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Heat Penetration Characteristics and Shelf Life of Ready to Serve Mahseer Curry in Opaque Retortable Pouches

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Ready to serve thermal processed fish curry in Mughalai style has been developed using Mahseer (*Tor khudree*). The fish curry was vacuum packed in an indigenously developed three layered retortable pouch consisting of 12.5 µm polyester / 12.5 µm aluminum foil / 80 µm cast polypropylene of size 18 x 11 cm and processed in a still over pressure retort at 121°C. The total process time was 38 min with a Fo value of 8.5 min and cook value of 76 min. Changes in biochemical parameters like free fatty acid, thiobarbituric acid and organoleptic parameters like colour and sensory scores during storage were studied. The processed products were found to be sterile and acceptable even after a period of 12 months at ambient storage of 28 ± 2°C.

Key words : *Tor khudree* (Deccan Mahseer), cook value, Fo value, retort pouch processing, storage studies

Thermal processing has been used to achieve long-term shelf stability for a wide range of seafood products and is one of the most widely used methods for fish preservation (Teixeira & Tucker, 1997). The main objective of the thermal processing is to produce a safe and high quality seafood product at a price affordable to the consumer (Guntensperger & Escher, 1994). The success of thermal sterilization necessitates balancing the beneficial and destructive influence of heat on the desirable characteristics of foods. The heat treatment destroys the pathogens and spoilage enzymes that would bring about spoilage of the fish whereas nutritional quality is reduced by the high temperature deployed (Lund, 1975). Studies have shown that thermal death rates of bacteria generally proceed much faster with increased temperature (Stumbo, 1973).

Retort pouch packaging has gained importance due to several reasons over metallic cans. The retort pouch is a flexible, laminated package that can withstand

thermal processing and has the advantages of cans as well as flexible packages. Thin profile containers like retort pouches facilitate larger surface area which helps to increase the rate of heat transfer into the food and reduce process time and maximize the retention of quality factors of the fish product. Reductions in heat processing time in pouches have been reported (Lampi, 1977; Chia *et al.*, 1983; Durance & Collins, 1991; Mohan *et al.*, 2006). Dymit (1973) found shrimps to have better colour and flavour in retort pouches compared to cans. Thermal processing of different fish products in retort pouches resulted in products with good sensory attributes and also gave a shelf life of more than one year at ambient temperature (Ravishankar *et al.*, 2002, 2008; Gopal *et al.*, 2001; Bindu *et al.*, 2004; Manju *et al.*, 2004).

Present market trends are indicative of extensive demand for ready to cook or ready to serve convenience products processed out of a wide variety of fish and shell fish. One

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of the ready to serve products is fish curry in different styles. Mughlai style of fish curry is in good demand and highly relished in the northern parts of India. Freshwater fishes like rohu are commonly used for making this product while possibilities of using mahseers an important source of food fish (Ogale, 2002) have been looked into. As a food fish, they are highly esteemed owing to their taste, large size and keeping quality. Hence, attempts were made to develop a process for the preparation of Mughalai style curry in opaque retortable pouches using mahseer fish and to study its shelf life and quality characteristics at ambient temperature storage.

Materials and Methods

Fresh mahseer (*Tor khudree*) weighing about 1-2 kg caught from the upper region of the Chalakudy river in Kerala, was put in ice in the ratio 1:1 and brought to the laboratory in insulated containers. The fish was washed thoroughly in potable water and filleted skinless within 12 h of catching. The fillets were cut into 3 x 3 cm pieces and used for the Mughalai style curry preparation using ingredients given in Table 1. Turmeric and salt were smeared to the fish pieces, marinated for about 10 min and fried in refined oil for 5-8 min at 170°C and kept aside. Cashew nut, cinnamon and cardamom were wet ground into a paste and kept aside. Likewise, onions, garlic and ginger were also made into a paste. Refined oil was heated in a frying pan, onion, ginger, and garlic paste were added and fried till attaining a golden colour. The coriander powder, chilly powder and garam masala powder were added and warmed. Tomato puree and cashew nut paste was added and cooked in low flame for 3 min. Salt was added to taste. Finally water and cut green chilly were added and boiled for 10 min. About 40 g fried fish and 60 g gravy was filled into retort pouches of size 18 x 11 cm, vacuum packed and sealed. These pouches were further processed in an overpressure autoclave. The Mughalai curry was processed to

three different F_0 values of 7, 8.5 and 10 min and taste panel studies were conducted to standardize the same. The trials indicated that processing at F_0 of 8.5 min gave a product with good textural and sensory attributes and hence the curry was processed to F_0 value of 8.5 min for storage studies.

Indigenously manufactured retortable pouches (MH Packaging, Ahmedabad, India) having a three layer configuration of 12.5 μ m polyester / 12.5 μ m aluminum foil / 80 μ m cast polypropylene of size 18 x 11 cm were used for the study. As the quality of the retort pouch was expected to have an important bearing on the shelf life and packaging performance, its detailed properties were analyzed. Physical properties (Table 2) of the retort pouches were ascertained by the tests like total thickness (IS: 2508-1984), overall migration residue (IS: 9845-1981), internal burst strength for seal integrity (Duxbury 1970), heat seal strength (ASTM-F 88-68-1973), process resistance test (Gopakumar, 1993), tensile strength and elongation at break (IS: 2508-1984) and residual air in the pouch (Shappee *et al.*,

Table 1. Ingredients of Mughalai style mahseer curry

Ingredients	Quantity (Weight/Volume)
Dressed fish (mahseer)	1 kg
Grated onions	200 g
Green chilly	25 g
Ginger	50 g
Garlic	50 g
Turmeric powder	5 g
Chilly powder	10 g
Cardamom	10 g
Cinnamon	10 g
Refined oil	400 ml
Tomato Puree	200 ml
Cashew Nut	100 g
Garam Masala	6 g
Coriander Powder	20 g
Water	300 ml
Salt	15 g

1972). The sterility of the pouches was determined as per IS: 9845 (1981).

Table 2. Physical properties of retort pouch

Parameters	Values
Total thickness	105 μm
Thickness of Aluminum foil	12.5 μm
Thickness of Cast Polypropylene layer	80 μm
Thickness of Polyester layer	12.5 μm
Tensile strength (Machine direction)	450 kg cm^{-2}
Tensile strength (Cross direction)	450 kg cm^{-2}
Elongation at break (Machine direction)	20 %
Elongation at break (Cross direction)	20 %
Heat seal strength (Machine direction)	70 N 25 mm^{-1}
Heat seal strength (Cross direction)	61 N 25 mm^{-1}
Bursting strength	21 $\pm$ 1.00 psig for 15 min
Overall migration residue	
Water extractives (121°C 2 h ⁻¹)	0.80 $\pm$ 0.01 mg dm ⁻²
n-heptane extractives (66°C 2 h ⁻¹)	3.64 $\pm$ 0.02 mg dm ⁻²
Residual air after processing	1.82 $\pm$ 0.04 ml 100 g ⁻¹

A pilot-scale mill wall Model 24 rotary retorting system (John Fraser and Sons Ltd, Newcastle-upon-Tyne, U.K.) was used for the experiment. The retort was operated in the steam/air mixture mode during the sterilization cycle. For heat penetration studies pouches were fixed with thermocouple glands through which thermocouples were inserted. Thermocouple output was measured using an Ellab CTF 9008 data recorder (Ellab A/S, Roedovre, Denmark). The tips of the thermocouples were inserted into the fish pieces for recording the core temperature during heat processing in a still over-pressure retort. The retort temperature (RT) was maintained at 121°C and air pressure was maintained at 28 psig throughout the heating and cooling period. After processing the pouches to required F_0 value, they were cooled rapidly to prevent

overcooking as well as survival of any thermophiles (Ravishankar *et al.*, 2002) till the core temperature of the product reaches 55°C (T_c) by pumping water into the retort and recirculating it. The lag factor for heating (J_h), slope of the heating curve (f_h), time in min for sterilisation at retort temperature (U) and lag factor for cooling (J_c) were calculated. The parameters f_h/U , final temperature deficit g , process time B and total process time (T_B) were calculated by the mathematical method (Stumbo, 1973). The parameters were determined by plotting temperature deficit ($RT-T_c$) on semi log paper. Total process time (T_B) was determined by adding process time (B) to the effectiveness of the come up time which has been established to be 42%. The thermal processed pouches were tested for sterility by using thioglycollate broth medium as per IS: 2168, (1971). Cook value (C_g), was also determined by measuring the quality changes during processing in a manner similar to the D value, except that the reference temperature is 100°C instead of 121°C, and the z value was 33°C, (Ranganna, 2000).

Proximate composition of the sample was estimated according to AOAC (1984), free fatty acid (FFA) expressed as oleic acid by the method of AOCS (1989) and thio-barbituric acid (TBA) was estimated spectrophotometrically according to Tarladgis *et al.* (1960). Organoleptic characteristics were determined on a 10-point hedonic scale using a trained panel of ten members and scores below 4 was taken as the unacceptable limit. The characteristics covered under the taste panel were flavour, texture and overall acceptability. Under texture characteristics such as (a) succulence, (b) toughness and (c) fibrosity were studied. The scores were assigned with 1 being the least and 10 being the greatest for attributes described by IS: 6273 [II] (1971). Sensory evaluation of mahseer curry was carried out at every three months during the storage period.

Experimental data were analysed using SPSS version 10.00 (SPSS, 2000).

Results and Discussion

The physical properties of the indigenous retort pouch used for the study are given in Table 2. These opaque retortable pouches have high tensile strength in both machine and cross direction adequate for withstanding the rigors of heat processing in over-pressure autoclave. The bursting strength of the pouch was 21 psig, which meets the prescribed standards. The overall migration residue when determined with water extractives at 121°C for 2 h and heptane extraction at 66°C for 2 h was found to be 0.80 mg dm⁻² and 3.64 mg dm⁻² respectively which are well below the limits specified for food contact application. Residual air after processing was below 2% indicating the effectiveness of vacuum inside the pouch.

The proximate composition of the fish curry was 60.98% moisture, 15.07% protein, 21.16% fat and 5.14% ash. Since the preparation required fish to be fried and used for the curry preparation the fat content was slightly high.

The heat penetration characteristics of the masher curry prepared are represented in Table 3. The F_0 value of the product was

Table 3. Heat penetration characteristics of mahseer curry in indigenous retort pouch

Parameters	Values
RT (°C)	121.10
f_0 (min)	8.50
f_h (min)	17.00
J_h	1.09
J_c	1.04
g (°C)	0.96
U (min)	8.50
f_h/U	2.00
B (min)	34.00
T_B (min)	38.00

Where, RT = Retort Temperature, f_0 = cumulative lethality, f_h = slope of heating curve, J_h = lag factor of heating, J_c = lag factor of cooling, g = final temperature deficit, U = time in min for sterilization at retort temperature, B = Ball's process time, T_B = total process time.

8.5 min. The recommended F_0 value for fish and fish products ranges from 5 - 20 min (Frott & Lewis., 1994). The come up time to attain 121°C was 7 min, which is sufficiently shorter as recommended by NCA (1968). The f_h value was 17 min and the process time (B) was 34 min. The total process time (T_B) was 38 min, which was arrived at by adding heating value of comeup time to B . The heat penetration characteristics in relation to F_0 value are given in Fig. 1 and cook value is given in Fig. 2. F_0 value of 8.43 min was sufficient to get good textural properties in mackerel (Gopal *et al.*, 1998) while 8.15 min was optimum for processing seerfish moilee to obtain desired texture, sensory parameters and shelf life (Manju *et al.*, 2004). The F_0 value was 8 min for prawn kuruma (Mohan *et al.*, 2006) and the cook value for the finished product was 76 min.

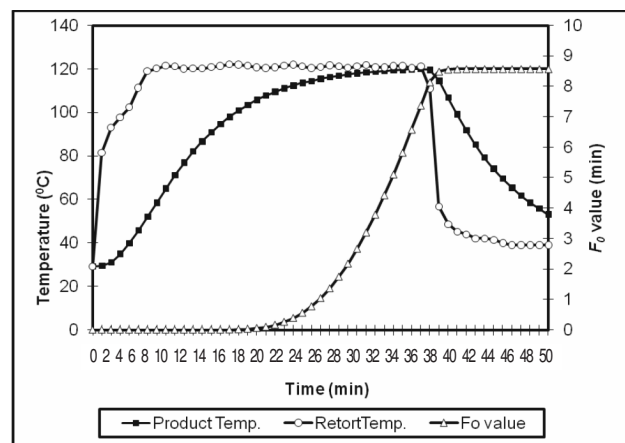


Fig. 1. Heat penetration characteristics of Mughalai style mahseer curry with respect to F_0 value

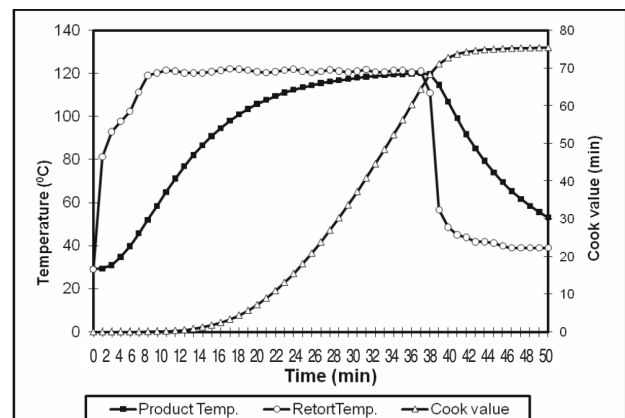


Fig. 2. Heat penetration characteristics of Mughalai style mahseer curry with respect to cook value

Chemical parameters like FFA and TBA showed a gradual increase during storage though their values were very low and within the prescribed limits (Fig. 3, 4). This slow increase may be due to the oxidization of unsaturated lipids to highly reactive peroxides during the frying of fish for the curry. These peroxides have hydrolysed to form FFA during the storage period. A slight increase in the FFA content has been observed by Aubourg (1998) for canned tuna muscle after 1.5 years of storage. Mai *et al.* (1978) reported that canning process followed by storage produced an increase in the proportion of FFA in the muscle lipids.

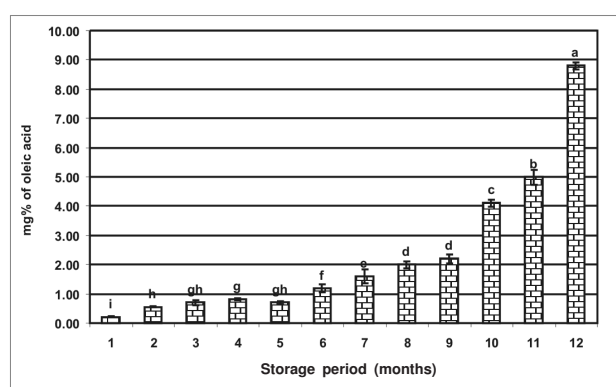


Fig. 3. Free fatty acid content of Mughalai style mahseer curry during storage

Bars represented as average $\pm$ standard deviation of at least 3 observations

a,b,c,d,e,f,g,h Means in bars with the different superscript letters are significantly different ($p < 0.05$)

TBA value, an index of secondary lipid oxidation showed an increasing trend in this study during the storage period (Fig. 4). The peroxides formed may have decomposed to compounds which include aldehydes such as malonaldehyde during storage indicating, increasing values. Similar results have been reported for ready to eat clams (Bindu *et al.*, 2007) and for fried green mussels (Bindu *et al.*, 2004). An increase in the TBA value of canned tuna after 5 months of storage was reported (Tanaka *et al.*, 1985; Medina *et al.*, 1998; Aubourg *et al.*, 1995).

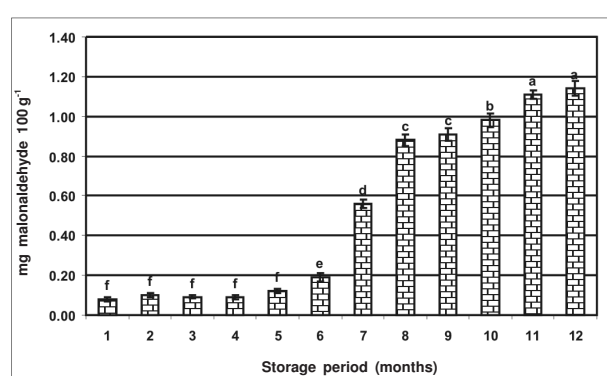


Fig. 4. Changes in TBA content of Mughalai curry during storage

Bars represented as average $\pm$ standard deviation of at least 3 observations

a,b,c,d,e,f,g,h Means in bars with the different superscript letters are significantly different ($p < 0.05$)

Changes in the sensory score of mahseer curry in Mughalai style in retortable pouch during storage are presented in Table 4. All

Table 4. Changes in sensory scores of Mahseer curry on storage

Characteristics	Storage (months)				
	0	3	6	9	12
Flavour	8.45 $\pm$ 0.08 ^a	8.55 $\pm$ 0.11 ^a	8.11 $\pm$ 0.13 ^b	7.63 $\pm$ 0.23 ^c	6.65 $\pm$ 0.21 ^d
Texture					
(a) Succulence	8.52 $\pm$ 0.21 ^a	8.48 $\pm$ 0.17 ^a	8.02 $\pm$ 0.12 ^b	7.52 $\pm$ 0.16 ^c	7.04 $\pm$ 0.22 ^d
(b) Toughness	8.36 $\pm$ 0.13 ^a	8.25 $\pm$ 0.28 ^a	8.23 $\pm$ 0.15 ^a	7.49 $\pm$ 0.31 ^b	7.47 $\pm$ 0.19 ^b
(c) Fibrosity	8.04 $\pm$ 0.12 ^a	8.05 $\pm$ 0.10 ^a	8.02 $\pm$ 0.11 ^a	7.48 $\pm$ 0.14 ^b	7.04 $\pm$ 0.21 ^c
Overall acceptance	8.52 $\pm$ 0.17 ^a	8.02 $\pm$ 0.31 ^b	8.03 $\pm$ 0.24 ^b	7.54 $\pm$ 0.20 ^c	7.05 $\pm$ 0.18 ^d

Each value is represented by the mean $\pm$ standard deviation of scores given by 10 taste panel members.

a,b,c,d Means in a row with the different superscript letters are significantly different ($p < 0.05$)

All traits measured on 10-point scale with 1 being least and 10 being the most

traits were measured on 10 point scale with 1 being the least and 10 being the most. Each value is represented by the average $\pm$ standard deviation of scores given by 10 taste panel members. It was observed from the results that there was a significant decrease in flavour score towards the end of the storage period. This may be due to the oxidation of lipids present in the product and formation of other breakdown compounds. The severe heat treatment and the presence of catalysts in the muscle of the fish facilitate non enzymatic lipid oxidation and hydrolysis which may result in flavour changes and nutrient loss (Hsieh & Kinsella, 1989). Textural parameters like succulence, toughness and fibrosity also showed decreasing trends during storage. The initial overall acceptability score of about 8.52 gradually reduced to around 7.05 after 12 months of storage. The products remained in good condition and were acceptable even after 12 months of storage at ambient temperature.

The results show that F_0 value of 8.5 min and cook value of 76 min were found to be optimum for processing Mughalai style mahseer curry in retortable pouch. The product remained in good condition in both sensory and biochemical aspects after a storage period of 12 months at ambient temperature. This technology would help in proper utilization of the Deccan mahseer.

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