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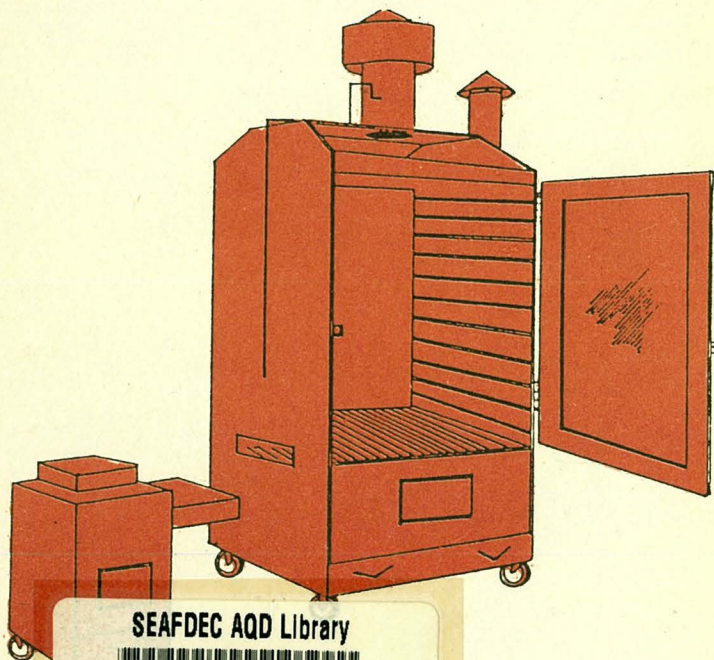


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SMOKE-CURING OF FISH



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SMOKE-CURING OF FISH

by

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and

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The Secretariat

Southeast Asian Fisheries Development Center

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The information presented in this manual incorporates the findings of a project entitled "Standardization of Smoking Procedures for Round Scad (*Decapterus macrostoma*), Herring (*Sardinella* sp.), Indian Mackerel (*Rastrelliger kanagurta*) and Mussels (*Mytilus managlimus*)" carried out by the National Science and Technology Authority-University of the Philippines (NSTA-UP). It has been adapted by Dr. Florian Magno-Orejana for extension purposes.

SMOKE-CURING OF FISH

by

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and

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INTRODUCTION

Smoke-curing of fish (*pagtitinapa*) is a process which consists of exposing the fish (either whole, split open or filleted) for a certain length of time in an enclosed environment filled with smoke. The purpose of the smoke-curing process is attained when the fish has acquired a golden brown colour.

Smoke generation (*pagpapausok*) is achieved by burning sawdust or wood shavings. The combustion is controlled so that flames are avoided.

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This manual discusses in detail the smoking process for fish, presents improved designs of smokehouses and recommends standardized procedures for the smoke-curing of some species of fish, using appropriate technology.

The traditional process for producing wood smoke is to kindle live or smouldering pieces of wood until glowing embers are produced, then covering this with sawdust to initiate the production of dense smoke. By using a mechanized smokehouse where heating coils are installed, the process is much easier because sawdust is fed mechanically onto the red-hot coils. As the sawdust burns, the lignin constituent of the wood is thermally degraded producing a variety of substances that contribute to the peculiar smell and taste of smoked fish. These substances include phenols, aldehydes, ketones, and organic acids, which constitute the main components of wood smoke. Phenols are responsible for the smoke aroma, while aldehydes and ketones are believed to cause the formation of a golden brown colour through Maillard reaction.

The smoke generated during kindling is led into the smoking room where the fish are hung or where the trays of fish are placed. As the smoke passes through, it comes into contact with the wet fish. Smoke settles on the fish scales and flesh, if the fish is split open, and the fish loses some of its moisture. The smoke then gradually penetrates the flesh and continues to do so even long after the smoke-curing process has ended.

Smoke-curing normally requires two hours when conditions are ideal. The finished product acquires a typical smoke aroma, a golden brown colour, and a fairly juicy texture. The final texture depends on the extent of desiccation during the smoke-curing process, i.e., on the moisture content of the finished product. From the consumer's point of view, a moisture content of around 60 to 65 per cent is generally preferred, although a 55 per cent moisture does not make a great difference to the acceptability of the product.

Improved designs of smokehouses are shown in Figs. 1-A and 1-B.

MATERIALS NEEDED IN SMOKE-CURING

A. Fish

There is no limit to the species of fish that can be smoked. From the commercial point of view, however, the following species are important:

1. Milkfish, locally called *bangus* (*Chanos chanos*)
2. Roundscad, locally called *galunggong* (*Decapterus macrosoma*)
3. Indian Mackerel, locally called *alumahan* (*Rastrelliger kanagurta*)

Fig. 1 Smokehouses (Improved smokehouses available at the University of the Philippines in the Visayas, College of Fisheries, Department of Fish Processing Technology)

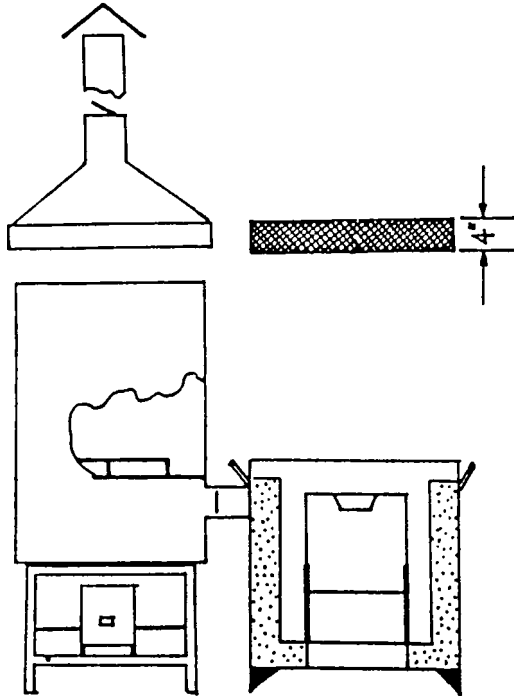


Fig. 1-A Improved drum smokehouse for small-scale production (Fabricated under NSTA-UP Project 8105 in Operation Manual available from Prof. Marceliano B. Nieto, Department of Fish Processing Technology, UPVCF, Diliman, Quezon City)

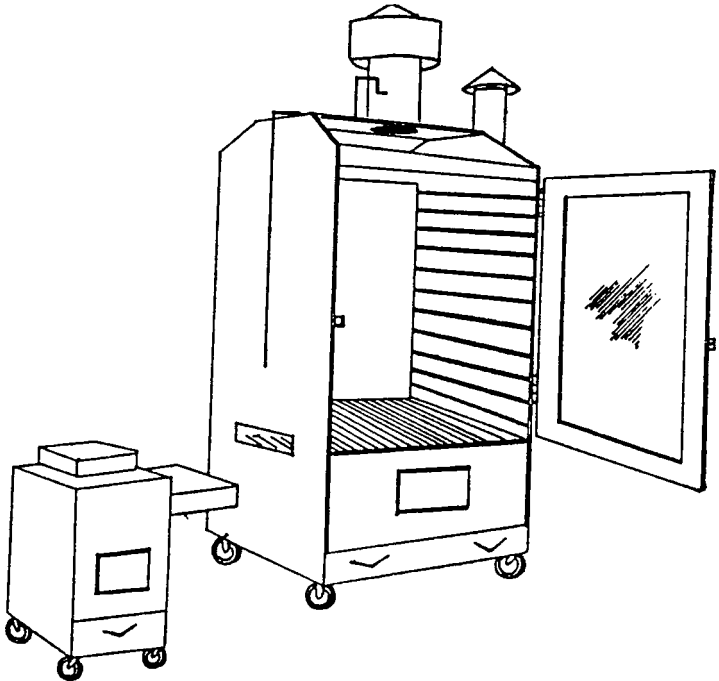


Fig. 1-B Solar-agrowaste multipurpose drier/
smoker (Fabricated under NSTA-UP Project
8106 in Operation Manual available from
Dr. Florian Magno-Orejana, Department
of Fish Processing Technology, UPVCF,
Diliman, Quezon City)

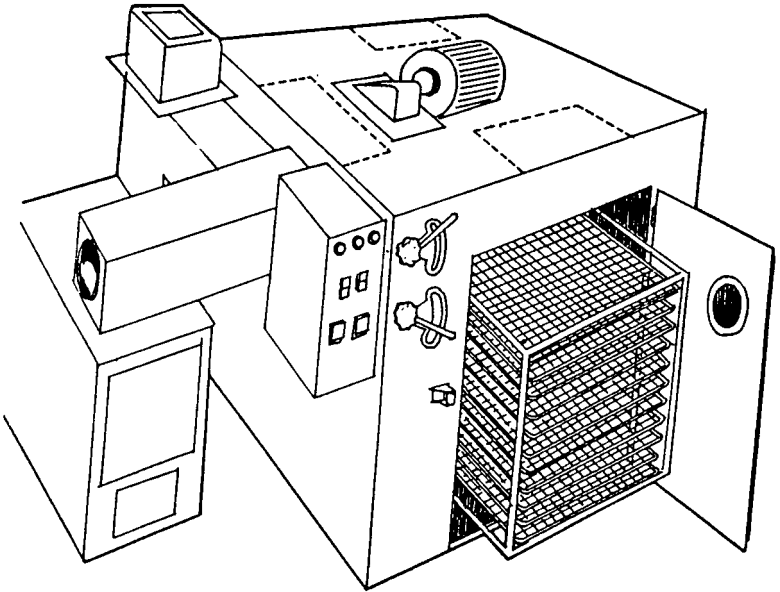


Fig. 1-C Torrey Kilin - Mechanized (Courtesy of GTZ Project in Operation Manual available at the Department of Fish Processing Technology, UPVCF, Diliman, Quezon City)

4. Herring and Sardines, locally called *tunsoy* (*Sardinella longiceps*), *tamban* (*Sardinella fimbriata*), *lapad* (*Sardinella perforata*) and *tawilis* (*Harengula tawilis*)
5. Mussels, locally called *tahong* (*Mytilus smaragdinus*)

B. Salt

Sun-dried salt is used. A high grade sun-dried salt is preferable, since it contains less sand and other visible impurities. Filtration of the salt solution, by means of a fine cloth, is necessary when a third grade salt is used.

C. Sawdust or Wood Shavings

Sawdust or wood shavings from hardwood are preferred as smoking fuel. Softwoods, e.g. palochina and pine, which are resinous, impart an acid taste; moreover, when burned, they release harmful smoke components that are deposited on the fish.

Bagasse is also used in some smoking plants but the smoke produced, although not offensive, is different from that of hardwood and atypical.

When using the non-mechanized smoke-house, a mixture of sawdust and wood shavings or pieces of wood is more suitable for continuous kindling and smoke generation.

D. Boiling Basket

A boiling basket is made of bamboo. The diameter of the basket depends on the size of the steel vat in which the brine is heated (Fig.2-B). The lifespan of this basket ranges from six months to one year of continuous use.

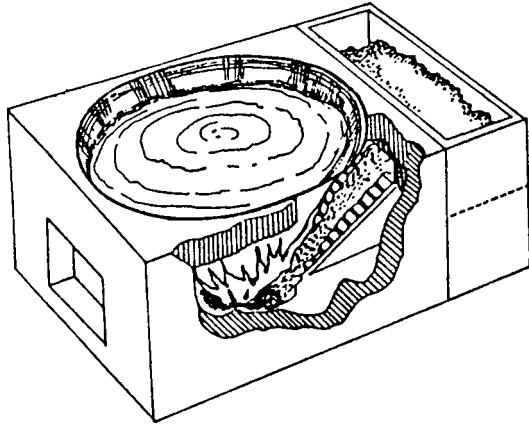


Fig. 2-A Stove and Boiling Vat

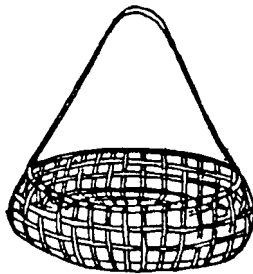


Fig. 2-B Boiling Basket

STEPS IN SMOKE-CURING

A. Selection of Raw Material

Any of the species of fish mentioned earlier can be smoke-cured. The reason for selecting these species is their commercial value since they are already known to consumers as smoked items.

Whatever fish is used, it must be fresh. A fresh fish is firm in texture, has no off-odour, has bright red gills and clear eyes, and is silvery-coloured in appearance. When spoiled fish is used, the taste and texture of the product suffer. In addition, handling during production becomes very difficult and wastage due to physical damage increases.

B. Cleaning the Fish

Cleaning of the fish to be smoke-cured varies depending on the size. Bigger fish (15-25 cm or longer) such as striped mackerel, roundskad and milkfish must be gutted. Gutting consists of removing the internal organs of the fish and cleaning the belly cavity of blood. The gut imparts bitter and other off-tastes to the fish, while blood along the backbone in the belly portion makes the finished product unsightly during consumption. Spoilage is also faster in this portion since it contains the bulk of bacteria and enzymes that cause deterioration in fish.

C. Brining or Brine Salting

Brining is a process of salting fish by immersing it in a saltwater solution for a certain length of time. The purpose of brining is to impart the desired salty taste to the fish, leach the blood and make the flesh firm. Brining time depends on the size of the fish or thickness of the skin and flesh. (See Table 1)

Bigger fish like milkfish, roundskad and mackerel must be brined so that the salt penetrates evenly into the flesh. Small species like herring and sardines need not be soaked in brine prior to boiling.

A saturated brine is normally used because it is easy to prepare and the rate of salt intake by the fish is faster, hence, a shorter soaking time is required.

The preparation of this brine consists in dissolving salt in water until the salt ceases to dissolve. The solution is then filtered using a fine cloth to strain it of sand, other particles and visible impurities.

Table 1. Recommended brining and boiling times for different species

Fish and Size	Brining Time (minutes)	Boiling Time (minutes)
Roundscad		
11 - 13 cm long	(5)	5*
14 - 16 cm long	20	5-8
17 - 20 cm long	45	10
Striped Mackerel		
20 cm long	20	10
25 cm long	30	10
Herring and Sardines		
10 - 12 cm long	(10)	5*
13 - 15 cm long	(20)	10*
Milkfish		
250 g/fish	60	10-15
350 g/fish	90	10-15
500 g/fish	120	10-15

- Note: 1. Brining time enclosed in parentheses means that it may be omitted.
2. Boiling time with asterisk means that saturated brine is used for boiling fish.

D. Boiling in Brine

A 10% brine is generally used for boiling the fish if these have been pre-soaked in brine. This is prepared by dissolving 10 parts (takal) of salt in 90 parts of water, or equivalent to 1 part of salt in 9 parts of water. A saturated brine, on the other hand, is used when fish have not previously been brined as in the case of sardines and herring. The brine is heated to boiling point before the fish are immersed. This process cooks the fish, arrests temporarily the enzymic and bacterial activities, and makes the surface of the fish sticky, assisting in rapid smoke absorption. Since boiling makes subsequent handling delicate and difficult, special care must be taken after the fish have been boiled.

Boiling is done by batches in a steel cooking vat the fish being arranged in layers in boiling baskets. The time of immersion depends on the size of the fish. It can be judged to be sufficient when the eyes of the fish have become opaque. See Table 1 for the boiling time of different species.

E. Smoke-Curing

Smoke-curing is done to impart the desired golden brown colour to the fish and the typical smoke aroma. The process consists in generating smoke by kindling sawdust in the combustion unit and channelling it to the fish. Smoking time depends on the temperature but, ideally, this requires two hours at the most when smoking is done at 40°C for 30 minutes, and at 80°C for the rest of the time.

Smoke-curing can be classified into two types based on the smoking temperature, i.e., cold and hot smoking. In cold smoking, the temperature does not exceed 45°C in the smoking chamber while in hot smoking the temperature may reach 90°C. In the Philippines, hot smoking is traditionally practised.

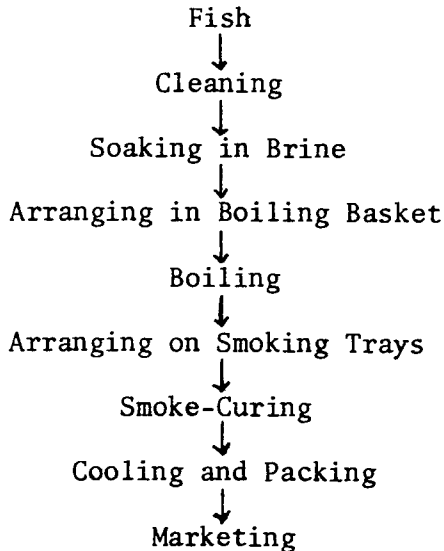
The surface of the fish must be wet so that the smoke will be absorbed faster. Similarly, the smoke coming in must contain a little moisture so as not to dry the fish surface. However it must not contain too much moisture otherwise water vapour will condense on the fish and will wash off absorbed smoke through dripping. This normally happens when the weather is cold and humid or when it is raining, in particular if smokehouses without chimney fans are used.

In burning the sawdust, care must be taken not to produce flames. The proper way to do this is to control the in-coming air so that the sawdust is merely kindled. If flames are produced, the smoked fish become sooty and harmful smoke components such as PAH (polyaromatic hydrocarbons) are released and deposited on the fish.

F. Cooling and Packing

The smoked fish must be cooled first before they are packed, otherwise vapour will condense and moisten the inside of the package. It is not advisable to pack smoked fish in plastic material if storage is to take place at room or chilling temperatures. Plastic is suitable only when the product is to be frozen. In the former case, clean brown paper can be used as wrapping or lining of carton boxes or trays; alternatively, banana leaves can be used.

The steps to be followed in smoke-curing fish are as shown below:



TECHNICAL PROBLEMS OF SMOKE-CURING

A. Smoke Deposition and Colour Formation

Smoke deposition is a complex process. It is not sufficient that smoke is dense and moving, and the fish surface moist. The need for controlling the temperature and relative humidity has been found to be of great importance for successful smoke-curing. On a humid day, it is very likely that smoke deposition will be adversely affected and colour will not form because inside the smoking room, humidity will have built up, which will result in moisture condensation and washing off of the deposited smoke through dripping. On the other hand, if the environment is cold, heating of the smokehouse becomes difficult owing to heat loss through the walls. The upper part of the smokehouse will be cooler, thus increasing moisture condensation. This problem is encountered in any non-mechanized smokehouses with built-in heaters and chimney fans.

If the surface of the fish is dry, smoke penetration will be very slow and the golden brown colour will barely form. This occurs during a very dry day in a smokehouse with a mechanical exhaust or chimney fan which continuously and rapidly sucks off the humid air inside the smokehouse. When such a smokehouse is used, the chimney fan must be properly regulated. A dry sunny day, however, is ideal for successful smoke-curing using the non-mechanized designs.

For successful smoke-curing, it has been found that a relative humidity of around 60 per cent and smoking temperature of about 80°C

are optimum. The range of relative humidity may also be from 50 to 70 per cent; below and above this range smoke deposition is adversely affected. Temperatures ranging from 70^o to 85^oC also show good results.

B. Smoke Generation and Formation of PAH

Polycyclic aromatic hydrocarbons (PAH) are undesirable substances that are formed together with the other smoke components mentioned earlier. These are known to be carcinogenic; therefore, while burning wood, every precaution must be taken to reduce or eliminate PAH.

Controlled smoke generation has been found to reduce the level of PAH in smoked foods. Care must therefore be taken to avoid producing flames while kindling the sawdust; otherwise, more PAH will be deposited on the product.

Similarly, the burning of sawdust just below the layers of fish, which is being practised in most traditional smokehouses in the Philippines, increases PAH levels in the smoked fish. Smoke generation must therefore be done in a separate unit as shown in the improved designs of smokehouses given in this manual. Having the source of smoke some distance from the fish filters off PAH or causes precipitation at the particular phase of smoke generation at which PAH are mainly formed.

SPOILAGE OF SMOKED FISH

Smoked fish normally contains a high amount of moisture, ranging from 55 to 70 per cent. Because of this, the product is not stable when stored at room temperature. The shelflife of the smoked products is from 3 to 5 days at the most. Spoilage is brought about by bacterial action, and growth of yeast and mould.

The possible microbial risks associated with smoked fish include the following:

- (a) *Botulism*. This is a very lethal form of food poisoning caused by *Clostridium botulinum* growth in a product which may occur when the product is packed and sealed in plastic bags. Sealing and vacuum packaging increases the growth of this bacterium, in addition to causing sweating and easy spoilage of the smoked fish.
- (b) *Aflatoxin Production by Moulds*. When the moisture content of smoked fish is around 55 per cent, conditions are conducive to mould growth and spoilage due to these fungi takes place. The process is quite fast - a matter of days - and the fish can easily be covered with moulds once growth has started.

Some kinds of moulds produce aflatoxin (a toxic substance), namely, the *Aspergillus flavus* group which survives well in smoked products.

Vendors often scrape off mould growth on the surface of the smoked fish to avoid loss. This is a very dangerous practise since it increases the consumer's risk of food poisoning from smoked fish.

- (c) *Growth of Escherichia coli, Vibrio parahaemolyticus, Staphylococcus aureus and Salmonella*, all disease-causing organisms, is also found in smoked fish. If sanitation is poor and post-process handling is careless, levels of these pathogens in the product may be very high. To avoid food poisoning, hygienic handling practises must therefore be followed. To minimize risk to the consumer, frying of the smoked fish prior to consumption is highly desirable in order to kill these pathogenic organisms. This is particularly important in the case of commercial smoked fish and also if the product has been stored for some time before consumption.

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LIST OF SAFIS EXTENSION MANUALS

- SEC/SM/1 Khumual liang pla namcheut (Freshwater Fish Farming: How to Begin)-- in Thai
- SEC/SM/2 Oyster Culture
- SEC/SM/3 Mussel Culture
- SEC/SM/4 Ang Pagpuna ug pagtapak sa pukot (Net Mending and Patching)-- in Cebuano Bisaya
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- SEC/SM/8 Macrobrachium Culture
- SEC/SM/9 Selection of Marine Shrimp for Culture
- SEC/SM/10 Induced Breeding of Thai Silver Carp
- SEC/SM/11 Culture of Sea Bass
- SEC/SM/12 Smoke-Curing of Fish

SAFIS

0 What is SAFIS?

SAFIS is the Southeast Asian Fisheries Information Service. It is a project of the SEAFDEC Secretariat set up to provide extension materials for small-scale fishermen and fish farmers in the region.

0 What are its objectives?

The immediate objectives are to collect and compile fisheries extension manuals, brochures, pamphlets and related aids for small-scale fisheries development, and to translate selected literature into local languages for distribution to fisheries extension workers in Southeast Asia.

0 What services will SAFIS provide?

SAFIS will attempt to provide information and publications such as:

- lists of available texts in fisheries extension services,
- translation of suitable manuals,
- manuals of appropriate technologies,
- photocopies of appropriate fisheries extension literature,
- a current awareness service of regional fisheries.

0 How much will these services cost?

A nominal cost of US \$0.15 per page will be charged for photocopying, handling, and surface mail. Airmail costs will be extra. The publication cost per manual will vary according to the book.

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