Fermented and Dried Seafood Products in Southeast Asia

A. G. VAN VEEN

Graduate School of Nutrition, Cornell University, Ithaca, New York

I. Introduction

Millions of people living in Southeast Asia have remarkably low amounts of total protein in their diet, particularly compared with standards commonly accepted in North America and Western Europe. The animal protein content is even lower.

One of the most important sources of such protein in Southeast Asia is fish, both salt and fresh-water varieties. Fish, either fresh, dried, or salted or in the form of paste or sauce, is a common ingredient in the diet of the rice-eater. Nevertheless, the relatively high price of fresh fish and the limited supply of fish products, as well as their poor keeping quality together with inadequate marketing systems, have all hindered a larger consumption. Even along the coastal areas and the numerous rivers and lakes as well as in the neighborhood of fish ponds, consumption frequently is lower than would be expected. This is partly due to lack of efficient fishing equipment and to unsatisfactory methods of preservation.

Since World War II many governments in Southeast Asia have been endeavoring to expand fish production for local consumption. In general, however, the increases have been just about enough to keep pace with population growth. Exceptions are Japan and the Philippines, where an increase in per capita consumption has resulted. Such augmented fish production would of course be of limited value unless reliable methods of preservation were adopted at the same time, so that supplies could be...
made available to the large portion of the population living beyond the fish centers.

Canning, freezing, and icing, which are simple and relatively cheap methods of preserving fish in Europe and North America, are generally too expensive in Southeast Asia. Even very cheap Japanese canned fish products, available in the area prior to World War II, were usually too costly for the great majority of the population.

Tastes and dietary habits of the rice-eater differ from those of the American or European and require consideration. The Southeast Asian diet is usually monotonous and dominated by rice. Fish pastes and fish sauces with curries and Spanish peppers are much in favor. Drying, salting, and the making into pastes and sauces are therefore the most common ways of preserving fish in these (van Veen, 1953) and other underdeveloped countries. Fish in these forms are, however, subject to the action of numerous microorganisms. These may come from the entrails, the gills, and the slime of the fish, or be introduced with salt, air, etc. Many food products of high nutritive value prepared in this area, and subjected intentionally or otherwise to the action of bacteria, yeasts, or fungi, would be called spoiled or even decomposed in the West. They should, however, rather be compared with fermented foods such as cheese, sauerkraut, and yoghurt, which are equally rarely found to cause food poisonings.

The quality of many of the fish products under discussion is influenced not only by the method of preservation and the kinds of microorganisms present, but also by such factors as the nutritional condition of the fish (fat content, etc.), the activity of the enzymes in the tissues (autolysis), and the impurities present in the salt. In this connection, it may be useful to remember the part of the texture and taste of pickled herring in the Netherlands is attributable to the enzymes originally present in the fish pylorus, which is retained during the gutting operation (Liebert, 1924).

By following more or less fixed techniques (simple as these may be) over a period of many years, a fairly standardized product can be obtained. Alterations in texture, appearance, or flavor caused by microorganisms or by tissue enzymes are kept within uniform bounds. Fish products so treated develop uniform characteristics during ripening, which appeal to consumers accustomed to them.

The author found, when working on certain food products prepared in Java with the aid of certain fungi, that the microbial flora in and around the place of manufacture consists mainly of the fungi used in the preparation. The same is probably true with regard to the bacterial flora in many small plants in the Far East where, over the years, fish has
been salted and prepared in the same way with ingredients of the same origin.

A number of these indigenous methods of fish preservation in the Far East will be reviewed. Of those described, many are more or less standardized for a given village or region. However, many minor or even major modifications are used in other places in the same area. A few examples will be given, indicating how these relatively simple methods of fish preservation offer a number of possibilities for further research, the results of which should enable the existing cheap methods to be improved. However, the acceptability of the products from the point of view of the rice-eater must always be kept in mind.

Consideration will be given to (1) fish sauces; (2) fish pastes; (3) salted fish not (or partially) dried; (4) dried, or salted and dried, fish products; and (5) miscellaneous products. The salted and partially dried fish and the fish sauces have been studied more extensively than the other products. The rather primitive methods of manufacturing fish meal and oil and smoked fish are not discussed because of their limited local importance.

II. Fish Sauces

A number of fish sauces are well known in Southeast Asia. Some of them are extremely popular in Thailand, Cambodia, and Vietnam, but scarcely known in Indonesia and practically unknown in India. A very good review of the literature concerning the investigations of the numerous fish products in former Indochina has been given by Westenberg (1941). It seems probable that fish sauces first came into use in regions where the climate is too rainy to allow sun-drying of the fish and where sufficient fuel cannot be found for artificial drying.

Fish sauces are limited in nutritive importance, due to their high salt content which is a major hindrance to large intake. They contain mainly hydrolyzed protein and minerals (sodium chloride and calcium salts), and are therefore comparable to soy sauce. They contain sufficient calcium salts to be rather important sources of this mineral if eaten regularly and in sufficient quantity. They are used chiefly as condiments for flavoring rice dishes. In countries such as Vietnam, Cambodia, and Thailand, the fish sauce industry is a very important one.

Microbiological and other processes play an important role in the preparation of many fish products, such as pastes and undried salted products, but their most pronounced effects are noted in the fish sauces. One of these, "nuoc-mam," has been carefully studied by a number of investigators, and many of the findings concerning nuoc-mam may be to a certain extent applicable to other fish products of Southeast Asia.
Lafont (1955) has discussed the dietary role of the fish sauces in Southeast Asia as well as their methods of manufacture.

A. Nuoc-Mam

The nuoc-mam produced in former Indochina is consumed almost entirely by the domestic trade, although exports formerly were made to Thailand and Malaya. It is not easy to determine the total annual production, but estimates range from 35,000 to 100,000 tons (Gruvel, 1925). In 1935 about 67,000 tons were produced (Bouvier and Autret, 1944). The economic status of nuoc-mam is evident from the amount of salt used: in the year 1925 in the province of Binh-Thuan, the total salt used was approximately 15,000 metric tons and from this about 40.6 million liters of nuoc-mam was manufactured (Guillerm, 1928). During World Wars I and II, nuoc-mam was concentrated, canned, and shipped to the Annamite troops in France (Rosé, 1919b,c; Bouvier and Autret, 1944).

Nuoc-mam is a clear brown liquid, rich in salt and soluble nitrogen compounds. It has a distinctive odor and flavor. It is produced along the coasts (Rosé, 1918a–d, 1919a–c; Brémond, 1919; Mesnard and Rosé, 1920; Gruvel, 1925; Guillerm, 1928). The most important production centers in Vietnam are in the province of Binh-Thuan (South Annam) and on the island of Phu Quoc. The best products have a rather strong cheese-like odor and salty taste. The cheaper products are unattractive and generally not liked by the Westerner. Nuoc-mam is usually prepared from different kinds of small sea fish, mainly species of clupeids and carangids such as Decapterus, Engraulis, Dorosoma, Clupeodes, Stolephorus, and others.

During and after the war the production of nuoc-mam from freshwater fish increased greatly. Formerly this had a poor reputation due chiefly to deficient methods of manufacture. However, it does not seem to have quite the flavor of nuoc-mam prepared from sea fish. It is usually made of small noneviscerated fish. The possibilities for increasing the production of nuoc-mam from freshwater fish in Cambodia are enormous (Lafont, 1950). Nuoc-mam can also be prepared from shrimp (Truong Tan Quon, 1951).

In the most primitive method of manufacture, small fish are first kneaded and pressed by hand, then salted and placed in earthenware pots that are tightly sealed and buried in the ground. They are left there for several months. When dug up and opened, the supernatant liquid that has formed is carefully decanted. This constitutes the nuoc-mam. In the commercial manufacture of nuoc-mam in South Annam, large vats with a bamboo tap fitted near the bottom are used (Rosé, 1918a; Gruvel, 1925).
The fresh uncleaned fish are mixed with salt and dumped into the vats. The amount of salt varies according to the kind of fish; usually 4–5 parts salt to 6 parts fish are used (Rose, 1918a). For some species of fish proportionally more salt is added to the upper layers in the vat. The fish are piled above the top of the vat. A final layer of salt is placed on the pile of fish. After 3 days, the collected turbid and bloody liquid ("nuoc-boi") is drained off. A part of it is returned to the vat; another portion is saved and used later. On exposure to the air, the liquid becomes somewhat clearer (Guillerm, 1930). The fish settle below the top of the vat, and the layer of salt almost disappears. The fish are now packed down thoroughly. Some of the nuoc-boi is poured back over the fish until they are covered to a depth of about 10 cm. The contents are then covered with large bamboo wickerwork and heavily weighted.

The period of aging now begins and varies according to the kind of fish used (Rose, 1918a). Only a few months are required to produce good nuoc-mam from small fish, but a year or even 18 months may be needed for large fish. Generally, the higher the concentration of salt (e.g., 200 g. per liter) the more the proteins are hydrolyzed into amino acids and other products of low molecular weight, and the better will be the keeping qualities of the nuoc-mam.

Originally, the nuoc-mam was allowed to stay in the same vat until ready for consumption; now, however, lixiviation is frequently practiced. After maturing, the pickle is run off through the tap; this is the first-quality nuoc-mam or "nuoc-nhut." A product of lower quality is then obtained by extracting the residual mass with boiling sea water. Here the liquor from the first vat is transferred slip-wise into a number of other vats, and the first vat is again suffused with sea water. This procedure is repeated several times (in a counter-current manner) in order to lixiviate the fish as thoroughly as possible. The several extracts are usually mixed together. This mixture constitutes nuoc-mam of lower quality, with much poorer keeping qualities. Before lixiviation, caramel, roasted rice, molasses, or corn (first boiled and then roasted) is sometimes added to the fish in order to darken the color and give the product a certain flavor. These additives also improve the keeping properties of the poor-quality nuoc-mam (Rosé, 1918b; Guillerm, 1928), probably because they produce acids, such as butyric, which lower the pH (Vialard-Goudou, 1941, 1942).

The undissolved fish residuum, the so-called "xat-mam" or "nuoc-xat," is usually sold as a manure. If Dorosoma nasus Bloch or other fatty fish are used, oil comes to the top of the pickle during the ripening. This oil can be separated and sold.

The methods of manufacturing nuoc-mam may vary somewhat in
other parts of the country. The basic principles are the same. They involve careful regulation of the enzymic degradation and extraction of the fish proteins and other substances under mild pressure and anaerobic conditions.

An improved and simplified method for the manufacture of nuoc-mam was reported by Ngo-Ba-Thanh (1963) which in essence represents a modification of the classic process.

One part fish gives 2–6 parts nuoc-mam, depending upon the nitrogen content of the end product. According to 1933 regulations, nuoc-mam must contain 15 g. nitrogen per liter in the south of former Indochina and 5 g. per liter in the north.

In Cambodia, according to Bouvier and Autret (1944), 1 liter first-quality nuoc-mam contains 15.85 g. total nitrogen (of which 11.15 g. is organic nitrogen and 5.0 g. amino nitrogen), 270 g. sodium chloride, and 0.5 g. CaO; in the north, 1 liter undiluted first-quality nuoc-mam contains 19.3 g. nitrogen (11.7 g. organic nitrogen and 8.7 g. amino nitrogen), 276 g. chloride, and 0.565 g. P₂O₅ (see also Nguyen-Xuan-Tho, 1952).

The poorer classes use about 4 times (60 ml.) the daily amount of nuoc-mam consumed by the wealthy (Nguyen-Thi-Lau and Richard, 1959). The former category in the same area eat about 20 g. daily of “mam-ca” and 30 g. daily of “ca-kho,” two other fish preparations. Toury et al. (1958) found that nuoc-mam prepared at Dakar (Africa) was a good source of essential amino acids, especially lysine.

Because of the great importance of nuoc-mam, official methods of analysis were set up before the last war in former Indochina (Rosé, 1918a; Guillerm, 1928), mainly in connection with legal standards. These include tests for total nitrogen, organic nitrogen, amino nitrogen (Sorensen’s formol), volatile nitrogen bases, salt content, and pH.

Hydrolysis of the fish proteins takes place under sterile conditions also (Mesnard and Rosé, 1920); peptides, amino acids, and ammonia are the resulting products. Therefore the enzymes in the fish (meat and entrails) appear to be as important as the microorganisms in bringing about protein hydrolysis. Glycerol extracts of the entrails are particularly active, even in the presence of salt.

Products made aseptically, however, lacked the typical nuoc-mam flavor and, when prepared on a semicommercial scale, were not acceptable (Krempf, 1924). This also appears to be true for fish meal prepared in former Indochina (Krempf, 1934). As a result, Krempf (1928–1929) occupied himself with the practical problem of producing the true aroma of these products.

Boez and Guillerm (1930a,b) isolated an anaerobic spore-bearing bacterial species from fish. It seems to be a new (as yet unidentified)
Clostridium and is said to produce the typical flavor of nuoc-mam. The organisms are strictly anaerobic, form gas, and show optimal growth between 28° and 45°C. (82.4° and 113°F.). Milk is coagulated and digested, egg protein is digested, and no PbS is formed from lead acetate, even after addition of hyposulfite. Glucose, maltose, fructose, and sucrose are fermented with the formation of gas. This organism also has strong proteolytic properties and seems to be the main producer of the volatile nitrogen bases from maturing nuoc-mam. On Veillon agar medium (15 g. glucose and 1 g. KNO₃ per liter) the characteristic nuoc-mam odor developed. Later these workers and also others in Indonesia and Thailand discovered many other bacteria which could produce the typical flavor. It is said that fish meal exposed to the action of these bacteria acquires the proper flavor and was acceptable to the population. The slow breakdown of the fish protein seems to be due to two causes: the fish enzymes and the enzymes from bacteria.

In this connection it is important to mention that in the western part of former Cochin China (Chevy, 1931–1932) the nuoc-mam is produced from eviscerated fish which, because of the lower content of proteolytic enzymes, go into solution very slowly. To hasten the process, fresh proteolytic pineapple juice is added. If nuoc-mam has a high pH (6.8–7.2), it cannot be kept for long (Guillerm, 1928).

Experiments were conducted in France (Gauducheau, 1928) on flavoring the meat of animals after slaughter by injection of nuoc-mam into the large veins; the results are said to have been favorable. This is said to have been done also with tuna fish by Japanese fishermen.

The author (unpublished) found that practically all the nitrogen compounds in nuoc-mam can be dialyzed, indicating that the protein is completely broken down. But nuoc-mam did not contain significant amounts of thiamine, riboflavin, or pyridoxine. It is therefore not a good source of the B vitamins.

Nuoc-mam has a high content of methyl ketones, which probably account for the cheese-like odor (van Veen, 1941c); diacetyl and methyl-acetyl carbinol are absent (van Veen, 1941c; Dang M-Kha, 1941); Autret and Vialard-Goudou (1939, 1940) have published data on the amino acids in nuoc-mam, and Vialard-Goudou (1941, 1942) on the volatile bases and acids. Histamine was found by Cousin and Noyer (1944).

Other fish sauces are manufactured in former Indochina and elsewhere in Southeast Asia; however, they are less interesting than nuoc-mam, and fewer studies have been done on them. There is also a kind of sauce called “nuoc-mam ruoc” which is prepared from shrimps along the coast of Thailand and differs in flavor from the ordinary nuoc-mam (Chevy, 1929). Boury (1952) states that nuoc-mam can also be manufactured
from a good grade of ordinary fish meal. This has been tried in other places in Southeast Asia, but in general these products lack the cheese-like flavor of a good nuoc-mam.

B. OTHER TYPES

Fish sauces are common in the Philippines (Martin and Sulit, 1955). They are usually prepared by fermenting sardines, anchovies, ambassids, and shrimps (Atya sp.). The method of manufacture is somewhat similar to that for nuoc-mam; although less complicated, it requires considerable time (Division of Fisheries, Manila, 1946). "Patis" is a by-product of the manufacture of "bagoong" made from shrimps by draining off the liquid obtained in the fermentation and boiling it (Miller et al., 1946).

In Thailand, fish sauces are called "nam-pla." They are made preferably from Stolephorus, but also from small Scomber and certain clupeids. The manufacture is similar to that for nuoc-mam but usually somewhat simpler. The process takes about 6 months, but for better qualities 2-3 years may be required. Approximately 1 liter is produced from 1 kg. fish. As in former Indochina, the product is sometimes made from fresh-water fish (see also Velankar, 1952).

In a number of places in Southeast Asia, the liquors obtained from salting fish in different ways are cooked and concentrated (for example: "tuk-trey" in Cambodia and "petis" in Indonesia). These products are usually inferior to the fish sauces that have been mentioned. The nitrogen:salt ratio is rather low.

Shimo (1951) describes a product from Japan called "shottan" that is used for the same purposes as soy sauce and prepared from sardines, cuttlefish, herring, or fish waste materials. Fukuda (1955) recommends the use of antioxidants to prevent rancidity of "shikara," a product prepared by autolysis from fish guts, livers, etc., which seems to deteriorate easily.

III. FISH PASTES

Fish pastes are eaten almost everywhere in Southeast Asia, generally as a condiment for rice dishes. Sometimes carbohydrates (roasted cereals, glutinous rice, flour, and bran) are added in varying amounts to the pastes. In this case the expression "fermented fish" is applied. The absolute amounts of these products consumed in the diet are small, although on the basis of their nitrogen content they are eaten in greater quantities than the fish sauces.

The method followed in the Philippines for preparing the fish paste, bagoong, is as follows. From January to May large quantities of sea fish, anchovies, and ambassids are available and are caught for conversion to
paste. A species of small shrimp (Atya sp.), "alamang," is also used. The fish are first cleaned and uniformly mixed with coarse-grained salt in the proportion of 1 part salt to 3 parts fish, then put into clay vats to mature until ready for consumption, either raw or cooked. In bagoong, most of the protein breakdown is done by the fish enzymes and not by bacterial enzymes (Uyenco et al., 1953). The resulting product is of a pasty consistency but very palatable. Sometimes it is colored by adding "ankak" —a fermented rice product, reddish from a wood dye (Miller et al., 1946).

Hamm and Clague (1950) recommend that bagoong be prepared with only the amount of salt that will saturate the moisture in the fish. The moisture content varies, but most of the commonly used fish contain about 80%. One part of salt (with 99% or more NaCl) to 3.5 parts by weight of fish yields a product with but slight excess of salt. These workers indicate that pure salt should be used, since digestion is more rapid and fewer difficulties are experienced with halophilic bacteria.

Hamm and Clague also observed that bagoong manufacture can be accelerated by storing at 45°C. during manufacture. Martin and Sulit (1953) have shown that dried "dilis" can be used for the preparation of bagoong. Hermetically sealed tin containers are preferable for aging, although large deep containers may be used.

Sulit and Santiago (1949) report that, according to the Philippine Pure Food and Drug Law, bagoong should contain 40% solids, 12.5% protein, 20–25% sodium chloride. Martin and Sulit (1955) give extensive information not only on bagoong but also on the fish sauce, patis. They mention that a good grade bagoong has a cheese-like odor.

Many kinds of fish paste are manufactured in Southeast Asia by methods that are often rather complicated. The fish paste of Cambodia is called "prahoc." At least two methods of preparation are employed. In the first, cyprinids are used (e.g., Rasbora sp. and Thynnichtys sp.); in the second, Ophiocephalus sp. and others are used. Descriptions of the first method are given by Brémond (1919) and Le Poulain (1938). The fish are beheaded and eviscerated and put into a wicker basket without being scaled. The heads are either thrown away or may be preserved for the manufacture of oil. The fish, which half fill the basket, are trampled by foot to remove scales and press out entrails. The fish are washed in a river or pond, then stirred by hand until the scales are completely removed. They are again pressed in order to remove water. The upper part of the basket is covered with banana leaves and weighted with stones for about 24 hours.

The following day the fish are mixed with coarse salt for about half
an hour, and then spread out on matting in the sun for a day. The salted and dried fish are returned to the basket for packing.

The next phase, pounding small quantities of the fish in a wooden mortar for about 20 minutes, takes place in the homes of villagers, and it is salted to taste. The paste is then placed in open earthen jars in the sun. During the evening the jars are covered to keep out insects. Fermentation or ripening now takes place, and a pickle gradually appears on top of the paste, which is removed every day. The Cambodians use this as nuoc-mam. This phase of the process may last a month. When no further pickle forms, the prahoc is finished and is ready for immediate consumption. It is used principally in the preparation of soups, which play an important role in the Cambodian diet.

Three parts of fish produce one part of prahoc. In many cases, the paste during the ripening is kept out of contact with air by carefully closing the containers. According to Chevey (1930-1931), autolytic enzymes are not very important in this process since the entrails have been removed. Bacterial activity appears to be mainly responsible for the characteristic properties of prahoc. However, a paste can be made out of the washed and salted entrails together with fresh fish meat. Roe may also be used.

In Cambodia, Vietnam, and Laos, fish pastes are also prepared with addition of cooked glutinous rice, roasted rice, rice bran, and other cereal products. "Padec" is a fish paste from Laos made with salt and rice bran.

In Cambodia, salted fish with heads and entrails removed are kneaded with glutinous rice pretreated with a native yeast preparation. This is called "phaâk" or "mam-chao." In other parts, small salted fish are treated with roasted rice, or roasted rice and sugar, and kept under pressure in containers. This product is called "mam-cu-sak" and may be mixed with unripe papaya or pineapple to accelerate the ripening, or with ginger in order to obtain a special flavor. It is said that these products can be kept for years if the containers are kept closed. Nothing is known of their chemical composition.

Some work has been done on the chemical composition of fish pastes (Brémond and Rosé, 1919). They consist of a soluble part (mineral salts, protein cleavage products, ammonia, etc.) which is somewhat comparable to nuoc-mam, and the insoluble unfermented fish. The moisture content of the samples investigated was 52–63%, and the soluble part 26–30%. Soluble nitrogen is usually less (in a few products much less) than 50% of the total nitrogen. The digestion process is therefore far from complete.

According to Bouvier and Autret (1944), prahoc contains 37.8 g.
nitrogen per liter of which 22.4 g. is soluble, with 17.9 g. organic nitrogen of which 4.3 g. is amino nitrogen. According to the same authors, padec contains about 17–27 g. nitrogen per liter. “Mam-tom,” a paste made from shrimps, contains 21–23 g. (see also Lafont, 1951).

In Thailand, pastes are made from shrimps, preferably small ones, as well as from small fish. The fish are said to give a product of poorer quality. Sometimes various forms of carbohydrate and dyestuffs are added.

In Indonesia, especially on Sumatra, a fish paste called “trassi” is manufactured in large quantities and exported to Java. It can be made from fish as well as from shrimps. The method of manufacture is different from that used in the Philippines and former Indochina; the paste is not put into containers but is exposed to the sun in thin layers. “Trassi udang” (Markus, 1929) is made from a type of plankton consisting of very small shrimps called rebon (Schizopodes, Mysis, etc.). The most important center for its manufacture is Bagan Si-api-api (Sumatra).

Aboard the fishing boats, the shrimps are mixed with about 10% salt. When the boats have returned to harbor, the rather ill-smelling mass is mixed after a few days with another 5% salt. After grading, the mass is spread out on large floors and exposed to air and sun for 1–3 days. The moisture content decreases from about 80 to 50%, and the very evil smell of the decomposing product, infected with fly larvae, grubs, etc., slowly disappears. The mass is then carefully mixed by kneading for about 15–20 minutes. It is further dried in the sun and kneaded again; at the same time red synthetic dyestuffs (for example, carthamine DD and rhodamine B) are added. The end product usually contains 50–75% moisture, 15–20% salt, and 27–30% solids (protein, Ca salts, etc.). On the average, 3 parts of shrimp give 2–2.5 parts of trassi. The product, a red-colored sticky mass, is often adulterated with starches, rice bran, potato peel, etc.

“Trassi ikan” (fish paste) is also manufactured, usually from small fish, in large quantities in Bagan Si-api-api. The fish are mixed with salt in the boats. When the boats reach harbor, the salted mass has often a very disagreeable smell. The mass is dried in thin layers in the sun as soon as possible, mixed with more salt, and pounded until a paste is obtained that will lose no more water in the hot tropical sun. Trassi ikan is usually mixed with dyestuffs to give it a more attractive appearance.

These trassi products usually have a strong smell, keep for a very long time, and are often mixed with Spanish peppers, etc., to give very spicy products called “sambal” that are used regularly in Indonesia with every rice meal together with dried and salted fish.

Trassi ikan usually contains 35–50% moisture, 20–45% protein and
protein degradation products, 10–25% minerals (NaCl and Ca salts), and a small percentage of fatty substances.

Jansen et al. (1953) found “trassi” to have a high content of vitamin B₁₂.

Not much is known of the fish pastes from Burma, very popular in that country. U Chit Thoung (1941) describes three kinds of “nga ngapi” prepared from fish, often previously sun-dried. The average composition is: moisture content 40–50%, protein 20–30%, fat 3–5%. There is also a “ngapi seinsa” made from shrimp and prawns. Duchateau et al. (1953) analyzed the nonprotein amino acids of this product.

In general the raw material is dried in the sun for 3–4 days, pounded to a paste (sometimes very incomplete) with addition of salt (usually in a wooden mortar), and kept in jars for at least 3 months. Only “ngapi” made from big fish “ngapi gaung,” is salted fresh. Very often these pastes still contain large chunks of the original fish.

It is unfortunate that so few studies have been done on fish pastes. Elimination of the entrails for the preparation of certain pastes, short or long exposure to the sun for others, and sometimes ripening under more or less anaerobic conditions seems to be important in producing their characteristics. The pastes can probably be best compared with products such as “pedah,” which will be mentioned in the next section. Without doubt enzymic and microbial processes, as described for nuoc-mam, play an important role; however, they produce much less pronounced results than in the case of fish sauces.

IV. Salted Fish Not (or Partially) Dried

In Thailand, one of the most important sea fish, Scomber neglectus (“pla-thu”), and the closely related species, Scomber kanagurta (“pla-lang”), are salted and exported to Malaya and Indonesia. It is not known whether the salted pla-thu and pla-lang for export are treated more carefully or in any other way than the product consumed in Thailand itself. However, the product from Thailand is highly valued, especially in Indonesia, because of its good keeping qualities and its special flavor. In Java it is called “pedah Siam” and this name will be used. It is not known whether the results of the investigation also apply to the unexported product. The fresh fish is called “kembung” in Java.

The pedah Siam arrives in Indonesia in very large bamboo crates, in which it can be held for a number of months. Unpacked, the product can be kept for a few weeks or a couple of months at the most, depending on the quality. Because of its superior quality, the pedah Siam has been studied extensively in Indonesia, especially by the present author (van Veen, 1941,a,c). It was possible to prepare the product from local kem-
bung (*Scomber* sp.) as well as from other species. The experimental work was halted by the outbreak of the war in the Far East in 1941.

The best pedah Siam ("merah basah," meaning, brown, wet, and soft) is a fatty, partly dried fish of a beautiful brown color, weighing about 40–70 g. Generally the fish is not cut open, since the entrails are removed, together with the gills, via the throat. Usually there is scarcely any salt left between the fish when they are unpacked after arrival in Indonesia, but sometimes a lot of salt mixed with exuded dark brown fat can be found. This salt is highly prized in Java and used for a number of purposes, including the manufacture of soy sauce. This extra salt is probably added to prevent spoilage, if the fish is not quite fresh when salted for the first time, or when washing and drying take too much time.

Cheaper qualities contain less fat and do not have so intense a brown color. The deep brown color and high fat content (7–14%) go together. The cheaper "white pedah" ("putih kering," meaning white and dry) is usually relatively poor in fat (2–7%) as well as rather dry. The brown fat pedah consists mainly of *Scomber neglectus* van Campen (a coastal variety), whereas the white lean pedah is prepared from *Scomber kana-quarta* Russel (a deep-sea variety).

Not as much is known about the exact method of preparation in Thailand. The fish are salted, stored for 12–24 hours, and washed and dried very superficially. Sometimes more fresh salt is added, and the mixture is carefully packed in large crates in which it is submitted to a maturing or ripening process which takes a number of weeks or months. When the maturing is finished, the fish meat should have a more or less pasty consistency and a fresh red color. These are two of the factors for judging quality on the market. The pH of the meat should be 6.0–6.4; a pH of 6.5 or higher usually indicates a low keeping quality, as is true with nuoc-mam. We came to the conclusion in our investigations that careful packaging of the fish is very important; maturing under anaerobic conditions is a *sine qua non* for getting a high-quality product. Moreover, the liquid formed during this period should be allowed to drain away; otherwise, a sauce or paste will result.

The content of volatile nitrogen bases (ammonia and traces of mono-, di-, and especially trimethylamines) is usually very low; they therefore do not contribute to the peculiar flavor of the product. Only when the keeping quality is low and spoilage sets in as the pH rises to 6.8 or higher are considerable amounts of these products formed and liberated. The immature pedah has a rather strong fishy odor.

The content of volatile water-soluble fatty acids is low, and the content of volatile water-insoluble fatty acids is very low. The volatile fatty acids do not therefore contribute much to the peculiar flavor.
The brown color of the best qualities of pedah Siam is due to oxidation products of the body fat. The peculiar odor of the fish has been analyzed and found attributable partly to methyl ketones. There appeared to be a parallelism between market quality and methyl ketone content (measured by the salicylic acid condensation method according to Täufel et al., 1937). After unpacking and exposure to the air, the intensity of the flavor and the amount of methyl ketones present increase considerably. This is especially true if the fish have been made into a paste. Furthermore, a relatively large quantity of butyl aldehyde can be isolated in the form of its 2,4-dinitrophenylhydrazone, i.e., 50 mg. crude product from 100 g. pedah (van Veen, 1941a, b, c and unpublished results). A third odoriferous substance was found to be a volatile, very unstable, unsaturated aldehyde of which no crystalline derivative could be prepared. Epihydrinaldehyde (Kreis test), diacetyl, or methylacetylcarbinol was not found. Traces of volatile fatty acids and nitrogenous substances contribute slightly to the pedah flavor.

It should be observed that pedah in its wholesale packing, with air excluded, is far more durable than when it is unpacked, exposed to air, and infected by new microorganisms such as putrefactive bacteria. In the tropical climate the quality of the unpacked pedah will gradually decrease until actual spoilage sets in.

A good quality of merah basah contains 44-47% moisture, 7-14% fat, 21-22% total protein (N x 6.25), and 15-17% NaCl; putih kering contains about the same amount of moisture, 2-7% fat, 26-37% protein, and 12-15% salt.

In the experiments in which we tried to manufacture pedah Siam, we started with the assumption that ripening is caused partly by autolytic enzymes and partly by invading microorganisms. We were able to isolate from pedah Siam a strain of non-spore-forming bacteria which was highly resistant to salt and able to live under both aerobic and anaerobic conditions. It was even possible to induce a pedah flavor in salted herring; later, however, this strain deteriorated owing to unfavorable circumstances (unpublished data). We tried a number of admixtures which are often used in these regions, such as rice bran, roasted rice flour, cane sugar, "ragi" (Javanese yeast preparation, containing rice flour), and also salt obtained from imported pedah Siam (perhaps containing the right sort of bacteria). As was mentioned, the salting usually took only 1 day but, when the product had to be transported a long distance, several days might be required.

In our own small-scale experiments, after washing with tap water and superficial drying in the sun, the fish were mixed with other substances and closely packed in large wide-mouth glass and earthenware
jars, on top of which a few bricks were placed. Every couple of days the drip was drained off.

We also tried to make a pedah paste by either pounding or milling the fish at the beginning or at the end of the ripening process. Usually after 1–3 months a pedah flavor started to develop in the whole fish, as it did in the pastes. Texture, color, pH (6.5), methyl ketone content, and content of volatile nitrogen bases of the meat served as very useful guides.

Usually the fish were eviscerated; however, it might be possible that this is not necessary. The fresher the fish when salted and the shorter the time for washing and drying, the better the quality of the final product.

Good pedah could be prepared in this way not only from both Scomber species mentioned, but also from "lemuruh" (Clupea leioaster C.V.) with 7.8% fat; and from selar (Caranx sp. div.) with 3.5% fat. In certain cases, salt from imported pedah and additions of cane sugar or roasted ragi gave very good results. They were, however, rather irregular, and probably the technique for using these additions could be considerably improved.

We also started experiments on making dry cakes either from local pedah (after pounding or milling) and pedah paste or from mixtures of these with roasted soybean flour, dry food yeast, etc., which seemed to offer great possibilities as far as keeping qualities and acceptability by the population are concerned.

It is much easier to prepare pedah from fat fish than from lean; however, there are probably still a number of technical and scientific problems the solution of which will facilitate the study and improvement of the maturing process. From a commercial point of view, pedah from fat fish is to be preferred to pedah from lean fish. For example, in one experiment pedah merah basah lost only 10% by drip, whereas putih kering lost 30%. Both, however, retain much more weight (water) than dried salted fish.

In the preparation of nuoc-mam the purpose is to get as much breakdown of the protein as possible by means of autolysis and bacterial enzymes. This can best be accomplished not only by leaving the entrails in the fish but also by keeping the fish submerged in the pickle. In the preparation of pedah Siam the aim is to retain as much fish as possible of the right flavor and texture. This is achieved by cleaning the fish and draining off as much as possible of the resulting pickle, which contains many bacteria and perhaps many dissolved enzymes. In both processes the best products are obtained under more or less anaerobic conditions.

A very important fish product in Indonesia is "pindang." The fish are
put in pots or cans and cooked in water with an amount of salt, equal to 5-50% of the weight of the fish; sometimes spices and flour (tapioca) are added. At the end of the cooking process, the product is put in earthenware pots and covered with leaves, or in closed gasoline cans, in order to exclude air and prevent air-borne infections. The product can be kept for a few days only or for a few months, depending on the amount of salt used, before spoilage or rancidity begins in the tropical climate. The closed pots or cans are transported inland. Pindang-like products are known elsewhere in Southeast Asia.

It can easily be understood why a preparation like pindang, especially when prepared without much salt, causes serious fish poisoning (very severe gastroenteritis) in the tropics (Mertens, 1939). The microorganisms involved are not yet known.

In Ceylon, eviscerated fish with gills removed and washed in 10% saline solution were satisfactorily kept in saturated brine if a mere 2% of citric acid was added to control pathogenic microbes and to aid in the initial salt penetration (Gunasekera et al., 1956).

A. SALTING AND DRYING

Ordinary drying, or salting and drying, are the least expensive and simplest methods of preserving fish. Such products are reasonably cheap to transport over long distances as compared with iced or canned fish, but of course do not keep as well in the hot damp tropical climate as in colder and/or drier regions. This is especially true if the salt used is very crude and hygroscopic. The only possible procedure then is to re-dry the fish frequently, which may have detrimental effects on the product as far as nutritive value, flavor, color, etc. are concerned. Preservation of either salted or unsalted fish by smoking, done in several countries such as former Indochina and the Philippines, is on a small scale. Reference will be made to a few of the more interesting methods.

Small fish and shrimps can be dried in the sun. In Sumatra, shrimps are cooked for a short time with water and a small amount of salt, sieved, dried in the sun for a couple of days, and thrashed to remove the shell.

Anchovia commersoniana Lacépède is the most common anchovy of the Philippine waters. It is usually dried and called "monamon" or "dilis" and made into bagoong (Miller et al., 1946). Other species of anchovy are also used in this way. "Daing" refers to any kind of fish which has been salted and then dried. The dried salt-water shrimps "shiba" are a good source of protein (50%).

It is reported that fish are very often dried for home consumption without salting. In Indonesia small fish are dried in the sun with little or no salt. Somewhat larger fish are cut open, cleaned, and sun-dried.
In Cambodia, which has a dry climate for about 7 months of the year, cleaned fish are dried in large quantities.

In Malaya, "filis" (*Stolephorus* spp.) is usually found on the market and may be sold fresh, cooked, or dried; the last is the most common. Since dried filis contains about 45% protein, it is a good cheap protein source (Svasti, 1954).

**B. SALTED PRODUCTS**

There are numerous methods of salting fish. Fish can be treated with dry salt in small quantities, but this usually results in poor keeping quality. Larger amounts of salt, up to 50% and even 100% of the weight of the fish, may be used if this is economically possible. In other regions, fish are put in brine. The fish are salted after eviscerating, or in some cases the whole carcass is salted intact. In many places, the salt or brine is used twice. This might seem to be an economic measure only, but it may be important in securing the desired flavor. The action of bacteria contained in the once-used salt or brine may be responsible. In some areas the fish are in salt for only a couple of days, in other places up to several weeks or more. Dried, pickled and dried, or salted and dried fish usually does not keep longer than 2–3 months in Java.

In some regions the fish are cleaned and salted when fresh. However, it has been reported that in Cambodia the fish, with the heads removed, are put in fresh water for a period of 12–16 hours before salting. In this case, the fish become heavily infected and autolysis sets in. The growth of the infecting microorganisms is subsequently stopped by the added salt. It is said that this procedure gives the product a better taste and appearance.

The salting itself is done in several ways. The salt may be rubbed in the fish, or fish and salt may be placed in alternate layers. Usually, the salted fish are dried in the sun. It is reported that in Tonkin the salted fresh-water fish are first treated with roasted and pounded rice and then dried in the sun. Nothing is reported on the properties and keeping properties of this interesting product (Westenberg, 1941). Lafont (1950) described the manufacture of dried-salted, smoked, and fermented fish products in Cambodia (see also Lafont, 1952). Krishna Pillai *et al.* (1956) studied the chemical quality of fish products from the west coast of India that had been cured in different ways, such as sun-drying, dry and wet salting, and pit curing; Saha *et al.* (1949) analyzed some 15 varieties of sun-dried fish available in Bengal.

In Japan, "amino hosh" is made by salting, boiling, and carefully dehydrating, and is a patented product. The salt content should not be less than 10%. It is said that this product has a high keeping quality.
In some of the islands in the South Pacific, fish meat is boiled over a slow fire with sea water and an equal amount of coconut milk until dry. It is stated that the resulting dried product has better taste and keeping quality than ordinary fish; this interesting product should be further investigated as to biological value of the protein and bacterial count (McKee, 1956).

From the foregoing it is clear that there are many ways in which fish are salted in the Far East. This is due partly to the fact that fish of different species and of varying size must be handled differently. Salt will penetrate small fish within a few hours, whereas large fish have first to be cut open and carefully cleaned before salting.

Price and quality of the salt are very important. If the price is very high, the fisherman will be inclined to use as little as possible and even try to use the salt a second time. Old habits also play a great role in the methods of salting. There is not much exchange of ideas and experience in this part of the world (outside the large cities), and the simple techniques of drying and salting are, for the most part, traditional.

A most peculiar method used by the Dyaks in central Borneo, near the Kapuas River, was reported to the Southeast Asia Fisheries Conference held in Singapore in 1947. The salted fish is partly dried and in a short time is heavily infested with fly larvae. At this stage, the fish is put in closed pots for about 12–24 hours, then removed, the dead maggots which have come to the surface are thrown away, and the fish is carefully dried in the sun. It is said that the resulting product will keep for about 9 months and is resistant to fly larvae. The author tried to investigate this phenomenon in the Eykman Institute in Batavia. He attempted to find some sort of antibiotic activity in the end product but was not successful.

The quality of the salt is of importance especially in respect to the calcium and magnesium contents and perhaps the microorganisms found in it. Much also depends on unknown factors; for example, in Holland pickled herring (pekelharing) can readily be prepared from herring caught in the North Sea, but those from the (former) Zuider Zee are not suitable since they do not acquire the characteristic flavor of the product.

V. Miscellaneous

In many parts of Indonesia, cleaned fish (Lates and Stolephorus spp.) are mixed and kneaded or pounded with an equal weight of tapioca and about 20% salt. The mixture is made into long rolls, which are steamed, sliced, and dried into thin disks. Fish as well as shrimps (Palaemon and Penaeus) can be used for similar preparations called “krupuk.” They
have a very high keeping quality when dry. Sometimes sugar and eggs are added before steaming. The product is fried in oil before eating and is highly valued by the local populations and by others.

Makassar fish (red fish) is a very remarkable product manufactured near Makassar (Celebes, East Indonesia). It consists of small salty fish in a spicy red sauce and is used as a condiment. The fish (*Engraulis* and *Stolephorus* spp.) are decapitated and placed in earthenware pots with a large amount of salt. After a few days the product is mixed with "angkhak" (an intensely red-colored rice product) and ragi (prepared from rice flour infected with yeasts and fungi), and spices. After a few days the fish and the liquid become a deep red. The product is sold in glass bottles; it contains about 65.8% moisture, 15% protein, 0.4% fat, and 16.9% ash.

In the Solomon Islands, fish are cleaned and boiled for 30 minutes in 3 parts sea water and 1 part coconut water, boned, broken into small pieces and slowly dried for 24 hours over a fire. The resulting flakes keep well and are a good source of protein (analyzing 56.3% crude protein) (Peters and Wills, 1957).

Angkhak (red rice) is imported from China. It is prepared by inoculating cooked, highly milled, white rice with angkhak powder, which contains the deep red-colored fungus *Monascus purpureus* Wentii. After 6 days of storage in a cool environment, the product (consisting of red-colored rice grains and fungus mycelium) is ready; it is then dried.

Nguyen-Thi-Lau and Richard (1959) describe two fish preparations used by the poorer classes in Vietnam: "mam ca" is prepared at home from eviscerated fish salted and then coated with rice flour and sugar, and contains 26–29% protein; "ca kho" is made from dried salted fish and is eaten with rice, or among rich people, it may be used as hors d'oeuvres. Both are cheaper than fresh fish.

Attention in many countries today is given to edible fish protein concentrate, deodorized or nondeodorized, manufactured from either fresh fish or first-quality commercial fish meal. Such a fish flour, with 75–80% protein and a high calcium content, would in principle offer great possibilities if made from local fish and therefore cheap. It is easy to pack, inexpensive to transport, and keeps well. With all these advantages there are nevertheless a few problems. Nondeodorized fish flour when not manufactured in a hygienic way may become a source of bacterial infection. Deodorized fish flour, usually sterilized during a solvent extraction process, does not have this disadvantage, but solvent-extracted foods are often (and usually erroneously) regarded unfavorably because of the alleged association with carcinogenic substances.

Fish flours for human consumption are under study (or even pro-
duced on a small scale) in a number of countries in Southeast Asia, such as the Philippines, Netherlands, New Guinea, Indonesia, Thailand, and Burma. One of the most promising experiments has been with dilis flour in the Philippines (Alcaraz-Bayan and Leverton, 1957).

Richard et al. (1960) analyzed industrially prepared canned fish, fish sausages, and fish flour. While all these products supply concentrated and stable protein, it is not clear whether the population will accept them.

VI. Summary and Conclusions

An attempt has been made to indicate why the study of the simple but little known fish preservation methods in Southeast Asia is important from a scientific as well as a practical point of view. In many tropical countries, the native diet contains relatively little animal protein; often the main source is fish. Increasing the production of fish, both salt- and fresh-water fish, seems to offer the best possibilities for raising the animal protein level of the national diet in these countries. The economic level of most of the population is low; among the factors limiting greater consumption of fish are the high cost of imports and the lack of efficient methods for preserving the indigenous supplies. It is not generally appreciated in the technically developed countries, even in countries having a low economic level, that modern methods of fish preservation, such as refrigeration and canning, tend to make fish products far too expensive to be used freely by the general population.

Most interesting to the biochemist and food technologist are fish pastes, salted and partially dried fish products, fish sauces, and fish flour. It is probable and at least proven for the few products studied in these categories that, although enzymes of the fish itself along with bacterial enzymes are responsible for the alteration of the fish meat (partial or total hydrolysis of the proteins, disintegration and eventual liquefaction of the meat), certain of the bacteria produce the typical flavors during the maturing process. When fish proteins are hydrolyzed by mineral acids or alkali and suitably treated, they produce liquids resembling fish sauces; these liquids, however, are not comparable (as far as flavor and certain other qualities are concerned) with real fish sauces prepared in the traditional ways.

From the biochemical point of view, salted and dried fish products are less interesting than the sauces and pastes. Many problems are still unsolved. Since purified salt is usually too expensive in this part of the world it would be worthwhile to investigate the inorganic impurities which influence the taste and keeping qualities of the products. There are also problems in connection with off-color (red coloration) and
off-flavor (according to local standards), which have not been extensively studied.

Only very few studies have been made and little is known of what really happens in the fish-product processes described in this paper. The chemical composition of the intermediate and end products in fish pastes and sauces is for the most part terra incognita. Our knowledge of the beneficial influence of added carbohydrate (rice and other cereals, sugar, bran, etc.) and other materials on the properties and quality of pastes and sauces is equally deficient. Flavor problems have hardly been investigated at all. Studies in the fields of biochemistry and microbiology could do much, however, to clarify the numerous problems and underlying biochemical reactions. They might well lead to better understanding and to more standardized methods of fish preservation in this part of the world, resulting in higher quality products of better keeping capacity in the tropical climate.

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