Heat Penetration Characteristics and Quality evaluation of Ready-to-Eat Pangasius Fish Fillet Chunks (*Pangasius hypophthalmus*) in Masala Using Flexible Retort Pouches

ABSTRACT

A South Indian dish was developed using Pangasius fish (*Pangasius hypophthalmus*) fillet chunks in masalas as a medium. The aim of the current study was to optimize the various F_0 values for Pangasius fillet chunks packed in masala, using flexible, retortable pouches. After being processed at different lethality levels, the product showed a similar heating and cooling lag factor. For F_0 values of 7.37 and 8.12 minutes, the total process times were 26.94 and 31.37 minutes, respectively. The Fh values for products processed at F_0 values of 7.37 and 8.12 minutes were 13 and 16.5 minutes, respectively. The cook value obtained for the thermally processed product was 64.70 minutes for F_0 7.37 minutes and 65.87 minutes for F_0 8.12 minutes. Over a storage duration of up to 90 days, all instrumental texture indicators exhibited a declining pattern. The product treated at F_0 7.37 minutes was considered more favourable based on organoleptic assessment

.**Keywords:** *Pangasius hypopthalmus, F_0 value,* TPT, Cook value, *fh* value, organoleptic evaluation.

INTRODUCTION

Conventional thermal methods of processing (e.g., boiling, frying, roasting, grilling, and smoking) produce organoleptically acceptable and tasty goods, but they have a number of limitations, including limited heat penetration, long processing times due to poor heat transfer, and nonhomogeneous heat distribution, which can result in overheating or underheating issues [1] [2] [3]. If food products like fish are not handled and prepared properly, they will deteriorate quickly due to microbial development, oxidative reactions, and enzymatic autolysis. This is one of the several preservation techniques that have evolved [4], and thermal processing is one of them. The idea behind thermal processing is to heat foods for a given amount of time at a specified temperature.

~~The h~~Heat treatment used for canning of fish is designed to kill pathogenic bacteria as well as other spoilage-causing bacteria during storage. *Clostridium botulinum* is an anaerobic bacterium that produces toxin in low-acid products with pH values greater than 4.5, such as canned fish [5]. Thermal treatment of fish in sealed metallic cans prevents both bacterial and autolytic spoilage, resulting in products with shelf lives of 1 to 2 years at room temperature. Bigelow et al. [6] mathematically expressed the death kinetics of bacterial spores. According to Esty and Meyer [7], the heat resistance of a population of *Clostridium botulinum* was determined by the number of microorganisms present at the beginning, and it was concluded from the data that the decline was exponential with time. Microorganism inactivation is still measured in decimal reduction time, or the time it takes to lower the number of microbial cells by a factor of ten, or D value. The z value is the increase in temperature that occurs when the D value is reduced by a factor of 10. Esty and Meyer [7] reported that the highest heat resistance was recorded at 121.1 °C for the proteolytic *C. botulinum* in canned food. The heat penetration parameters (f_h, f_c, j_h, j_c) given by Ball [8] are the traditional method of measuring the lethal effect of thermal processing.

Its sensory evaluation is the result of a combination of various characteristics that cover every sensation from the moment the fish makes contact with a surface in the mouth until it is fully masticated [9]. Fish muscle texture is a significant quality parameter that is influenced by a number of intrinsic and external factors. Texture profile analysis (TPA) is a technique that was established in 1963 at the General Foods Corporation Technical Centre to provide evaluations of texture parameters. It was created as a two-cycle compression that would resemble

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successive "chews" [10]. Force-time curves are useful in determining how much force is applied to food during oral mastication [11].

Retort pouches are becoming more and more popular because of their many advantages over metal containers. These include being less cheap, thin compared to jars and cans, requiring less time to process, having a having a simpler opening, the processed food can be consumed right out of the pouch, taking up less storage space, and having easier disposal [12]. When compared to empty cans, retort pouches take up 85% less space and weigh much less [13].

Pangasius, a catfish with characteristics like rapid development, air breathing, low dissolved oxygen tolerance, and polyculture compatibility, has gained interest in several Asian countries. Due to the influence of international markets, a large number of farmers in India have become interested in cultivating *P. hypopthalmus* [14]. Because of the absence of a fishy odor, as well as little bones and skin, Pangasius fillets characterize Their flavor is delicate, and their texture is firm when cooked, allowing for a wide variety of food treatments [15]. Various types of value-added products have been developed from Pangasius fish [16], but the data regarding thermally processed Pangasius fish fillet chunks in masala packed in retort pouches is very scanty. In light of this, the present study has been done to evaluate the textural, biochemical and sensory changes that occur in the processed Pangasius fish fillet chunks.

2. Materials and methods

2.1. Materials

The freshly farm reared Pangasius fish (*Pangasius hypopthalmus*) ~~is~~ was used as ~~a~~ the raw material. It weighs around 1.5 kg and is obtained from private fish farms located at Nellore, Andhra Pradesh, through the Karnataka Fisheries Development Corporation (KFDC), Mangalore and taken to the laboratory in an aseptic and chilled condition. A four-ply laminated flexible retortable pouch with a capacity of 300 g and a dimension of 150200 mm was used for packaging of chunks with masala. It was made of 12 µm polyester (outer layer) with 9 µm aluminum foil, 15 µm nylon (middle layer), and 70 µm polypropylene (inside layer). These pouches were purchased from Floeter India Retort Pouches Pvt. Ltd., Haryana, India. The pilot-scale horizontal overpressure retort (steam/water spray) used in the study was procured from Lakshmi Engineering Works, Chennai, India, having a loading capacity of 25 pouches per process.

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2.2. Preparation of Pangasius fillets chunks in masala

The Pangasius was dressed aseptically by removing the enthrails and washed with the chilled potable water. Fish fillets were made into small chunks having a thickness of 3-5 cm. Cleaned fillet chunks were subjected to marination with salt, turmeric and a slight amount of oil and kept in the refrigerator for 30 min to enhance the flavour. Pangasius fish masala was prepared by following methods as follows. Mustard seed, cumin seed, fenugreek seed, coriander seed, big onion, tomato, garlic, ginger and red chili were fried until the colour changed to brown. After frying, fine paste was made with it. On a pan, vegetable oils and green chili, curry leaves, turmeric powder, shallots (small onions), coconut water and turmeric were added and fried in a low flame for a few minutes and curry paste was added and heating was gradually carried out over a modest flame. Salt was added to enhance the taste. Water was added to increase the consistency of fish masala as per requirements. Pangasius fillet chunks in masala prepared using the recipe given in **Table 1**.

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Table 1: Recipe for preparation of Pangasius fillet chunks in masala

Ingredients	Weight
Big onion	200g
Tomato	300g
Garlic	50g
Turmeric powder	10g
Shallots (Small onion	100g
Chilli powder	10g
Coriander leaves	25g
Coriander seeds	300g
Cumin seed	10g
Fenugreek	10g
Red chilli small	20g
Coconut	1 piece
Curry leaves	10g
Ginger	50g

Mustard seed	15g
Button red chilli	20g
Vegetable oil	150 ml
Salt	As required
Water	As required

2.3. Filling and sealing of the pouches

Around 250 ± 10 g cooked Pangasius fish fillet chunks with masala were added in retort pouches. ~~The f~~Few pouches were punched from the bottom (after determining the slowest heating point) using a punching tool and the packing gland was tightly screwed for heat penetration. The punched hole was positioned so that the thermocouple tip would eventually be at the cold spot. Steam exhaustion was done in an autoclave at 100 °C to remove the air entrapped in the pouches. The sealing region of the pouches was carefully monitored to prevent contamination and then pouches were sealed using a continuous vertical band sealing machine (Gempack, Chennai, India).

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2.4. Thermal processing of Pangasius fillets chunks in masala

Heat penetration data of the process product is recorded using the Ellab eval Flex Four Channel Thermal Validation and Sterilization Monitoring System, Cat. 21401004 (Ellab A/S, Trollesmindealle 25, DK-3400 Hilleroed, Denmark), with an Ellab CTF 9004 Precision Thermometer and F_0 value integrator was used. Copper/cupronickel thermocouples (Ellab SSA 12050-G700-TS) of stainless-steel electrode probe was used with a length of 40 mm and diameter of 1.2 mm. A total of four thermocouple probes were employed, with two being used to record pouch temperature and the other two being used to monitor retort ambient temperature. The data was recorded at a 1 second interval. Process time was determined using the Ball formula method [8] and total process time was calculated by adding 58% of the retort's come-up time to the ball's process time given by Stumbo [17]. Cook value (CV) was computed using the reference temperature of 100 °C and the z value of 33 °C, which is required for thiamine denaturation.

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3. Quality evaluation

3.1. Proximate, biochemical, and microbiological analysis

Moisture, ash and crude protein were analysed using AOAC [18] and crude lipids were analysed using Bligh and Dyer [19]. Raw and processed Pangasius fillet chunks were analyzed for biochemical characteristics such as TVB-N, FFA and TBA-RS. TVB-N were analysed using Conway's micro diffusion method [20]. TBA value was analysed using the Raghavan and Hultin [21] method and FFA was analysed using Dyer and Morten [22]. Total coliforms, total plate count, faecal Coliforms, *Escherichia coli*, *Vibrios*, *Salmonella*, *Listeria spp.* and *Staphylococcus* spp. were estimated for raw Pangasius fish using APHA [23].

3.2. Commercial sterility test

To verify the growth of any survivors of mesophiles and thermophiles in the product, the pangasius fillet pieces in masala were processed at various F_o values (7.37 and 8.12 min) and then incubated at 37 °C for 15 days and 55 °C for at least 5 days, respectively. A sterile forceps was used to remove about 1-2 g of the samples from the incubated pouches, which were then aseptically opened in a laminar air flow chamber and inoculated into test tubes having pre-sterilized fluid thioglycolate broth. The tubes of fluid thioglycolate were overlayered with sterilized liquid paraffin ~~on~~to the top of the broth to create an anaerobic condition and incubated at 37 °C for 48 hours and at 55 °C for 5 days, respectively. After the incubation period, the tubes were checked for turbidity.

3.3. Texture profile analysis

To assess the texture of muscle, texture profile analysis (TPA) was used. It is analysed based on the compression of samples with the muscle texture analyser (TA-XT Plus, Stable Micro Systems, UK) having a load cell of 75 mm diameter cylindrical probe equipped with a sensor of 50 N. Raw Pangasius fillet chunks as well as cooked Pangasius fillet chunks from the pouch were used for studying the TPA (n-3). The texture analysis consisted of two simultaneous 40% compressions at a crosshead speed of 12 mm/min, a trigger force of 0.5 kg, and a time and distance of 5 seconds and 6 mm. Mean values of the TPA parameters were calculated with force by time data as described by Bourne [24].

3.4. Sensory evaluation

Sensory evaluation was based on characterization and differentiation of the various sensory characteristics such as appearance colour, flavour, chewiness, succulence, 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 [25]. To assign the score, thermally processed pouches were heated in boiling water for 5 minutes and served warm to panelists. 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.

3.5. Statistical analysis

The biochemical, sensory and texture profiles of Pangasius fillet chunks were statistically analysed using the SPSS 10.00 statistical package. The mean ± standard deviation was used to express the results. A one-way ANOVA was used to determine the mean difference, and Duncan's multiple range tests were employed to compare the means at the 5% significant level.

4. RESULTS AND DISCUSSION

4.1 Thermal process evaluation

In this study, ready to eat Pangasius fillet chunks in masala products were developed based on the different literature and culinary styles followed in the southern parts of India. The product was standardised based on the organoleptic evaluation and texture profile attributes. For fishery products, Frott & Lewis [26] recommended a F_0 value of 5–20 minutes. The literature reports that the F_0 value for ready to eat fish ranges from 5 to 10 minutes. [27][28][29]. As a result, for the optimization study, a F_0 value of 7 and 8 minutes was chosen. Initially, a number of trials have been conducted at 121.1 °C before the actual experiment, which helps to decide the lethality requirements of the product. The cumulative lethality (F_0 value) obtained after the two-process ~~trails~~ trials were F_0 7.37 and 8.12 min.

4.2 Heat penetration characteristics

Heating and cooling factors of Pangasius fillet chunks in masala in retortable pouches at F_0 7.37 min and F_o 8.12 min, respectively, are given in **Fig. 1** and **Fig. 2**, and **Table 2** shows the heat penetration characteristics of Pangasius fish fillet chunks in masala at two different F_0 values. The slope of the heating curve, cook value, Ball's process time, and total process time

are increased with respect to increasing F_0 values. The come-up time was obtained at 9 and 8 min for F_0 7.37 and F_0 8.12, respectively. The total process time was 26.94 min and 31.37 min for F_0 7.37 min and F_0 8.12 min, respectively. The cook values achieved were 64.70 min and 65.87 min for F_0 7.37 min and F_0 8.12 min, respectively. Some of the researchers also stated a cook value of 57.19 to 92.12 min in sardine [30], 69.73 to 125.65 min for mackerel [31]. For the thermally processed Mackerel (*Rastrelliger kanagurta*) in retort pouches, Xavier [32] reported process time of 53.087, 31.790, and 22.303 for three different temperatures: 115 ^{o}C, 121 ^{o}C, and 126 ^{o}C respectively.

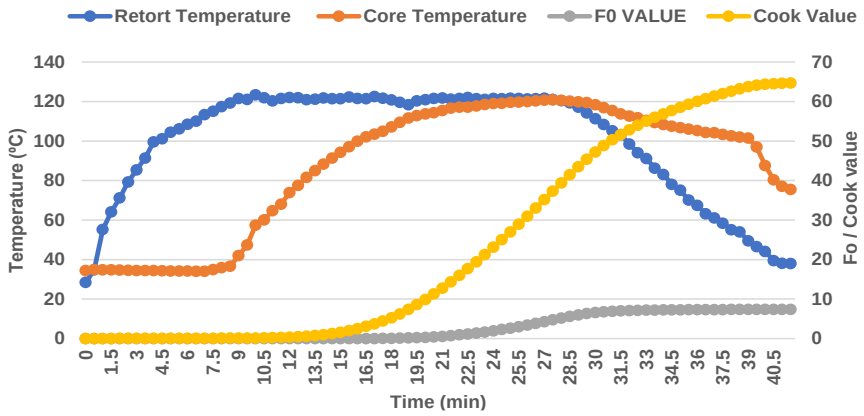

Fig. 1. Heat penetration rate, F_0 value and cook value of Pangasius fillet chunks in masala processed at F_0 7.37 min.

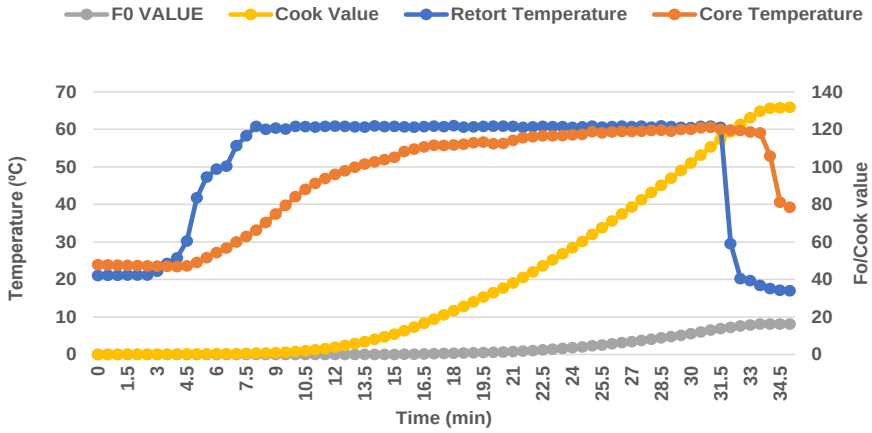

Fig. 2. Heat penetration rate, F_0 value and cook value of Pangasius fish fillet chunks in masala processed at F_0 8.12 min.

Table 2: Heat penetration characteristics of Pangasius fillet chunks in masala processed at F_0 7.37 and 8.12 min

Parameters	F_0 7.37	F_0 8.12
Come-up-time (min)	9 min	8 min
Heating lag factor (J_h)	1.15	1.09
Cooling lag factor (J_c)	1.12	1.01
f_h slope of heating curve (min)	13	16.5
g (°C)	1.56	1.928
Cook value (min)	64.70	65.87
Ball's process time (min)	23.45	26.73
Total process time (min)	26.94	31.37

4.3. Proximate, biochemical, and microbiological analysis

The proximate composition of fresh Pangasius fish constitutes moisture, fat, crude protein and ash contents are shown in **Table 3**. The results of this study were in agreement with the findings of Karl et al. [33]. Karl et al. [33] observed a moisture content of 79.32 ± 0.87 %, protein 16.96 ± 0.31 %, fat 2.02 ± 0.06 % and ash 1.44 ± 0.18 % in Pangasius fish. ~~The m~~More or less similar results were obtained by Rao et al. [34]. ~~Also adding~~Addition of ~~an~~ oil during masala preparation ~~that~~ would have contributed to the increase~~s in~~ fat content in processed product [35].

Table 3: Proximate composition of fresh Pangasius fish and processed Pangasius chunks

SI. No.	Parameter	Fresh Pangasius fish (%)	Processed Pangasius fillet chunks (%)
1.	Moisture	70.29 ± 0.19	64.67 ± 0.40
2.	Crude protein	16.70 ± 1.37	17.10 ± 0.67
3.	Total lipid	5.28 ± 0.33	7.89 ± 1.05
4.	Ash	1.89 ± 0.05	2.38 ± 0.42

Values are expressed as mean ± standard deviation (n=3)

4.4 Biochemical evaluation of pangasius fish fillets chunks

TVBN, FFA and TBARS were determined and compared with the fresh material used in the study (**Table 4**). The biochemical indices showed an increasing trend with respect to storage days and it was found that all biochemical parameters were within the limit. Proteins, amino acids, and other nitrogenous substances, such as TMAO, may have broken down during thermal processing, which might account for the higher level of biochemical compounds in processed products [36] [37] [38]. The research done by Bindu et al. [39] and Kamalakanth et al. [40] shows a similar trend of FFA values.

4.5 Microbial evaluation of raw Pangasius fish fillets chunks

The total plate count was enumerated and found to be $4.96 \pm 0.85 \times 10^4 \pm 0.64$ CFU/g. Important bacterial pathogens including Salmonella, Vibrio, Escherichia coli, Staphylococcus species, and Listeria species were also studied. However, in the samples examined for this investigation, none of the pathogens were found. This results in agreement with the study conducted on *Litopenaeus vannamei* by Puthanangadi Dasan et al. [41].

Table 4: Changes in biochemical parameters of fresh and thermally processed Pangasius fillet chunks in masala processed at F_0 7.37 and F_0 8.12 min.

Attributes	Fresh	5 days		15 days		30 days		45 days		60 days		75 days		90 days	
		F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	$F_0$7.37	F_0 8.12
TVB-N (mgN/100g)	2.83± 0.06^{i}	8.06±0. 23^{h}	8.69±0. 01^{g}	11.25± 0.01^{f}	11.20±0. 76^{f}	12.65± 0.57^{e}	13.01± 0.02^{e}	13.53± 0.56^{d}	15.14± 0.01^{c}	15.25± 0.05^{c}	16.75± 0.03^{b}	17.17± 0.30^{ab}	17.43± 0.02^{a}	17.22 ±0.08^{ab}	17.53 ± 0.09^{a}
TBA-RS (mg MAD /kg)	0.54± 0.02^{h}	0.55±0. 01^{h}	0.85±0. 02^{g}	0.9±0.0 1^{g}	0.97±0.0 2^{f}	1.10±0. 01^{e}	1.11±0. 01^{e}	1.10± 0.02^{e}	1.16± 0.01^{d}	1.2± 0.02^{cd}	1.22± 0.04^{c}	1.32± 0.01^{b}	1.49± 0.04^{a}	1.34 ± 0.01^{b}	1.5 ± 0.05^{a}
FFA (% of oleic acid)	0.27± 0.02^{i}	0.28±0. 28^{i}	0.51±0. 05^{g}	0.46±0. 01^{h}	0.57±0.0 2^{f}	0.52±0. 02^{g}	0.61±0. 01^{ef}	0.59± 0.01^{f}	0.70± 0.01^{d}	0.64± 0.02^{e}	0.89± 0.02^{a}	0.73± 0.02^{cd}	0.80± 0.05^{b}	0.77 ± 0.02^{bc}	0.9 ± 0.02^{a}

Values are expressed as mean ± standard deviation. Different superscript in small latters (a,b,c,...) same rows indicate significant differences ($p<0.05$) (n=3).

4.3. Commercial sterility test

The commercial sterility of thermally processed chunks in masala was examined, and no growth was observed in the medium. This suggests that the total lethality given to the product was sufficient to accomplish commercial sterility.

4.4. Texture profile analysis

Hardness (kgf), springiness (mm), cohesiveness, and chewiness (kgf.mm) values for fresh Pangasius fillet chunks were found to be 1.88 ± 0.53, 1.00 ± 1.42, 0.96 ± 0.21 and 1.81 ± 0.16, respectively. TPA shows a decreasing trend. Texture profile analysis for F_0 7.37 and F_0 8.12 min. is given in **Table 5**. The natural protein structure was changed by heat treatments, which causes muscle protein to become denatured and alter the texture of the products, which eventually makes the muscle softer [42]. According to Ali et al. [42]; Mallick et. al. [43]; Majumdar et al. [29], and Putanangadi Dasan et. al. [41] textural parameters like hardness, springiness, cohesiveness and chewiness decrease as the F_0 value increases. Low values of hardness, springiness, cohesiveness and chewiness of the thermally processed Pangasius fillet chunks in masala than fresh material may be because of a slight alteration in protein denaturation.

Table 5: Instrumental texture profile analysis for fresh and thermally processed Pangasius fillet chunks in masala processed at F_0 7.37 and F_0 8.12 min.

Product Parameter	Fresh	5 days		15 days		30 days		45 days		60 days		75 days		90 days	
		F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12	F_0 7.37	F_0 8.12
Hardness (kg.f,)	1.88± 0.53^{a}	0.80±0.33^{b}	0.71±0.11^{b}	0.72± 0.42^{b}	0.72± 0.07^{b}	0.68± 0.08^{b}	0.53± 0.13^{b}	0.61± 0.21^{b}	0.52± 0.49^{b}	0.53± 0.12^{b}	0.42± 0.56^{b}	0.31± 0.16^{b}	0.30± 0.05^{b}	0.32 ± 0.02^{b}	0.32 ± 0.01^{b}
Springiness (mm)	1.00± 1.42^{ab}	1.16± 0.23b^{c}	0.82± 0.11^{bcd}	0.86± 0.23^{a}	0.73± 0.02^{cdef}	0.75± 0.11^{cde}	0.65± 0.04^{defg}	0.63± 0.12^{efgh}	0.60± 0.01^{efgh}	0.49± 0.04^{ghi}	0.55± 0.18^{fgh}	0.44± 0.06^{hi}	0.33± 0.09^{i}	0.42 ± 0.06^{hi}	0.33 ± 0.05^{i}
Cohesiveness	0.96± 0.21^{a}	0.59± 0.21^{bcd}	0.56± 0.04^{bc}	0.53± 0.12^{b}	0.52± 0.02^{bcde}	0.51± 0.02^{bcdef}	0.49± 0.0^{bcdefgh}	0.47± 0.0^{bcdefgh}	0.38± 0.14^{defgh}	0.43± 0.02^{cdefgh}	0.36± 0.06^{gh}	0.37± 0.06^{fgh}	0.37± 0.01^{efgh}	0.33 ± 0.10^{h}	0.33 ± 0.04^{h}
Chewiness (kgf.mm)	1.81± 0.16^{a}	0.55± 0.40^{bc}	0.34± 0.11^{bc}	0.42± 0.22^{bc}	0.27± 0.04^{bc}	0.27± 0.06^{bc}	0.17± 0.05^{bc}	0.19± 0.11^{bc}	0.13± 0.23^{bc}	0.11± 0.03^{bc}	0.16± 0.13^{bc}	0.05± 0.03^{c}	0.04± 0.01^{c}	0.04 ± 0.01^{c}	0.03 ± 0.01^{c}

Values are expressed as mean ± standard deviation. Different superscript in small latters (a,b,c,…) indicate significant differences ($p<0.05$) (n=3).

4.5. Sensory analysis

Score obtained for sensory analysis at $F_0$7.37 min and F_0 8.12 min were in the range of 8.9 to 6.2. Sensory parameters showed a decreasing trend with the storage period and are mentioned in **Fig. 3**. A similar trend is seen in the previous study done by Vijayan et al. [44], Puthanangadi Dasan et al. [41], Shankar et al. [45]. According to Ma et al. [42], the muscle firmness and texture of the product are affected by thermal processing. The longer the product heated, the more the denaturation, coagulation, and oxidation in the native protein, and the combined effect influence of all of these factors that control the organoleptic quality of the product [29].

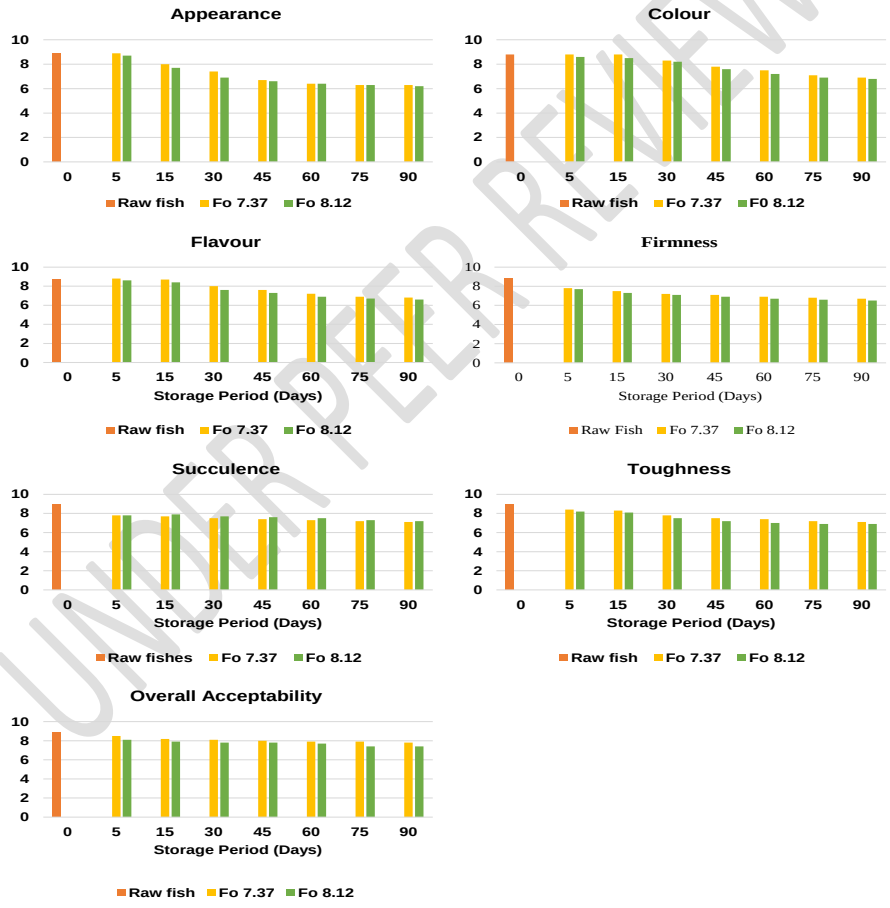

Fig 3. Sensory Evaluation of fresh and thermally processed Pangasius fillet chunks in masala processed at F_0 7.37 and F_0 8.12 min.

5. CONCLUSION

This study concluded that, among F_0 7.37 and 8.12 min, F_0 7.37 indicated better sensory characteristics for ready to eat Pangasius fish fillet chunks in masala medium using flexible retortable pouches. Though biochemical parameters present in processed food were in the acceptable limit but the product processed at F_0 7.37 contains less biochemical presence compared to F_0 8.12. The processed product also showed a similar heating and cooling lag factor, resulting in process times of 39.79 and 38.80 minutes for lethality of 7.37 and 8.12 minutes, respectively. When compared to 7.37 minutes, processing to lethality of 8.12 minutes took 16.44% increase in processing time. The cook values at F_0 7.37 and 8.12 minutes are 64.70 and 65.87, respectively. In terms of quality and safety, the Pangasius fish fillet chunks in masala processed at *an F0* value of 7.37 minutes showed better qualities than the product processed to an F_0 value of 8.12 minutes. Thus, it is concluded that an F_0 of 7.37 minutes may be used to prepare ready-to-eat Pangasius fish fillet chunks in masala medium using a retort pouch.

DISCLAIMER

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

ETHICAL APPROVAL

Not applicable

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