UTILIZATION OF SARDINES*

P. MADHAVAN & T. S. UNNIKRISHNAN NAIR
Central Institute of Fisheries Technology, Cochin-11

Oil sardine *Sardinella longiceps* stands out as the single largest pelagic fishery in India contributing to about 30% of total marine fish landings. Commensurate with the volume of the fishery, efforts at proper utilization of the fish by processing into canned and frozen products or by distributing in fresh state to internal consuming centres by quick transport have remained rather very poor. The paper presents the problems and prospects with regard to the utilization of the fish on the above lines. Results of investigations made at C. I. F. T. on the utilization of sardine body oil into industrially useful products such as factice, vehicle for paints, additive in lubricating oil and base for printing ink have also been discussed.

INTRODUCTION

Sardines, belonging to the family of clupeoids is widely distributed in tropical marine environment and constitute the largest single fishery in India. *Sardinella longiceps*, known as the oil sardines is the most important among the group and contribute more than 25-30% of the total marine landings in India (Table I). More than 80% of the annual average catch of sardines is contributed by *S. longiceps* while the rest is constituted by other less known species like *Sardinella fimbriata*, *Sardinella gibbosa*, and *Sardinella sirm*.

TABLE I

Yearwise Landings of Sardine in India

Quantity in Metric Tons.

Year	Oil sardine	Other sardines	Total Marine landings	% oil sardine with respect to total
1964	274333	40398	859582	31.9
1965	261863	42770	832777	31 4
1966	247214	64643	890311	27.7
1967	256326	37261	891888	28.5
1968	301641	43450	934611	32.2
1969	174249	52467	913630	19.0
1970	226984	55239	1077466	21.0
1971	208982	63775	1154822	18.9

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Oil sardines are available from west and east coasts of India. Their occurrence in the east coast is reported as sporadic and the specimens are less fatty compared to their counterparts at the Malabar coast (Antony Raja, 1969), the main sardine fishery being dependant on other species mentioned above. The fishery is heavily concentrated along the west coast bordering Mysore and Kerala.

Oil sardines is a fishery which has exhibited wide fluctuations showing a variation in contribution from as low as 1% to as high as 32%, the respective figures being 7412 tons in 1956 and 301641 tons in 1968. Fishing season also is restricted commencing with the premonsoon showers, becoming regular by July— August, the peak season being October to January, declining thereafter and ending by March. Seasonal variation in landing is more predominant along the Mysore coast than the Kerala coast.

Even though in composition and nutritive value (Table II) oil sardine compares very well with other relished fishes the price realised, particularly during peak seasons are often very poor because of the lack of means of quick transport to the consumers in the interior, improper methods of handling and preservation and probably because of the peculiar flavour of the fish resulting from high oil content. However, with the provision of a net work of motorable roads connecting the landing places with the interior markets, employment of quick means of transport like trucks, availability of ice at landing places and the improved technical knowhow, the consumption of this fish in the fresh form has showed a commendable upward trend.

TABLE II

Proximate composition of sardine fish.

Moisture	65.28%
Fat	14.34%
Crude Protein	18.10%
Ash	1.65%
Inorganic phosphrous	175 mg%
α-amino Nitrogen	105 mg%

In spite of the high landing figures and the prominence this fishery enjoyed over others by its volume, industry based on this did not develop to any significant extent. High capital cost involved, short duration of the fishery, unsteady supply of raw material due to high fluctuation and above all, the technological problems involved in handling, preservation, processing and transport of the fish may be some of the reasons. This paper presents an account of the problems and prospects of the oil sardine industry with particular reference to transport in fresh condition, freezing, canning and utilization of body oil for industrial purposes.

PRESERVATION AND TRANSPORT.

Expeditious transport of oil sardine to the potential markets situated thousands of kilometres away from the landing places has not been easy. Conventional practice of preservation by icing is not effective due to the high oil content. Even the introduction of refrigerated trucks and rail wagons in limited numbers has not been able to solve the problem to any significant extent. The main problems linked with low temperature preservation and transport of fresh fish are the selection of a cheap and efficient container, economy of use of ice, and a detailed knowledge of physical and chemical changes of the fish like:

a) *Belly bursting.* During ice storage, freezing and thawing belly flaps break letting the viscera protrude out by which,

though the fish remains unaltered in quality, the consumer appeal is reduced. This is influenced by maturity of the fish, fat content and nature of stomach contents. (Perigreen and Govindan, 1969)

b) *Rancidity*. With high fat content and degree of unsaturation the incidence of rancidity is very high.

c) *Loss during ice storage*. 5 days ice storage results in a weight loss up to 5% accompanied by loss in nutritive value due to loss of soluble protein components and the considerable changes occurring in the major protein fractions (Devadasan and Rajendranathan Nair, 1970). Further, it has been shown that canned and frozen products prepared from ice stored sardines kept for more than two to three days are sub-standard (Madhavan, Balachandran and Choudhuri, 1970; Vasanth Shenoy and Pillai, 1971).

As regards the containers for transport, investigations have shown that sardines could be preserved for 10-12 hours in bamboo baskets when packed with 1:1 ice and for 14-18 hours in tea chests. By providing an inner lining of gunny and polythene or bitumen-coated kraft paper the storage life could be further increased up to 18-20 hours (Rao and Perigreen, 1964). When the tea chests are insulated with 25 mm thick thermocole covered with polythene (to prevent wetting of thermocole) the storage life goes up to 55-60 hours (Anon-1965).

FREEZING.

Freezing is an alternate method for prolonged preservation of the fish. Belly bursting is a serious problem encountered here. This phenomenon, found to be a maximum in small size sardines with low fat and minimum with bigger specimens with high fat could be overcome by a dip treatment in 15% brine for 30 minutes prior to freezing (Perigreen, Govindan and Pillai, 1969).

Taking advantage of the above findings, attempts have been made in the country to transport bulk frozen oil sardines over long distances involving 3 to 5 days journey in tea chests/plywood boxes insulated with 25 mm thermocole. The fish did not show any apparent loss in quality. It will however, reach the end point in a thawed state.

The problem of oxidative rancidity in freezing and preservation of oil sardines could be effectively controlled by dipping the fish in 0.05% solution of hydroquinone for 5 minutes or in 0.4% agar agar solution (Cyriac Mathen, Choudhuri and Pillai, 1966). The influence of different pre-freezing ice storage period on the biochemical and organoleptic qualities in the individually quick-frozen and block frozen forms of sardines reveals that there is no significant difference in the above characteristics between the two forms of frozen sardines (Vasanth Shenoy and Pillai, loc. cit). Oil sardines loss their acceptability and shelf life if the pre-freezing ice storage exceeds three days.

CANNING.

Commercial canning of oil sardines is of relatively recent introduction in India. Although sardine occupies a commanding position as a fishery and provides one of the cheapest raw material for processing, canning of this fish for export has not received the attention it deserves irrespective of the vast opportunities it offers for export to foreign markets. Attempts at commercial canning of sardine has been very scarce and the few canneries that produce canned sardines cater mainly to the internal

TABLE III

Important of canned sardines by different countries in 1968-1970 from principal exporting countries.
(Year Book of Fishery Statistics, Fishery commodities F A O 1968)

Country	Import in tons		
	1968	1969	1970
U. S. A.	14,700	22,500	18,500
France	14,300	13,900	14,600
Italy	1,100	3,300	1,200
West Germany	7,400	9,200	6,600
U. K.	20,800	24,800	8,800*
Australia	4,800	5,100	4,700

* This figure does not include import from South Africa.

TABLE IV

Export of canned sardine by different countries 1966-1970 (Qty. in tons).
(Year Book of Fishery Statistics, Fishery commodities F A O 1968)

Country	1966	1967	1968	1969	1970
Morocco	36,800	34,900	41,100	39,100	36,300
S. Africa	32,200	32,800	35,900	33,300	24,400
Norway	23,600	22,400	23,900	22,000	23,700
Portugal	54,800	52,000	D N A*	30,900	28,300
Spain	9,400	7,000	12,700	17,900	26,800

* Data Not Available.

markets. To-day, there is an installed capacity for the production of a lakh of cans a day; however, the annual output is within a mere 33 lakh cans.

TABLE V

Production of canned sardine in India.

Year	*No. of cans*
1965	1213159
1966	2647172
1967	3296051
1968	1768082
1969	1576417

The principal impediments that might have stood in the way of developing a lucrative and voluminous sardine canning industry in the country might perhaps be:

a) Seasonal nature of the fishery and fluctuations in day today catch which will force the plant to be idle for most part of the year,

b) Non-availability of olive oil in India, and

c) Abnormally high cost of the containers for packing the fish.

A series of investigations conducted with small purse seines in the off shore zone upto 80 metres depth have consistently yeilded an average catch of 3.2 tons of sardines per haul (Devidas Menon, 1971). This, together with the observation that deep frozen fresh sardines can be kept in processable condition for short period upto two to three months and the expected explosion in sardine catch with the introduction of 5500 small and 300 large sized vessels by the end of the present plan (Madhava Raj, 1971) and the sucessful completion of the Pelagic Fishery Project can dispel the fears of unsteady supply of raw material. Instead, canning should emerge as the most important method for conservation and long term preservation of the catch.

Deodorized ground nut oil is the popular filling medium used in canned sardines in India. This medium, quite unpopular in importing countries, has limited the entry of our products to those markets. In world imports 70% are packed in soybeen oil, olive oil etc. While soybeen oil is most popular in U.S.A. and Canada olive oil is finding increased use in Western Europe. Further, diversification of the canned sardine products like 'Skinless and boneless flesh' type produced in Portugal and Morocco, smoked and packed in oil or sauce as done in Norway and the tomato sauce packs of South Africa can help very much in the entry of Indian products in the world markets. However, India produces at present a negligible quantity of sardines packed in tomato sauce.

The popular type of containers used by the Indian packers are the 1/4 dingly type cans with lip or the 8 oz. and 12 oz. round cans. The non-availability of containers popular with sophisticated consumers abroad like the aluminium cans with pull tab lid, the $\frac{1}{2}$ lb. oval cans or the three piece cans restricts the display of variety in containers. Tin plates required for the manufacture of cans are imported and aluminium cans are not manufactured in the country adds to the cost of containers exhorbitantly. The cost of containers itself averages nearly 40% the total cost of the canned product.

Besides, there are certain technological problems associated with the conventional oil packs of sardine. The most important among them is the presence of water in the fill which reduces the consumer acceptability in the importing countries particularly because of the lower shelf life of such products due to the increased incidence of P.V. and F.F.A. in oil (Varma, Choudhuri and Pillai, 1970).

Taking all such aspects into consideration, in order to improve the quality of canned sardines and to bring down the cost of production suitably modifying the process and packing medium, a good amount of work has been done at C I.F.T. and elsewhere in the country. The most important and promising outcome of such work, done particularly in C.I.F.T. appears to be the development of a process for 'Sardine Natural Pack' in which the fish is packed in its own juice. This saves labour and the cost of oil and yields an attractive product with flavour quite akin to the natural one, unparllelled in any other sardine pack known to the consuming markets. Methods have also been standardised for packing fish in tomato sauce and also for canning in oil pack with negligible amount of water in the fill. It has also been reported that sardines packed in a mixture of 1:1 ground nut and sardine oil increases the acceptability (Sen and Revankar, 1971). Attempts have also

been made to pack sardine in refined sardine oil itself.

Industrial Utilization Of Sardine Oil

With a very high content of body oil, the value reaching as high as 17% on wet weight basis, which incidentally coincides with the season of maximum landing, the fish, oil sardine, offers vast scope for proper exploitation of its oil in industry. In the earlier days, sardine oil was known mostly as a material used in painting the bottom of the fishing crafts. The method of extraction followed at present is crude by cooking the fish in iron vats with insufficient quantity of water yielding oil poor in quality with respect to colour, odour and other chemical characteristics. Methods have now been worked out for extraction of sardine oil with very good characteristics and comparable to fish body oils produced in other countries.

Besides it use in painting country crafts, the other uses of the low grade oil produced earlier were in the fat liquoring of leather, tempering of metals, batching of jute and in insecticidal soaps (C.S.I.R., 1962), the last of which, though less potent than organic insecticides, are non-toxic to man unlike the former (Velankar, 1968). The high unsaturation, easy susceptability to rancidity, flavour reversion and related changes create technological problems in its use in hydrogenated product, soap manufacture and domestic consumption (Madhavan and Kaimal, 1968). Controlled direct interesterification of the hydrogenated oil (hydrogenated under atmospheric pressure to I.V. 100) gives a butter like consistency (Sen and Revankar, loc. cit).

Refined sardine oil produced by the modified process has the following characteristics.

Table VI

Comparison of the qualities of oil prepared by the improved method to those of the commercial oil.

	Commercial oil	Oil prepared by improved method.
Colour	Deep brown to black	Light yellow to brown
Clarity at room temperature	Turbid	Clear
Odour	Rancid	No rancid odour
Refractive index	1.4780	1.4755
Sp. gravity	0.9250	0.9219
Moisture%	0.25 - 0.62	0.20 - 0.40
Nitrogen	0.02 - 0.10	Nil
Saponification value	190 - 198	192 - 195
Iodine value	99 - 161	152 - 175
Peroxide value	0.4382 - 7.2	0.32 - 2.7
Unsaponifiable matter%	0.84 - 1.55	0.83 - 1.55
Free fatty acids%	5·8 - 49.58	0 56 - 3.89

Fatty acid composition of the lipids of oil sardine shows a high content of polyunsaturated fatty acids constituted by decosahexaenoic and eicosa pentaenoic acids (Gopakumar and Rajendranathan Nair, 1966). Polyunsaturated acids are

known to be pharmacologically important as they may keep the cholesterol content in the blood low thereby lowering the incidence of heart disorders (Velankar, *loc. cit*). A method has already been worked out for the isolation of the highly unsaturated fraction of fatty acids from sardine oil.

Refined sardine oil could be used in the manufacture of hard soaps after hydrogenation at about 100 p.s.i.g. and 150-170°C using 2% Rufert Nickel catalyst for 5 hours when the oil becomes hard pale white solid with I. V. 10 (Aggarwal, 1968). The netural sardine oil can be split into fatty acids by fractional distillation into three groups. (Kotwal and Pai 1968).

(a) Fraction ,with I.V. 65-82 with a yield of 47-58% constituting both saturated and unsaturated fatty acids up to and including C_{18} with comparatively little fishy odour, when properly mixed with other oils can be used in the manufacture of laundry soaps;

b) A low yield of 5-20% of poly unsaturated fractions with I.V. of about 220, comprising mainly of arachidonic, clupanodonic and other unidentified fatty acids, useful in paints; and

c) A non-distillable polymerised unsaturated fatty acid, neutral sardine oil and unsaponifiables finding its acceptance in varnish manufacture.

Yet another possible utilization of sardine oil is in the manufacture of oil modified alkyd resins using penta erythrytol and phthalic anhydride (Ahluwalia, 1968). Another introduction is "distilled fatty acids" (paint type), a mixture of poly unsaturtted fatty acids arachidomnic and clupanodonic with high unsaturation (I.V. 230-250) of the conjugated type alongwith a lower grade "polymerised oil" suitable for dark colour varnishes.

An important breakthrough in the possible utilization of modified sardine oil for industrial purposes was achieved as the results of investigation carried out at the Central Institute of fisheries Technology. Standard methods have been worked out for the conversion of heat bodied and air blown sardine oil into a variety of products of industrial importance. Factice, a filler used in rubber compounding industry, is prepared by treating sardine oil, whose I.V. is reduced to 80-100 by preheating, with 20% elemental sulphur added in small amounts with stirring at 180-200°C and by adding at the final stage 10% raw sardine oil. The comparison of the property of sardine oil factice with a commercial sample in a treadmix is given in table VII.

TABLE VII

Properties of commercial factice and sardine oil factice in a tread mix.

	Commercial factice	Sardine oil factice
Moony scorch mts.	16	13½
Tensile strength (lbs./in²)	2750	2600
Modulus 300% (lbs/in²)	1500	1800
Elongation%	550	450

Stearine separated and heat bodied sardine oil can be used as a vehicle in paint and printing ink industries in place of linseed and other vegetable drying oils and as an additive in lubricating oil (Madhavan and Kaimal, loc. cit.).

FISH MEAL

The press cake left after extraction of oil from oil sardines forms one of

the chief source of raw material for the manufacture of fish meal, which can be used as a cattle or poultry feed by suitably formulating with shrimp waste and other ingredients. The most common form of fertilizer is fish guano, the residue left after oil extraction by the crude method. This is generally beach-dried and is found to contain 8 - 10% nitrogen. The trimmings and wastes from the sardine canning factories will constitute a good source for manure. It has been reported that sardine press cake can be used for preparing liquid fertilizer in combination with shrimp wastes giving 2 different NPK ratios, 8 8:16 and 7: I0:15 suitable for common crops like coconut, ginger, tapioca, pepper and vegetables. (Ismail and Madhavan 1970)

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