6. SUMMARY AND CONCLUSIONS
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Fish occupies a prominent role in human nutrition. The value of fish for human nutrition lies in the relatively high protein content, good digestibility and high biological value of fish proteins. Fish is consumed in many forms in the developed countries; the value added fish products are consumed in substantial quantity. In today's affluent society, people prefer to buy ready-to-cook and ready-to-serve convenience products from supermarkets than buying raw fish, which is cumbersome to prepare for the table. All over the world, the tendency now is to take convenience foods, such as assembling meals, rather than preparing from basic ingredients. Besides exports, demand in internal market for convenience product is increasing in India. Among different value added food products, canned product is one of the most important one.

Canning is defined as the process of heating hermetically sealed foods to a temperature that kills harmful microbes. The containers may be made of metal, glass or any other material that is airtight and heatable. For the purpose of canning, different containers are used such as glass, tin, Tin-Free steel, aluminium etc. Several workers have tried to preserve the fish products in tin containers. 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, expensive and are difficult to open. In the case of aluminium cans earlier studies were carried out using imported aluminium cans which are not cost effective. India exported very insignificant quantity of canned shrimps amounting to 3.5 tonnes valued at 4.4 lakh rupees in 1996. This quantity is less than 1% of the total seafood exports of 353675 tonnes during that year. There after no significant export of canned seafoods has taken place. Most of the canned seafood production is going for the defence supplies and small quantity to the domestic market. Global trade of canned seafoods during 2000-2001 worked out to be 9379 million US dollars. Export of
canned seafoods reached its zenith in 1997-1998, which was found to be 9476 million US dollars. The USA, UK, France, Japan, Germany and Canada were the leading importers. Thailand is the major exporter of canned fishery products and become the market leader by exporting 2069 million US dollars of canned seafoods.

The fish like tuna, sardine, mackerel and others now being exported from the country to neighboring countries in the form of raw material could be canned with value addition. With our sound infra structure and availability of relatively cheap labour prospects for developing an export oriented canning industry are very bright. It is relevant to draw examples from Maldives, Mauritius and Seychelles where massive canneries bank only on their rich raw material base and successfully run a global trade in canned seafood by heavily relying on imported material and expertise inputs.

The canning industry got a boom in India in the late fifties, mainly intended for canning of prawns for the export market. Export of this commodity started in the year 1959 which after touching the highest record of 2,200 tonnes worth Rs.52.4 million in 1973 records a steep fall due to the very same reasons that caused the closing down of the first fish canning factory in the country. One of the major factors for downfall of the Indian canning industry is inadequacy of indigenous tin cans with respect to their quality and price. The quality of lacquer, the finish and diversity are the elements essential to ensure shelf life and consumer appeal. In India, the price of the can alone works out to nearly 30% of the cost. Added to the cost of labour, cartons and other items shoot up to 50% of the total production cost making it ill affordable to the average Indian consumers and not competitive in most of the overseas market. In India the most promising alternative to tin cans for fish canning is found to be aluminum cans since the basic ore of aluminium Bauxite is available in large quantities. Recently some companies had ventured in to the indigenous manufacture of
aluminium cans. In India, only Klass Engineering Pvt. Ltd, Bangalore manufactures aluminium containers for food canning.

The present study was aimed to find an alternative container to tin cans for fish canning with emphasis on the suitability of indigenous aluminium cans and heat penetration and process time calculations. The physical properties of the aluminium cans studied include: Test for Lacquer, Air pressure test, Resistance to sulphur staining and impermeability, Test for suitability of can for food contact applications, and cut out analysis. The test cans had a dry lacquer film weight of 4.2 gms/m$^2$. The lacquer also gives positive results for phenolic epoxy resins. The air pressure test showed that the cans withstood internal pressure of 25 psig. So the mentioned aluminium cans have got the required strength to withstand the processing conditions. Results of experiments also showed that 8 oz aluminium cans used for the study don't require overpressure during thermal processing. The test aluminium cans had water extractives of 0.07 mg/ sq. inch and chloroform extractives of 0.04mg/ sq. in. The extractive values are much below those specified by FDA, which implies that the test aluminium cans are quite suitable for food contact applications. The cut out analysis showed that the indigenous aluminium cans have got a good overlap of 62.16% and the body hook and cover hook are 0.1596 cm and 0.1501 cm respectively. Cut out test revealed the double seaming suitability of aluminium cans.

Canning studies were carried out in aluminium cans (8 oz) using tuna in oil tuna in brine, tuna curry, mackerel in oil, mackerel in brine and mackerel curry. Tuna in oil were thermally processed to Fo 5, 7 and 10 and with Fo10 and rpm 2,4, and 6 to study the heat penetration. Total process time (B+0.42 of come up time) taken to reach an Fo value of 5 was 44.31 minutes, Fo 7 was 57.07 minutes and for Fo 10, it was 64.43 minutes. The Cook Values obtained during the process were 86.52 minutes for Fo 5, 103.78 minutes for Fo 7, and 121.65 minutes for Fo 10. From the study it was found that Fo 10 is found good for tuna.
according to cooking and sterility characteristics. Aluminium can filled with tuna in oil were subjected to different rotational speeds (2, 4 and 6 rpm) by subjecting to heat processing to the same Fo value to study the changes in heat penetration. There is decrease in process time with increase in speed of rotation. The total process time taken to reach an Fo value of 10 with 2 rpm was 57.22 minutes, Fo 10 with 4 rpm was 56.16 minutes and Fo 10 with 6 rpm was 55.38 minutes. The corresponding cook values are 115.35 minutes, 114.45 minutes, and 108.93 minutes. Finally, Tuna in brine and Tuna in curry were heat processed to F0 10 and studied the heat penetration characteristics. Total process time taken in the case of Tuna in brine was 41.03 minutes with a cook value of 96.60 minutes and total process time taken in the case of Tuna in curry was 58.33 minutes with a cook value of 113.43 minutes. Tuna in brine has got much faster heat penetration compared to Tuna in oil and Tuna in curry and resulted in a less total process time.

Mackerel in oil were initially heat processed to Fo 5, 7 and 9. Total process time taken to reach a Fo value of 5 was 34.06 minutes, Fo 7 was 41.29 minutes and Fo 9 was 45.09 minutes. In the case of mackerel Fo value of 9 was taken as optimum depending upon the sterility, cook value and also the softening of the bones. Cook value for mackerel in Oil processed to F05 was 70.60 minutes; F0 7 it was 86.23 minutes and for mackerel in oil, processed to F0 9 was 100.53 minutes. In the next stage mackerel in oil were subjected to different rotational speeds 2, 4 and 6 rpm) by heat processing to a Fo value of 9 to study changes in heat penetration. Total process time taken to reach a Fo value of 9 with 2 rpm was 42.28 minutes, for Fo 9 with 4 rpm was 41.38 minutes and for Fo 9 with 6 rpm was 38.22 minutes. The cook value of Mackerel in Oil processed with F0 9 with 2 rpm was 95.09 minutes, with 4 rpm was 94.49 minutes and for 6 rpm was 84.60 minutes. In the last stage, mackerel in brine and mackerel in curry were heat processed to Fo 9 to study the changes in heat penetration. Total process time taken to reach an Fo value of 9 in the case of mackerel in brine was
38.06 minutes and in case of mackerel in curry, it was 57.31 minutes. The cook value of mackerel in brine processed to Fo 9 was 92.83 minutes and mackerel in curry processed to Fo 9 has got a cook value of 116.25 minutes.

Sterility tests were done in all the cases and all the Fo values tried both in the case of mackerel and tuna were found to be sterile. But in the case of tuna products an Fo of 10 was taken due to better texture and optimum cook values and in the case of mackerel products Fo 9 was taken due to the optimum cooking and also due to the better softening of bone.

Tuna in oil, tuna in brine and Tuna in curry medium were heat processed to Fo10 and mackerel in oil, mackerel in brine and mackerel in curry were heat processed to Fo 9 and stored at room temperature and at 37°C to determine the shelf life. The characteristics studied include changes in TBA value, pH, Sensory characteristics and Texture profile analysis. In all the tuna products, stored at room temperature, and at 37°C, TBA value were increasing upto a certain period of storage and decreasing after that when stored for a period of 12 months. In the case of mackerel products also, TBA value increases upto a certain period and thereafter it decreases. pH of all the products remain more or less unchanged during the 12 months period of storage. Sensory score of tuna in oil stored at room temperature after 12 months of storage was 6.75 and that stored at 37°C was 6.63. Sensory score of tuna in brine after 12 months of storage was 6.50 in the case of product stored at room temperature and that of 37°C was 6.25. Sensory score of tuna in curry stored at room temperature was 6.00 and that stored at 37°C was 5.50 at end of storage period. After 12 months of storage tuna in oil stored at room temperature was more acceptable compared to any other tuna products.

Mackerel in oil had a sensory score of 6.00 when stored at room temperature and stored at 37°C had a sensory score 5.75 after 12 months of storage.
Mackerel in brine at room temperature had a sensory score of 6.38 and that of accelerated temperature obtained a sensory score of 5.88 after 12 months of storage. Mackerel curry stored at room temperature had a sensory score of 5.75 and that stored at 37°C obtained a score of 5.50. Among all the products mackerel in curry resulted in least acceptable sensory score according to sensory evaluation after 12 months of storage.

Hardness of the products increased up to a certain period of storage and then it decreased. In the case on tuna in oil and tuna in curry hardness increased up to 4 months of storage and then hardness decreased. Tuna products stored both at room temperature and at accelerated temperature are having a cohesiveness of almost 0.3 during the entire period of storage. Like tuna products hardness of mackerel products are also increasing up to certain period of storage and then it decreasing. In the case of mackerel products cohesiveness is about 0.2 during the storage period. Springiness in the case of mackerel products varied between 2.5 mm and 3 mm during the period of storage. Compared to mackerel products tuna products had a hard texture as indicated by the hardness. Estimation of aluminium in the canned fish after 12 months of storage indicated that there is not any significant migration of aluminium into the product, indicating the very good lacquer quality.

Finally transportworthiness tests of finished products were carried out in master cartons. It has passed the tests like compression; drop test, vibration test and rolling test. Transport worthiness tests indicate the master carton prepared out of 120 gsm Kraft paper withstand all the transport worthiness tests like drop, rolling and vibration tests. The research findings can be summarized as follows.

- Indigenous aluminium cans are found suitable for the thermal processing of fish products.

- 8 oz aluminium cans do not require over pressure for thermal processing.
• Tuna products require a Fo of 10 for optimum sensory and textural characteristics.

• Mackerel products require a Fo of 9 for optimum sensory and textural characteristics.

• There is reduction in process time with the increase in the speed of rotation for the same Fo value (Fo 10 in the case of tuna and Fo 9 in the case of mackerel). 2 rpm is found to have an efficient reduction in process time.

• The three Fo values were found to be sterile in the case of mackerel and tuna products.

• Migration of aluminium from the can to the product is very insignificant.

• All the products were acceptable at the end of storage period. Comparatively curry products were least acceptable.

There are high prospects for canned seafood exports as the consumption of canned seafood abroad is on the increase. The advantages of reviving the seafood industry in the country will increase our export earnings. Similarly the fishing industry will also be benefited whenever the freezing sector reduces their production due to fluctuating overseas market. The reduction in cost of processed food may also increase domestic consumption of canned seafood. Therefore, the future for marketing canned seafood is very bright by using indigenous aluminium containers.