PROCEEDINGS OF THE

NATIONAL CONFERENCE ON TUNAS

21 & 22 APRIL 1989, COCHIN

Sponsored by

INDIAN COUNCIL OF AGRICULTURAL RESEARCH,
FISHERY SURVEY OF INDIA,
MARINE PRODUCTS EXPORT DEVELOPMENT AUTHORITY,
SHIPPING CREDIT AND INVESTMENT COMPANY OF INDIA,
ASSOCIATION OF INDIAN FISHERY INDUSTRIES
AND
SHIPYARDS ASSOCIATION OF INDIA

Organised by

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
P. B. No. 1603, COCHIN - 682 014

APRIL 1993

Limited Circulation

Published by

Dr. P. S. B. R. JAMES

Director

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

COCHIN - 682 014

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Cover Layout : Shri A. A. Jayaprakash

PROCESSING AND UTILIZATION OF TUNA

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INTRODUCTION

Popularly known as chicken of the sea, tunas comprising of a number of species forms a major world fishery. Against a world landing of 3,418,450 tonnes in 1986 the annual Indian catch is 30,000 tonnes eventhough the estimated annual exploitable resources in the country's Exclusive Economic Zone is around 2,00,000 tonnes. However, no organised effort has so far been made in the commercial exploitation of these species. Proper exploitation of these resources can, no doubt, add a new dimension to the Indian fishery sector by way of expansion of their catch and also provide a new raw material for the much needed diversification programme of its processing sector.

Tuna, fresh or processed in different styles, is a very important commodity in the world trade for fish and fishery products. The quantum of world production and trade in tuna and tuna products are presented in Tables 1a and 1b. But for some sporadic instances our contribution to the world trade in tuna and tuna products has been quite insignificant as is evident from Tables 2a,b where the data regarding export of processed tuna from India over a decade are presented.

Considering the above it can reasonably be assumed that if we step up exploitation of our tuna resources to a logical level and develop the necessary technological base to process them into products as needed by the overseas buyers, there is ample scope for development of a tuna based industry in our country. However, it should be emphasised that the success of an export market will also depend on the simultaneous development of a strong domestic market and promotional efforts are needed in this sector.

The tuna fishery of India is mainly located near Lakshadweep and Andaman islands. Their catch is mostly skipjack (Katsuwonus pelamis), a light meat variety tuna, most of which is going for preparation of 'Mas', canning as also for fresh consumption. The mainland catches from the inshore waters consist mostly of coastal tunas and bonitos which are the red meat varieties and are not very much relished as food fishes. They have a high proportion of red meat around the back bone and their flavour and taste are not acceptable.

White and light meat varieties of tuna like the albacore and yellowfin tuna have great demand in the export market either in fresh or processed form. However, these being oceanic species used to occur only sporadically in the Indian catches and therefore most of the research work reported from India on tuna are on the skipjack and little tuna (Euthynnus affinis).

BIOCHEMICAL COMPOSITION

Red and white meat of tuna show distinct differences in their biochemical compositions. Moisture, protein, nonprotein, nitrogen, sarcoplasmic proteins, free amino nitrogen, lactic acid, inorganic phosphorus and ribose are more in white meat while salt soluble protein, glycogen, fat, pigments etc. are more in the red meat. Concentration of haemoglobin and myoglobin are about five times more in red meat than in white meat. The red meat which is about 11% of the whole weight of the fish is accumulated more in the middle portion (12.8%) compared to the head (10.5%) or tail (9.5%) portions.

Moisture content shows a decreasing trend from head towards tail both in white meat and red meat. A similar trend is noticed with respect to salt soluble nitrogen which may be accounted for by the higher content of connective tissues in the tail portion. However, increase is noticed in the amino - nitrogen, ribose and inorganic phosphorus from head towards tail portion in red and white meats. Pigment concentration is more in the middle portion and fat accumulation is more in the red meat. Fat shows a decreasing content from head towards tail. Organoleptic evaluation also has shown the middle portion as better than the meat at head or tail portion (Chinnamma George, 1975).

NUTRITIONAL EVALUATION OF WHITE AND RED MEAT OF TUNA

Beause of the concentration of pigments, changes in which are more associated with the off odours of tuna and fat, which can easily undergo oxidation resulting in changes in flavour, red meat has a peculiar taste often not liked by consumers. However it is nutritionally comparable or even superior to white meat. It is significant to note that the protein of red meat is rich in essential amino acids and is also a rich source of energy and fat soluble vitamins A and D. Lipids of red meat has a high content of all essential amino acids. Red meat is also a rich source of iron. Proximate composition and calorific value of white and red meat is presented in Table 3 while their amino acid composition is given in Table 4. Requirements of aminoacids for humans per day as per FAO/WHO standards is given in Table 5 which definitely show that tuna meat in general and red meat in particular is an ideal source for all these essential amino acids. Mineral contents of tuna meat in comparison with that of skim milk powder is given in Table 6. Vitamin A and D contents in tuna meat are presented in Table-7.

The above data clearly indicate the superiority of red meat over white meat in several respects. Animal feeding studies using albino rats with formulated diets containing white meat, red meat and casein conclusively proved that tuna proteins are better than casein as a growth promoter, the proteins of red meat being the best.

Tuna meat in general,and red meat in particular having thus been established as superior to white meat and casein with respect to content of essential amino acids, essential fatty acids, vitamins A and D and minerals, experiments were conducted to study its effectiveness in combating malnutrition and anaemia in growing children in the age group 1-6 years deficient in essential nutrients in association with the Intensive Child Development Scheme of the Government of Kerala. The diets studied had the composition given in Table-8.

The studies conclusively proved that red meat is as effective in providing essential amino acids as white meat and casein and also that red meat can substantially improve heamoglobin levels in anaemic children a capacity not seen in milk protein, white meat and other protein sources except liver. A summary

of the results of the child feeding trials is given in Table-9 (Mukundan et al.,1979; Mukundan, 1986).

FREEZING

Consumption of tuna is mostly in the canned form, but are mostly frozen on board, kept frozen and thawed immediately before delivery to the canneries. Brine freezing of whole tuna is the most popular method.

Some studies have been carried out on freezing and cold storage of skipjack in India. Skipjack was frozen as whole after evisceration and removal of gills, as fillets and as chunks and stored at -18°C. Periodical examination and evaluation of the samples biochemically as well as organoleptically showed that shelf life is maximum for whole fish estimated at 30 weeks and the least for fillets at around 20 weeks. During storage red meat becomes badly affected due to the changes in fat, particularly so in fillets which is also affected by dehydration (Chinnamma George, 1975).

Some of the major problems experienced in frozen tuna are the occasional development of green and brown discolourations which becomes evident on cooking. The pigment responsible for the normal pink colour in cooked meat is hemochrome, derived from the reaction of myoglobin with non-heme constituents. Browning is due to the formation of metmyoglobin in the muscle through autoxidation of ferrous myoglobin. Greening is due to pigments resulting from the oxidation of hemochrome that occurs when the meat is unduly exposed to oxidative condition during and after cooking.

Proper evisceration and removal of blood immediately after catch can reduce the risk of discolouration in tuna. It has been suggested that undesirable changes in yellowfin tuna meat can be averted if the fish is frozen at full rigor, stored at a temperature of -23° to -27° C and defrosted by still air at 10°C (Tanaka 1961).

CANNING

Canned tuna is a very popular item in several countries abroad particularly Japan, U.S.A., U.K., Canada as well as Western and Eastern Europe. There is

no organised canning activity in India meant particularly for tuna except for that at Minicoy where a plant set up exclusively for canning tuna can produce about 1500 cans of 200 g net wt each per day. Other plants on the mainland occasionally process canned tuna depending on the availability of raw materials and demand from the market. Apart from its export potential canned tuna is also steadily gaining a domestic market.

A recent study has estimated the annual sales of canned fish products in the domestic market as being between 1000 and 1500 tonnes of which 60% is consumed by the civilian sector and the rest by the Armed Forces. This survey also highlights a severe under supply of canned fishery products especially for the military use. It is also stressed that the domestic market could easily consume double the present quantity without any promotional activity. Products now popular in these markets are canned sardine and mackerel, shippers and hoteliers being significant consumers for canned tuna (Rogers, Coulter and Jeffs, 1986).

It should be emphasised here that due to shortage and consequent rise in the price of sardine and mackerel most of the canneries have not been able to supply steadily to these markets. They work only for periods ranging from 40-120 days per annum. The cost of sardine and mackerel rising to uneconomic levels for canning, tuna and related oceanic species are sure to gain a place of prominence in the Indian canning sector.

Indian Standards Institution (Now Bureau of Indian Standards) has laid down quality standards for tuna canned in oil (IS:4304, 1976). According to these specifications only those species specified in Table-10 can be used for canning. Of these the canning requirements for three species viz. skipjack, yellowfin tuna and bigeye tuna to yield products conforming to the quality requirements laid down in Indian Standards have been worked out (Madhavan and Balachandran, 1971).

A good quantity of Indian catches of tuna is comprised of dark meat varieties, a prominent one being little tuna (Euthynnus affinis) which is not covered by the species mentioned by ISI. The dull colour of the meat, high proportion of red meat and the generally unacceptable taste and flavour reduces its overall acceptability either for fresh consumption or processing. To improve its acceptability in canned form a process has been worked out which involves canning in oil

spiced with extract of red chilly. The red colour of oil masks the dull colour of meat and the slight pungency improves the overall taste and flavour of the pack (Balachandran, Vijayan and Jose Joseph, 1982).

Tuna canned in oil is most popular, but brine peak also is acceptable. A new trend is packing fish meat along with vegetables, peas, onions, etc. in spiced oil (Table 11).

MASMIN

A traditional product processed out of skipjack in Lakshadweep, masmin is a cured/smoked product. A substantial portion of the landed skipjack is converted into masmin. This is a product which also enjoyed some export market, particularly in the neighbouring south east Asian countries. However, the traditional product is processed employing crude methods and offers plenty of scope for improvement. With a view to improving its quality and increasing its marketability a modified method has been worked out which is as follows:

Fillets from fresh fish after washing are wound with ribbon like split green coconut leaves to prevent breaking of the meat and boiled for an hour in 3% salt solution or a mixture of sea water and fresh water in tinned copper vessel. After cooling the fish is smoked in a chamber for 3-4 hours. The coconut leaf winding is removed from partially smoked strips which are then dried for few hours. Smoking and drying are repeated three or four times until the meet strips are hard and dark brown in colour. The product has a normal shelf life of over an year. But with special care during storage and occasional redrying and resmoking it can be kept well for three to four years. Flow sheet for production of masmin is given in Table-12.

Being a low moisture product masmin is less prone to bacterial and enzymic spoilage. However it faces a serious threat in its susceptability to insect infestation, which occurs mostly when the product is in store. Infested products gradually gets reduced to a fine powder.

The islanders claim temporary protection against insect menace by covering the finished product with dry loose sand. As long as the product is under sand

insect activity may be kept curbed. But contamination by insect eggs might have already taken place at any of the stages of processing and under favourable conditions the eggs may hatch and larve may come out. This may occur in the product which is ready packed for the market.

A very simple and effective method has been worked out to control insect infestation in masmin. This involves heat treating masmin for 15 minutes at 125°C followed by cooling and hermetically sealing in suitable containers (Valsan, 1968).

TUNA SHAVINGS

Another smoked cured product processed out of tuna is 'fish shavings'. The method of preparation involves dipping tuna fillets in saturated brine for an hour followed by smoking at 70-80°C for eight hours. The smoked fillets are further dried in air at 70°C for about 16 hours. The fillets which have become very hard by this time are trimmed and converted into thin shavings using a carpenter's planer. This can be packed in polythene bags or glass bottles and can be stored at ambient temperatures. Shelf life of the product is estimated as six months (Lokesh, Chandrasekhar and Hanumanthappa, 1987). Flow sheet for production of tuna shavings is given in Table-13.

TUNA PASTE

Tuna paste is another traditional product in Lakshadweep. This is prepared from the water used for boiling tuna fillets for processing masmin. Traditionally three parts of sea water with one part of fresh water is used for boiling tuna fillets. The same water is repeatedly used for boiling fresh batches of fillets until the water becomes thick. It is then further concentrated to yield a thick paste. Scrappings of dried masmin is some times added to the paste which will increase its nutritional value. The paste is stored in earthen ware vessels and is used as a flavouring agent. Shelf life of tuna paste is normally one to two years. Apart from the particular flavour it imparts, tuna paste is also good nutritionally. Proximate composition determined on a representative sample of paste is given in Table-14 (Valsan, Kandoran and Rao, 1964).

TUNA MEAT PICKLE

An an appetizer and as a side dish, pickles made out of a variety of vegetables, fish, shell fish or meat find a prominent place in Indian cuisine. Though became popular only recently, fish pickles are gaining popularity in the domestic market. There is more or less a sustained export market also for this commodity. Tuna meat has been found quite suitable for processing pickles. Light salted and partially dried small pieces of tuna meat (including black meat) is fried in vegetable oil and is mixed with prefried ingredients like ginger, green chilly, garlic chilly powder, and other flavouring agents etc. It is then well mixed with the required quantity of vinegar and balance salt, allowed to stand for few days and then packed in clean dry wide mouthed glass jar and closed (Vijayan, Balachandran and Surendran, 1987). It has been observed in the case of tuna pickle that absorption of vinegar by the fried pieces of fish is rather slow which is turn affects the hemogeneous appearance of product. Addition of a small quantity of edible gum like gum guaiac can correct this defect.

TUNA MEAL

As is true of any fish processing industry tuna processing also turns out good quantity of waste. The viscera alone will work out 3-8% of the whole weight of tuna. Head, fins, bones and red meat, if not used for human nutrition as discussed elsewhere, will be available as waste. An efficient way of utilization of this waste will be converting them into fish meal.

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Table 1 a. Production of preserved and processed tuna commodities except canned

Qty. in tonnes

	1981	1982	1983	1984	1985	1986
Frozen (excluding fillets)	60620	190542	144827	130315	152446	172387
Dried and unsalted	23708	27478	28628	26329	30324	31620
Dried, salted or in brine	88816	97047	99426	97503	97302	100703
Smoked	17220	18437	20638	18686	20996	21536

Table 1 b. Production and export of processed and preserved tuna (canned)

	1981	1982	1983	1984	1985	1986
Production	678283	636896	702077	781155	802273	913340
Exports	142811	136801	171901	199745	242921	306311

Table 2 a. Export of frozen tuna from India

Country		1978	1980	1986	1987
U.K.	Q	635			
	V	4,329			
Singapore	Q		20		
	V		160		
Japan	Q			2,90,940	49,995
	V			26,42,146	6,44,997
Switzerland	Q			30,000	
	V			3,71,245	
Malaysia	Q				38,304
	V				3,73,799
Italy	Q				38,249
	V				3,77,925

Q = Quantity - Kg. V = Value - Rs.

Table 2b. Export of canned tuna from India

Country		1978	1979	1980	1981	1984
Belgium	Q	12,480				
	V	2,01,643				
Spain	Q	1,056				
	V	18,015				
Saudi Arabia	Q		108			
	V		2,012			
U.A.E.	Q		368	2,919	5,376	720
	V		13,123	1,05,119	2,45,271	24,659
Iraq	Q				4,800	
	V				1,27,744	
Fed. Rep. Germany	Q			4,800		
	V			1,18,374		

Q = Quantity - Kg. V = Value - Rs.

Table 3. Proximate composition and calorific value of red and white meat of tuna in relation to liver tissue and whole egg

Type of meat	Moisture %	Fat %	Protein %	Carbo-hydrate %	Calorific value Kcal/100 g
Red meat	69.37	4.631	18.28	0.750	120
White meat	70.94	3.056	18.90	0.263	104
Liver tissue	70.90	4.200	19.80	3.60	133
Egg whole	74.00	11.50	12.80	0.70	159

Table 4. Amino acid composition of red and white meat of tuna

	Amino acid composition g/100g dry muscle	
	Red meat	White meat
Isoleucine	5.00	5.53
Leucine	8.57	8.50
Lysine	4.17	9.48
Methionine + cystine	3.88	3.80
Phenyl alanine	4.31	4.64
Tyrosine	Not determined	
Threonine	4.99	5.38
Valine	4.24	5.36
Histidine	2.38	5.36
Glutamic acid	13.35	14.01
Tryptophane	0.45	1.70
Arginine	4.65	5.95
Serine	3.83	4.59
Proline + hydroxy proline	7.18	6.21
Aspartic acid	7.46	7.92
Glycine	3.93	2.86

Table 5. FAO/WHO suggested pattern of essential amino acids

	Amino acid requirement g/day		
	Infant	Child	Adult
Isoleucine	3.5	3.7	1.8
Leucine	8.0	5.6	2.5
Lysine	5.2	7.5	2.2
Methionine + cystine	2.9	3.4	2.4
Phenyl alanine	6.3	3.4	2.5
Threonine	4.4	4.4	1.3
Valine	4.7	4.1	1.8
Histidine	1.4		

Table 6. Mineral composition of red and white meat of tuna in comparison to that of skim milk powder mg/100 g.

	Sodium	Potassium	Calcium	Iron
Red meat	107.3	78.5	442.2	36.47
White meat	156.75	1290.3	590.0	10.68
Skim milk powder	318.0	1240.1	1008.0	1.5

Table 7. Vitamin A and D content in tuna IU/g

	Vit. A	Vit. D
Tuna white meat	140	7.5
Tuna red meat	1500	850.0

Table 8. Proximate composition of experimental diets

	Red meat diet	White meat diet	Skim milk powder diet
Moisture %	10.00	10.00	10.00
Protein %	10.00	10.00	10.00
Fat in protein source %	1.19	0.18	10.00
Ground nut oil %	-	1.01	1.09
Carbohydrate %	76.50	75.20	76.70
Balance as ash %	3.50	3.70	2.20

Table 9. Summary of results of feeding trials

	Average total intake kg.	Haemoglobin % before	after	Weight gain kg.	Height gain cm.
White meat diet	3.52	9-13.5	11-14	0.5-3.4	1.9-9
Red meat diet	3.37	9-13	13.1-16	0.25-1.75	1.3-4.5
Casein diet control	3.76	8.5-12	10.1-14.3	0-1.5	1-3.7

Table 10. Species of tuna which can be used for canning (as per IS 4304 - 1976)

English name	Species name
Yellowfin tuna	Thunnus albacares
Albacore	Thunnus alalunga
Bluefin tuna	Thunnus thunnus syn. Thunnus thunnus orientalis
Big eye tuna	Thunnus mebachi syn. Thunnus obesus mebachi
Northern bluefin tuna	Thunnus tonggol syn. Kishionella tongga
Oceanic skipjack	Katsuwonus pelamis

Table 11. Flow sheet for tuna canning

Tuna

Brine freezing on board

Drying up and holding in dry storage

thawing before unloading (temp. of fish about 28°F)

unloading

Quality evaluation
(mostly by organoleptic means)

grading

Butchering (removes viscera)
Cleaning in water

Precooking in steam after arranging in wheeled racks

Cooling (generally in cold rooms)

Cleaning, cutting and canning

Cleaned meat packed in cans, salt, oil and other optional flavouring ingredients added, exhausted, sealed and retorted.

Table 12. Flow chart for production of masmin

Tuna fillets

Winding with ribbon-like split green coconut leaves

Boiling in brine for an hr.

Cooling and smoking for 3-4 hrs in a chamber

Removing the coconut leaf winding and drying

Repeated smoking and drying for 3-4 times to get hard-brown product

Packing in gunny bags or other suitable containers

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Table 13. Flow sheet for production of tuna shavings

Tuna fillets

Brining in salted brine for one hour

Draining, smoking at 70°-80°C for eight hours

Drying smoked fillets in air at 70°C for 16 hours

Trimming the fillets and converting into shavings using carpenter's planer

Packing in polythene bags or glass bottles

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Table 14. Proximate composition of tuna paste

Moisture (%)	:	43.53
Total solids (%)	:	56.47
Ash content (%)	:	17.95
Acid insoluble ash (%)	:	0.07
Salt content (NaCl) (%)	:	10.40
Fat (dry wt. basis) (%)	:	0.60
Total nitrogen (%)	:	6.56
Non-protein N (%)	:	5.63
Amino N (%)	:	1.43
T.V.N. mg (%)	:	309.00
Calcium (%)	:	0.43
Phosphorus-P_2O_5 (%)	:	2.77

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