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Polymer Coated Tin-free Steel Cans for Thermal Processing of Fish

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Polymer coated Tin-free Steel (TFS) cans suitable for thermal processing of fish are now available in India. However, for successful use in thermal processing, the cans need to meet various performance criteria with respect to physicochemical properties. These cans were extensively tested for its suitability for processing different fish products. In this study, the physico-chemical properties such as sulphur staining test, delamination test, global migration test, air pressure test etc. were studied and the results compared with standards. Different fish products were processed at different Fo values and shelf life was determined by organoleptic test. The result indicates that the TFS cans locally available are suitable for thermal processing of fish and fishery products.

Key words: Polymer coated TFS cans, thermal processing, physicochemical properties, fishery products.

For the purpose of canning food products, different containers are used such as tin, aluminium etc. As far as India is concerned, tinplate for making cans is imported and hence it is disadvantageous economically. Many of these containers have the problems of disintegration of lacquers, are expensive and difficult to open. One of the recent developments in rigid containers is Tin-free Steel (TFS) cans. These are drawn and re-drawn steel cans with chromium coating and are manufactured with easy open ends and are coated inside with polymer, which does not react with products. Naresh *et al.* (1989) have reviewed on the chromium coated steel plate as an alternative to tinplate for canning food products. Hottenroth & Verpack-Rdsch (1972) investigated the suitability of chromium coated steel plate for packing food products and compared with electrolytic tin plate. Pielichowska & Chrzanowski (1972) studied the suitability of tin-free steel cans for canning various fish products and compared with anodized aluminium and electrolyte tin plate cans. The results of the investigations carried out in India by Mahadeviah (1984) have indicated the possibility of introducing tin free steel containers for canning sulphur containing vegetable and fish products. Polymer coated TFS cans are now available in India and not much work has been carried out on the suitability of these cans for processing fish and fishery products. The present study was undertaken with a view to assess the suitability of indigenous polymer coated TFS cans for thermal processing fish products with respect to physicochemical properties and compatibility.

Materials and Methods

Polymer coated Tin Free Steel (TFS) cans of 309 x 119 size, having 307 triple fold easy open ends with 6 oz fluid capacity obtained from M/s DNI International Inc., Bangalore, India were used for experiments. Resistance to sulphur staining and impermeability of the can was done according to IS: 5818-1970. Delamination test of the can was done by using organic solvents like acetone,

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carbon tetra chloride, chloroform, diethyl ether, ethyl acetate, n-heptane, methanol, petroleum ether and toluene. The TFS cans were cut into pieces of 1 x 1 cm panels and were immersed in organic solvents. After 24 hrs, the panels were taken out and examined for any peeling of polymer coating. When there was no peeling, the panels were stored for another 12 h. After 36 hours of dipping, the panels were heated in water bath for 5 min, and examined for peeling (ASTM, 1972). The suitability of cans for food contact application as indicated by water extractive and n-heptane extractives were determined by the method described in FDA (2002) and IS: 10910 - 1984.

Determination of capacity of can was done as per IS: 6093-1971. The vacuum in the can was determined with a vacuum gauge of the piercing type (IS: 3336-1968). In order to check the pressure holding capacity and also for any leakage through seams, the cans were subjected for air pressure test as described in IS: 2471-1963 and IS: 9396 - 1979. The double seamed can was pierced using a special tool that can seal an air inlet and a pressure gauge was used in the test and air was pumped into the can using a hand pump. The cans were first immersed in boiling water for a period of 5 min and then subjected to internal air pressure test as specified in standard IS: 2471-1963 for a period of 15 seconds.

Cut out analysis of the double seam was done by using a semi automatic double seam analyzer (SEAMetal 9000M, Quality by vision Ltd., Israel). Method by Lin *et al.* (1984) was followed to determine the double seam integrity of the can. Three or four equidistant points on the circumference of the seam were cut by seam cutter and analysed. The double seam parameter such as seam length (L), seam thickness (T), the countersink depth (CS), body hook (BH), cover hook (CH), body thickness (t_b), end plate thickness (t_c) and percentage overlap were measured by using the seam analyzer SEAMetal 9000M.

Some of the fish products viz, Mackerel in brine and oil (IS: 3849-1976), Mussel in oil and brine (IS: 10760-1983), Fish in curry media (Vijayan *et al.* 1998), Tuna in oil (IS: 4304-1976) and Prawn in brine (IS: 2236-1968) were processed to different Fo values and shelf life was determined by sensory evaluation. The procedure for thermal processing are given in the Flow Chart 1-7.

Fish/shrimp/mussel of about 140 g were filled in TFS cans with hot (90°C) filling medium of about 60 ml and the cans were double seamed. The pilot scale mill wall model 24 rotary retorting system (John Fraser and Sons Ltd, FWS House, Stoddart Street, New Castle-upon-Tyne, UK) was used for processing. Constructed of mild steel, the retort could withstand a working pressure of 3.5 bar. It has a standard square cage, with perforated side slots. It was set at 121.1°C with a steam pressure of 1.05 bar. The retort has a Programmable Logic Controller (PLC) assisted manual control i.e. retort operation performed manually but with the help of discrete electronic programmable input detector controllers for temperature and pressure.

Filled and sealed TFS cans were heat processed to different F_0 values. The F_0 recommended for fish products ranges from 5-10 (Frott & Lewis 1994). The preliminary standardization for Fo value of different fish products was done at three Fo values viz 8,9 and 10. The Fo values chosen for Mackerel in oil (MIO), Mackerel in brine (MIB), Fish curry (FC) was of 9, where as for Mussel in oil (MUIO), Mussel in brine (MUIB), Prawn in brine (PIB), was of 8 and for Tuna in oil (TIO) it was 10, based on sensory attributes. The thermal processing of fish products were

done by the following way. The thermal data were taken by inserting thermocouple needles into the product. Thermocouple outputs were measured by using an Ellab CTF 9008 data recorder (Ellab A/S, Roedovre; Denmark). Time - temperature data were recorded for every minute of processing. The recorded data were analysed using a computer. The heat penetration data were plotted on a semi log paper with temperature deficit (RT-CT) on log scale against time. Lag factor for heating (J_h), slope of the heating curve (f_h), time in minutes for sterilization at retort temperature (U) and lag factor for cooling (Jc) were determined. The process time was calculated by mathematical method (Stumbo 1973). Actual process time (TB) was determined by adding process time and the effective heating period during come-up time ie, 42% of the come up time. Sterility of the product was tested as per IS: 2168 (1971). After processing the cans were kept at ambient temperature (28 ± 2^0C) for storage study.

The post process performance of the TFS cans and fish products were evaluated every two months during the storage of 24 months. Sensory characteristic of the fish products were evaluated by a 10 member trained taste panel on a ten point scale (IS 6273[II] 1971; Vijayan, 1984). Sensory evaluation of fish products were carried out based on the score sheet given in Annexure at regular intervals. A sensory score of 4 was taken as the limit of acceptability.

Results and Discussion

The test for resistance to sulphur staining indicated that there was no blackening on the test panels and the cans were sulphur resistant. The delamination test carried out using various organic solvents for a period of 36 h showed no delamination, which is due to the proper adhesion of polymer to the can body.

Table 1. Physicochemical parameter of TFS can

Tests	Result
Capacity of can	180 mL
Vacuum of can	100 mm Hg
Air pressure test	100 kpa for 15 seconds
Sulphur staining test	No blackening/staining
Delamination test	No peeling

Average of 5 readings.

All the plastic materials contain some non-polymeric components, these material may leach out in to food at the time of thermal processing. The safety of the can for food contact application was evaluated by conducting the migration tests using food stimulants like distilled water and heptane. The Bureau of Indian standard specifies 60 ppm for finished material (IS 10910-1984; FDA, 2002). It has been seen from the Table 2; the migration into water is less as compared to n-heptane. The overall migration residue i.e. water extractive and n-heptane extractive of the sample was 6.9 mg/l and 25 mg/l respectively, which is below the prescribed limit for food contact application. These results suggest that polymer coated TFS cans use in the study were suitable for food contact application.

Table 2. Performance of the TFS cans with respect to Global Migration

Food stimulants (^{0}C/h)	Value (mg/l)
Water extractive (121/2)	6.9 ± 0.006
Heptane extractive (66/2)	25 ± 0.005

Each value is represented by the mean ± standard deviation of at least 3 determinate.

The capacity of can is determined to know the quantity to be filled in the container. According to IS: 6093-1971, the filling should be done 90 to 95% of capacity of can. The capacity of the TFS can is given in the Table 1. The air pressure test serves to detect the leak in the container. No signs of leakage and deformation of cans were

Table 3. Cut out analysis of TFS cans

Tests	Result
Body plate thickness (tb)	0.183 ± 0.003 mm
Cover plate thickness (tc)	0.287 ± 0.002 mm
Body hook length (BH)	1.480 ± 0.023 mm
Cover hook length (CH)	1.982 ± 0.015 mm
Seam length (L)	2.681 ± 0.020 mm
Seam thickness (T)	1.423 ± 0.030 mm
Free space (G)	0.183 ± 0.043 mm
Percentage overlap	63.526 ± 0.065%
Percentage body hook butting	70.452 ± 0.032%

All the values are average of 5 reading ± standard deviation

observed, when subjected to internal air pressure of 100 kpa for 15 seconds. This ensures that there won't be any chances of leakage through seams during heat processing and cooling operations.

The cut out analysis of TFS cans are given in Table 3. It was observed that the percentage for body hook butting was 70.45 ± 0.03 and percentage overlap was 63.53 ± 0.07. These results indicate that the seam efficiency is perfectly in order and the values are well above the minimum prescribed limits (Gopakumar, 1993).

Table 4. Heat penetration characteristics* of fish products in different media

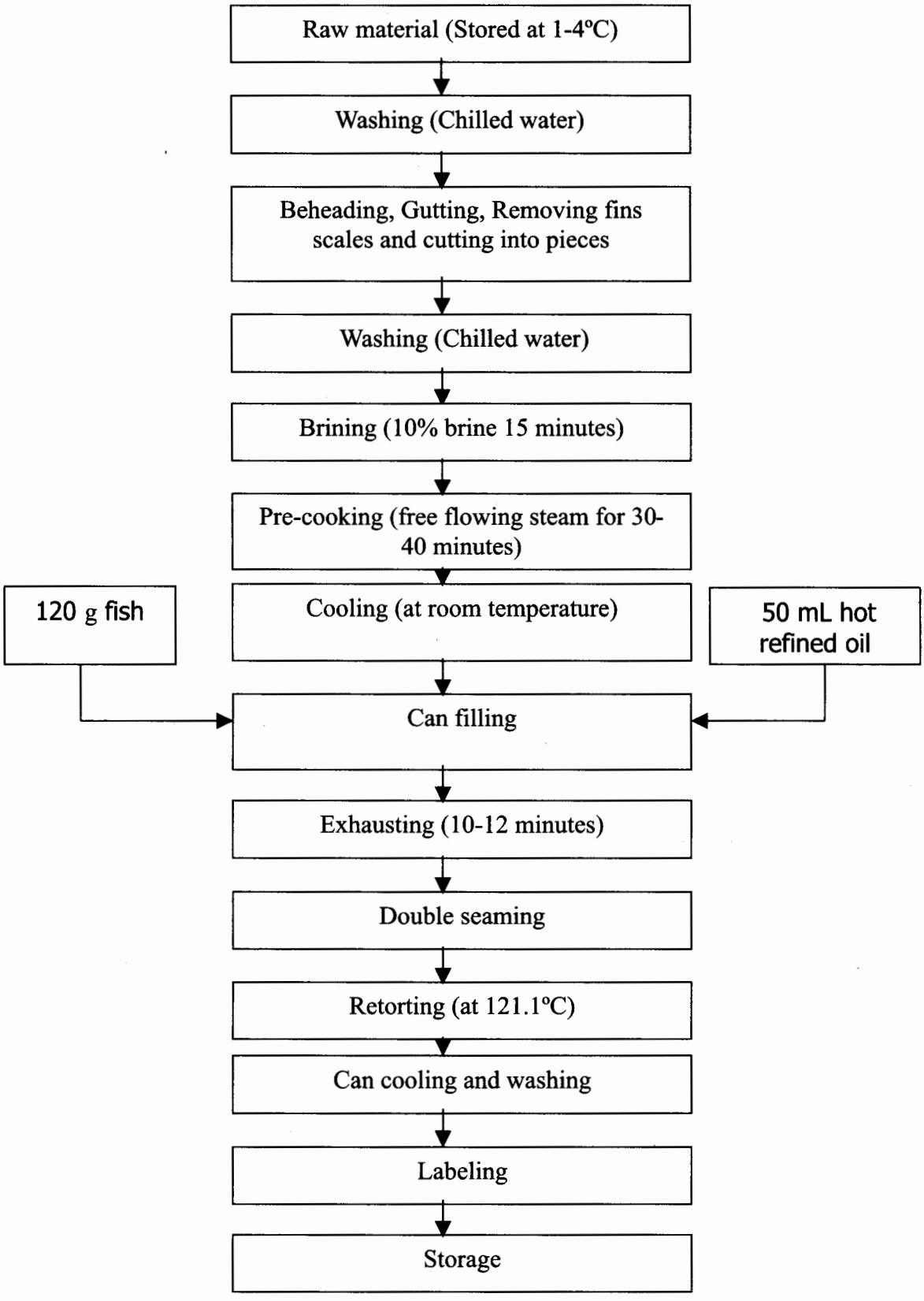
Products	Jh	Jc	fh (min)	fh/U	g	Cg (min)	B (min)	TB (min)
MIO	0.71±0.03	1.26±0.05	28.21±0.22	3.09±0.02	2.03±0.15	100.53±1.3	42.21±1.01	45.09±0.99
MIB	0.89±0.01	1.22±0.07	20.12±1.12	2.29±0.12	1.34±0.05	92.83±0.69	35.57±1.00	38.06±1.29
MUIO	1.11±0.32	1.22±0.05	24±1.06	3.00±0.22	1.94±0.02	100±0.98	41.08±1.73	46.88±1.81
MUIB	1.12±0.33	1.05±0.03	21±0.48	2.59±0.43	1.49±0.07	95±0.79	38.02±1.64	43.81±1.52
FC	1.29±0.13	1.09±0.02	29±1.5	3.11±0.32	1.94±0.04	102.28±1.4	46.42±1.22	49.9±1.54
TIO	1.30±0.14	1.17±0.09	38.15±0.86	3.82±0.15	2.46±0.06	125.65±5.3	62.09±0.42	64.43±1.20
PIB	0.99±0.51	1.07±0.07	14.5±1.32	1.81±0.12	1.42±0.02	69.73±2.3	25.86±1.4	31.66±1.6

* Each value is represented by the average ± standard deviation of at least 3 determinants
Jh = lag factor of heating, Jc = lag factor of cooling, fh = slope of heating curve, U = time in minutes for sterilization at retort temperature, g = final temperature deficit, Cg = cook value, B = Ball's process time, TB = Total process time, MIO = Mackerel in oil, MIB = Mackerel in brine, MUIO = Mussel in oil, MUIB = Mussel in brine, FC = Fish curry, TIO = Tuna in oil, PIB = Prawn in brine,

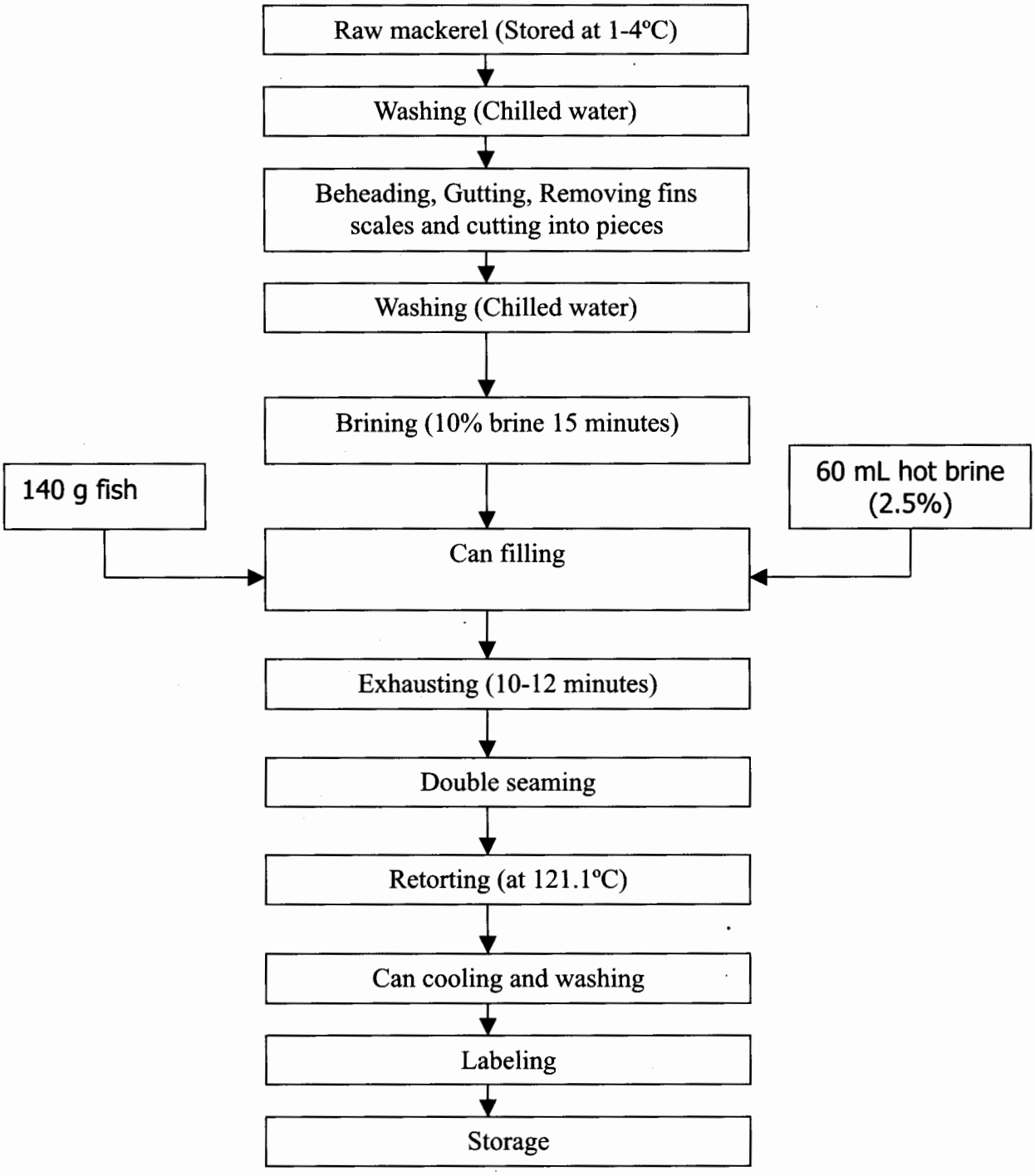
Table 5. Sensory evaluation (Overall acceptability) of thermal processed fish products in different medium during storage at ambient temperature.

Months	MIB	MIO	MUIO	MUIB	TIO	FC	PIB
0	8.50±0.00	8.63±0.25	8.50±0.00	8.38±0.25	8.75±0.29	8.50±0.00	8.50±0.41
2	8.25±0.28	8.38±0.25	8.25±0.28	8.38±0.25	8.63±0.00	8.38±0.25	8.10±0.29
4	8.13±0.25	8.13±0.28	8.13±0.25	8.25±0.28	8.50±0.28	8.13±0.28	8.00±0.41
6	7.75±0.25	7.75±0.00	7.75±0.25	8.13±0.25	8.25±0.25	7.75±0.25	7.88±0.29
8	7.63±0.25	7.63±0.25	7.63±0.25	7.88±0.25	8.00±0.25	7.63±0.25	7.75±0.57
10	7.50±0.28	7.25±0.28	7.50±0.28	7.75±0.28	7.88±0.25	7.22±0.28	7.50±0.65
12	7.50±0.28	7.13±0.25	7.50±0.28	7.63±0.25	7.50±0.27	7.15±0.48	7.38±0.48
14	7.13±0.25	7.00±0.28	7.13±0.25	7.50±0.00	7.50±0.25	7.04±0.41	7.25±0.41
16	7.00±0.00	6.88±0.28	7.00±0.00	7.13±0.25	7.38±0.29	6.91±0.53	6.75±0.29
18	6.75±0.28	6.88±0.47	6.75±0.28	6.88±0.25	7.38±0.25	6.73±0.44	6.63±0.25
20	6.38±0.25	6.75±0.25	6.38±0.25	6.75±0.28	7.20±0.00	6.57±0.38	6.50±0.25
22	6.25±0.41	6.13±0.00	6.00±0.28	6.38±0.25	7.00±0.27	6.44±0.25	6.38±0.29
24	6.14±0.32	6.00±0.25	5.75±0.28	6.00±5.50	6.75±0.29	6.29±0.42	6.25±0.41

* Values are mean ± standard deviation of 10 observations.
MIO = Mackerel in oil, MIB = Mackerel in brine, MUIO = Mussel in oil, MUIB = Mussel in brine, FC = Fish curry, TIO = Tuna in oil, PIB = Prawn in brine,

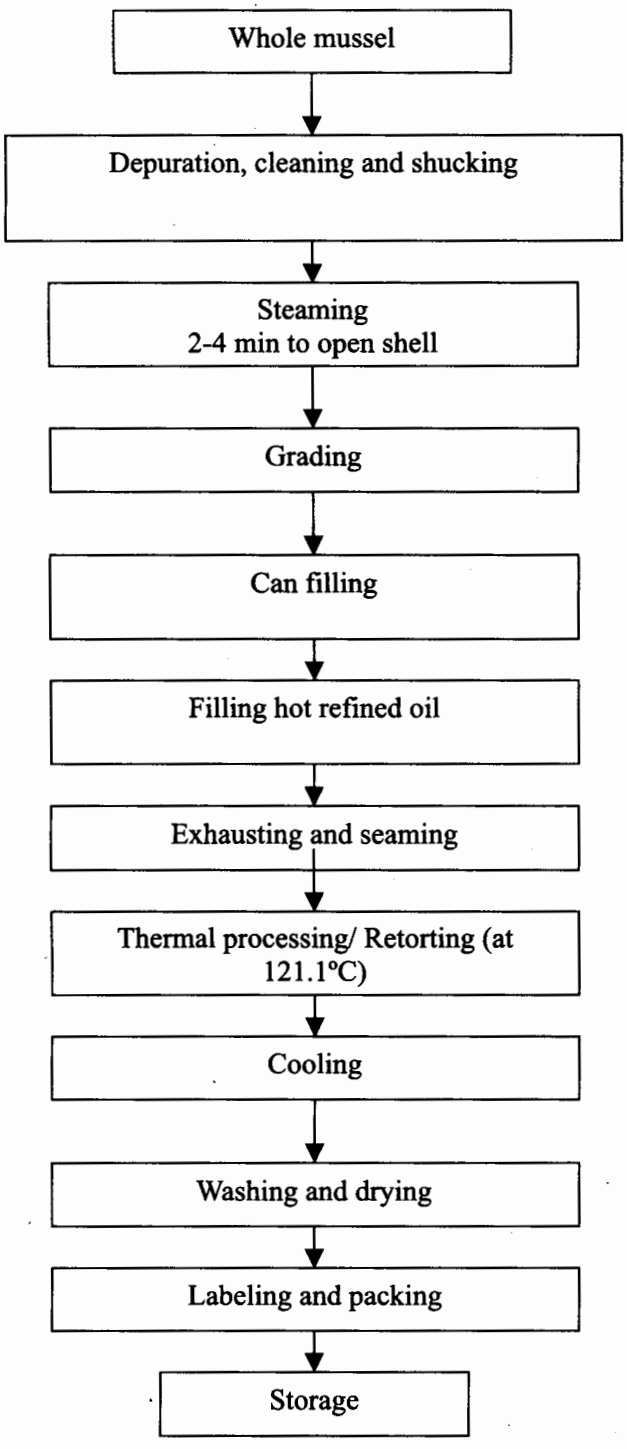


Flow Chart-1. Canning of Mackerel in Oil

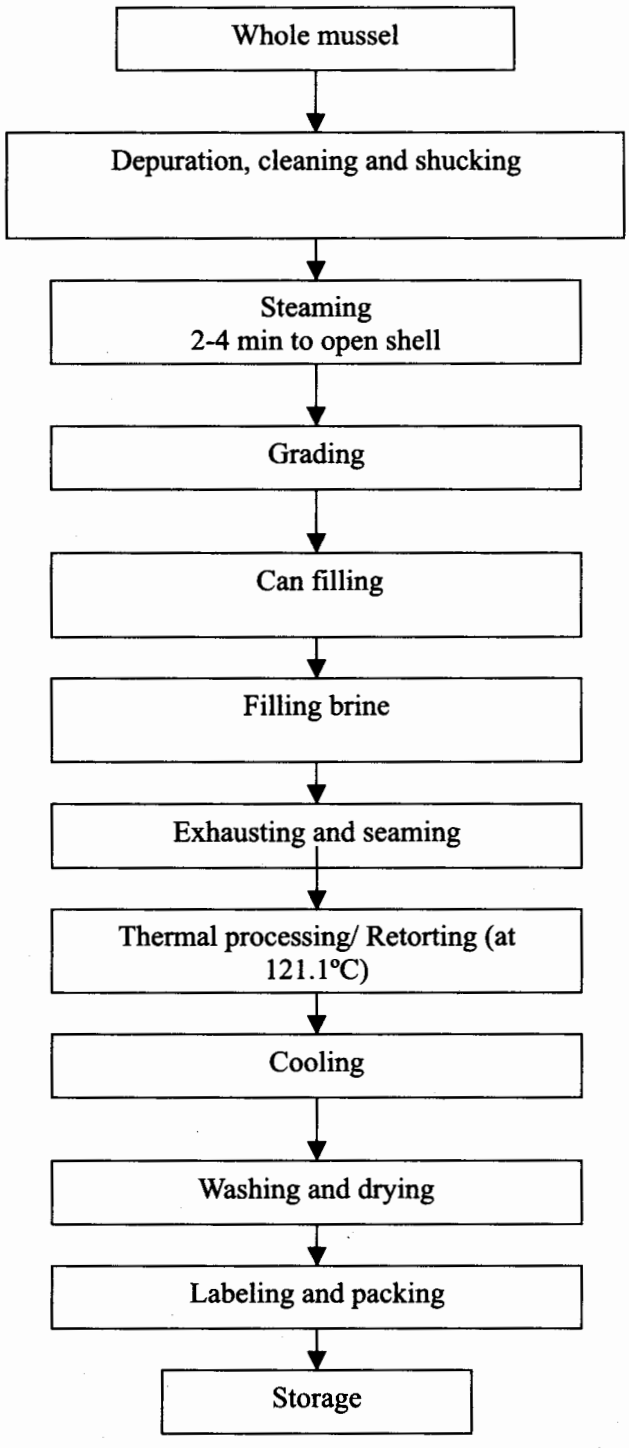


Flow Chart-2. Canning of Mackerel in Brine

The process parameters and heat penetration characteristics of different fish products calculated by plotting time temperature data on a semi log paper are given in Table 4. It is seen from the table that, the total process time for MIO, MIB, MUIO, MUIB, FC, TIO and PIB were 45.09 ± 0.99, 38.06 ± 1.29, 46.88 ± 1.81, 43.02 ± 1.52, 49.9 ± 1.54, 64.43 ± 1.20 and 31.66 ± 1.60 respectively. This process was sufficient to get a commercially sterile product. Details regarding F_0 values the cook value (Cg) are given in the Table 4, which is meant to achieve commercial sterility and tenderness



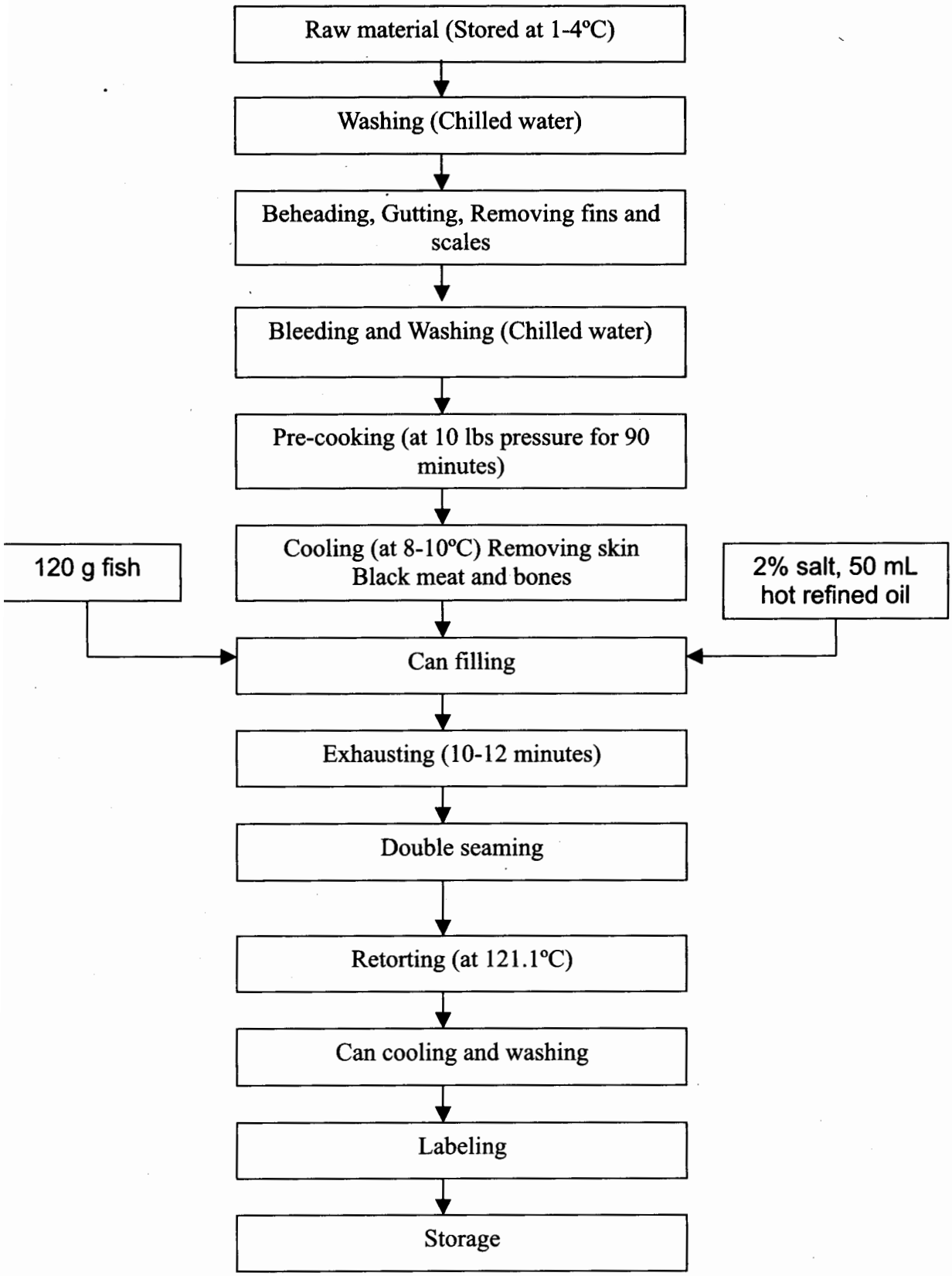
Flow Chart-3. Canning of mussel in oil



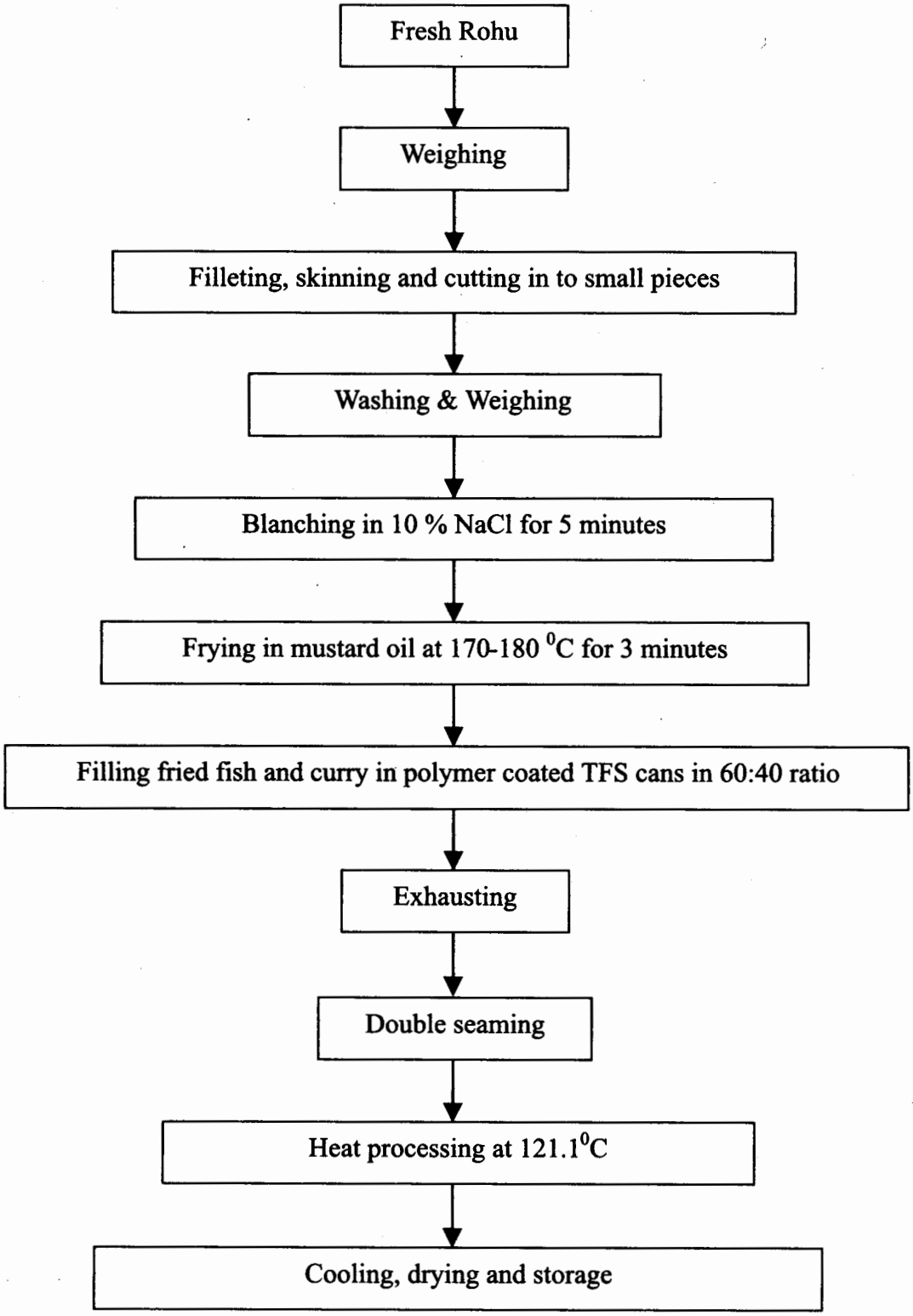
Flow Chart-4. Canning of mussel in brine

respectively in finished product. The products had very good appearance and the bones were soft in case of fish products.

Sensory evaluation of fish products canned in TFS cans was carried out at regular intervals of 2 months. Changes in overall acceptability of products during storage at ambient temperature are presented in Table 5. It is seen from the results that, the fish products were acceptable even after 24 months of storage at ambient temperature. The initial overall acceptability score of about 8.5 gradually reduced to around 6.



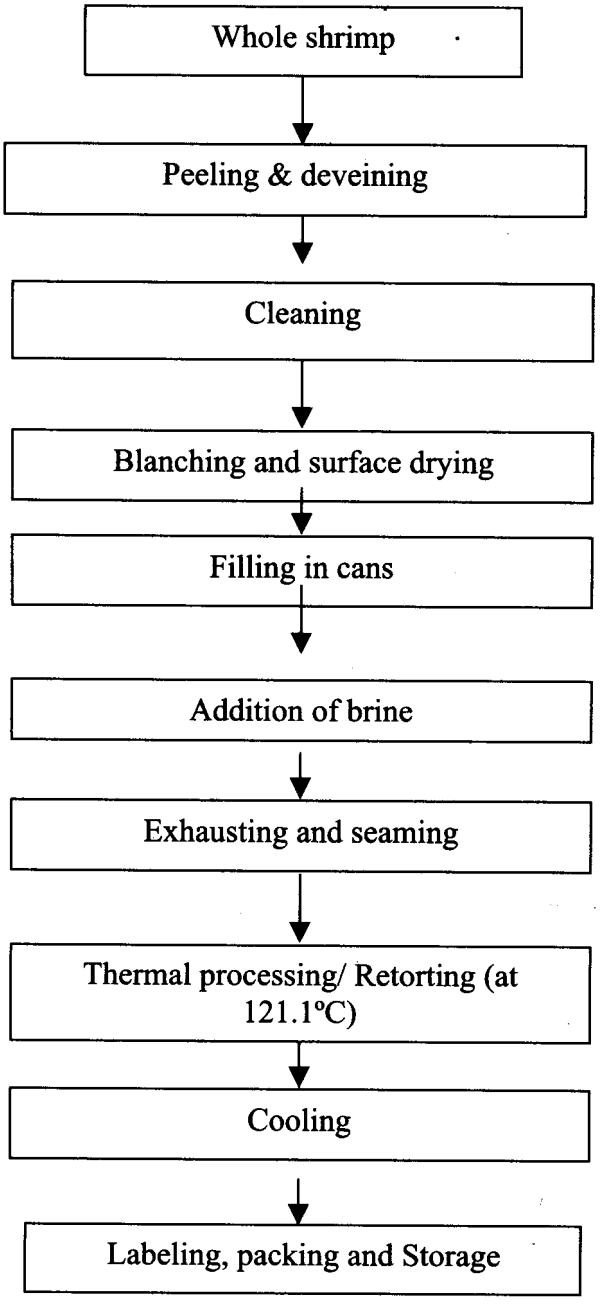
Flow Chart-5. Canning of tuna in Oil



Flow Chart-6. Canning of fish curry

Shelf life of different products processed in the TFS cans are presented in the Table 6. It is seen from the table that all food products showed a shelf life of more than 24 months at ambient temperature and were commercially sterile.

The results of the present experiments showed that the polymer coated TFS cans are



Flow Chart-7. Canning prawn in brine

suitable for processing fish products. Polymer coated TFS cans were found to withstand all the conditions of thermal processing. The study indicates that the TFS cans, which are now available in India, can be used for thermal processing various fish products as an alternate to tin and aluminum cans.

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Table 6. Shelf life of different fish products processed in the TFS can

Various fish products	Fo value	Shelf life at ambient temperature (28 ± 2°C)
Mackerel in oil	9	More than 24 months
Mackerel in brine	9	More than 24 months
Mussel in oil	8	More than 24 months
Mussel in brine	8	More than 24 months
Fish in curry media	9	More than 24 months
Tuna in oil	10	More than 24 months
Prawn in brine	8	More than 24 months

Annexure: Sensory evaluation of canned fish

Assessor.....

Date.....

(Please score the sample by placing a cross (×) at the relevant point along the scale.)

Sl. No.	Characteristics	Score
1.	Excellent	10
2.	Very good	9
3.	Good	8
4.	Moderately good	7
5.	Neither good nor bad	6
6.	Slightly rancid, bitter or other off-flavors	5
7.	Moderate rancid, bitter or other off-flavors	4
8.	Strong rancid, bitter or other off-flavors	3
9.	Very strong rancid, bitter or other off-flavors	2
10.	Extremely rancid, totally unacceptable.	1

OVER ALL ACCEPTABILITY

Like Extremely 10 9 8 7 6 5 4 3 2 1 Dislike Extremely

COMMENTS

Signature

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