Fermented fish products of South East Asia

by

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Fermented fish products of South East Asia

M.R. Adams¹, R.D. Cooke² and Pongpen Rattagool³

Abstract Fermented fish products are reviewed with especial reference to the lactic fermented products of Thailand and the Philippines. Two categories of product are described: (i) product preservation primarily by water activity reduction (fish/salt formulations) which have been reviewed before, and are treated only superficially here; (ii) product preservation by combined water activity reduction and lactic acid generation (fish/salt/carbohydrate formulations). The dietary rôle of the former category, i.e. fish sauces and pastes, is limited by their high salt content and cost to a mainly condiment function. The second category of products is usually consumed as a main course. The product formulations and characteristics are described. Their current economic importance is less than that of the first category, perhaps because of the variable quality, limited shelf-life and spoilage problems. Developments to minimize these problems are discussed. Low cost food preservation by fermentation may offer new product possibilities from under-utilized fish species in SE Asia.

Key words: Lactic fermentation, fish products, fish sauces, Thailand, Philippines.

Introduction

Fish flesh is a very perishable commodity. It offers micro-organisms conditions of good nutrient availability coupled with a high water activity (a_w) and moderate pH (Shewan, 1962). Typically the ultimate flesh pH is in the range 6.2–6.5, in contrast to that of meat from unstressed mammals which is usually around 5.6 (ICMSF, 1980). This is thought to be due to the depletion of glycogen reserves during the death struggle of the fish which limits the degree of post-mortem acidification. Those fish which have more acidic tissues, e.g. halibut, pH 5.6, generally show superior keeping qualities (Amlacher, 1961).

In tropical countries the problem posed by the intrinsic suitability of fish flesh as a medium for microbial growth is further compounded by a high ambient temperature. Fish stored under these conditions is considered spoiled within 12 hours (FAO, 1981).

The shelf-life of fish in the developed world is increased primarily through the technologies of chilling, freezing and canning. In the tropics, however, traditional curing processes that depend upon the reduction of a_w as the principal preservative factor (Sperber, 1983) are important, e.g. salting, drying, smoking. Traditional fermented fish products are particularly popular in SE Asia. Presumably, the term fermented was adopted in view of the extensive biochemical changes that take place during processing. However, in many cases, the rôle of micro-organisms in the process has not been clearly established.

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As commonly applied, the term fermented fish covers two categories of product: (1) fish/salt formulations, e.g. fish sauce; and (2) fish/salt/carbohydrate mixtures, e.g. plo in Thailand. These categories do not, however, comprise a series of well-defined products with precise and generally accepted composition. A single title can encompass a wide range of recipes. This reflects the fact that, apart from the fish sauces, they are usually produced on a small-scale by numerous individuals.

Fermented fish products have been reviewed periodically, the focus usually being on the first category of product, i.e. the more widely used fish sauces and pastes (Van Veen, 1965; FAO, 1971; Steinkraus, 1983; Orejana, 1983). In this paper, particular attention is paid to the second category in which a lactic acid fermentation of the added carbohydrate occurs and contributes to the extended shelf-life. This category may offer greater scope for the introduction of new products and the use of under-utilized fish species (discussed later). Currently the fish/salt products are more important economically, but their rôle is limited by their high salt content and cost to a primarily condiment function.

**Fish/salt products**

The most widely known and popular of these are the various fish sauces and pastes (Table 1). Their importance both nutritionally and as a flavouring agent to enliven an otherwise bland rice diet has been discussed by several authors (see, for example, Amano, 1962; FAO, 1971).

In Thailand fish sauce, known as nam-pla, is a ubiquitous accompaniment to, or ingredient in, Thai meals. The finest quality sauce is made from anchovies (*Stolephorus* spp.) and in 1983 retailed at around 12-15 Baht for a 700 ml bottle (in 1983, 34 Baht = £1). Sardines, lizard fish (*Saurida elongata*) and others are also used, but the cheapest varieties employ trash fish and retail for around 3-5 Baht for 700 ml.

<table>
<thead>
<tr>
<th>Country</th>
<th>Name</th>
<th>Paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burma</td>
<td>ngapi</td>
<td>ngapi</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Ketjap-ikan</td>
<td>trassi (shrimps)</td>
</tr>
<tr>
<td>Kampuchea</td>
<td>nuoc-mam-gau-ca</td>
<td>prahoc</td>
</tr>
<tr>
<td>Laos</td>
<td>nam-pla</td>
<td>padec</td>
</tr>
<tr>
<td>Malaysia</td>
<td>budu</td>
<td>belachan (shrimps)</td>
</tr>
<tr>
<td>Philippines</td>
<td>patis</td>
<td>bagoong</td>
</tr>
<tr>
<td>Thailand</td>
<td>nam-pla</td>
<td>kapi</td>
</tr>
<tr>
<td>Vietnam</td>
<td>nuoc-mam</td>
<td>mam-ca (fish)</td>
</tr>
</tbody>
</table>
Table 2. Fermented fish/salt products common in Thailand

<table>
<thead>
<tr>
<th>Name</th>
<th>Type of fish</th>
<th>Form</th>
<th>Approx sal/fish ratio</th>
<th>Production period</th>
<th>Type of use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hoi-dong</strong></td>
<td>Molluscs</td>
<td>Whole or without shells</td>
<td>1:7</td>
<td>3 wks.</td>
<td>Main dish</td>
</tr>
<tr>
<td><strong>Kapi</strong> (fish or shrimp paste)</td>
<td>Small fish crustaceans</td>
<td>Whole</td>
<td>1:4-6</td>
<td>3-4 months</td>
<td>Condiment and main dish</td>
</tr>
<tr>
<td><strong>Nam-pla</strong> (fish sauce)</td>
<td>Variety of fish</td>
<td>Whole</td>
<td>1:1-3</td>
<td>18 months</td>
<td>Condiment</td>
</tr>
<tr>
<td><strong>Nam-budu</strong></td>
<td>Variety of brackish or marine fish</td>
<td>Whole</td>
<td>1:1-3</td>
<td>After 3-12 months</td>
<td>Condiment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10% raw sugar added. The mixture is then boiled and bottled.</td>
<td></td>
</tr>
<tr>
<td><strong>Nam-khoei</strong></td>
<td>Shrimps crustaceans</td>
<td>Whole</td>
<td>1:4</td>
<td>-</td>
<td>Condiment</td>
</tr>
<tr>
<td><strong>Pla-thu-khem</strong></td>
<td>Mackerel</td>
<td>Whole eviscerated fish</td>
<td>1:3</td>
<td>2-3 months</td>
<td>Main dish</td>
</tr>
<tr>
<td><strong>Tai-pla</strong></td>
<td>Variety of fish</td>
<td>Bowels</td>
<td>1:3</td>
<td>6-8 months</td>
<td>Main dish</td>
</tr>
</tbody>
</table>

*Nam-pla* is produced throughout Thailand, but in the south several closely related products are also popular, e.g. *nam-budu, nam-khoei* and *tai-pla* (see Table 2). In 1979, 79,591 tonnes of marine fish and 2,808 tonnes of freshwater fish were used in *nam-pla* production. In 1980 the figures were 75,024 and 3,744 respectively and a survey of Thailand's 23 coastal provinces recorded 98 fish sauce factories. Between 1978 and 1980 exports of *nam-pla* increased in quantity from 2,689 tonnes to 5,432 tonnes and in value from 24 to 68 million Baht. The principal markets overseas were the United States (53% of exports) and France (22%).

In the Philippines in 1971 it was estimated that there were 20 factories producing the local fish sauce, *patis*, and more than 700 families in Navotas and Malabon producing *patis* on a small scale (Del Rosario, 1971). In 1975 the export of *patis* from the Philippines amounted to 416 tonnes, valued at US $285,000 (Steinkraus, 1983).

The lengthy production process for fish sauce is broadly similar in most countries (for more detailed accounts, see Van Veen, 1965; Steinkraus, 1983). Usually whole fish is mixed with salt in an approximate ratio of 3:1 (published estimates for the fish:salt ratio in Vietnamese fish sauce, *nuoc-mam*, range from 1.2-1.5:1 (FAO, 1971) to 5.6:1 (Rosé, 1918 cited in Steinkraus, 1983)). It is then packed into jars, concrete tanks or wooden vats, covered and left to ferment for a period of up to 18 months. The sauce is then decanted off from any solid residues, sometimes filtered, and then bottled.
The process consists of three important elements;

(1) The restriction of the normal microbial spoilage flora by the addition of high levels in salt. A fish: salt ratio of 3.5:1 is, theoretically, more than sufficient to saturate the water content of fish (ca 80%). The low a$_w$ and anaerobic conditions result in a decreasing microbial count throughout the period of fermentation (Sai-sithi et al., 1966).

(2) Autolytic breakdown of the fish muscle proteins and the separation of a nitrogen-rich liquid phase (Orejana, 1983). The high levels of salt slow the action of endogenous proteases but assist in the osmotic extraction of liquid from the fish tissues.

(3) The development of the correct flavour and aroma. This has been characterized by Dougan and Howard (1975) as consisting of an ammoniacal component due to ammonia and trimethylamine, a cheesy component due to volatile fatty acids, and a complex meat aroma.

Cheaper varieties of fish sauce may not have undergone this full process or they may be produced simply by the further extraction of the solid residues with brine.

The fish and shrimp pastes are produced by similar procedures often involving a shorter fermentation period in order to restrict liquefaction. Pastes can also be made from the solid residues remaining after fish sauce production, e.g. bagoong in the Philippines. Occasionally they may be partially dried, e.g. pra-hoc in Kampuchea.

**Fish/salt/carbohydrate products**

These products are generally salted at a lower level than fish/salt products, but employ a lactic acid fermentation which assists the preservation. There is a considerable variation in formulations for these products, but in Thailand the recipe used appears to be governed by two empirical rules:

(1) more salt signifies a longer preparation time but better keeping quality;
(2) more carbohydrate (almost invariably rice) means a more rapid fermentation and a stronger acid taste (see Table 3).

In both Thailand and the Philippines these products are most popular in inland areas (North and North East Thailand and Central Luzon, respectively) so that freshwater fish are the more usual substrate used. It may also be that lactic acid adds a piquancy to the generally more neutral taste of freshwater fish.

As noted above the principal carbohydrate source used is cooked rice although in some products partially saccharified rice (see pla-jao below) is used or, on occasion, small amounts of cassava flour (see som-fak below).

**Thailand**

The total freshwater catch for 1980 is officially recorded as 144995 tonnes. It is acknowledged, however, that the true figure is considerably higher since the statistics include only those fish entering the market. It is estimated that the true freshwater catch may be 200,000 tonnes, about 10% of the total (marine plus freshwater).

Government statistics for 1980 give the quantity of freshwater fish used in fermented products other than fish sauce as 15175 tonnes, roughly 10% of the officially recorded total catch. However, the true figure is likely to be higher. At the Ubolratana reservoir, 50 km from Khon Kaen, where fishing is controlled and monitored, 2000 tonnes of fish are landed per annum and about
Table 3. Fish/salt/carbohydrate products of Thailand

<p>| | | | | | |</p>
<table>
<thead>
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</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td><em>Pla-ra</em></td>
<td>C, N, NE</td>
<td>Fish (whole or pieces): salt:roasted rice. 3:1:0 2-4</td>
<td>6-12 months</td>
<td>1-3 years</td>
</tr>
<tr>
<td>3.</td>
<td><em>Pla-som</em></td>
<td>NE, C</td>
<td>Fish: salt:boiled rice: garlic 10:2:1:0.25-1</td>
<td>5-12 days</td>
<td>3 weeks</td>
</tr>
<tr>
<td>4.</td>
<td><em>Pla-jom</em></td>
<td>NE, C</td>
<td>Fish: salt:roasted rice: garlic 10:1:3:1</td>
<td>3-7 days</td>
<td>2 weeks</td>
</tr>
<tr>
<td>5.</td>
<td><em>Som-fak</em></td>
<td>NE, N</td>
<td>Fish (minced): salt:rice:garlic 10:0.5-1.5:2-3:1</td>
<td>5-10 days</td>
<td>2 weeks</td>
</tr>
</tbody>
</table>

Products 1-4 are also produced using shrimps. In these cases the prefix 'pla' is replaced by 'kung'. Ang-kak: red mould rice obtained by fermenting rice with *Monascus purpureus*.

C, Central; N, North; NE, North East; S, South of Thailand.
15% of that total (300 tonnes) is used in fermented products (Oopathan Pawaputanon, personal communication). Normally it is the smaller fish of poorer quality that are used in these products.

**Pra-ra**

This is the most popular of the lactic fermented fish products of Thailand, and can be eaten as a condiment or side dish. In appearance it ranges from a dark brown, turbid liquid to partly dried, brown fish pieces and there is a marked regional variation in the preferred type. In NE Thailand a more liquid product is preferred and brine rather than dry-salting is often used in its preparation. The liquid is used as a flavouring agent in dishes such as *tam-som* where it is mixed with raw papaya. In Central Thailand a drier product is sold and it is the fish pieces that are eaten.

The production process involves two distinct stages. Firstly, the fish, most commonly *Trichogaster trichopterus* and *Ophicephalus striatus*, are descaled, gutted and mixed with salt (approximately 3 parts fish: 1 part salt) and packed tightly into jars. It is kept under these conditions for a period ranging from 2 weeks to several months, the period being governed as much by market factors as any presumed technical consideration.

For the second stage the fish are removed from the pots, usually washed and allowed to drain before being mixed with ground roasted rice. The proportion of rice is not known with certainty. It is usually dispensed by eye, but estimates of the rice : fish ratio have ranged from 1:20 to 1:1. The acidity generated increases with the proportion of rice used. Increasing the rice content also, perhaps more importantly, lowers the unit cost of the product.

The fish/rice mixture is repacked into the pot and left for a further period at ambient temperature. During this stage, which may last from 1-6 months some gas evolution may take place and the characteristic flavour develops. The flavour is said to be best at between 2 and 5 months. The product itself has a long shelf life estimated at 1-3 years.

A survey of 280 samples of *pla-ra* from various parts of Thailand (National Research Council of Thailand, 1981-82) found that the pH and titratable acid of the product (expressed as lactic acid) ranged between 4.7-6.2 and 0.37-3.15% respectively. The salt content was 7.8-17.9% and bacterial counts which included the genera *Pediococcus*, *Staphylococcus*, *Micrococcus* and *Bacillus* were between $2.2 \times 10^6$ and $8.9 \times 10^7$ cfu/g. A more limited survey of samples from the Bangkok region in 1983 carried out by the present authors gave results broadly in accord with those of the NRCT survey (Table 4). *Pla-ra* also showed a high count of presumptive lactic acid bacteria (growth on MRS medium Gram positive, catalase negative).

At the Ubolratana reservoir in NE Thailand it was estimated that nearly all the fish used in fermentation went into *pla-ra*. In the area around the main landing stage there were several small household enterprises producing *pla-ra* or simply salting the fish before its transportation in 20 kilo cans to other sites for the second stage of processing.
Table 4. Analytical data for commercial samples of fermented fish products

<table>
<thead>
<tr>
<th>Sample</th>
<th>Price/Kilo</th>
<th>pH</th>
<th>TTA (mg lactic/g)</th>
<th>Salt (%)</th>
<th>Moisture (%)</th>
<th>Total nitrogen (%)</th>
<th>Non-protein nitrogen (%)</th>
<th>Fat</th>
<th>Total counts</th>
<th>Lactic acid bacteria</th>
<th>Faecal coliforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>pla-som</td>
<td>50B</td>
<td>4.45</td>
<td>22.6</td>
<td>8.65</td>
<td>59.32</td>
<td>3.06</td>
<td>0.27</td>
<td>7.95</td>
<td>6.18</td>
<td>7.32</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>(common carp)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>pla-jao</td>
<td>46B</td>
<td>4.25</td>
<td>28</td>
<td>5.84</td>
<td>69.35</td>
<td>2.39</td>
<td>0.28</td>
<td>1.13</td>
<td>6.26</td>
<td>7.76</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>(catfish)</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Kung/pla-jom</td>
<td>40B</td>
<td>4.60</td>
<td>38.5</td>
<td>8.80</td>
<td>66.70</td>
<td>1.62</td>
<td>0.72</td>
<td>1.64</td>
<td>5.59</td>
<td>6.86</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>pla-ra</td>
<td>28B</td>
<td>5.20</td>
<td>16.3</td>
<td>12.27</td>
<td>62.39</td>
<td>2.21</td>
<td>0.73</td>
<td>2.17</td>
<td>5.56</td>
<td>6.15</td>
<td>23/g</td>
</tr>
<tr>
<td>(mixed)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pla-ra</td>
<td>-</td>
<td>5.20</td>
<td>9.8</td>
<td>21.34</td>
<td>58.32</td>
<td>2.64</td>
<td>0.74</td>
<td>0.96</td>
<td>-</td>
<td>-</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>(snakehead)</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>som-fak</td>
<td>-</td>
<td>5.00</td>
<td>11.2</td>
<td>5.58</td>
<td>67.68</td>
<td>2.18</td>
<td>0.43</td>
<td>6.56</td>
<td>-</td>
<td>-</td>
<td>38</td>
</tr>
<tr>
<td>pla-ra</td>
<td>-</td>
<td>5.35</td>
<td>16.3</td>
<td>19.34</td>
<td>53.58</td>
<td>2.66</td>
<td>0.68</td>
<td>5.93</td>
<td>-</td>
<td>-</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>(gourami)</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>kung-ra</td>
<td>-</td>
<td>5.00</td>
<td>20.3</td>
<td>12.97</td>
<td>67.81</td>
<td>2.84</td>
<td>1.08</td>
<td>1.77</td>
<td>-</td>
<td>-</td>
<td>&lt; 3</td>
</tr>
</tbody>
</table>
Table 5. Scale of pla-ra production in Thailand

<table>
<thead>
<tr>
<th>Size of factory (output per year)</th>
<th>800-1000 tonnes</th>
<th>50-100 tonnes</th>
<th>10-20 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of factories</td>
<td>10</td>
<td>300-500</td>
<td>1-2000</td>
</tr>
<tr>
<td>Personnel/factory</td>
<td>8-10</td>
<td>2-3</td>
<td>Family concerns</td>
</tr>
</tbody>
</table>

A larger factory in this area used about 80 tonnes of salted fish per month in pla-ra production. The data in Table 5 has been extrapolated from a survey of 16 towns in NE Thailand.

Pla-jao
The fish species most commonly used are the freshwater carp, Puntius gonionotus and catfish. The fish are gutted, scaled, washed, chopped into ca 2 cm cubes, and then salted overnight with 10-20% salt. The fish pieces are then sometimes washed and drained before sun-drying to around 60% moisture. The partially dried, salted pieces are mixed with 1-2 parts of the sweetened rice, kao-mark. This material is prepared from glutinous rice that has undergone an anaerobic fermentation with look-pang, a preparation of moulds, yeasts and bacteria. A mixed lactic/alcoholic fermentation takes place to give a white, moist-solid product which has a sweet-sour and slightly alcoholic taste and contains about 0.9% lactic acid, 1.2% alcohol, 11% sugar and 14-25% starch (NRCT, 1981-1982).

The mixture of fish and kao mark is pressed tightly into jars and stored at around 30°C. The product is at its best after 10-14 days when cooked with coconut milk and eaten as a main dish. The NRCT survey (1981-82) of 230 samples of pla-jao found the pH, titratable acidity and salt contents to be in the ranges 4.5-3.3, 1.80-3.80% and 4.35-9.48% respectively. The microbiological count varied between $3.8 \times 10^6$ and $2.7 \times 10^9$ CFU/g and Pediococcus cerevisiae, Staphylococcus spp., Micrococcus spp. and Bacillus spp. were isolated. In our own limited survey (Table 4) a large yeast count was observed on MRS agar.

Decreasing the kao-mark or increasing the salt contents extends the pla-jao storage life. The product usually develops an unacceptably strong alcoholic odour after 1 month. After 2-3 months, the rice grains lose their shape and the colour of the product turns from white to yellow or brown. A similar product known as phaak or mam-chao is made in Kampuchea (Van Veen, 1953).

Pla-som
This is based on the same species used in pla-jao or on the snake head (Ophicephalus striatus) or on the featherback (Notopterus chilata). The fish flesh is chopped into small pieces and salted with 10-20% salt; the quantity of salt varying with the intended shelf-life. The fish is kept in salt for a period ranging from a few hours up to 2 days. Cooked rice (sometimes minced) is added at a level of 1-5% (if the product is required sooner, the rice content is increased), together with 3-5% of crushed garlic. The mixture is pressed into sealed containers and left to ferment at tropical ambient temperature. After 3 days, a sour taste is apparent but the product is still reminiscent of raw fish. After 7 days, the product is ready to eat as a main dish mixed with herbs, spices and vegetables.

In 80 samples tested, the pH was 4.0-4.6, the titratable acidity 2.12-4.01% and the salt content 2.25-5.90%. Pediococcus cerevisiae, Lactobacillus brevis, Staphylococcus sp. and
a Bacillus sp. were isolated and a total count ranging from $1.6 \times 10^6$-6.1 $\times 10^{10}$ cfu/g was obtained (NRCT, 1981-82). The shelf-life of pla-som is about 1 month.

Pla-jom
This is prepared from several fish species including the freshwater and marine anchovies. The procedure is similar to that used in pla-som except that powdered roasted rice is added to the fermentation mix, in addition to or in place of the boiled rice. The fermentation period is about 3 days, and the product assumes the brown colour of the roasted rice.

In the NRCT survey (1981-82) the same species of lactic acid bacteria were isolated from both pla-jom and pla-som. The pH was generally higher, 5.0-6.1 (100 samples), the titratable acidity range slightly wider, 1.97-4.45%, and the salt content range narrower, 3.75-4.80%. The shelf-life of the product is about 2 weeks.

Som-fak
Synonyms are som-fug; som-doc, NE Thailand; pla-fug, N Thailand; pla-mug, E Thailand and fug-som, some parts of NE Thailand.

The flesh of a freshwater fish, particularly Ophicephalus micropeltes or Notopterus notopterus is minced into a sticky paste with salt (estimates of the salt addition vary from around 1-3% up to 15%), cooked rice (2-20%), garlic (4-10%) and sometimes cassava flour. The mixture is squeezed into polythene bags (traditionally banana leaves are used) and wrapped tightly. The product is at its best after about 5 days, but can be kept up to 10 days under refrigeration.

The NRCT survey (1981-82) of 90 samples found the pH to range from 4.05-5.00, the titratable acidity to be 1.08-2.82%, and the salt content to be 2.5-4.8%. The latter figure suggests that the salt addition most commonly used is nearer the bottom of the range quoted above. The bacterial count was $1.3 \times 10^6$-2.8 $\times 10^8$, Pediococcus cerevisiae, Lactobacillus brevis, a Staphylococcus sp. and a Bacillus sp. being isolated.

Of particular importance to the acceptability of som-fak is its texture which must be relatively firm and springy. It is generally eaten raw as a main dish or sliced as a snack.

Among the lactic-fermented fish products of Thailand, som-fak is exceptional in that minced flesh is used, it employs the lowest salt content, and it has a meat (pork) equivalent in the sausage, nam.

Som-fak does not enjoy the same widespread popularity as nam in Thailand. This may be due to a preference for a meat taste, but may also arise from reported difficulties in obtaining a consistent quality product. Common failures are said to be the breakdown of the texture of the product, loss of elasticity and microbial spoilage.

Pla-paeng-daeng
Thsi is produced in the southern part of Thailand from several species of marine fish. The fish is de-scaled and gutted and mixed with salt in the ratio of 3:1, sometimes after dicing the flesh to 2-5 cm cubes. After leaving overnight, it is washed and mixed with equal parts of red rice (see footnote to Table 3). In the case of whole fish, the body cavity is stuffed with the rice. The mixture is packed into a bottle, sealed and left to ferment for 5 days.

The product is semi-solid with a salty and sour taste and a characteristic red colour. It is consumed as a main dish, usually after cooking and has a shelf-life of 6 months to 1 year. In 86
samples (36 brackish water fish, 50 marine fish) the pH was 3.9-5.2, titratable acidity 1.42-2.10 and salt 4.49-9.20% Pediococcus halophilus, a Pediococcus sp., Staphylococcus aureus and S. epidermis were isolated from samples which had bacterial counts in the range 2.4 x 10^3-8.5 x 10^9/g (NRCT, 1981-82).

The Philippines
Production and consumption of lactic fermented fish products in the Philippines is confined to the Central Luzon area.

Burong-isda
Burong means salted or fermented, and isda means fish. This is a general name given to these products. Individual burong-isda products take the name of the fish species used (see Table 6) and can occur as one of two types, white or red. The former has the natural product colour whereas the red varieties are coloured by the addition of ang-kak (cf pla-phaeng-daeng in Thailand). Sakai, Caldo and Kozak (1983a) noted that there is a strong regional preference for the different types. White burong-isda is prepared and consumed in three western provinces of Central Luzon, while the red variety occurs in six eastern provinces.

Fish for the production of burong-isda is scaled, gutted, washed and drained, before salting with 10-30% salt. After 2-6 hours the fish is removed from the brine that develops and mixed with boiled rice in an approximate ratio of 3-5 parts rice: 1 part fish. If a red burong is being prepared then ang-kak is mixed with the rice at a level of 1.5%. Ginger and garlic may also be included as flavouring ingredients. The fish and rice are packed together into a jar and left for 1-2 weeks before consumption. the product is usually sautéed with garlic and onion, and eaten with vegetables such as broiled egg-plant.

Table 6 Lactic fermented fish products in the Philippines; the varieties of burong-isda

<table>
<thead>
<tr>
<th>Name</th>
<th>Philippino</th>
<th>English</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burong ayungin</td>
<td>Ayungin</td>
<td>Silver perch</td>
<td>Therapon plumbeus</td>
</tr>
<tr>
<td>Burong bangus</td>
<td>Bangus</td>
<td>Milkfish</td>
<td>Chanos chanos</td>
</tr>
<tr>
<td>Burong dalag</td>
<td>Dalag</td>
<td>Mudfish</td>
<td>Ophicephalus striatus</td>
</tr>
<tr>
<td>Burong gurami</td>
<td>Gurami</td>
<td>Goramy</td>
<td>Osphronemus goramy</td>
</tr>
<tr>
<td>Burong hito</td>
<td>Hito</td>
<td>Catfish</td>
<td>Clarias batrachus</td>
</tr>
<tr>
<td>Burong kanduli</td>
<td>Kanduli</td>
<td>Sea catfish</td>
<td>Arias manillensis</td>
</tr>
<tr>
<td>Burong tilapia</td>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Tilapia nilotica</td>
</tr>
<tr>
<td>Balao-balao or</td>
<td>Tagunton</td>
<td>Shrimp</td>
<td>Macrobrachium sp.</td>
</tr>
<tr>
<td>Burong hipon</td>
<td>Suwahe</td>
<td>Shrimp</td>
<td>Penaeus indicus</td>
</tr>
</tbody>
</table>
A survey of burong-isda products (Sakai et al., 1983a, b) found that white products had pH values of 4.1-4.5 whereas red types were in the range 3.0-3.9. This may be due to amylolytic enzymes in ang-kak increasing the extent of the lactic acid fermentation by increasing the availability of readily fermented sugars. The counts of acid producing bacteria and yeasts, 10^8 and 10^7 respectively, were similar for both types of product. The salt contents ranged from 2.5-4.8% for white burong-isda and from 1.4-4.4% for the red variety.

Laboratory studies of red burong-isda fermentation by Orillo and Pederson (1968) found one sample to show a microbial succession similar to that reported to occur in some vegetable fermentations. An initial count of the microflora showed the presence of a miscellaneous collection of aerobes. This was placed after 1-2 days fermentation by a predominance of Leuconostoc mesenteroides and Streptococcus faecalis. After 4-5 days Pediococcus cerevisiae and Lactobacillus plantarum were the most abundant species, and at 7 days the first yeasts were isolated. Presumably, the high yeast counts recorded by Sakai et al. (1983a) and found to be largely Saccharomyces cerevisiae, Candida tropicalis, C. parapsilosis and Pichia strasburgensis were due to the age of commercial samples. Sakai et al. (1983b) also found Torulopsis mogii and P. viniti in some high salt samples. In a second batch prepared using a slightly different formulation, Orillo and Pederson (1968) did not find an early predominance of Leuconostoc mesenteroides although S. faecalis was present in maximum numbers on day 2 and P. cerevisiae and L. plantarum took over from around day 3. This second batch also showed a slower decrease in pH. A more recent study of burong-isda also showed a similar progression of a Streptococcus followed by a Leuconostoc and Pediococcus (Mabeza, 1983). A similar sequence was noted in the case of balao-balao (see below) by Solidum (1979), although there was some doubt about the species involved.

Balao-balao
Synonyms are burong-hipon, taqbilao (balao=hipon, a small shrimp). This is a fermented shrimp product, this accquires a pink-red colour naturally during the course fermentation (NSDB, 1980).

Balao-balao is prepared by removing the antennae of live shrimps, washing a draining. The shrimps are then salted with 15-20% salt, left to stand for 3-6 hours a then drained. They are then mixed with salted boiled rice (shrimp:rice:salt: 1:4-8:0-2) a packed into jars to ferment for 7-10 days (Arroyo et al., 1977). The product is sautéed oil with garlic and onions before serving.

Two samples of balao-balao analysed by Salt et al. (1983a) had pH values of 3.2 and 3.7, salt contents of 1.2 and 3.0% and counts acidogenic bacteria and yeasts of 10^9-10^9 and 10^7 respectively.

Discussion
The fish/salt/carbohydrate products depend for their extended shelf-life on reduce water activity (salt addition) and the proliferation of lactic acid bacteria (LAB). La inhibit the growth of spoilage micro-organisms by several mechanisms such as by act production and consequent pH reduction (ICMSF, 1980); by competition for essential nutrients, and by the production of antibiotic-like compounds and hydrogen peroxid (Lindgren and Clevstrom, 1978)

The traditional products described above depend on natural inoculation with appropriate micro-organisms. The success of the initial competition between LAB and the spoilers depends on the mixture formulation and fermentation conditions, which are likely to be quite variable (Section 3), and the hygiene, i.e. the size of the spoiler micro-organism population. The very variable quality of the products in part reflects this problem.
Lactic acid fermented products can be prepared in a shorter time (and hence more cheaply) than the fish/salt products which depend primarily on autolytic processes. Their lower salt contents also permit them to be consumed as a main course, rather than the condiment rôle of the high salt fish sauces and pastes. This suggests that the lacticfermented products offer greater scope for low-cost fish preservation in SE Asia than the simply low water activity products. However, this potential is limited by the currently variable organoleptic quality and shelf-life of these products.

An analogous situation has existed in Europe and N America with respect to lactic-fermented meat products such as salami. The introduction of scientific methods to control the course of the fermentation has contributed to a considerable stimulation of this industry (Bacus, 1984). The TDRI and the Department of Fisheries, Thailand are initiating a collaborative research and development programme to characterise the factors predisposing to the successful lactic acid fermentation of fish products. This involves studies of the effects of salt concentration, fish species, fermentation conditions, the use of LAB starter inocula, and the use of different carbohydrate sources.
References


