 8.37 and *F$_o$* 9.29 min
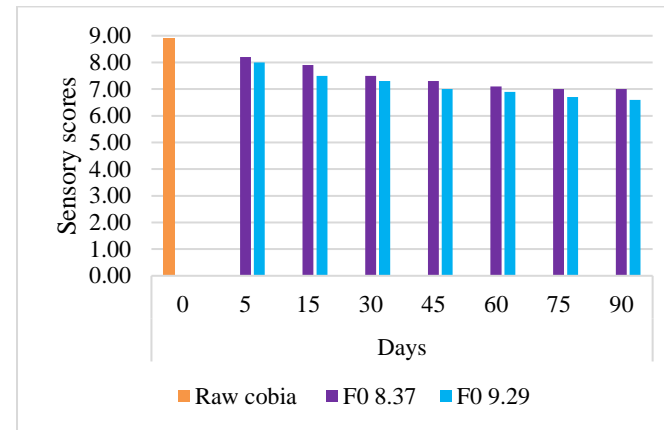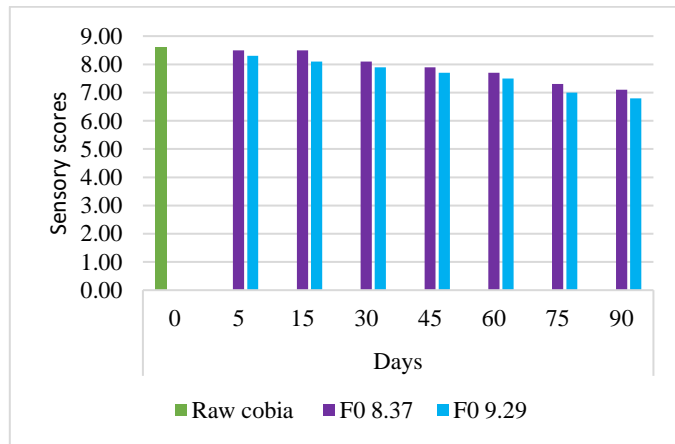

Fig. 5. Color of fresh and thermally processed Cobia fillets chunks in curry processed at *F$_o$* 8.37 and *F$_o$* 9.29 min
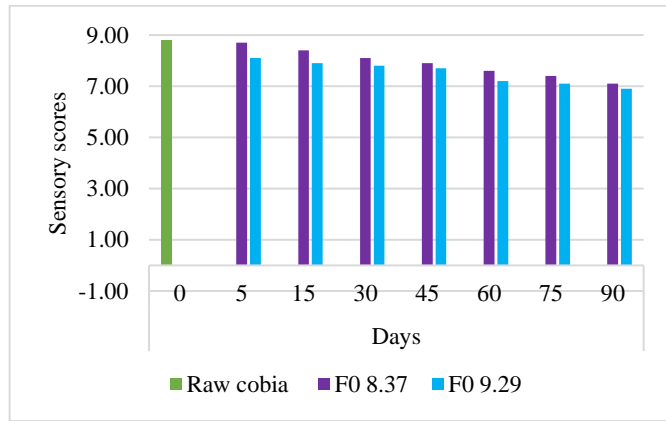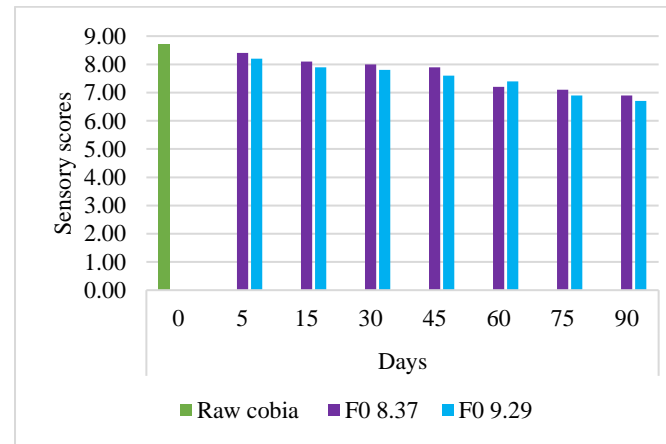
Fig. 6. Flavor of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min
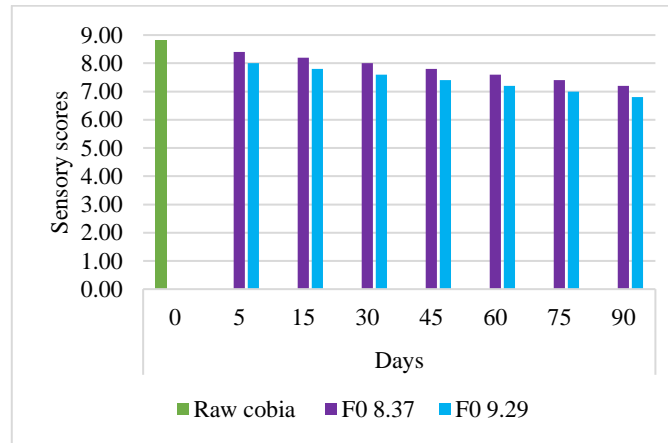

Fig. 7. Firmness of fresh and thermally processed Cobia fillets chunks in curry processed at F_o 8.37 and F_o 9.29 min

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

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 (Mallick AK et al, 2010, Tanaka M et al, 1985). 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 (Ali A et al, 2005, Mallick AK et al, 2010, Sreenath PG, 2006). The sensory textural parameters and instrumental textural parameter showed very good correlation (Majumdar RK et al, 2017). 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. However, the results revealed that all the sensory attributes showed a declining trend and increase in storage time for all the samples. Putanangadi Dasan (Puthanangadi Dasan G et al, 2021) 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 (Ma LY et al, 1983).

3.5 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 (York RK and Sereda LM et al, 1994). 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 (Manju S et al, 2004, Vijayan PK et al, 1998, Majumdar RK et al, 2015). The panellists were asked to provide a score of 1-9 for appearance, colour, flavour, odour, taste, texture, and overall acceptability (Vijayan PK et al, 1998).

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 (Puthanangadi Dasan G et al, 2021, Majumdar RK et al, 2015, Akande GR et al, 1998). 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 (Puthanangadi Dasan G et al, 2021, Majumdar RK et al, 2017, Akande GR et al, 1988).

4. CONCLUSIONS

The research study optimized the total lethality (F_0) for developing RTE cobia fish chunks in curry medium using retort pouches upon selecting F_0 value of 8.37 min and 9.29 minutes based on the evaluation of sensory parameters during initial trails. 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 parameters levels were within the acceptable limits for the duration of 90 days storage. The product processed at F_0 8.37 minutes received

higher sensory scores and rated better for its overall quality. The results summarize that cobia fish chunks in curry medium could be an excellent raw material for developing ready to eat fish products.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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