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THE TUNA INDUSTRY OF SOUTHERN SPAIN [1/]

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Contents

HISTORY OF THE FISHERY

Fishing for tuna (Thunnus thynnus L.) and its preparation for commerce form one of the oldest industries of southern Spain. The Phoenicians caught and salted tuna here and many of their coins show a clearly executed, unmistakable representation of this fish. During the Roman domination the fishing industry flourished, and salted tuna was one of the main exports to Rome from the port of Gades (Cadiz). Remains of old Roman brick and cement salting tanks are still to be found in several tuna-salting establishments. The Arabs developed the fisheries further, and the present designation of tuna-fishing establishments, Almadraba, is of Arab origin. This name is applied to the whole establishment or to the net.

The big net reaches from the sea bottom to the surface, with cork floats on the surface and heavy iron anchors at the bottom. The Almadraba is rectangular: about 270 by 80 meters. It is subdivided into several sections, which can be lowered or lifted from the boats to compel the fish schools to move where desired. The last compartment, the so-called bunt or bag, has a net bottom. This compartment can be closed, once the fish are maneuvered into it. The net walls are lifted by man power, and the fish killed and taken out of the water with short, iron hooks. The net is connected with the shore by net walls

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1/ Translated from the Spanish.

(usually made of esparte grass) with 25-inch mesh from knot to knot. The fish are frightened by the shadow of the net, and are guided into it, lastly arriving in the end compartment.

Organization of the fishery--Tuna fishing rights were a hereditary privilege of certain noble families and corporations until 1817. In that year special fishing rights were abolished by the Crown and since have been awarded to the highest bidder.

The Spanish tuna fisheries are situated on the south Atlantic shore (Andalucia), in the southern part of the Mediterranean coast, and on the shores of Spanish Morocco. The less important are those of the Mediterranean, the concessions of which yield annually to the Spanish treasury only about 50,000 pesetas. Concessions are given for 25 to 50 years. Next in importance are the fisheries of the African coast, with concessions there granted for 20 years. Those of the Atlantic coast, the most important tuna fisheries of Europe, were consolidated in 1928 in such a way that the newly formed amalgamated company, the "Consorció Nacional Almadrabero," pays the Government the total of the sums paid previously by the numerous smaller concessionaires. The Government owns 48 percent of the shares of this Company, with the proprietors of the former tuna-canning factories and tuna fisheries of the coast the other stockholders. As a result of the formation of this important Company most of the small competing factories and a good number of the fishing establishments were closed. Only 4 factories and 5 of the fishing stations (almadrabas) were operated. Thus the industry became more concentrated and the small number of factories could be developed intensively.

The published statistics of 1940 give the following catches of tuna in all of Spain in kilograms: Mediterranean coast - 179,642 kg.; Atlantic coast (C.N.A.) - 5,120,375 kg.; African coast - 66,663 kg.; total 5,961,680 kg., which works out at approximately 50,000 fish of an average weight of 120 kg. each. In 1943, an exceptionally good year, the C.N.A. alone caught over 75,000 fish, weighing more than 11,000 metric tons.

Of the 5 "almadrabas" of the C.N.A., 3 are in the province of Cadiz (Tarifa, Barbate, and Sanctipetri or Punta de la Isla), and 2 in the province of Huelva near the Portuguese border. The 4 canning factories are situated in Tarifa, Barbate, Sanctipetri, and Isla Cristina (near Ayamonte).

THE FISHING SEASONS

The fat-fish season starts early in May, when the schools of fish reach the coastal waters on their way to the spawning grounds. At this time, the fish travel in an easterly direction and the entrances of the nets are directed, accordingly, to the west. The fish encounter the net walls and, swimming along them, are directed into the net. The fish enter the compartments of the net sometimes in schools of more than a thousand fish. The captain of the "almadraba" then has to use all his skill to maneuver the proper number of fish (a few hundred at a time) into the bunt or bag, without letting the rest escape. If too many fish enter the last section, there is always the danger that the 180-200 men of the crew can not lift the net, and that the fish too crowded in the net will be "drowned" and sink to the bottom. In this case, part of the netting must be cut away and not only the fish and a large portion of the valuable net, but also several days of the best fishing time, are lost.

The fat-fish season lasts until the 10th or 15th of July, at which date, the fat fish disappear from the catches. Most of the "almadrabas" are then closed down for the year, the nets taken out and the factories closed. Only 2 of the fisheries are left working: Barbate and Isla Cristina. The spawned fish do not return by the route they arrived, and only a few points near the shore are touched on their return journey. In these two fishing places the position of the nets is changed so that the entrance to the compartments is toward the east.

The return season, which may last until the middle of August, is of much less importance than the first part. Less than 25 percent of the total catch consists of spawned fish. Only 13,000 out of a total of 75,000 fish were caught in 1943 during the lean-fish season.

The fish at this time of the year have much less value than the fat fish. They are spawned out. The formerly fat parts are spongy and flabby, and even the lean meat has a certain flabbiness. Great care must be taken to deal with the spawned fish quickly, as they deteriorate rapidly and acquire a sour and unpleasant flavor. Besides, at this time of the year, the temperature is sometimes very high, which makes the work still more difficult. The meat from spawned fish is not used for barrel salting but only for canning or drying. The canned goods are of considerable less value, and are labeled differently to distinguish them from the fat fish ("atun de derecho") and are marked "de reves" or "ritorno."

How quickly this meat deteriorates is illustrated by one of my experiments. I prepared a quantity of fish balls in the usual way from meat left over from the previous day and kept it in cold storage. The machinery broke down during the night and the temperature rose to about 7° C. The meat had been minced, mixed with the ingredients in the mixing machine, and the fish balls packed and processed immediately. Next day every can was blown up, which had not happened during the fat-fish season even on the hottest days.

In general, it must be noted that tuna is one of the most perishable fishes. They die in the net if too crowded, and almost immediately when lifted out of the water. They deteriorate quickly if piled in the boats even for a short time. To prevent deterioration, the fish are bled as soon as they are landed. In Sicily this bleeding is done by a man armed with a long broad-bladed spear, with which he stabs the fish in the heart. On the French coast the fish are beheaded on board immediately after being caught, and are hung on deck to drain. In Spain this is not done as fish are too plentiful and the time which elapses between catching and delivery to the factory is usually short.

CUTTING UP THE FISH

After the fish have been brought ashore, they are hauled to the factory in narrow-gauge wagons with drop sides for unloading. Immediately the fish are rinsed with sea water from a hose, beheaded, and the entrails taken out. One man easily handles a fish weighing up to 500 pounds or even 600 and more pounds by means of a short hook. Two kinds of knives are used for cutting up the fish: a big chopper, sharpened on one side and at the top, and a butcher knife. By a stroke of the chopper the lateral incision is made, which reaches about 1/5 to 1/4 of the length of the body. By the next stroke the head is severed from the body, after the connection between the body and the gills has been cut at the throat. After this, the belly cavity is opened and the viscera removed. Care is taken to separate them without tainting with the contents of the gall bladder. This is however not often achieved, as the rough handling of the fish and the

pressure of the bodies piled in the boats has already burst the gall bladder.

If plenty of recently caught fat fish arrive at the factory they are used for canning, and are hung in the so-called "bosque" (forest), under cover, with plenty of aeration. The fish are hung by their tails with a rope fastened to the beams of the roof. A wheel-barrow with a long handle serves as a lever to lift the fish into position. Here they are left hanging for the night to drain off the blood.

The meat cannot be cooked for canning if too fresh, as the slices break during the cooking process. "A Complete Course of Canning," edited by the "Canning Trade," May 1924, says about canning salmon: "While the packers generally prefer the fish to be out of the water from 12 to 24 hours, in order to shrink slightly, a longer period becomes dangerous. The custom of delaying the butchering arose with the use of soldered cans and its continuance seems to be more a matter of tradition than one of desirability or necessity." I am unable to say whether the author is right in connection with the salmon, but there is no doubt that such a delay in cooking tuna is a necessity.

If the fish have been out of the water a few hours or are to be salted, the cutting continues and the meat is salted immediately. For salting, the meat should be as fresh as possible.

The next stage in cutting is the continuation of a lateral incision to the tail end. The next cuts are made on both sides of the fins, then along the back of the fish on both sides of the dorsal fin.

Now 4 big fillets can be separated: 2 of the back, and 2 of the belly. The pectoral and ventral fins are then cut off, together with the backbone.

It is customary to subdivide the 4 fillets by cutting from the dorsal fin to the anal fin. Then the big fillets of the belly are divided in 3. When separated from the bone, the inner, protruding part next to the spine is cut off. This section is called "descargamento" and is used for salting, being the most lean part of the fish. The side is now divided into parts. The belly proper, called the "ventresca" or "barriga," is the most valuable, fattest, and most tender part of the fish, while the "tarantelo," is considered next best.

Thus the fish is divided into 12 pieces, 6 on each side. The 2 pieces of the back are called together "cuarto negro" (black quarter) and are separately called "cuarto negro de la cabeza" (of the head); and "de la cola" (of the tail); "tronco de cola del cuarto blanco" (tail end of the white quarter); the already mentioned "tarantelo;" and the belly or "ventresca." Inside the "tarantelo" lies the "descargamento," and from the "tronco" sometimes the inner part is severed and is then called "descargado." In this case, the total number of cuts rises to 14. By cutting up the fish in this way the meat is classified according to its fatness and the different kinds are separated for different treatment.

Besides the parts mentioned, several pieces of meat are cut from the head, but these have limited industrial importance.

On an average, a fish yields about 60 percent meat. Thus, a fish of 200 kilograms, live weight, would yield a total of about 120 kg. of meat, of which:

24 kg. or 20 percent "ventresca" (belly) (fat meat).
6 " " 5 " "tarantelo" (sides) (medium).
90 " " 75 " "tronco" and the "descargamento" (lean meat).

The average distribution of the parts of the fish for different kinds of preparations is as follows:

	Percentage
Meat for canning	55-65
Meat for salting	8-10
Meat for drying	6-8
Roe for salting	0.64-1.5
Roe for canning	0.3-0.4
Liver salted	1
Stomachs and intestines, dry	1.0-1.5
Meat cuts f. salting	7-8
Offal for fish meal	17-22
Useless offal	0.2-1

SALTING

A certain amount of tuna meat is salted, according to market demand. Some part of the tuna is always salted and sun dried, being too lean and dry to be used for canning.

As soon as the fish arrive at the factory a certain proportion is usually sent to the salting department, the so-called "chanca," where the fish are immediately butchered and cut up for salting. The meat is immediately salted down in big concrete vats about 3 meters deep and 4 meters wide. Each part of the meat is salted separately: "ventresca," "tarantelo," and "tronco." Besides these parts, which are salted in separate vats, all kinds of smaller meat cuttings and the upper part of the narrow strip holding the bases of the dorsal fins are salted separately and later sold cheaply to the poorer classes of the population on the east coast of Spain.

Big lumps of meat are cut into pieces and deep incisions are made in them, penetrating nearly the whole thickness of the meat making strips approximately 2 inches wide. These pieces are thoroughly washed in sea water and drained, after which women rub the whole piece thoroughly with coarse salt, filling the cuts, and then throw them into the vat, where the salter arranges them in layers, covering each layer with a considerable quantity of coarse Cadiz salt.

After a short time copious brine is formed. About 30 percent in weight of salt is used, of which according to my observations about 5 percent is spilt on the floor, so that about 25 percent is really put into the vats (including the salt used for rubbing the pieces and filling the incisions).

The first catches of the season, in May and the beginning of June, are usually left in the salt only a week or so. Then they are packed with a light sprinkling of salt in barrels of 500, 250, and 125 kg. net, of fish, left to settle during one night, after which the barrels are topped, filled with the original (filtrated) brine, and shipped for immediate use. The rest of the salted fish is kept in the vats for more than a month, then washed in strong brine to remove the slime and excess of salt, and packed in barrels as tightly as possible with a good sprinkling of fresh salt between the layers of meat.

After the fish have settled, the barrels are headed, filled with saturated brine, and put on the platform or wharf of the factory, in the sun, with the bunghole open. The latter is surrounded by a mound, approximately 2 inches high, of a special thick clay or mud (the mud from the bottom of the salt ponds), forming a kind of funnel. This funnel is filled every day with fresh strong brine, so that no air can possibly penetrate into the barrel. The oil from the fish rises, under the influence of the already very high temperatures and the direct insulation, to the surface and collects in this funnel, from where it is skimmed off every day before filling in the new brine. Considerable quantities of oil are thus collected, and this oil commands good prices on the market, being sweet and of a light color. Some of the poorer people use it for cooking. The idea of exposing the barrels with the salted fish to the direct rays of the very hot Andalusian sun (July) is to eliminate as much oil from the salted fish as possible, as this prevents the fish from having a rancid taste.

The barrels are kept in the sun and heat sometimes for more than a month, until finally they are shipped for consumption.

It is calculated that for salting, packing, and brining, during the storage time, about 35 pounds of salt, in all, are used for every 100 lbs. of fresh meat.

DRYING

Mojama:--The part of the meat nearest to the spine, called "descargamento" and "descargado" of the unspawned fish (May to the middle of July) and all parts of the meat of the spawned fish, but the belly, are cut in strips of a quadrilateral section, about 2-1/4 inches each side, and about 20 inches long. These strips are salted in kenches with plenty of dry coarse salt underneath, between the layers, and on top. The kenches are about 3-1/2 feet high. Here the meat remains for a day or 36 hours and is then taken out of the salt, washed up to four times in sea water, slightly soaked, and drained. A sharp stick (a small piece of split cane) is then inserted at one end and the piece of meat, called "mojama," hung by a string on the beams of the open-air drying ground, usually in the shade of rush mats. Here the "mojama" dries in the wind during two or more weeks, until perfectly dry, after which it is taken down, the cane removed, untidy parts trimmed away, and packed in wooden, paper-lined boxes for shipment.

"Mojama" is made from the leanest parts of the fish, the "descargamento" and "descargado" of the unspawned fish, or from any part but the belly of the lean, spawned fish. The latter is considered of inferior quality as the meat is somewhat spongy, but it keeps better and does not become rancid, as the better "mojama" from the fat fish sometimes does, especially if not kept perfectly dry. The main point is to use only really lean meat for the manufacturing of the "mojama," as even small amounts of fat easily become rancid during the drying and storing.

"Mojama" of good quality, black-red color and fresh smell, is considered a great delicacy as an hors d'oeuvre. It is cut into very thin slices and moistened with good salad oil, and served with sliced Spanish onions.

THE ROE

Only the roe of unspawned fish is used for preservation. It is taken out of the fish immediately at the factory. Great care is used not to damage it nor taint it with the contents of the gall bladder. The roe is never left over until the next day without treatment. The roes are graded. Big and medium sized roe is taken for curing, while the smaller ones are usually sent to the canning department, where they are cleaned, boiled in light brine, skinned after cooling, cut to size, and canned in olive oil. Later I shall describe a better way of canning them, introduced by me.

The larger roes are first of all cleaned by skilled workmen. The big lobe of adipose tissue, adhering to the roe, is cut off. Until lately this lobe was thrown away. The oviduct is cut off, the big vein removed, and the blood from the smaller veins squeezed out with the blunt back of the knife. A few punctures are made at the lower end of the bag, so that the liquid may escape during the drying process. Then the roes are thoroughly washed in sea water and dry salted on the concrete floor in kenches with plenty of coarse salt, so that every roe is practically buried in salt. The piles are 2-1/2 to 3 feet high. The roe remains here 24 to 36 hours, is then taken out of the salt, washed and put on large boards which have been sprinkled with a little fine salt. The roes are again sprinkled with a little salt and covered with another board, on which more roes are placed in the same manner, until 6 to 7 rows have been added. The boards are then pressed lightly together in a simple screw press with large cross beams. Every day the roes are taken out, rinsed with sea water and the salt renewed (each day a lesser quantity of salt being used), and put again in the press, with the pressure increased. After a week or so no salt is added and the pressure is again increased. After a few more days (in all the roe remains in the presses 9-10 days), the roe is finally taken out from the press, washed, and rubbed very thoroughly in fresh water with a hard fibre brush, to remove any impurities, salt and slime, and hung on the beams of the drying ground in the same way as the "mojama," in the shade of rush mats. The color of the roe changes during the drying process from pinkish-yellow to a deep red-brown on the outside and a rich orange color inside.

When the roes are quite hard from the outside (in about 15 days) they are taken down and packed in paper-lined wooden boxes for shipment.

The average weight of the roes before salting is approximately 4 kilograms a pair, and during curing and drying they lose about 60 percent of their weight, so that a pair will have the weight of approximately 1.6 kg. This is of course the average weight of the larger roe used for drying, while the average weight of 774 pairs of mixed sizes (weighed by me) was about 2 kg. a pair. Very large roe may weigh as much as 5 kg. a pair.

The salted and dried roe is esteemed as an hors d'oeuvre and commands high prices. It is consumed in the same way as the "mojama," cut into thin slices, and moistened with oil (sometimes with vinegar).

PREPARATION OF THE STOMACH, INTESTINES, AND LIVER

The stomach and the intestines are taken out during the butchering, immediately after the arrival of the fish. They are cleaned, washed, the stomach split open, and then dry salted for 2 days, washed again, and hung up to dry in the sun. The intestines are treated in the same way, but not split. These

parts are sold to the poorer population, mostly in eastern Spain (on the Levante coast). For serving, they are soaked in fresh water and either fried in oil or cooked together with rice and tomatoes.

A few years ago the livers were discarded and until the discovery that their oil had a high vitamin content. Now, they are taken out of the fish immediately at the factory, thoroughly washed, all offal, including the big veins and any parts tainted by gall removed and the blood from the veins squeezed out with the blunt back of a knife. Then they are cut into strips 1-1/2 to 1-3/4 inches broad and salted in tight barrels, well soaked in brine, with 25 percent coarse or medium salt. They are left in the barrels until shipment, when they are taken out again and repacked with very little salt, and the barrels filled with brine.

Until recently all livers were exported, mostly to the United States with only an insignificant part to Germany, as there were no factories for extraction of tuna-liver oil in Spain. At present there are several of them in Madrid, Palencia, and Sevilla, and the amount of available livers is now below the demand. High vitamin concentrates are prepared and some of them are said to contain up to 500,000 I.U. of vitamin A and 40,000 of vitamin D. The oil content of tuna livers is relatively low, much lower, of course, than cod liver and even than halibut liver.

BUCKROE

Until 2 years ago all buckroe was discarded and only a small proportion of it was taken home by the workmen. The Spanish way of preparing buckroe for home consumption is by boiling in slightly salted water, cooling, cutting into slices, and adding vinegar, oil, sliced onions, pepper, and salt.

CANNING

The fat unspawned fish which are caught from the first days of May until the middle of July result in a better canned product. The lean, spawned fish are caught in smaller numbers, from the middle of July until about the 20th of August, have low value from all points of view; not only are catches irregular, but the spawned fish are lean and spongy, and the meat easily spoils. The whole job of canning or salting (salting only for dried "mojama") must be performed quickly, otherwise the meat becomes sour and ferments, especially as summer temperatures in southern Spain are very high (often more than 110° F.). Therefore the fish are dealt with immediately after they arrive at the factory and, if possible, during the cooler hours of the night.

Thus, most of the meat of both the fat and the lean fish is canned. The meat is divided into 3 grades and treated separately: "ventresca" (belly); "tarantelo" (sides); and "tonno" or "tronco" (back and tail). The oil content of these parts is different and so is the structure of the meat; while the belly is fat and tender, the back is lean, but firm and rather coarse, the sides or "tarantelo" occupying an intermediate position.

The back and tail pieces are skinned, while the belly is cut up with the white and scaly skin on. The 3 grades of meat are cooked separately.

The big pieces of meat are fed into a cutting machine with parallel circular knives, the distance between which can be adjusted according to the size of the cans to be packed. The machines, electrically driven, move on rails along the row

of cooking kettles. The circular knives work under strong jets of sea water. The cut pieces fall into big troughs with running sea water for washing, in order to extract the blood. Each cooking kettle has a trough.

The slices are about 1 to 1-1/4 inches thick and are calculated in such a way, that one or several layers, when packed, will fill the can, allowance being made for shrinkage of the meat during the cooking process. The cans must be filled to the top, to avoid an excess of oil.

Until a few years ago the cutting of slices of exact thickness for cooking was done by skilled men with big sharp choppers on thick wooden blocks. In the smaller factories of the Mediterranean coast and in Africa cutting is still done by hand.

The cooking is done in open flat bottomed, galvanized iron kettles of 160 cm. diameter and 51 cm. height (volume practically 1 cubic meter). The kettles, 20-30 in all, according to the size of the factory, are mounted in 1 or 2 rows in a low brick oven, in the open air, to let the steam escape freely (it seldom rains during this season in these parts). Each kettle has its own fireplace and fire-lock, and the whole battery is provided with a big chimney. Between every 2 kettles a large water tap with hose is provided for filling the kettles with fresh or sea water. The kettles are usually filled with water to a little more than one half and salt is added. The salt is piled near the kettles in baskets. The content of each is so calculated, that adding one basketful of salt the strength of the brine rises by one degree Baume.

In general, it can be said that the brine used for cooking is fairly strong and the taste of the boiled meat salty (Italian style). This strong taste is partly softened by the oil in the can. The different kinds of meat are cooked in brine of slightly different strength, but the differences are not great and vary according to the ideas of the foreman, who is responsible for the cooking. It can be said that the fatter the meat, the stronger the brine should be.

A sample of the strength of the brine used in cooking is given by L. Bellon Uriate in a publication of the Spanish Oceanographic Institute; 1926:

Kind of meat	Cans of 10 kg.	Cans of 5 kg.	Small cans
Tronco	17 - 18 B.	16 - 17 B.	---
Tarantelo	18 - 19 B.	17 - 18 B.	11.5 - 12 B.
Ventresca	19 - 20 B.	18 - 19 B.	---

Degrees B. are measured on the boiling brine, which is not correct, but convenient, as it allows a constant control of the strength of the brine. All indications of the strength of the brine in the canning factories always apply to boiling brine.

The boiling brine is skimmed with a big ladle of aluminum or tinplated iron. The washed and soaked meat is taken from the troughs into wicker baskets, slightly drained, and dumped into the boiling brine. If the meat is too fresh, the pieces often crumple and break. Therefore the fat fish is not boiled before it has been at least 1 day out of water. The proportion of brine and meat is about 2 to 1, and the stokers keep at this moment a rather lively fire so that boiling is not stopped by dumping in the meat. During the cooking, the brine is kept simmering constantly.

During the cooking process, the meat is stirred from time to time with a big ladle, consisting of a strong iron ring with heavy hemp net inside and attached to a pole. Usually the cooking is over in about 1 hour, when the foreman in charge of the cooking considers the meat well done. Then the fire is lowered and a certain amount of cold water thrown into the kettles to stop the boiling and to make the liquid rise slightly, by which means the oil on the surface is removed and flows along a drain to the settling tanks, where it is recovered.

Clear oil commands good prices on the market. The output is about 6 percent of the weight of the fresh meat.

The meat is taken out of the kettles by means of the same net ladles and dumped into special stretchers, which consist of large low wooden boxes with handles and with bottoms made of reed. The stretchers are then wheeled to the packing room and put on special jacks to dry and cool until the next day. To protect the meat from flies, the rows of stretchers are covered with big sheets of a thin, porous cotton fabric.

The meat loses a considerable part of its weight in cooking: the belly 35 percent and the sides and backs about 36 percent. This may vary, but in practical calculations in the factories the average figures are considered correct.

A fish of 100 kilograms live weight yields 60 kg. of meat, of which 12 kg. or 20 percent are belly, 3 kg. or 5 percent are sides and 45 kg. or 75 percent are back and tail meat. Thus, these 100 kg. fish would yield:

12 kg.	belly	-	7.8 kg.	cooked	and	6.24	canned
3 "	sides	-	1.92 "	"	"	1.04	"
45 "	back	-	28.8 "	"	"	21.6	"
60 "	-		38.52 "	"	"	28.88	"

The loss from the cooked fish to the canned product is calculated to be 20 percent for the belly (which often is canned with parts of the skin) and 25 percent for other meats. This great loss is explained by the removal of the black meat during the packing and by the loss of the small crumbs, which remain on the stretchers. The black meat, called "sangacho" is discarded, as it has a disagreeable taste. Lately, some of it has been canned in the Portuguese way (firmly packed with very little oil or tomato pulp), but even the poorer classes are not likely to accept this preparation.

The cooled meat (three kinds separately) is then packed in cans of 10; 5; 2-1/2; 1; 1/2; and 1/4 kg. size. In the larger cans, the top and the bottom are formed by big pieces of meat, neatly put together to give the surface a pleasing look. Smaller pieces of meat are packed in the middle of the cans, but always in layers. It takes 8.4 kg. belly (canned weight) or 8.8 kg. "tarantelo" or "tonno" (back) to fill a 10 kg. can. The necessary quantity of oil for such a can is 800, 900, and 1,000 gr. for belly, side and back meat, respectively, the rest of the weight being made up by the weight of the can. These figures are, of course, only correct as an average for the fat fish season; in the lean fish season more oil is used, as the texture of the meat is at this time very lean and spongy and the loss in cooking is much higher. The practical calculation of a loss of 45 and 50 percent in weight is therefore correct for both seasons together.

After packing, the open large cans are wheeled to the oiling room, where they are put on large slightly inclined zinc tables with high boards (2 inches) and a drain tube at one corner. Here the cans are filled with the best grade refined olive oil (acidity less than 0.3 and of a light golden color). As the meat absorbs plenty of oil, the cans are filled once or twice and are left standing open until the next day, when they are finally filled with more oil and closed in the double seamer. No exhaust box is ever used.

The small cans (1/2, 1/4, and 1/8) are stacked for the night in large zinc tanks, which are filled with oil. Next day the superfluous oil is drained off and the cans are sealed.

After double seaming the cans are processed in big autoclaves, usually at 105° C., the 10 kg. cans up to 4 hours. Time and temperature are empiric, as no proper studies of processing have been undertaken in Spain. In my opinion, the time of processing is probably grossly exaggerated, but as the results are satisfactory, it would be difficult to persuade the canner to change time for economy's sake, and difficult to sacrifice a few of the expensive 10 kg. cans for experimenting. Some day of course it will have to be done by some research station.

CANNERY TRIMMINGS

The meat, the tongue, and a lump of fat muscles from the neck are cut off the severed head for salting or immediate consumption. Then the head, the backbone and the tail, the skin of the back, the fins, parts of the intestines and other offal are discarded to the primitive fertilizer plant. All the offal is dumped into large cemented pits about 3 meters deep, with steam coils at the bottom. A wooden perforated platform is first lowered to the bottom, the refuse is dumped on the latter, and a certain amount of water added. Then the steam is turned on and the mass is heated and boiled in live steam for several hours (formerly about 4 hours, now a little less), until the very hard bones of the spine and the head become soft.

The oil at the surface is then skimmed off. The liquid is drained into settling pits to separate the oil; the platform with the solid refuse is hoisted up and filled by hand into big hydraulic (or hand-) presses, where the oil and glue water are pressed out. The solid press cakes are then broken up with a heavy hammer and spread on the concrete floor of the drying ground in the sun. In some of the factories mechanical steam heated driers are used. The dried offal is then milled and sold as cattle or chicken food. The sun dried stuff of course can be used only as fertilizer. In every case the quality of the scrap is very poor, as a great part of the proteic matters are lost during the prolonged cooking. Here are some analyses of tuna meal produced in southern Spain:

	Percentage
(1) Moisture	5.82
Mineral salts	35.72
Fat	6.48
Proteic matters	42.44
Na Cl	0.31

	Percentage
(2) Moisture and volatile matter	11.02
Organic matter	46.74
Mineral matter	42.24
Nitrogen	4.56
P_2O_5	14.24

A. Thomas, who investigated tunny offal in Sicily in 1925, gives the following data about the composition of a good fish meal which he made from tuna offal:

	Percentage
Moisture	11.500
Fat	2.100
Proteine	58.150
Ashes	28.250
Calc. phosphate	21.500
NaCl	1.230

An analysis of a meal manufactured from offal by the local crude process, similar to that described above for Spain, is:

	Percentage
Moisture	9.400
Fat	8.225
Nitrogen	6.660
Ashes	42.000

One can judge the great loss of nitrogen by the primitive method as compared with a more modern one. Thomas gives the following figures as to the output at the biggest factory in Sicily, that of Favignana: from 400,000 kg. of waste 25,000 kg. (6.25 percent) of oil and 80,000 kg. (20 percent) of fertilizer were obtained.

With this, the data of the biggest and best equipped south Spanish factory, that of Barbate, in the Province of Cadiz, may be compared. It is calculated, that the average weight of a fish is 125-140 kg., which gives 22 percent or about 30 kg. of offal; 100 kg. of offal yields 10 percent oil and 31 percent fish meal or fertilizer. Thus, one fish should yield 3 kg. of oil and 9 kg. of fertilizer, and an average catch of 30,000 fat fish, 90,000 kg. of oil and 270,000 kg. of meal or fertilizer. This compares favorably with the data from the Favignana factory in Sicily. Of course it must be said, that the factory in Barbate has a steam drier, although the cookers are primitive. All the scrap in Favignana (1920-1921 and 1925) was dried in the sun, as is done in the other Spanish factories.

The total output of oil in Barbate is higher, as the oil of the cooking kettles and that collected from the barrels of salted fish has to be added. The total output of oil is nearer to 100,000 kg.

The oil obtained in the fertilizer factories, the so-called "red oil," is of a very poor quality. It is dark brown, nearly black, very thick, of very high viscosity and has a strong and repugnant smell of putrid organic matter. I measured acidities from 11 to nearly 29 percent. Besides the output is much too low.

Of all fish oils, tuna oil is the most easily oxidized and by prolonged boiling in the open air this oil becomes completely oxidized, thick and sticky. Besides, it forms an emulsion with the strong glue solution yielded by the skins, fins, and tails, and thus a big proportion of the oil does not separate from the cooking water (glue-water) in the settling tanks and is drained into the sewer, while a considerable part cannot be separated by pressure from the solid matter. I recommended a classification of the offal, especially a separation of the glue

stock (fins, skins, and tails), which contains little oil, and the separate treatment of fat and lean offal.

Later, I shall explain a reasonable reform of the whole process of utilizing the tuna offal in order to obtain more and better by-products.

NEW METHODS OF PRESERVATION

My experimental work (during two seasons) on the improvement of canning practice in the tuna industry and of the manufacturing of by-products was: (1) to create some new and finer varieties of canned tuna, which would compare favorably with the other canned fishes and would appeal to fastidious customers; (2) to utilize all parts of the fish which have been discarded, but which could possibly yield valuable by-products, edible or not; (3) to increase the output of oil and meal.

As the meat of the different parts of the tuna varies widely in its structure and oil content, not all parts can yield palatable canned products. The meat of the back and the tail parts is rather coarse and fibrous. It admits of all kinds of preparation, but is best if larded and baked in an oven with a few vegetables, such as onions, tomatoes, and potatoes.

But best of all fine canned goods is the belly part of the tuna and, to a certain extent, the "tarantelo."

SMOKING

The belly part (ventresca) and to a lesser extent the sides (tarantelo) makes excellent smoked meat. I use small smoking kilns, 1 meter wide, 2 meters deep, and 2 meters high, with a conical roof rising 1 meter above the smoking racks, and a 2-1/2 meter chimney. The iron door opens in 3 sections, so that the draught may be regulated. The belly part of the tuna is cut across into big pieces of 1 to 1-1/2 kg. The skin is not removed. The pieces are thoroughly washed and soaked for a short time in sea water to remove the blood, then brined in 18° B. brine for 10-12 hours, or in 23° B. brine for 4 to 4-1/2 hours, after which they are well rinsed in sea water and perforated with a little sharpened piece of reed. They are then hung up in some well-aerated place in the shade until the surface is perfectly dry. In wet weather the drying is done inside the warm smoking kiln with the chimney and door wide open to produce sufficient draught. The meat is left there for the night.

As soon as the surface of the fish is perfectly dry, a light open fire of hard wood is built inside the kiln, with the doors and the chimney open, never allowing the flame to become too high. The temperature at this stage should not exceed 70° C. The time necessary for this first part of the smoking process varies widely depending on the weather conditions and the wind, and may vary from 20 minutes to 1-1/2 hour. The surface of the fish should feel like dry parchment paper and be fairly hard. Small drops of oil separate at the surface, if the meat is very fat. No cracks or fissures in the meat should appear, as this would result in a loss of juice and a drying-out of the meat during the smoking.

After the surface of the meat has the required appearance, the doors of the kiln are shut, leaving only the lowest part half open, so that the fire does not go out. The chimney is closed, leaving only enough draught so that the smoke can rise in the kiln. The fire is covered with a good supply of chips of hard wood (oak, beech, chestnut, etc.). The best chips are those obtained from

a mechanical planing machine. If the chips are too dry, they should be slightly moistened with water, so that the fish does not dry out too much during the cooking and smoking process.

During this part of the process the fish is practically steamed until done and at the same time permeated by the smoke to give the meat a special flavor. Care has to be taken that there is always enough dense smoke. To obtain this the flames are covered from time to time with more chips. During the whole smoking process the temperature inside the kiln should be maintained at 85° C. to 90° C. After 2 hours or so of smoking and steaming, the fish is sufficiently cooked and impregnated with smoke. The doors and the chimney are opened, and the fire is taken out and extinguished.

After this the fish is removed from the kiln and put to cool in a well-ventilated place, or left with doors and chimney wide open, inside the kiln until the next morning.

When removed, the pièces should be dry on the surface and soft inside, with a brilliant, clear, chocolate-colored surface, without any whitish, foamy spots, which are a sign that the fish were not sufficiently dry before smoking or that too high temperatures were applied during smoking (for instance over 100° C.).

Once thoroughly cooled, the meat is cut with sharp knives into slices about 1/4 inch thick and packed in square quarter-cans. It is good to add a small amount of grated nutmeg and a clove or two. The cans are filled then with olive oil, left to soak in the oil for a short time, refilled, sealed, and processed in the usual way. I use 108° C. for 70 minutes for square quarter-tins. (Quarter tins on the continent mean 1/4 kg. bruto.).

The side-meat (tarantelo) may be smoked and canned in the same way, but may need a little higher temperature during smoking. This meat is coarser and leaner and needs less drying. Care should be taken not to dry out the fish during the smoking process by using dry chips. The amount of oil used for this kind of meat is slightly higher than that for the "ventresca."

Smoke-cured tuna:--I tried to cure and smoke different parts of the tuna, but found that best results are obtained by treating in this way the bellies of the small fish of 50 to 60 kg., live weight. Their meat is tender and the bellies very fat and when properly cured and salted, their flavor and structure are reminiscent of smoked salmon.

I butcher the small tunas very carefully in order not to tear the meat. After severing the head, opening the belly, and taking out the entrails, the fish is cut up in the same way as the large fish, with the difference that the collar- or nape-bone is left in its place and only the pectoral and ventral fins are removed. The thick inner part of the belly, the "descargamento," is then cut off as usual and on the remaining big portion, which is about 2-1/2 inches to 3 inches thick, deep incisions across are made, about 2-1/2 inches apart, from the meat side. The skin side is left intact. These incisions are necessary in the hot climate, in order that the salt and later the smoke may penetrate more readily. If the salting could be done in cold-storage, this probably would not be necessary. The meat has to be thoroughly washed, which must be done carefully, in order not to break the meat. The bellies are then salted down in wooden butts, meat side up. The incisions are filled with salt and enough salt is put on each

layer of fish to cover them. The last layer is put meat side down. A wooden perforated cover is put on top and a basket of salt put on for weighing down the fish. For salting I use a mixture of fine and coarse salt and potassium nitrate (of the latter 5 to 6 gr. to the kg. of salt). The nitrate gives the meat a pleasant pink color.

In a few hours enough brine is formed to cover the fish. The meat remains in the salt for about 3 days in a cool place, after which it is inspected and eventually a little more salt is added. After another day or two the fish is thoroughly cured.

If I had the opportunity to cure fish in cold storage, I would use less salt and keep the fish in salt for a longer time.

Two string-clips are then passed under the collar-bone. The sides are rinsed to remove the salt and then hung in a trough in clean sea water to soak and freshen. The time for soaking depends entirely on the temperature. The water should be drained off from time to time and replaced by fresh water. I usually soaked the fish over night in sea water (about 16-17 hours) and about 2 hours in fresh water. After washing and inspecting the sides, they are hung in a shady place with plenty of draught. In order to avoid flies (blue bottles), I put the smoking sticks and the meat in a big cage of wire netting and lift this cage on pulleys to the ceiling, where there is plenty of draught. Here the sides of meat are left to dry in the wind for 2 or more days. The proper time must be judged by inspecting the sides; their surface, including the incisions, must be perfectly dry and on the lower part small drops of oil or fat should be sweating out.

After this the sticks and sides of fish are hung in the smoking kiln which should be high, so that the meat is about 3 meters above the ground. A height of about 4 m. is necessary. On the floor a few heaps of hardwood sawdust are piled and kindled in the middle part of the heaps, so that they smolder and give off dense smoke. I used oak or chestnut sawdust, but any hard wood will do. Care should be taken to prevent the temperature from rising above 30° Centigrade as the maximum. A temperature of 20° C. is still better, as the meat dries less.

In 24 to 36 hours the meat acquires a golden-brown color. How much smoke is given the meat depends entirely on the requirements of the market. Sometimes it is useful to let the fire go out and rekindle it after the kiln has cooled down, for instance the next morning. It should always be remembered, that the lower the temperature during the smoking process, the less the meat dries out and the better the flavor, but the poorer the keeping qualities.

After the smoking is finished and the sides are cooled thoroughly, they may be sewn in some cotton fabric or cheesecloth and kept in cold-storage. For shipping they are packed in wooden boxes in the cloth covering and the boxes filled with bran.

The smoked sides may also be sliced very finely and packed in small cans in oil. In this case, some preservative must be added to the oil (e.g. benzoic acid). In packing, each slice must be first dipped in the oil. If the sides are intended for packing in cans, they should be soaked less before smoking, so that they retain more salt. The salty taste is softened by the oil and the keeping qualities improve. These cans must be kept always in cold-storage. Cold-smoke cured tuna-bellies are a great delicacy.

TUNA CAVIAR

Only the big, well-developed and undamaged roes can be used for salting and drying in the manner described above. The others (small, damaged, deformed) roes were usually made into a second-grade dried roe and sold very cheaply, or canned in olive oil after boiling them in strong brine and cutting off the thick, skinny outer portions, - a cheap and rather flavorless pack.

In order to obtain a new valuable pack I worked out the following recipe, which has since been introduced on the market under the name of "Tuna Caviar."

The roes were washed, split open, and then boiled in the following brine:

Water	80 l.
Salt	2 kg.
Peeled lemons	8
Onions	1 kg.
Celery	8 bunches
Green Spanish pepper	10-12 big ones
Black pepper, garlic, bay-leaves	

The roes are lowered into the boiling liquid in a wire basket and stirred from time to time in order to separate them, as they easily stick together and do not cook evenly in this case. Care should be taken to stir gently, as many grains may otherwise separate and be lost. When thoroughly cooked (about 20 min. simmering) the baskets are taken out and put to drain and cool. When hand-warm, the eggs can be broken loose in lumps from the fibrous tissue, by hand, without the use of a knife. After this the eggs are passed through the finest disk of the meat mincer. They have now a yellow-pinkish color. They should be dealt with very soon, as when left standing they turn gray under the influence of air. The eggs are now dumped into the mixing machine and the ingredients added in the following proportion:

Ground roe	30 kg.
Salt	300 gr.
Lard	2500 gr.
Canned sweet pepper (minced)	8 cans of 1 lb.
Vinegar (2-1/2 percent)	900 cc.
White ground pepper	45 gr.
Ground clove	15 gr.
Sweet ground red pepper (sweet paprika)	300 gr.
Minced onions, fried golden in lard or oil	2500 gr. (weight minced and fried).
Stock in which the roe was cooked, filtered	3l.

These ingredients are thoroughly mixed and thus transformed into a soft paste of a very pleasant flavor and color. This paste is filled in 1/8 cans (holding 100 gr. net), topped and processed. Care must be taken to fill the cans well, without overfilling, so that no air remains in the can. I process at 108° C. for 50 minutes.

This paste should be served on sandwiches with a little butter, which improves the flavor greatly. But it is not advisable to add margarine or more lard to the paste during the manufacturing process, as in cooling the grease may separate from the paste and give it an unpleasant appearance. Care should also be taken not to add too much stock, as the excess of moisture may separate too during the processing.

BUCKROE

Buckroe was formerly thrown away. My experiments have proved, that smoked buckroe results in an excellent canned product. But the method of curing and smoking slightly differs from that used in curing meat.

The buckroe must be cleaned carefully and the fibrous and adipose parts removed. The fine membrane covering the organ is opened in some places, the big vein and ducts removed, as the whole organ does not take salt easily. I wash the buckroes thoroughly after the cleaning and, by means of a perforated wooden cover, to keep them submerged in a strong (23° B.) brine for the night (10-12 hours), and wash them well again. Then they have to be hung in the air (draught) on the smoking rods (wooden ones), which are put into the frames to dry for several hours, until the surface is perfectly dry. Then the frames are put into the kiln (the kiln used for hot-smoking of the belly meat) with the lower part of the door open and open chimney, and a strong fire is kept burning. The temperature must be kept at least to 80° C. for 1-1/2 to 2 hours. The cooking and smoking are done in the same way as that of the meat, but at higher temperatures (100° C. - 105° C.), at least for 2 or 3 hours. One must make sure that the thickest parts of the buckroes are well cooked, otherwise later, in the cans, they would have a disagreeable slimy taste or may even produce swelled cans.

When cooled, the smoked buckroes are cut into thin slices and in an enameled trough mixed with a little lemon juice to flavor them, and packed in square quarter-tins with olive oil, adding a little grated nutmeg. Care should be taken that the oil moistens the slices from all sides, as they tend to stick together and bake together during the processing, hindering the oil from penetrating between the slices. Moistening the slices in oil before packing helps to avoid this.

For packing canned buckroes, I have sometimes used, instead of the common olive oil, a specially prepared oil, which I called "a la Sevillana," which is prepared by heating olive oil for several hours with the following ingredients:

20 liters olive oil.
250 gr. sweet paprika (sweet ground red Spanish pepper).
30 gr. hot paprika.
1 large head crushed garlic.
10 - 15 bay-leaves.
peel of 4 - 5 lemons.
200 gr. dry origan (or wild marjoran).
20 gr. white ground pepper.
10 gr. ground clove.
Several large green sweet Spanish pepper (5 or 6).

This oil with the ingredients is heated at about 90° C. to 100° C. and left to stand for a day in a hot place, so that all the spices can soften. Then the oil is filtered. It has a beautiful scarlet color and a very pleasant flavor.

Another preparation made from buckroe is a mild sandwich paste with a special flavor. This paste is prepared in the following way:

The buckroes are thoroughly cooked in weak brine (about 5 percent) for half an hour, then cooled and trimmed, and passed through the finest disk of the mincer.

Heat 400 gr. of lard in a frying pan with 500 gr. of bacon fat cut in little pieces, and add 4 or 5 bay-leaves. When the fat is well fried add 3 kg. of minced onions and fry until golden, then the onions and the bacon are taken out and the following ingredients put into the hot fat: ground dry sweet Cayenne pepper 20 gr.; wine-vinegar (2-1/2 percent) 1/2 liter; white ground pepper 5 gr. When well cooked, 10 kilograms of minced buckroe is added and the whole mixed well on the fire. In the meantime, the fried onions and bacon, 1 lb. of canned sweet pepper, and 50 good Seville olives (without pips) have been passed through the finest disk of the mincer. Both portions are then put into the mixer and thoroughly mixed, until a fine paste is formed. The mixture, which forms a thick, slightly pink paste, should be passed through a finishing machine, if possible.

It is then packed into small 1/8 cans (net weight 100 gr.), topped, and processed. In cooling it is convenient to turn the cans once, so that the fat may not separate and rise to the top. Process 1/8 cans at 108° C. for 50 minutes. In Europe, of course, no exhausting is used, but it probably would be useful to pass the cans through the steambox before sealing.

A good way of canning buckroe is the following: The preparation is somewhat complicated, but results in a palatable hors d'oeuvre. This method was tried out as a fancy pack on a small scale and introduced under the name of "tuna kidneys"; as a matter of fact its flavor is somewhat like that of kidneys in sherry. The buckroe is cooked in salt water (about 5 percent salt), cooled, trimmed, cut into slices, then cut with a tinplate tube into small kidney-shaped disks. After this the disks are fried until golden brown in a mixture of lard and olive oil, white wine, bay-leaves, pepper, cloves, garlic, sweet red pepper in powder, then filled in cans, some of the sauce added, and processed.

SPICED TUNA

The kind of prepared flavored oil "a la Sevillana" is used also in canned belly or side-meat. The meat is cut to size for canning, and the thick slices are first soaked in light brine, then boiled in a 6.5 percent brine with vinegar (to 10 liters brine, 3 liters of vinegar of 5 percent), a few lemons (without peel or pips), some celery, garlic, sweet Cayenne pepper, pepper-corns, cloves, and bay-leaves. For the belly more vinegar should be used than for the side-meat. The meat is boiled and left simmering for 45 minutes. After cooling, the meat is canned in the usual way, but with the flavored oil.

ANTIPASTO OR MIXED HORS D'OEUVRE

A fine canned product was prepared under the Italian name of "antipasto" or "hors d'oeuvre tuna." It consists of neatly packed slices of smoked belly, smoked buckroe, a few olives filled with red pepper and cut in halves, a few pieces of pickles, tomato-pulp, and oil. A few steamed and shelled mollusks (Tapes decussatus) were added. The whole is flavored with a little grated nutmeg and a clove or two. The cans were the usual 1/4 club and contained 225 gr., bruto weight, of which 73 gr. is the weight of the container.

All canned goods containing smoked buckroe must be very carefully processed, as swelled cans easily occur. I used 108°C. for 75 minutes for 1/4 club cans.

Besides those mentioned many other preparations from cannery trimmings have been tried. Of these experiments, I will mention here only a few, which gave good results. One of them is "frankfurter" made from the meat of the back with an addition of 10 percent of the fat meat of the belly. Another preparation, which was cheap and sold easily, was fish balls.

FISH BALLS

To find means for the utilization of the cannery trimmings, which forms an important proportion of the weight of the fish, was the main purpose of the series of my experiments. In butchering, a considerable amount of meat of a good quality adheres to the spine, as well as to the clavicular or nape-bones, which are severed from the fish, together with the pectoral and ventral fins. This meat can only be removed from the bones with special instruments. The meat of the spine is fairly lean, while that of the nape-bone is very fat. Besides this there is some meat which is cut off when the fish is prepared for salting and drying, but on account of its size cannot be used for salting or for canning. These are good for minced-meat preparations.

I ordered the meat from the spine and the nape-bone to be scraped off with round scrapers. From the fat fish an average of 1-1/2 kg. of meat each was saved, and from the lean fish 2-1/2 kg. The proportion of the lean meat to the fat scraps is about 3 to 1 as the lean fish are cut up less carefully.

All the scraped meat and the small cuttings are washed in sea water, then drained and passed through the mincer or cutter. Then the minced meat is mixed in the mixing machine with the following ingredients:

7 kg. minced lean meat.
3 kg. minced fat meat.
200 gr. salt.
500 gr. wheat flour.
300 gr. lard (or olive oil).
15 gr. white ground pepper.
10-15 gr. grated nutmeg.
Apr. 1 liter fish stock.
Minced parsley.

After being well mixed, the mass is formed into small balls by a machine, like the Norwegian apparatus made for this purpose. We used small individual apparatus made of tinplate, which served quite well but instead of balls, formed small cylinders. The balls or cylinders are dumped into a boiling weak brine (about 3-5 percent), where they are boiled for about 5 minutes, then taken out and immediately packed in flat round cans, so-called 1/2 cans, holding 7 to 8 balls each. Before packing, a big spoonful of thick vegetable pulp is put on the bottom of the tin. Boil in salt water for approximately 1 hour, drain off, and pass through the pulping machine.

5 kg. carrots.
4 big celery.
2 kg. onions.
Some sweet green Cayenne peppers.
10 peeled lemons.
Bay leaves, black pepper corns, garlic, parsley.

When the paste is prepared, finely chopped onions are browned in lard; a good proportion of thick tomato pulp, some pickled capers, and the vegetable paste, are added and the whole well mixed and boiled together. Some celery, salt, and grated nutmeg are added to taste. The sauce must have a fairly thick paste-like appearance.

Boil some tuna bones in the water in which the vegetables were cooked to obtain a good stock for use in filling the cans containing the balls and the vegetable-tomato paste.

These tuna balls make excellent eating and are very wholesome. The cans can be heated before opening them in order to obtain a hot meal, or the contents may be prepared in different ways. The contents of the round 1/2 can is 300 gr., net weight, of which on an average 232 gr. is the weight of the meat and 68 gr. that of the sauce.

From 3,239 fat fish (June-July) 18,800 round 1/2 cans of fish balls were obtained, or about 5-1/2 cans from each fish. During the lean-fish season (August 1945) fish yielded 22,000 cans, or over 10 cans per fish.

TUNA FLAKES IN TOMATO SAUCE

After the spines have been scraped, a certain amount of meat always adheres to them. So cut the spines into convenient pieces, wash and boil in a weak brine (5 percent) for a quarter of an hour. Take out and cool sufficiently to handle; pick the meat off by hand, taking care to remove all the small bones. In the meantime a sauce has been prepared by cooking together the following:

Tomato pulp 22.5 kg., netto.
Onions 4 kg., finely chopped and fried golden in olive oil.
Pepper, salt, and grated nutmeg to taste.
A few bay leaves.

I used for packing this inexpensive but savory dish round 1/4 cans (containing 200 gr. netto). A large tablespoonful of the thick sauce was put in each can, then the small pieces of cooked meat from the spines firmly packed, a clove or two put on top, and the can filled with olive oil. Very little oil is required for this kind of pack, as the tomato sauce rises nearly to the top of the can. In filling the cans, the open tins are usually stacked in big zinc containers. These are filled with olive oil and the cans left to stand for a few hours for the meat to soak in the oil, so that all air is driven out. After this the superfluous oil is drained off and the cans double-seamed and processed. The cans containing tomato sauce need a slightly longer processing than the pure oil pack. The result of this experiment was very satisfactory both as to flavor and appearance.

About 10 to 12 cans of these "Tuna flakes in tomatoes" were obtained from the previously scraped spine of each fish. Each can contained about 200 gr. net weight, being about 20 gr. oil, 50 gr. tomato-onion sauce and the remainder the bits of white tuna meat. The same kind of preparation was packed also in so-called round 2-1/2 kg. cans. They weighed bruto 2,300 each and contained 1620 to 1640 gr. fish and tomato sauce and approximately 500 gr. olive oil, the can itself weighing about 170 gr.

The spines are now quite clean, after scraping, boiling and picking off the meat, and rinsing, and can be used for glue extraction, for the manufacture of bone meal or of activated coal for oil bleaching, etc.

I tried to utilize also the small bits of cooked meat, which remain on the trays after filling the cans. Formerly, these crumbs were sent to the fertilizer plants. As they are salty and dried out during repeated handling, I added some of them to the minced raw meat for the fish balls, using less salt to season. But this mixture did not improve the flavor of the fish balls. Besides, at present, all these crumbs are packed, as far as possible, in small cans in olive oil and sold very cheaply to the poorer classes of customers, who use them, together with the oil, for preparing salads and omelets.

EDIBLE OILS

To the roe and the buckroe of the fat, unspawned, fish a big lobe of adipose tissue is attached. During the earlier part of the season this lobe may attain considerable weight, up to 1-1/2 kg. per animal.

In preparing the roe for salting this lobe is cut off and discarded to the fertilizer plant or wasted. It yields very little oil until minced, but when cooked tends to obstruct the presses.

I experimented with it in the following way. The lobes are removed, washed to remove dirt and blood, then passed through the meat mincer. The minced fat is put into a perforated tinplate container and into a small autoclave, and the steam turned on. By the escape valve on the lid, all the air is driven out and the mass heated at less than 100° C. for about 1/2 hour or more. The most important part of the process is the driving out of the air, so that no free oxygen remains in the steam box, and then letting the steam run freely through the box by means of the outlet in the lid. Thus, during the whole process no air can possibly enter the container. The oil melts out and is drained off into a suitable container.

After processing is finished, the valves are closed and the autoclave left to cool with a vacuum. Once the oil is cold, it can be taken out from the autoclave, washed, filtered, decanted, and poured into glass containers. The residue is pressed and yields another small portion of a little darker oil.

The first portion of the oil is slightly yellowish and has a pleasant smell (reminding one of fresh almonds) and an agreeable flavor. The glass containers should be well filled so that no air remains under the stopper, in order to avoid oxidation of the oil during storage.

This oil is sweet, of an acidity of less than 0.1 percent. As is usual in most fish oils, after a certain period of storage the glycerids of a higher melting point (stearine) start to settle and to separate as a snow-white sediment, which, if necessary, may be separated from the oil by the filter press or better by a centrifuge. At 33° C. the whole sediment disappears and the oil becomes clear.

The amount of oil from these adipose lobes of the roe and buckroe is large; from 6 kg. fresh weight I obtained 4.2 kg. (70 percent) oil by melting, and without pressing the residues.

If properly hydrogenated in order to transform the unsaturated acids into solid saturated ones, this oil may be used for the manufacture of margarine and other edible fats. I was unable to analyze the oil, but a clear brown Italian tuna oil has been analyzed by A. Thomas, who gives the following characteristics:

	Clear Oil	Dark Oil
	Percentage	Percentage
Specific gravity at 20° C.	0.9250	0.9253
Acid value	2.5	6.4
Saponification value	191.8	187.8
Iodine value	90.8	118.6
Unsaponifiable	0.7	0.3

As about 30,000 fat fish are caught by the fisheries of southern Spain (Atlantic coast) during the season, it may be assumed that the average weight of the lobes of these fish is approximately 1 kg., so that about 20,000 to 22,000 kg. of first grade oil may be obtained from them, besides a certain amount of second grade oil by boiling the scrap with water and pressing.

Of course, it is necessary to remove the mucoid or slimy-oil soluble matter by proper refining, before hydrogenating the white first grade oil. We have hydrogenated this oil and it gave a snow-white odorless solid fat, which may be used for manufacturing edible fat or fine soaps or for any other purpose.

OIL FROM CANNERY TRIMMINGS

After packing the boiled meat into the cans, there remains on the trays a certain amount of scraps and crumbs, which were considered useless or a nuisance, as they are slimy and soft (those of the belly) and they obstruct the presses of the fertilizer plant, or pass through them. The bellies and the lean meat are cooked and packed separately. After the edible meat is picked out, the residue on the trays is of a heterogeneous nature. On the trays, where the

bellies have been packed (the bellies are cooked with the skin attached) pieces of fat skin and adipose tissue remain. I obtained a good yield of light oil from these by mincing and steaming them, in the absence of air at 102° C. for one hour. The oil has the color of refined olive oil, a low acidity (0.25 percent) with practically the same characteristics (but the color), as the above described oil from the lobes of the roe. The yield was over 30 percent without pressing. It is interesting to note that during the lean-fish season the adipose lobes of the roe and buckroe are absent and the weight-length relation of the fish has greatly diminished, the only part where a large amount of oil is still retained, is the skin of the belly; consequently the trimmings on the packing trays contained over 30 percent of oil.

On the trays, where the tail part of the upper and the lower fillets and the back meat are packed, the trimmings do not contain any fat at all (not in the lean-fish season anyhow), but a certain amount of lean skins which make a good glue stock.

GLUE

A very high proportion of the offal is made up of glue stock: skins, fins, tails, and bones. Of course, not all these can be used for glue manufacturing for economical reasons. Thus, the heads, which contain a great amount of colagenous matter, cannot be economically dealt with, as the separation of the skins and bones from the fat and meat would not be economical. But the skins of the lean, back fillet, which is removed during the butchering of the fish, the fins, the tails, and lastly the cleaned back spines, if treated in the way indicated, are a first-class raw material for glue manufacturing. The skins of the backs of the bigger fish, when separated during the butchering, weigh on an average 2 kgs. per fish.

During my experimenting I obtained a very good glue, both solid and liquid, from the skins, tails, and fins. For this purpose I cut the big skins into pieces of approximately 1 square foot, soaked them thoroughly in often-changed fresh water, squeezing and moving them from time to time, for about 24 hours, in order to remove all salt, dirt, blood, and slime. The fins and tails were treated in the same manner. It would, of course, have been better to use a special tank with a wooden roller, but I did not have one at my disposal.

In experimenting I had to proceed in the most primitive way, as at that time no proper machinery nor apparatus were available. So I had to use simple open cookers or an open kettle suspended in boiling brine. The kettle contained the skins and fins and a small amount of fresh water. For preparing liquid glue a certain amount of acetic acid was added before boiling. I cooked the skins and fins for 3 hours, filtered the hot liquid through a flannel bag, and squeezed the residue. Later, I evaporated the liquid on large tinplate trays over a kettle of boiling water, so that the glue liquid was kept at an even temperature of about 70° C. Thus, I obtained both liquid and dry glue. To the former the necessary amount of acetic acid and about 1/2 percent of phenic acid (for preservation) was added.

For preparing dry glue, the skins were boiled without acetic acid, and the liquid was evaporated to a greater extent, 1/2 percent of phenic acid added, and the liquid left to cool and to set on cold metal trays in thin layers in a cool place. After setting, the glue was cut into slabs and dried under a strong electric fan for 24 to 36 hours.

The great difficulty in a hot climate is the drying process, as at temperatures of above 30° C. moist glue will melt and the slabs stick to the wire-netting, on which they are dried. Adding a certain amount of alum helps the drying, but lowers the joint strength of the glue.

In a hot climate, like that of Andalucia, it would be, maybe, more convenient to manufacture only a highly concentrated glue solution, adding to it one of the chemical preservatives, and to store this semi-solid product until the cooler time of the year and then dry it. It would be possible, of course, to use a special tunnel, where air, artificially dried by a refrigerator and later heated again to 27 to 28° C. could be used for drying.

The solid fish glue, obtained in this primitive way, was of a very light color, not unpleasant smell, and had a great adhesive quality. To test, I spread the glue on both contact surfaces of two pieces of beech wood, let them stand for a few minutes, placed them in the press for 24 hours and then let them stand for a few days. After sawing the pieces of wood across the joint into 1/2 inch slabs, I tried to break them at the joint, but the wood always broke first, although precautions to avoid this were taken.

As to the yield of fish glue from tuna trimmings I had no opportunity to study this question. D. K. Tressler (Marine Products of Commerce) gives the following information about the yield of glue from cod- and cusk skins: 60-80 gallons of liquid glue, containing 50-55 percent dry matter, from a ton of stock (equal to about 30-40 percent). If we count, that the dry glue contains about 85 percent of dry matter, we should obtain from 1,000 kg. stock, consisting of tuna skins and fins, approximately 170-230 kgs. or in an average 200 kgs. dry glue. If the total tuna catch of southern Spain is about 50,000 fish of an average weight of 120 kgs., which makes 6,000 metric tons, of which about 4 percent or 240 tons may be considered pure glue stock, the total yield would be approximately 48,000 kgs., dry, or 72,000 kgs., liquid glue; 950 grs. dry, or 1,450 grs. liquid glue, from each fish.

These figures seem somewhat high, especially as it is uncertain what proportion of moisture the glue stock, mentioned by D. K. Tressler contains. On the other hand, the proportion of 4 percent glue stock is calculated very low, if we consider the quantity of collagenous matter in the skins, fins, and tails, trimmings from the roe and the spines. So consider these figures as a good provisional estimate.

CONCLUSIONS

The general results of my investigations are as follows: At present the whole fish is not properly utilized and there remains a certain quantity of edible trimmings and inedible offal, which is wasted or partly wasted. In the plan here proposed, the basic preparations, such as canned, salted, and dried fish and salted and dried roe, are left out, as their manufacture is the result of market conditions. But too great a part of the raw material is discarded as offal, and treated in a summary way, which wastes a considerable portion of the fish and results in poor quality and an insufficient quantity of total product. At present, the proportion of cannery trimmings is too high (22-25 percent) and out of some of this, a much better quality and greater value may be obtained.

The following parts of the fish are discarded at present to the fertilizer plant: the heads, the tails, fins, skins, the spine with plenty of meat attached to it, the nape bone, with its fat meat, the buckroe, the adipose lobes

of the roe and buckroe, the spleen and the trimmings on the trays where the cans are packed, containing pieces of skin, of adipose tissue, and meat crumbs. All these parts, but the trimmings from the trays and the spleen, are sent at present to the fertilizer plant, where they are boiled by live steam in open tanks for several hours in order to soften the bones and to extract the oil, and then pressed in hydraulic presses and dried. The spleen is dumped into the sea as useless. The trimmings left on the trays are added directly to the boiled and pressed residue and dried, after having lost the greatest part of their oil in the heaps, where they had been dumped.

As the trimmings contain a large proportion of collagenous matter (heads, tails, fins, skins, bones) the liquid formed by the boiling process in the open boiling tanks contains plenty of glue and has a high viscosity. The prolonged cooking time is sufficient to extract a great proportion of this glue from the tissues.

But the remainder, such as heads, adipose tissue, nape bones, etc., at the same time, contain a high proportion of oil, and tuna oil is more easily oxidized than most other fish oils. Through prolonged cooking in open kettles, in the presence of air, this oil becomes oxidized, dark, and acquires a high acidity and a very high viscosity and adheres to the disintegrated meat and bones, which are not even minced before boiling. Besides containing other protein matter and mineral salts when boiled together with the glue water of high viscosity, an emulsion of oil in glue water is formed. This emulsion is not easily separated, not in simple settling tanks, anyhow, so that a considerable amount of oil is lost with the waste water, drained off to the sewer, or retained in press residues. Therefore, the output of oil is comparatively small, in fact about 10 percent in weight of the raw material, and its quality is very low, in color, acidity, and smell. To obtain a higher output and a better quality of lightly colored oil, it would be necessary to reduce the offal mechanically into a pulp before cooking it and to cook a much shorter time at low temperatures (100° C.-102° C.) in closed continuous cookers, so that all contact of the boiling mass with the air is avoided. This could be easily done, of course, with any modern machinery.

But the present method of mixing trimmings and waste in one mass and treating in a uniform way, is economically an unsound proceeding. The main idea of the present experiments was to prove that the proper way of dealing with the cannery trimmings is to classify them before treatment according to the different compositions and the use which can be made of every part. This classification does not entail much more work, as it can be done during the work of butchering, packing, or salting.

Thus, the general scheme of classifying the present edible and inedible products and treating each separately, would be as follows:

Cannery trimmings	Operation in which collected	Edible products obtained	Inedible byproducts
Spines with meat	butchering	fish balls crumbs in tomatoes	glue chicken feed
Nape bone	butchering	fish balls	bone glue chicken feed
Meat scraps	salting	fish balls	-----
Broken or small roe bags	butchering	tuna caviar	glue
Buckroe	butchering	smoked, canned paste tuna kidneys	meal
Adipose tissue of roe and buckroe	salting of roe, butchering	edible oil	oil meal
Scrap from the packing trays (fat)	packing	edible oil	oil meal
Scrap from the packing trays (lean)	packing	-----	glue fish meal
Tails, skins, fins	butchering	-----	liquid glue dry glue chicken feed

As the classification is done during the normal work of butchering the fish, the salting, and packing operations, practically no extra labor is required. Even the capital outlay for machinery will be of little importance, as the increased value of the byproducts will amply compensate for this item.

In order to obtain a clearer idea as to the economic soundness of this scheme, I give here an approximate calculation of the increased value of the byproducts: the total tuna catch of southern Spain is about 50,000 fish, of which 40,000 are fat and 10,000 lean. These fish weigh approximately 6,300 to 7,000 metric tons. Of these, 1,540 tons are sent to the fertilizer plant, the output of which would be thus approximately 450 tons of fertilizer or fish meal of a very poor quality and 150 tons of a dark and evil-smelling, highly oxidized oil of high acid index.

By this rough calculation we can get an idea what edible and inedible byproducts can be obtained from the same quantity of cannery trimmings. The spines, nape bones, and trimmings of meat left over in the salting department: from 3,239 fat fish I obtained 18,800 one-lb. cans of fish balls of 300 grs. netto each, which makes for 40,000 fat fish, 232,000 cans. But from 1,946 lean fish, 22,454 cans were obtained, which would work out at 115,000 cans or a total of approximately 350,000 cans of fish balls. The higher output in the lean fish is explained by the greater quantity of trimmings from the salting department. Besides, from 50,000 spines after boiling them, 600,000 small 1/4 cans of "crumbs in tomatoes" can be manufactured, after which the spines are already peeled clean

and can be used for glue production and later for manufacturing chicken feed, of activated coal or triphosphate.

Tuna caviar:--From 3,239 fish of which roughly one half were females, the roe of 732 females (45 percent)which was second-grade had to be used for caviar making, and 878 pairs of the large size roes were used for salting and drying. The average weight of one pair of the small and damaged roe is 1.83 kg.

We arrive at a similar figure of the average weight by the following calculation, based on many years practical experience: the proportion of roe for every 1,000 kg. of fish (male and female) is 9.6 kgs. As 1,000 kgs. of fish represent approximately 9 fish, of which 4 are males, the 4 females yield 9.6 kgs. of roe, or 2.4 kgs., the average weight of roe, large and small, per fish. As only small roes and occasionally damaged pairs of large ones can be used for caviar making, the average weight of the caviar grade can be reckoned as 1.5 to 1.83 kgs. a pair.

Calculating that from the catch of 40,000 fat fish 20,000 are females and that 55 percent of the roe of these could be used for salting and drying, the roe of 11,000 females has to be turned into caviar. The indicated average weight is high, as in the later part of the season a greater proportion of the roe is unfit for salting and drying. But even if we base our calculations on 1.5 kgs. of roe for every pair of roes, roughly 16,500 kgs. of roe would be utilized for caviar making. As from every kg. of roe 7.8 cans of 100 gr. net can be manufactured, the total output would be about 128,000 cans or 12,800 kgs. net.

Buckroe:--It is of course difficult to calculate the canned products which can be obtained from the 20,000 males, but roughly the average weight of one pair of buckroe is approximately 1 kg. (cooked weight) and that every kg. yields approximately 1-1/2 kgs. paste. Thus about 30,000 kgs. of paste or about 10,000 kgs. of smoked and canned buckroe could be manufactured.

The adipose lobe of the roe and buckroe. As already indicated, from 40,000 fat fish (the average weight of a pair of these lobes being 1. kg.) approximately 26,600 kgs. of first-grade edible oil may be obtained, and another 3,400 kgs. second-grade industrial oil.

It is certain that from the fat on the packing trays, which is mostly adipose tissue (on the trays where the bellies are packed), a considerable amount of edible and industrial oil can be obtained, but the quantity of this output is unknown, as I did not experiment with it sufficiently. Just for the sake of argument let us suppose that 1,000 kgs. oil can be obtained.

According to previous calculations, the total output of liquid glue from 50,000 fish may be approximately 70,000 kgs., if we use the skins, fins, and tails, the spines, and trimmings from the packing trays from the lean parts of the fish, as glue stock.

Thus the total list of byproducts obtained from 40,000 fat and 10,000 lean fish would be:

350,000 half kg. cans of fish balls.
600,000 quarter kg. cans of "crumbs in tomatoes".
128,000 1/8 cans caviar.
300,000 1/8 cans of buckroe paste (or 10,000 kgs. smoked buckroe).
27,600 kgs. edible oil.
3,400 " industrial oil.
70,000 " liquid glue.

To these estimates should be added that of the usual oil from the cooking kettles, the barrels of salted fish, and the fish meal, the chicken feed, and fish meal or fertilizer from the byproducts plant.
