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Effect of Filling Medium on Heat Penetration Characteristics and Texture of Skipjack Tuna (*Katsuwonus pelamis*) in Indegenous Polymer Coated Easy Open End Tin Free Steel Cans

K.A. Martin Xavier, P.G. Sreenath, S. Sil, C.N. Ravishanker*, J. Bindu, T.K. Srinivasa Gopal and P.K. Vijayan
Central Institute of Fisheries Technology, Cochin - 682 029, India

The effect of different filling media on heat penetration characteristics of Tuna (*Katsuwonus pelamis*) in indigenous polymer coated easy open-end tin free steel cans was studied. 110 g of Tuna meat was packed into 6 oz TFS Cans (302 x 109) and filled with 60 g of different media like brine (2%), oil (double refined ground nut oil), curry and tomato sauce. All these cans were processed at 121.1°C to a F_0 value of 10. Heat penetration data were recorded using Ellab TM 9608 Temperature recorder cum process value integrator. The process time to achieve F_0 10 was 25 minutes in brine, 40 minutes in curry, 41 minutes in sauce, and 43 minutes in oil. The results indicated that heat penetration is faster in brine followed by curry, sauce, and oil. Filling medium was also found to influence the texture properties of the meat.

Keywords: **Tuna, Tin free steel cans, *Filling medium*, Thermal processing, Heat penetration, F_0 Value, Cook value, Texture profile analysis**

Canned fish products play a significant role in the economy of many countries. Canned Tuna is one of the most important fish products in many countries supporting a significant market demand and playing an important role as diet component. These products are considered to have a high nutritional quality because of their high proportion of omega 3-polyunsaturated fatty acids (Gallardo *et. al.*, 1989; Medina *et. al.*, 1995), which have shown potential benefit to human health, particularly in the prevention of cardiovascular diseases (Carrol & Braden, 1986; Lees & Karel, 1990). Canning industry uses several filling medium and special additives in accordance with specific demands from the market. Brine is the most common filling medium in canned fish; refined vegetable and sauce are also popular as a filling medium. Ali (2003) studied heat penetration characteristics of tuna in oil, brine and curry medium in aluminium cans. Rai *et al.*, (1971) formulated a curry medium as an alternative-filling medium. A process for canning oil sardine in its own juice (Natural pack) was described by Nair *et. al.* (1974). Heat transfers in processed foods are affected by the medium used, resistance incurred at the container wall, size of the container and thermo physical properties of food. Moscarella & Vestito (1994) studied the effect of raw material characteristics and process variables during sterilization. Results showed that F_0 value of the sterilization process was highly depending upon the amount of raw material, cans and filling medium. Consistency of the medium affects the heat penetration characteristics of thermal processing. An increase in consistency of the medium increases the process time.

* Correspondence: Ph: 0484-2666845; Fax: 0484-2668212; Email: cnrs2000@rediffmail.com

Therefore, for arriving at the thermal process requirements, knowledge on the pattern of heat penetration in the food inside the can is very essential.

The present investigation has been taken up to study the effect of different filling mediums *viz* brine, oil, curry and tomato sauce on heat penetration characteristics and texture of skipjack tuna (*Katsuwonus pelamis*) in indigenous polymer coated easy open end tin free steel cans.

Materials and methods

Skipjack Tuna collected from Cochin fisheries harbour was brought to laboratory in iced condition. Tuna used for the experiments was of uniform quality with regard to size and chemical composition. After removing head and viscera, it was kept in chilled running water to remove the blood from meat. Fish was precooked in steam at 10 psig for 60 minutes to attain core temperature of 90-92°C, cooled and kept at 4°C in the chill room over night. The skin was peeled from cooked tuna and was split dorso-ventrally. Red meat lying along the lateral line was removed and white meat was carefully separated from the cooked fish and cut into slices of 1.5-inch thickness.

Indigenous polymer coated TFS cans of 307 X 109 size (6 oz capacity) manufactured by M/S Amtech Packs, Mysore were used for the study. The can is made of Electro Chemically Coated Steel (ECCS) plate with clear Polyester (PET) coating on either sides. The finished plate has a thickness of 0.19mm (0.15 mm of base steel + 20 μ PET coating on either sides). The cans are made out of the steel plate by Drawn and Redrawn (DRD) process. The chromium coating along with the PET coating provides the can with a smooth, greyish, glistening appearance in addition to act as a barrier between the product and the base steel. The bottom of the can is designed for better stackability so that it can be stacked vertically without risk of toppling on the shelf. This also helps to reduce the storage space requirement for the cans.

The easy open ends are of the same material with a thickness of 0.28 mm. The edges of the lid are provided with a Neoprene rubber-sealing compound that forms a hermetic seal with body wall when double seamed. The lids are provided with scoring in circular form towards the periphery on the public side, which facilitate easy and complete opening of the can by just pulling the tab. The tab is attached to the lid by means of a rivet that prevents any possible leakage through the Lid- Rivet joint. A unique feature of the EOE is the Triple Fold Technology that helps to avoid the potential injury to fingers on opening the can and the use of can openers. This is particularly advantageous over the conventional tin cans where the cut surface always acts as a source of injury.

The cans were thoroughly washed to remove adhering impurities and dried well to remove traces of water. Before filling the cans, a thermocouple was fixed at about one third from the bottom of the can to record the core temperature.

A specially designed Polyoxymethylen packing gland (type GKJ-13009-C042, Ellab A/S, Roedovre, Denmark) was used to enable the penetration of thermocouples into the can. It consisted of two rubber O-rings and nuts and the space bar had a hole in the center through which the thermocouple needle could be inserted into the cold spot of the product. Copper /copper nickel thermocouples (type SSA 12040 – G700 -TS, Ellab Co. Denmark), capable of measuring temperature in the range of - 45°C to 135°C with an accuracy of ± 0.1°C and a response time of 0.8 second, were used. The threaded electrode used in the assembly was made of stainless steel and had a length of 42mm, and the connecting cable was made of Teflon.

About 110 g of cooked fish meat were filled in TFS cans and filling medium used were 1) 2% brine solution 2) Commercial tomato sauce diluted with equal quantity of water 3) Double refined ground nut oil along with 2% dry salt 4) Curry medium prepared according to the recipe given in Table 1. About 60 g of the filling medium was added to each can. The filled cans were then steam exhausted for 10 minutes and immediately sealed in a double seaming machine.

Table 1. Recipe of the Curry medium

Ingredients	Weights
Chilly powder	80 gm
Turmeric powder	05 gm
Malabar tamarind	25 gm
Ginger	50 gm
Garlic	20 gm
Small onion	250 gm
Curry leaves	05 gm
Oil	50 ml
Coconut	1/2
Water	1 Litre

TFS cans were heat processed to F_0 value (Sterilization value) of 10 minutes in an overpressure autoclave (John Fraser and sons Ltd, model no 5682). Thermal data were taken by inserting thermocouple needles into the thermocouple gland. Heat penetration data were recorded using Ellab (TM 9608, Denmark) temperature recorder cum process value integrator. Data were recorded for every minute of processing.

Heat penetration data were plotted on a semi logarithmic paper with temperature deficit (Retort temperature – Core temperature) on log scale against time. Lag factor for heating (J_h), slope of the heating curve (fh), time in minutes for sterilization at retort temperature (U), lag factor for cooling (j_c), final temperature deficit (g), Cook value (cg) were determined. Total process time was calculated by the mathematical method of Stumbo (1973). Actual process time was determined by adding process time (B) and the effective heating period during come-up time ie, 58% of the come up time.

Sterility of the final product was tested as per IS: 2168 (1971). Proximate composition of tuna meat was done by AOAC (1990) method.

Texture profile analyses of canned tuna were done using the food texture analyzer of Lloyd Instruments, U.K. Model LRX plus (F.T-39 No-2) with software Nexygen. The test was done at a speed of 12mm/second using 500N load cell. The probe used for the experiment was a 50mm diameter cylindrical probe. The canned tuna meat was allowed for compression of 40% with a trigger force of 0.5 kg. From the double compression parameters like hardness 1 and hardness 2, Cohesiveness, Springiness and Chewiness were calculated.

Results and Discussion

Fresh tuna had 75.06% moisture, 20.86% protein, 2.44% crude fat and 1.68% of ash. Precooking is a very important step in fish canning to reduce the water content by 60-65%. In this experiment the precooked material had 64.57% moisture content. This is achieved due to the release of bound water of muscle tissues. The amount of moisture in precooked tuna is related to the extent of precooking. The Sterilization Value (F_0 value)

Table 2. Heat penetration data of thermally processed Tuna in different filling mediums in polymer coated TFS cans

Sl. No.	Filling medium	fh min	j_h	j_c	fh/U	g°C	Cg (min)	B (min)	Total Process time (min)
1	Brine	11.50	0.802	1.196	1.18	0.839	76.50	21.5	25.20
2	Curry	26.00	1.023	1.09	2.547	2.737	108.2	35.1	40.32
3	Sauce	26.50	1.000	0.987	2.82	3.01	98.70	37.2	41.20
4	Oil	27.00	1.134	1.189	2.428	2.66	109.4	38.6	42.76

(Lag factor for heating (J_h), slope of the heating curve (fh), time in minutes for sterilization at retort temperature (U), lag factor for cooling (j_c), final temperature deficit (g), Cook value (cg), process time (B))

recommended for the thermal processing of fish products ranges from 5-20 (Frott & Lewis, 1994). Ali *et. al.* (2005) reported that, a process value of F_0 10 was sufficient to get product with good sensory attributes and commercial sterility for tuna in oil. Hence in the present study F_0 10 was taken as optimum process required and all the products were processed to F_0 10. It was observed that all the products processed in different filling medium to F_0 value of 10 were commercially sterile.

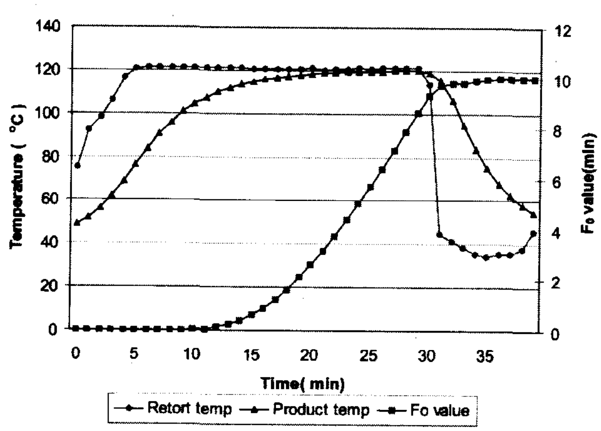

Fig. 1. Heat penetration Characteristics and Fo value of thermally processed tuna in brine

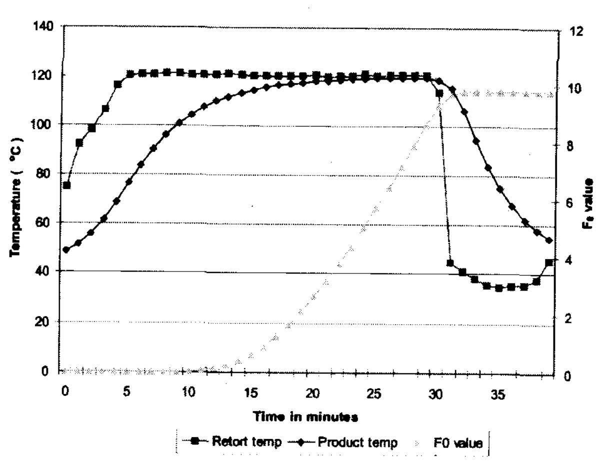

Fig. 2. Heat penetration Characteristics and Fo value of thermally processed tuna in Curry

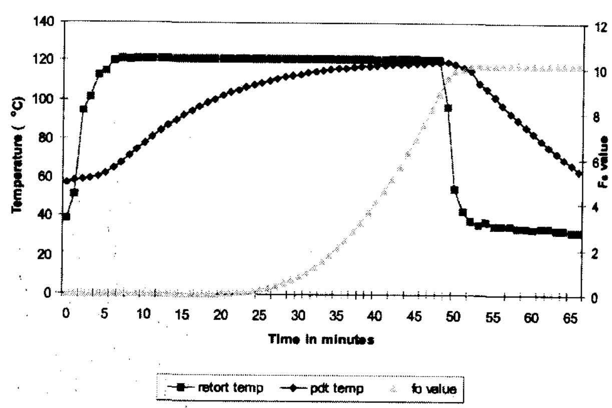

Fig. 3. Heat penetration Characteristics and Fo value of thermally processed tuna in Tomato sauce

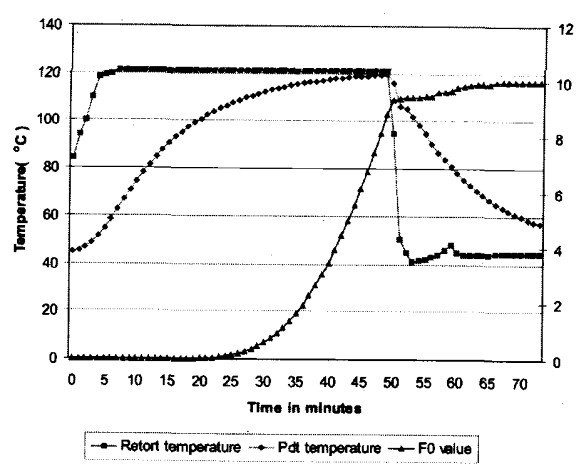

Fig. 4. Heat penetration Characteristics and F0 value of thermally processed tuna in Oil

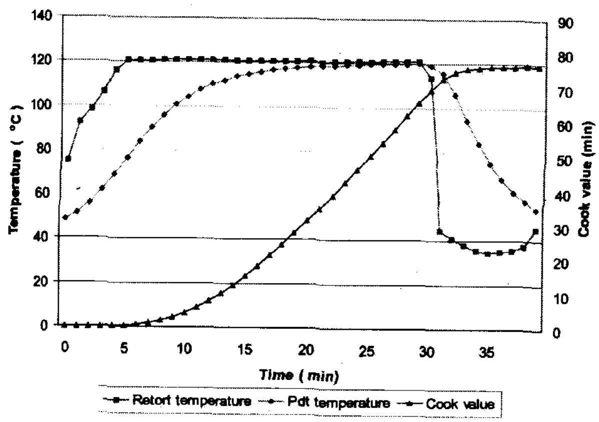

Fig. 5. Heat penetration Characteristics and Cook value of thermally processed tuna in brine

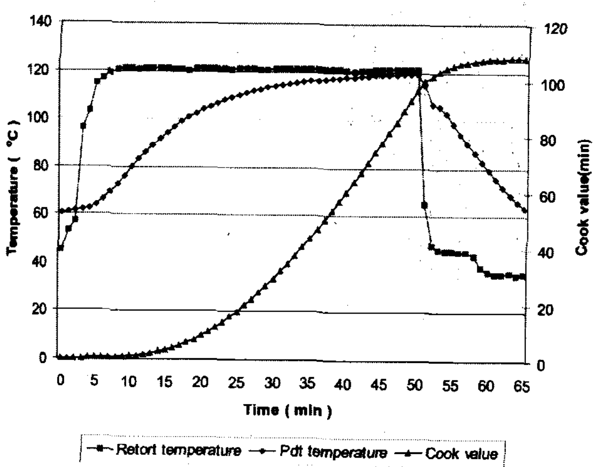

Fig. 6. Heat penetration Characteristics and Cook value of thermally processed tuna in Curry

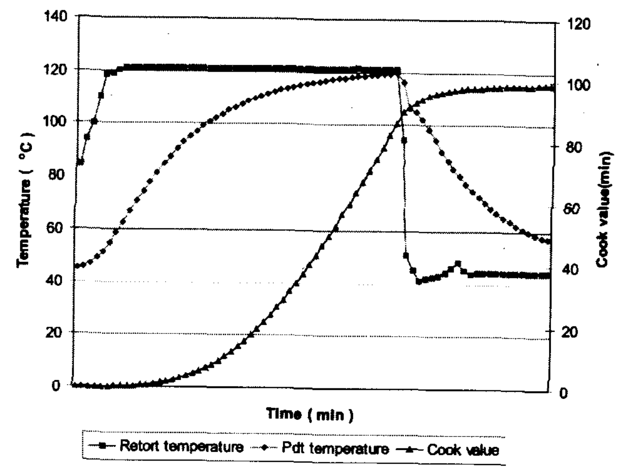

Fig. 7. Heat penetration Characteristics and Cook value of thermally processed tuna in Tomato sauce

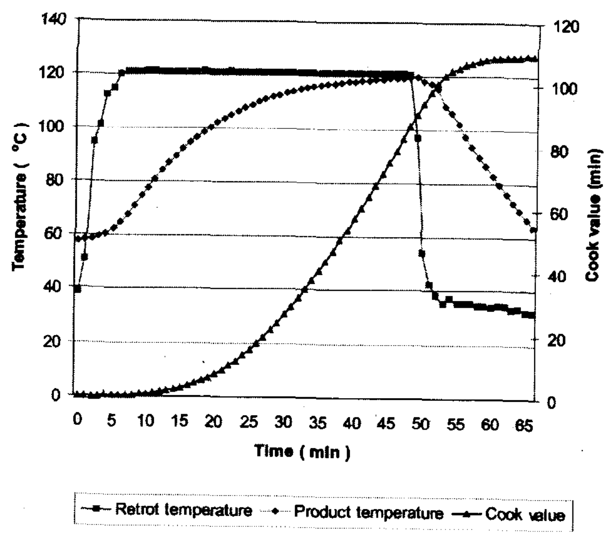

Fig. 8. Heat penetration Characteristics and Cook value of thermally processed tuna in Oil

Table 2 gives the thermal processing data of the tuna in different filling mediums in tin free steel cans. Time required to attain 1 log cycle reduction (fh- Value) was 11.5, 26.0, 26.5 and 27 minutes in brine, curry, tomato sauce and oil, respectively. Increase in heat penetration factor 'fh' was due to the decrease in sterilization value. This indicates that oil medium is more resistant to heat penetration than sauce, curry and brine. Data on core temperature, retort temperature and F_0 value of tuna processed in different filling media are presented in Figures 1 - 4 and heat penetration characteristics and cook value of the product in different media are shown in Figures 5 - 8. Cook value is aimed at obtaining an optimal tenderness in the finished product. Cook value for tuna was 76.5 minutes, 108.2 min., 98.7 min. 109.4 min. in brine, curry, sauce and oil medium, *respectively.*

Vanloey, *et. al.* (1994) reported that heat penetration characteristics at the cold point should be specific, if parameters such as filled weight, head space, type of container, dimension of container, come up time of the retort, heating media and initial temperature were uniform for a given product. Process

Table 3. Instrumental texture parameters of tuna meat in different filling mediums after thermal processing

Sample	Hardness I (kgf)	Hardness II (kgf)	Cohesiveness	Springines (mm)	Chewiness (Kgf.mm)
Precooked Tuna	5.67	4.16	0.28	4.88	7.71
Tuna in brine	4.63	4.09	0.378	3.16	5.63
Tuna in curry	7.17	6.16	0.464	4.39	8.677
Tuna in sauce	6.23	5.16	0.35	3.87	7.05
Tuna in oil	3.55	2.66	0.28	3.98	3.89

time required for different filling media were ranging from 25 to 43 min. The minimum time required to achieve F_0 10 for tuna in brine was 25.2 min. while curry, tomato sauce and oil medium required 40.32 min., 41.2 min. and 42.76 min., respectively. Curry, tomato sauce and oil mediums took 54%, 64% and 70%, time higher than the brine packs. Similar trends were also observed by Ali (2003) in tuna canned in oil, brine and curry media in aluminium cans.

Thermal processing had great impact on texture of meat after processing. Table-3 shows the Instrumental texture parameters of tuna meat in different filling mediums after thermal processing. Texture of meat foods is not static but changes during processing and by the process variables such as moisture content of the product, time, pH, metal ions and temperature of processing etc. During cooking, protein denaturation especially of myofibrillar proteins occur. Elasticity of the meat is due to the hydrophobic bonding between the polar and non-polar groups in proteins and also by the disulphide cross-links. Exertion of pressure was also found to increase tenderness of meat by disrupting the myofilaments. One of the problems encountered with fish and fish products is that the muscle is very heterogeneous making measurements and samplings difficult to reproduce. Texture profile analysis has provided results for hardness, cohesiveness, springiness and chewiness.

Hardness is the force necessary to create a given deformation in the food. In all cases, hardness 1 was more because the non-compressed sample will have a firm texture compared to the compressed samples. The hardness/ firmness of the precooked tuna meat was 5.67 kgf/mm, while the tuna in curry medium and tomato sauce medium showed higher values of 7.17 and 6.23 respectively. This may be due to the acidity of the medium. In case of brine and oil medium, hardness 1 was 4.63 and 3.55 kgf/mm hardness respectively. Tuna meat in oil medium showed lower textural values as it received more processing time because of slow heat transfer.

Cohesiveness is the ratio of positive force area during the second compression to that of first compression and indicate the extent to which a material can be deformed before it ruptures. This value is an indication of internal bonding of the muscle. Cohesiveness of the thermally processed tuna in different filling medium are shown in Table 3. Values for precooked tuna and tuna in oil medium were similar, while tuna in curry had the highest value and brine and tomato sauce had almost same values viz 0.378 and 0.35 respectively. Compared to precooked tuna, samples after processing showed higher values because of heat processing.

Springiness is the height that the tuna meat recovers during the time lapse between the end of the first compression and beginning of the second compression. In all mediums, springiness values were lesser than raw material. Among the processed samples in different filling media, maximum value of 4.39 mm was obtained for tuna meat processed in curry medium and minimum was found in brine. This indicates brine had good effect in reducing the elasticity of muscle. Chewiness is the energy required to masticate a solid food to a state ready for swallowing. It is a product of hardness, cohesiveness and springiness. (Szczesniak, 2002). Chewiness of the precooked tuna meat was 7.71 kgf.mm and it reduced to 3.89 kgf.mm during the heat penetration in oil medium. In brine medium also similar trend was observed, where as tuna processed in curry medium shows higher value than the raw material. This may be due to the low pH of the curry medium.

The present study showed that heat penetration was highly influenced by the type of filling medium used for the canning purpose. Among the different media used for the study, heat penetration was found to be faster in brine followed by curry, sauce and oil. The study also indicated that filling medium influenced textural parameters like hardness, springiness, cohesiveness and chewiness.

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