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Feasibility of Fish and Shellfish Curries Stored in Indigenous Polymer Coated Tin Free Steel Cans

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Abstract

The study indicated that the suitability of indigenous polymer coated TFS cans for processing at high temperature and pressure. The cook value was found to exhibit an inverse relationship with processing temperature ($p<0.05$) and was maximum at 115°C and minimum at 130°C. The fish products were acceptable even after 24 months of storage at ambient temperature. The initial overall acceptability score of about 8.75 and it was gradually reduced to around 6.78. It can be seen that the initial pH of fish, shrimp, crab and mussel curries are 5.9, 5.7, 5.6 and 6.0 respectively indicating that it is towards the acidic side. The acidic nature of the product can be attributed to the acidity contributed by the curry ingredients like tomato. During storage, the pH of the products was found to exhibit a decreasing trend. On the 6th, month of storage, the pH of fish, shrimp, crab and mussel curries are 5.7,5.6, 5.6 and 5.8 respectively which are significantly lower as compared to initial values. On the 12th month of storage, the pH of fish, shrimp, crab and mussel curries are 5.6, 5.6, 5.5 and 5.7 respectively. The results of the present experiments showed that the polymer coated TFS cans are suitable for processing fish products. Polymer coated TFS cans was found to withstand all the conditions of thermal processing. The TFS cans which are now available in India can be used for thermal processing of various fish products as a substitute to other packs.

Keywords: Fish; Shrimp; Crab; Mussel; Storage; TFS can

Introduction

Tinplate is light gauge, cold reduced, low-carbon steel sheet or strip, coated on both sides with commercially pure tin. It combines in one material the strength and formability of steel and the corrosion resistance and good appearance of tin. Just under one third of the world's total tin production goes into the manufacture of tinplate, for which food packaging is by far the largest of many diverse applications. Tinplate has been used for preserving food for well over a hundred years and today provides a robust form of packaging, allowing minimization of headspace oxygen and sterilization of the foodstuff within the hermetically sealed can, giving a long, safe, ambient shelf life with no, or minimal, use of preservatives. Worldwide, the total for food packaging is approximately 80,000 million cans. Four metals are commonly used for the packaging of food, steel, aluminium, tin and chromium. Today the opportunity for tin in canning become a great industry, material like tinplate and aluminium have become universally adopted for the manufacture of containers and closures for food and beverage, largely due to several important qualities of containers of these metals. These include their mechanicals strength and resistance to working, low of temperature and ideal surface for decoration and lacquering. Containers are also able to have their temperature, humidity, and gas atmosphere controlled, this is necessary in particular situations such as the transportation of frozen foods, chilled meats and fresh fruits and vegetables.

Canned products enjoy wide acceptance in domestic as well as international markets due to the convenience and ready to eat features. The scope for heat processed food are appears to be bright in future years in developing countries due to urbanization and busy life style. Heat penetration in canned food are influenced by several factors like can materials, size of the container, thickness of the can wall, thermo physical properties of food, filling medium, temperature of process, chemical additives, etc. Rotation of the cans has an effect on the heat penetration characteristic, which reduces process time [1]. The world wide effort that started in the sixties for finding a suitable container for canned products that is free of tin resulted in the birth of Tin Free Steel in Japan. The chromium coated steel plate has been reviewed as an alternative to tinplate for canning food products by many workers [2-5]. Recently chromium coated steel cans with polymer coating are available in Indian market. In these cans, the chromium coated steel is laminated with Poly Ethylene Terephthalate (PET) which prevents the direct contact between the metallic can and food material packed inside. In the present study feasibility of packing fishery products in indigenes polymer coated tin free cans were tried.

Materials and Methods

Containers

Indigenous polymer coated tin free steel can with Easy open ends (EOE): Indigenous Polymer Coated Tin Free Steel cans of size 307X 409 (6 oz capacity manufactured by M/s Amtech Packs, Mysore) were used for the present study (Plate 8). These are 3- piece cans manufactured by (Draw and Redraw) DRD process and are available along with Easy Open Ends (EOE). Both the can and EOE are made from Electrochemically Chromium Coated Steel (ECCS) plate coated with Poly Ethylene Terephthalate (PET) on either side. The plate has a thickness of 0.19 mm (0.15 mm of base steel +20µ PET coating on either side). The PET coating substitutes the lacquer coating of conventional tin and aluminium cans is laid as a continuous layer over the chromium coated steel plates by the process of lamination. The EOE is also manufactured from electrochemically chromium coated steel

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plates with polymer coating and is provided with unique features like triple fold technology, scoring along the periphery, and pull up tab all of which facilitates the easy opening of the cans without employing a can opener. Cans and EOE were thoroughly washed before use to remove adhering impurities and dried well to remove traces of water

Easy-open-ends of TFS cans: The easy open ends (EOE) have been developed for food cans. The easy open end has the convenience of opening the can easily using a finger. The easy open end can be made by TFS and thickness of 0.28 mm; it consists of two parts, the lid and the tab. The tab is secured onto the lid by means of integral rivet. By pulling the tab, the whole central panel can be removed. In EOE, TFS is pre-punctured to provide full aperture, which is sealed by an adhesive strip of metallised polyester film.

Oil

Double refined sunflower oil was used for the curry preparation.

Salt and other curry ingredients

Salt of edible quality confirming to IS: 594-1962 was used. All other ingredients used for the curry preparations were of good quality, food grade and fit for human consumption.

Prepared fish curry

The curry of fish, prawn, crab and mussel were prepared as in Ist chapter and evaluated using standards testing condition and TFS cans were used for packing. 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 bottom of the can to record the core temperature.

Analysis of can

Determination of water capacity (IS: 6093-1970): Two holes of 3-4 mm diameter were drilled about 5 cm apart as close as possible to the countersink, from inside surface outwards on a can end. This was attached by double seaming on the other end of the can body. The can was weighed to the nearest 1 g and the container was filled with water at 27°C employing a narrow water jet through one of the holes. Surplus water on the outside of the can was removed using a blotting paper and the filled can was weighed to the nearest 1 g. The difference between the weights was noted and to this 0.45% of the value was added. This represents the capacity in milliliters.

Air pressure test (IS: 9396-1979): This test was performed to determine the pressure holding capacity of the cans and to check for any leakage through the double seam. The cans were pierced with a piercing type of pressure gauge and then air was pumped inside using a foot operated pump until any distortion of the can or any leakage through the double seam area was noticed. The double seamed can was immersed in boiling water for 5 min prior to the test.

Determination of Vacuum (IS: 3336-1968): The vacuum in the can was determined with a vacuum gauge of the piercing type.

Test for coating perfection: The perfection of the PET coating was analyzed using the Lacquer Coating Breakage (LCB) detector. The can was filled with 10% brine and attached to the LCB detector in such a way that one of the electrodes was in contact with the edge of the flange where the base metal was exposed and the other electrode was dipped in the brine. Presence of any discontinuity in the coating allows the circuit to complete which was indicated by light and audio indicators.

Sulphide blackening test: Resistance of cans to sulphide blackening was analyzed following the cysteine test. For this, cans were filled with the test solution consisting of 0.5 g of cysteine chloride in 1liter of buffer solution (3.56 g KH2 PO4 and NA2H PO4. 2 H2O in 1 liter of distilled water). Filled cans were double seamed and retorted for 30 min at 125°C. They were then left to cool down at room temperature for 24 hrs and were opened and evaluated for any blackening [6].

Test for delamination of PET coating: The polymeric coating of TFS can was subjected to delamination test using various organic solvents like acetone, carbon tetra chloride, chloroform, diethyl ether, ethyl acetate, n-heptane, methanol, and petroleum ether. Panels of 1 X 1 cm size were taken and immersed in organic solvents. They were taken out after 24 hrs and examined for any delamination of the PET coating. When there was no peeling they were kept immersed for another 12 hrs. The panels were taken out and heated in water bath for few minutes and examined for delamination of the coating

Test for thickness of PET coating: The PET coating was first delaminated from the base metal by immersing in chloroform for 24 hrs. It was then dried in air at room temperature. The dried material was analyzed for its thickness using a digital micrometer.

Test for suitability of can for processing at different temperature and pressure: The cans were processed at different temperatures and pressures of 115 (10 lbs), 121.1.1 (15 lbs), 126 (20 lbs) and 130°C (25 lbs) in a pilot scale retort of model 24 rotary retorting systems (John Fraser and sons Ltd, UK. Model.No.5682) to determine its ability to withstand different processing conditions.

Test for food contact application: Suitability of the can for food contact application was found out by determining the water extractives at 121.1°C for 2 hrs and soluble chloroform extractives as per the methods of FDA (2003). The cans were filled with 200ml of hot glass distilled water and immediately heat-sealed. The sealed cans were heat processed at 121.1°C for 2 hrs. After processing the processed water was transferred into clean beakers and evaporated up to 50 ml. The contents of the beaker were transferred into another clean pre weighed tarred platinum dish and evaporated to dryness. After cooling the weight of the dish was again taken to the nearest 0.1 mg to find out the amount of water extractives. To those dishes containing water extractives 50 ml of chloroform was added to dissolve all the chloroform extractives. The contents were filtered and evaporated to dryness in a clean pre weighed tarred platinum dish. After drying the weight of the dish was again taken to the nearest 0.1 mg to determine the amount of chloroform extractives.

Test for seam integrity: The seam integrity of the polymer coated tin free steel cans was analysed following the cut out analysis [7] and using the semi-automatic Double seam analyzer (Quality by Vision, Model Sea Metal 9000M, Israel). For cut out analysis, double seamed cans were selected at random and three equidistant points were marked on the circumference of the seam of the can. Using a micrometer, the Seam length (L), Seam thickness (Ts), Body hook, Cover hook, Body plate thickness (Tb), Cover plate thickness (Tc), were measured.

From these parameters, the % overlap was calculated using the formula.

$$\%\ \text{Overlap} = \frac{\text{BH} + \text{CH} + 1.1\text{tc} - \text{L}}{\text{L} - (2.2\text{tc} + 1.1\text{tb})}$$

Where

BH = Body hook length

CH=Cover hook length

tc=Cover plate thickness

tb=Body plate thickness

L=Seam length.

For the purpose of seam analysis using the double seam analyzer, double seamed cans were selected at random and three cut sections were made on the double seam one after the other using the twin blades of the seam saw which are rotating at a speed of about 500 rpm. The cut width is 12.9 mm, which accurately fits to the camera of seam analyzer. The double seam parameters such as Seam length (L), Seam thickness (T), Body hook (BH), Cover hook (CH), Body thickness (tb), End plate thickness (tc) etc were measured using the seam analyzer Sea Metal 9000M.

Thermal processing analysis

Preparation of test cans: Adequate number of test cans was prepared to trace the thermal history during the heating and cooling phases of the canning operation. For this the cans were perforated from the side by using the can punch which can form holes through which the packing gland can be inserted into the can. The perforation was done in such a way that the thermocouple tip was pointed towards the centre of the can at one third heights from the bottom which is recognized as the slowest heating point. The packing gland was then tightly screwed into the can body with the rubber gasket which helps to forming leak proof joint.

Standardisation of optimum process parameters for ready to eat fish products in polymer coated tin free steel cans

Heat penetration studies were conducted with the purpose of standardizing the optimum process condition for various ready to eat fish products in tin free steel cans. The heat penetration studies of fish, shrimp, crab and mussel curry were carried out separately by thermal processing at 121.1°C to F_o values of 7, 8 and 9 and 6, 7 and 8 respectively in a stationary retort. In both cases, about 240 g of product was packed in washed and dried 6 Oz polymer coated easy open-end TFS cans, maintaining headspace of 10 mm. During can filling, care was taken to avoid the curry from contaminating the sealing area of the cans. Adequate numbers of test cans were prepared by fixing with thermocouple glands at about one third height from the bottom of the can with the tip of the gland pierced into the core of the meat. The cans were exhausted under steam in an exhaust box for 10 min and immediately double seamed in a double seaming machine. The sealed cans of fish, shrimp, crab and mussel curry were divided into 3 batches and were loaded inside the retort (John Fraser and sons Ltd, UK. Model.No.5682) separately on perforated stainless steel trays. The thermocouple probes were attached to the thermocouple glands that were already attached to the test cans. The lead wires from the thermocouples were attached to the Ellab data recorder (Model TM 9608, Ellab A/S). Three test cans were employed for each trial run of each product. Care was taken to maintain the initial product temperature at 35°C. Fish, shrimp, crab and mussel curry was processed at 121.1°C to three different Fo values of 7, 8 and 9 min while conducted. The cans were cooled rapidly by spraying water under pressure to a core temperature of 40°C so as to prevent the proliferation of thermophiles and the product from getting overcooked. The cooling water was maintained with constant chlorine residual level of 2 mg/L. Graves et al. [8] recommended a residual chlorine level of 1–3 mg/L to maintain bacterial control in cooling water. The thermal history of the retort and the test cans during the entire thermal process operation was collected at every 30 sec using Ellab data recorder (Model TM 9608, Ellab A/S) evaluated as described below heat penetration data. The cans were then dried, labeled and stored. The cans were stored at room temperature for about 15 days and then subjected for the analysis of commercial sterility, instrumental colour, texture, shear force and sensory parameters for the selection of optimum process conditions.

Storage study

Canned foods are one of the stable foods. Hayakawa et al. (1978) [9] reported that quality of canned products gradually deteriorates during storage, especially when it is stored at relatively higher temperatures. Since canned foods are stored for variable time periods before being consumed, it would be interesting to know the storage life of these products in orders to establish its expiry date. Ready to eat fish, shrimp, crab and mussel curries were prepared and processed in large scale according to the chosen F_o values and kept for storage studies at room temperature (30 ± 2°C) during which samples were taken on monthly basis and were analyzed for instrumental colour, TPA, shear force, TBA, pH and sensory characteristics for a period of one year. Since ready to eat products are consumed without any further preparation, parameters like colour and appearance play vital role in the acceptance of the product.

Analysis of Curry Meat

Physiochemical parameters

pH (IS: 2168-1971): 5 g of the sample was dissolved in 10 ml of distilled water and pH was measured by using pH meter.

Instrumental colour: The L*, a* and b* or CIE Lab colour values of the samples were analyzed using Hunter lab colorimeter (Model No: Miniscan-XE plus, Hunter associates laboratory, Virginia, USA). Fish, shrimp, crab, mussel curry muscle pieces were finely homogenized in a food homogenizer (Kenstar Kitchen Appliances India Limited, Aurangabad, India) and loaded inside the sample holder while all the four curry meat was made free of skin and bones before homogenising.

Texture profile attributes: The texture profiles of samples were analyzed using a food texture analyzer (model LRX Plus, Lloyds Instruments, Hampshire, U.K.) and Nexygen software (Lloyds Instruments). The sample was placed on a flat platform and was subjected to double compression by a cylindrical probe with a 50 mm diameter. The test was conducted at a speed of 12 mm/min using a 50-N load cell. The sample was allowed for a double compression of 40% with a trigger force of 0.5 kg and various textural parameters like hardness1, hardness2, cohesiveness, springiness, gumminess and chewiness were determined.

Results and Discussion

In the present study (Table 1) indigenous polymer coated Tin Free Steel cans was analyzed for their suitability for thermal processing and storage of fish and fishery products following standard methods. These cans had water holding capacity of 500 ml and were found to withstand internal air pressure of 30 psi for about 15 seconds without undergoing any bulging or leakage through the double seam area. Fish and fishery products are usually processed at 121.1°C with corresponding pressure of 15 psi cans were found to retain their original shape without any distortion, and they did not require any overpressure during processing. The cut out analysis of polymer coated tin free steel cans showed that the base plate and end plate have thickness of 0.19 mm (0.15 mm of base steel +20 µ PET coating on either side) and 0.28 mm (including PET

Parameters	**Result**
Water holding capacity	500 ml
Air pressure Test	Withstands 30 psi /15 seconds
Base plate and End plate thickness	0.19 mm /0.28 mm
Overlap percentage	63.3 %
Double seam Analysis	Analyzer SEAMetal 9000M/ good
Lacquer coating Testing	97%(LCB detector indicator)
Sulphide stains (black discolouration)	18 month/ Rust- Free
Delamination of PET coating	36 hrs of immersion no peeling
Thickness of PET coating	20 µ uniform thickness
Water soluble extractive value (TFS)	6.9 ppm
Chloroform soluble extractive value	0.64 ppm

Table 1: Physical properties of indigenous TFS can.

Tests	Result
Body plate thickness (tb)	0.193 mm
Cover plate thickness (tc)	0.287mm
Body hook length (BH)	1.480 mm
Cover hook length(CH)	1.982mm
Seam length(L)	2.681mm
Seam thickness(T)	1.423mm
Free space(G)	0.183mm
Percentage Overlap	63.3%
Percentage body hook butting	70.42%

Table 2: Cut out analysis of TFS cans.

Months	fish curry	shrimp curry	crab curry	mussel curry
0	9.08 ± 0.00	8.68 ± 0.22	8.75 ± 0.29	8.50 ± 0.00
2	8.51 ± 0.22	8.49 ± 0.25	8.63 ± 0.00	8.25 ± 0.28
4	8.37 ± 0.22	8.35 ± 0.28	8.50 ± 0.28	8.13 ± 0.25
6	8.21 ± 0.24	8.22 ± 0.25	8.25 ± 0.25	7.74 ± 0.24
8	8.01 ± 0.25	8.12 ± 0.00	8.00 ± 0.25	7.62 ± 0.26
10	7.76 ± 0.25	7.89 ± 0.28	7.88 ± 0.25	7.58 ± 0.22
12	7.16 ± 0.28	7.72 ± 0.28	7.50 ± 0.27	7.50 ± 0.28
14	7.35 ± 0.24	7.61 ± 0.27	7.50 ± 0.25	7.50 ± 0.28
16	7.28 ± 0.31	7.43 ± 0.47	7.38 ± 0.29	7.13 ± 0.25
18	7.10 ± 0.41	7.25 ± 0.28	7.38 ± 0.25	7.09 ± 0.25
20	7.02 ± 0.53	7.13 ± 0.30	7.20 ± 0.00	6.90 ± 0.00
22	6.94 ± 0.44	6.98 ± 0.47	6.98 ± 0.25	6.93 ± 0.28
24	6.75 ± 0.00	6.86 ± 0.32	6.76 ± 0.27	6.75 ± 0.30

*Values are mean ± standard deviation of 10 observations

Table 3: Sensory evaluation (Overall Acceptability) of thermal processed fishery products in different curries stored at ambient temperature.

coating on either side), respectively. The percentage overlap of polymer coated tin free steel cans is 63.3% which is higher than the required value of 45%. The results of double seam parameters done by using manual method was compared with that of the results by using the semi automatic double seam analyzer Sea Metal 9000M and good agreement could be achieved between the two methods. Testing for lacquer coating integrity of polymer coated TFS cans using LCB detector indicated that 97% of the tested cans had polymer coating free from any defects. The cans were found to be resistant to sulphide blackening which indicates the perfection of the polymer coating.

The indigenous polymer coated TFS cans was compared with other commercially available cans and its suitability for thermal processing and storage of fish and fishery products. All the containers were found to have percentage overlap which is much higher than the prescribed limit. Upon testing for pressure holding capacity, both tin and TFS cans were found to withstand an internal air pressure up to 30 psi without showing any bulging for the prescribed period of 15 seconds. Test for lacquer coating integrity using LCB detector indicated that the polymer coating of TFS cans are superior. On the contrary, about 97% of the TFS cans tested were found to pass the LCB test indicating the perfection of the polymer coating. The extractive value for TFS cans using distilled water as stimulant was 6.9 ppm, respectively whereas the chloroform soluble extractives for the same were 0.64 ppm respectively. The suitability TFS of cans for storage of fishery products showed that tin cans developed rusting on internal and external surface even at the sixth month of storage. TFS cans were free from any signs of rusting even at the end of 12 months and it extended up to 18 month storage period. TFS cans exhibited excellent content releasing property while fish pieces were found attached to the walls of tin and aluminium cans. Development of black discolouration could be noted on the inner surface of tin cans while TFS cans were free from any sulphide stains on storage. The raw materials used for the development of ready to eat thermally processed fish products were found to be in fresh condition. The values for various biochemical and microbiological parameters of the raw materials were well within the limits. Based on the analysis of commercial sterility, instrumental colour, texture and sensory parameters, Fish, shrimp, crab and mussel curry processed to Fo 7 min with total process time of 44.0 min and cook value of 91.1 min was found to be ideal and was selected for storage study Pushparajan et al. (2012) [10].

Fish, shrimp, crab and mussel curry thermally processed in indigenous polymer coated TFS cans were found to be acceptable even after one year of storage at room temperature based on the analysis of various sensory and biochemical parameters. The study indicated that the suitability of indigenous polymer coated TFS cans for processing at high temperature and pressure. The cook value was found to exhibit an inverse relationship with processing temperature ($p<0.05$) and was maximum at 115°C and minimum at 130°C. The cut out analysis of TFS cans are given in table 2. The percentage for body hook butting was 70.42% and percentage of overlap was 63.3%. This result indicates that the efficiency was perfectly in order and the values were well above the minimum prescribed limits [11]. Sensory evolution of fishery products caned 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 3. The fishery products were acceptable even after 24 months of storage at ambient temperature. The initial overall acceptability score of about 8.75 and it was gradually reduced to around 6.78.

The heat penetration data was plotted on an inverted semi log paper with product Temperature deficit (RT-CT) on vertical log scale (Y-axis) against time on the linear horizontal scale (X-axis) as described in NCA manual (1968) [12]. The lag factor of heating (jh), lag factor of cooling (jc), slope of heating curve (fh), time in minutes for sterilization at retort temperature (U), Temperature deficit (g), Cooking value (Cg), Process time (B) and Total process time (TB) were determined. Cooling curve was plotted and cooling process parameters were determined as described by Ramaswamy and Singh [13]. Using these parameters the

Filling medium	**jh**	**jc**	**fh**	**U**	**g**	**Cg(min)**	**B(min)**	**TB(min)**
Fish curry	1.134	1.26	29.15	2.54	0.98	121.1	50.30	53.60
Shrimp curry	1.084	1.09	14.58	1.81	1.81	69.73	46.42	50.48
Crab curry	1.12	1.08	6.02	2.42	2.73	108.2	35.70	40.43
Mussel Curry	1.11	1.07	24.48	3.00	1.49	121.1	50.81	54.72

(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) Temperature deficit,(Cg) Cooking value (B)Process time, (TB)Total process time.

Table 4: Heat penetration data of thermally processed different fish curries filling mediums in polymer coated TFS cans.

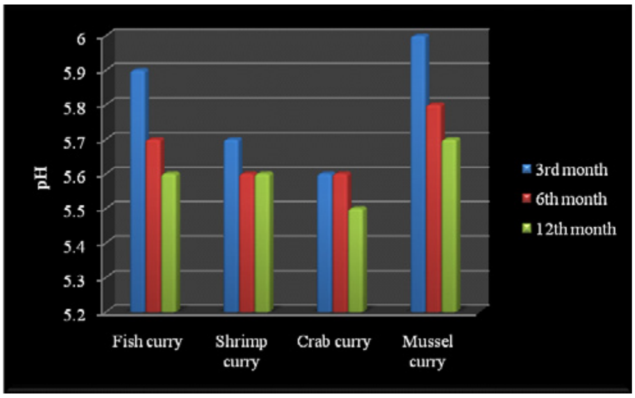

Figure 1: Change in the pH of fish, shrimp, crab and mussel curries during storage at room temperature.

Various curry	F° Value	Shelf life at ambient temperature (28 ± 2°C)
Fish curry	10	More than 18 month
Shrimp curry	10	More than 18 month
Crab curry	9	More than 18 month
Mussel curry	9	More than 18 month

Table 5: Shelf life of different fish curry products processed in TFS can.

process time (B) was calculated according to mathematical method [14]. The total process time was calculated by adding 58% of come up time (CUT) to B (Table 4). The Sterilization Value (F_o value) recommended for the thermal processing of fish products ranges from 5-20 [15]. In the present study F_o was taken as optimum process required and all the products were processed to F_o 10. It was observed that the products processed in different filling curry medium to F_o value of 10 were commercially sterile.

Storage analysis of Hydrogen ion concentration (pH) is of relevance in the case of muscle foods as it affects its texture. In case of heated fish muscle, an exceptionally high effect of pH on the toughness was reported at the range 5.7, 6.7 [16]. In the pH of curries during storage is summarised. It can be seen that the initial pH of fish, shrimp, crab and mussel curries are 5.9, 5.7, 5.6 and 6.0 respectively indicating that it is towards the acidic side. The acidic nature of the product can be attributed to the acidity contributed by the curry ingredients like tomato. During storage, the pH of the products was found to exhibit a decreasing trend. On the 6th, month of storage, the pH of fish, shrimp, crab and mussel curries were found between 5.7,5.6, 5.6 and 5.8 respectively which are significantly lower as compared to initial values. On the 12th month of storage, the pH of fish, shrimp, crab and mussel curries were 5.6, 5.6, 5.5 and 5.7 respectively (Figure 1). The results of present study agrees with the findings of Mallick et al. [17] who reported a decreasing trend in pH in case of north Indian style rohu curry stored in cans after 6 months of storage at room temperature at 37 ± 2°C . Mohan (2004) reported a slight reduction in the pH of kuruma shrimp upon storage in both retort pouch and aluminium cans [18].

The instrumental analysis of colour values of all four sample of fish, shrimp, crab and mussel curries had initial L* value of 16.85. This low lightness value was due to the addition of curry ingredients. With storage the L* value exhibited significant reduction in the case of all the four samples. The L* value of fish, shrimp, crab and mussel curries at the end of storage study was 14.85, 15.6, 14.17 and15.71 respectively. The initial a* value of fish, shrimp, crab and mussel curries are 8.23, 8.19, 8.4 and 8.36 respectively [10]. The higher a* value can be attributed to the addition of tomato and red chilly as curry ingredients. The a* value was found to increase slightly with storage and was 9.39, 9.31, 9.4 and 8.85 at the end of storage study. The b* value of fish, shrimp, crab and mussel curries on the first month of storage was 18.97, 19.21, 18.20 and 15.87 respectively which storage does not change appreciably. The b* value at the end of 12 month storage was 19.18, 19.82, 19.55 and 15.92 for fish, shrimp, crab and mussel respectively.

Shelf life of fish, shrimp, crab and mussel curries medium processed in the TFS cans are presented in the table 5. All products showed a shelf life of more than 18 months at ambient temperature and were commercially sterile. The processed fishery products were found to be sterile and acceptable even after a period of 12 months at ambient temperature [19,20]. The results of the present experiments showed that the polymer coated TFS cans are suitable for processing fishery products [17]. Polymer coated TFS cans was found to withstand all the conditions of thermal processing. The TFS cans which are now available in India can be used for thermal processing of various fish products as a substitute to other packs. The present studies suggest that the indigenous polymer coated TFS cans are suitable for thermal processing and storage of various fish and fishery products. The Indigenous polymer coated TFS cans was found to be superior over conventional tin and aluminium cans. The ready to eat fish, shrimp, crab and mussel curries processed in TFS cans could be stored at room temperature with acceptable qualities for more than one year. The study also indicated that indigenous polymer coated TFS cans with easy open ends can be a viable alternative to the conventional tin and aluminium cans. The fishery industry can utilize these cans for processed ready to eat fish and shellfish products for both domestic and export markets. This will help in reviving the canning industry in India.

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