Food Cycle Technology Source Book No. 4: Fish Processing

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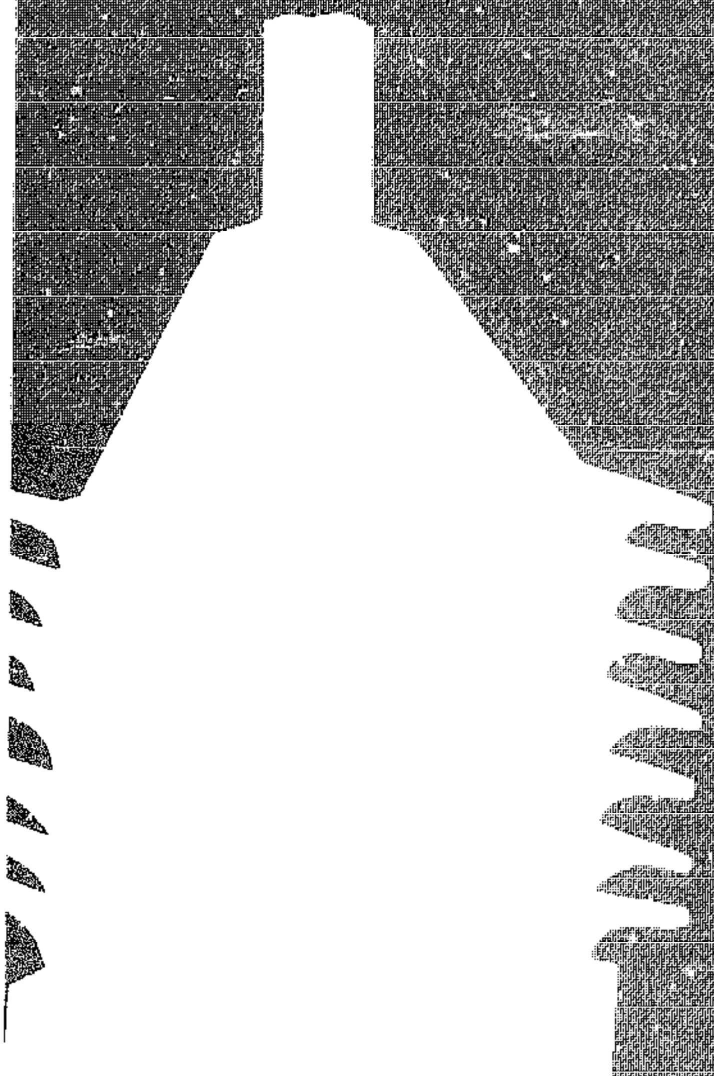
Fish Processing



4 FOOD CYCLE TECHNOLOGY SOURCE BOOK

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FOOD CYCLE TECHNOLOGY SOURCE BOOK NO. 4

Fish Processing

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THE UNITED NATIONS DEVELOPMENT FUND FOR WOMEN

PROJECT GLO/85/WO2 - WOMEN AND FOOD CYCLE TECHNOLOGY (WAFT) AND PROJECT RAF/86/WO3 - TRANSLATION AND PUBLICATION OF FOOD CYCLE TECHNOLOGY SOURCE BOOKS

With the collaboration of the

INTERMEDIATE TECHNOLOGY DEVELOPMENT GROUP
United Kingdom

1988

PREFACE

UNIFEM AND THE FOOD CYCLE TECHNOLOGY PROJET (WAFT)

The United Nations Development Fund for Women (UNIFEM) was established in 1976, and is an autonomous body associated, since 1985, with the United Nations Development Programme. UNIFEM seeks to free women from under-productive tasks and augment the productivity of their work as a means of accelerating the development process. It does this through funding specific economic projects which yield direct benefits and through actions directed to ensure that all development policies, plans, programmes and projects take account of the needs of women producers.

In recognition of women's special roles in the production, processing, storage, preparation and marketing of food, UNIFEM initiated in 1985 a Food Cycle Technologies project with the aim of promoting the widespread diffusion of tested technologies to increase the productivity of women's labour in this sector. While global in scope, this five-year project is initially being implemented in Africa in view of current concerns over food security in many countries of the Region.
The eventual aim of the project is to increase indigenous capacity to respond to the technology needs of women producers and to inform and influence the decision makers who can create the correct policy environment for this to happen. This will be achieved by providing appropriate technical assistance relating to the process of technology development and diffusion.

This source book is one of a series being compiled as part of the preparatory phase of the Food Technology project. UNIFEM hopes that the widespread distribution of these sourcebooks will increase awareness of the range of technological options and sources of expertise, as well as indicating the complex nature of designing and successfully implementing technology projects and diffusion programmes.

Titles in this series include: Oil Extraction, Fruit and Vegetable Processing, Cereal Processing, Rootcrop Processing, Fish Processing, Packaging, Drying and Storage. Source books will also be available in French and Portuguese.

ACKNOWLEDGEMENTS

This initial series of food cycle technology source books has been prepared at the Intermediate Technology Development Group (ITDG) in the United Kingdom within the context of UNIFEM's Women and Food Cycle Technologies (WAFT) specialization. During the preparation process the project staff have contacted numerous project directors, rural development agencies, technology centers, women's organizations, equipment manufacturers and researchers in all parts of the world.

UNIFEM and ITDG wish to thank the several hundred agencies and individuals who have contributed to the preparation of the source books. Not all can be mentioned by name, but special thanks are owed for their major contributions to the International Labour Organization (ILO), the Food and Agriculture Organization of the United Nations (FAO), the United Nations Children's Fund (UNICEF), the Economic Commission for Africa (ECA), the German Appropriate Technology Exchange (GATE/GTZ) in Eschborn, the Groupe de Recherche et d'Echanges Technologiques (GRET) in Paris, the Royal Tropical Institute (KIT) in Amsterdam, the International Development Research Centre (IDRC) in Ottawa, the Tropical Development Research Institute (TDRI) in London, Appropriate Technologies International (ATI) in Washington, the Institute of Development Studies, Sussex University (IDS), and the Save the Children Fund.

The preparation of the source books has been funded by UNIFEM with a cost sharing contribution from the Government of The Netherlands.

UNIFEM is particularly grateful to the Government of Italy for providing the funds for translation and printing of the source books and to the Italian Association for Women in Development (AIDOS) for implementing this phase of the project.

UNIFEM was cr ated during he United Nations Decade for Women to pı ɔvide technic l and financial support to benefit rural a ıd poor urba women in developing countries. Add ess: 304 East 5th Street. New York. N.Y. 10017 U3A

The I- ermediate Technolo y De lopment Group was founded in 1965 by he late Dr. E.F. Schumacher. The Group, an independent char , helps introduce technologies suitable for rural commu ties in developing countries. Address: Myson House. Ra way Terrace. Rugby. CV21 3HT UK

The Italian Association for Women in Develop ment (AIDOS) is a non-profit organization founded in 1981 to provide assistance to women's organizations throughout the developing world. Address: Via dei Giubbonari 30 Int. 6. 00186 Rome. Italy

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INTRODUCTION

This source book will deal with the importance of fish preservation in small scale fisheries. The term 'fishery' is used to cover the whole of the fishing operation from catching the fish to selling the product. Processing fish by curing describes methods used to preserve fish without the need for sophisticated techniques such as refrigeration, freezing or canning. It includes smoking, drying, salting, and fermentation. Boiling and frying used for short-term preservation are also covered.

The intention of this sourcebook is to provide consultants who have no technical or science background with a basic knowledge of principles behind fish processing and equipment used together with an awareness of fish curing undertaken by women in developing countries. It is also recognised that this book may be useful to field workers who see the need for upgrading local fish processing practices but who may not have any specific fish technology or science background.

The small-scale fisheries of developing countries play a vital role in fish production by supplying most of the fish used for direct human consumption and also provides a large number of people with a relatively low cost and nutritious food. Fish is often the cheapest form of animal protein available. In many cases, these fisheries are responsible for between 50 and 70% of a nation's catch. In Senegal, for example, artisanal fisheries provide 60% of national landings. In Peru, the artisanal fleet supplies 80% of fish for human consumption but only about 10% of Peru's total catch (5.5 million tonnes: 1986).

Small-scale fisheries are characterised by being highly labour intensive and having low capital investment. They are located in coastal areas, or near lakes, estuaries or rivers and catch fish mainly in shallow water. Improvements to the fishing operation such as the use of motorised boats and winches to haul nets have been introduced, but there have been few technological improvements to the handling and processing of the catch, with the exception of the introduction of ice and insulation. This may be because, in the past, increased fish production has received far higher priority from development agencies and local governments than the handling, processing and marketing of the existing catch.

There is often a gender division of labour associated with small-scale fishery operations. Women are usually confined to on-shore activities such as processing and marketing where the work will not conflict with other household duties, while the men go fishing. While women are often culturally forbidden from fishing they usually have a central role in the processing and marketing of fish and derive substantial status and income for their households from these activities. The importance of women in small-scale fish processing and the lack of response to them needs to be recognised and this document is therefore addressed to these issues.

Fish is an extremely perishable food commodity. For no other kind of food is there so much observed evidence of serious loss at every stage from harvest to consumption and so little documentation of the overall proportion of losses from fish production. (ECA, 1984). Exact assessment of post-harvest loss of fish is very difficult to quantify in developing countries because most of the artisanal catch is unrecorded and is caught by unregistered fishermen. Additionally it passes through many hands on its way from harvest to consumption. It has been estimated that 10% by weight of the world fish catch is lost by poor handling, processing, storage and distribution. However, losses in small-scale fish processing are particularly high and can sometimes amount to 40% (ITDG, private communication).

Because fish is a low-acid food which supports the growth of pathogens (micro-organisms causing disease) careful handling and rapid processing is essential. The fish is usually neither chilled nor adequately protected from the sun both on board fishing vessels and at the landing site. Basic principles of hygiene may be unknown or seldom applied so that by the time processors buy the fish, it may already be at various stages of spoilage. Bacterial and enzymatic spoilage is the most important at this stage. Bacteria present on the surface and in the guts of the dead fish multiply rapidly invading the flesh. Evidence of slime on the skin and an unpleasant smell usually appears too late to take any preventative action. At ambient tropical temperatures, fresh whole fish is rendered inedible within 12 hours (FAO, 1981). Removing the guts and disposing of them properly will help inhibit flesh deterioration.

The longer the processor leaves the fish before processing, in conditions favourable for spoilage, the greater the losses. It is quite common to see 'ripe' fish which was intended for sale in a fresh form being processed as a last resort. Additionally, moist fish is susceptible to damage by blowflies and their larvae, in particular, which are voracious feeders. Insanitary conditions on or near beaches or lakesides where the bulk of the catch is landed are excellent breeding grounds for blowflies. The adult fly will not lay eggs on fish which has been adequately dried and efficient processing will therefore help prevent spoilage. Traditional curing is often rudimentary and good hygiene is rarely practised. During the rainy season, when humidity levels are high, sufficient drying cannot be achieved using traditional methods. In such conditions, stored, cured fish will also reabsorb moisture and become susceptible to bacterial, fungal or insect attack.

Products which are sufficiently well preserved to prevent microbial attack are still susceptible to insect and vermin attack. After the curing process and particularly during storage, beetles are the main insects causing considerable damage to fish. Under the most adverse conditions, losses due to beetle infestation have been estimated at around 50% (FAO, 1981).

Losses can also result during storage from attack by any animal pests which can gain access. In such cases, attention must be paid to the adequacy of protection for stored fish. Further losses occur during transport and distribution to inland markets, mainly due to physical disintegration of the fish. This may be brought about directly or indirectly by incorrect handling techniques, inadequate packaging materials offering little protection, and poor processing techniques. An effective approach for increasing the amount of fish available for consumption is to minimise these substantial post-harvest losses. Now that fish resources are frequently over-exploited there is increasing emphasis on upgrading post harvest technologies. Now that overfishing is feared in the Bay of Bengal, for example, attention has been placed on funding the development of aquaculture and improved handling and processing. (ODNRI Private communication).

Traditional marketing channels can be complex social systems, not only in distribution patterns (which may involve four or more tiers of sale), but also in the roles played by men and women. Men may not always dominate the management of fishing vessels, nor the women the processing as sometimes the fishermen may look after the processing of their catch, and the women may own fishing boats and hire fishermen to obtain the catch. When introducing any improved technology it is important to closely examine the power relationships between fishermen, fish processors, traders and consumers since unless women processors have substantial control over the fishery system, benefits of these technical improvements may flow to other people. In many fishing communities, women take over the function of buying and selling fish and they have accumulated important trading experience. Women in Bolivia ('Cholas'), for example, play an almost monopolistic role in fish marketing and derive powerful status from this activity. Not only is it useful to examine the power relations between members within the distribution chain in order to assess the likely impact of the technology, but it may be necessary to look at power relations amongst processors and within the household in order to determine who has access to the technology and on what conditions.

The location of the fishing ground in relation to the markets may determine the proportions of fresh and processed fish for sale. With no ice or refrigeration facilities available to artisanal fish processors, and in order to sell the fresh fish before it is spoiled, distribution is limited to markets within easy access. For distant markets or those with difficult access, the fish is preserved by traditional processing techniques, such as salting, drying and smoking. Taking into consideration the poor infrastructure and limited transport facilities, traditional fish processing is often the only option. Unfortunately, in areas where fresh fish is a more desirable commodity, artisanal fish processors, with their less preferred cured products, may face fierce competition from larger-scale fish processors who have access to refrigeration and transport facilities.

Here, not only have the limitations of traditional processing methods been pin-pointed, but also those outside the control of the processors. It is equally important to realise that traditional processing methods have many advantages. They supply desirable products to local markets and are low cost operations. In addition a sophisticated market structure has evolved to cater for these products. To overcome some of the limitations mentioned above, the type of assistance that is needed is unlikely to involve huge financial injections or the provision of mechanised equipment which may upset the well established traditional marketing structure. Often only small changes, which are within the financial capabilities of the processors, are needed. Such changes may include the provision of clean water, education and training facilities, simple equipment, or basic materials.

Fish processors are not only at a disadvantage due to their traditional methods, and affected by economic pressures but also by the variable nature of fish supplies. The amount of locally exploitable fish may change due to seasonal fluctuations in fish movements and availability, man-made environmental changes or changes in climatic conditions. In addition, the onset of adverse weather for example the monsoon, may make fishing activity too difficult. Fishermen may also have other seasonal occupations such as farming which interfere with their fishing activity.

Although there are over 20,000 species of fish, the characteristics of fish which affect the way it is processed are its size, oil content and flesh texture. (ILO, 1982). If there is a change in the type of fish caught, then the processing technique may change. For example, the introduction to Lake Victoria of East Africa Nile Perch, which are a lot larger in size, and have a higher oil content than the Tilapia species originally predominant, has brought about a frying technique previously unused in the area. (ITDG, private communication).

The potential for improved processing technology is to reduce post harvest losses, to provide employment and to retain product acceptability, or make the product more desirable so that fish processors can maintain or increase their incomes and their selling power in the markets. Consumer preference must not be ignored as they often dictate product quality. For example, in South America salted-dried fish for Easter is preferred rancid (yellow colouration) rather than white.

When considering or recommending the introduction of an improved technology to small scale fish processing, not only must the change be requested by the participants and the impact of the technology on their beliefs, values and social organisation be taken into consideration, but also the cause of the problem must be identified correctly. Although problems in fish processing may be readily identified, these may not be of critical importance to the processors. The solution might need to be targeted at other areas such as fish handling and hygiene, marketing and transportation.

This source book is divided into six sections covering general principles of fish processing, and traditional and improved fish processing technologies. It also illustrates the socio-economic framework surrounding small scale fish processing activities with several case studies. A checklist of questions which helps to place fish processing in the wider context of the fishery system, (such as food habits, marketing, socio-economics) is enclosed.

General Principles of Fish Processing

The whole subject of fish handling before processing is outside the overall scope of this Source Book. Its importance however cannot be ignored and the following sections are included to provide consultants with a minimum background so that they will be more aware and able to recognise such problems. They will be further expanded on in Section 4. Some pre-processing problems related to the practices of the fishermen are invariably totally beyond the control of processors and consultants should contact local fisheries specialists for advice.

Other pre-processing problems related particularly to hygiene and keeping fish cool after it has passed into the hands of the processor can, to some extent, be overcome within a project.

Spoilage

Fish spoilage is due to three main factors:

a) activity of micro-organisms (bacteria, moulds and yeasts)

b) Chemical deterioration not due to micro-organisms (breakdown of oils and fats (rancidity), enzymatic activity)

c) Attack by insects (blowfly and beetle infestations) and vermin (this term refers to various scavenging animals eg, cats, dogs, rats, chickens, crows, fish eagles, mites etc.)

Each one of these three factors is a complex topic in itself and it is beyond the scope or purpose of this book to go into too much detail. Suffice to say that there is no one simple solution to the prevention of spoilage. There are however, basic principles of preservation which can be applied to fish to inhibit these factors and therefore act as preventative measures against spoilage. Centuries-old practices such as drying and curing of fish are examples of the methods of preservation used. Before any improvement on traditional methods can be suggested, it is important to understand the principles behind the preservation methods.

As soon as a fish dies, it will begin to deteriorate. This natural process is irreversible and the preservation principle is to *slow down* the deterioration, hence increasing the overall quality and storage life of the product. The sooner any preventative measures are taken after capture of the fish, the greater the chance of reducing post-harvest losses.

To do this it is necessary to control the conditions which influence the activity of micro-organisms, processes of chemical deterioration and incidence of insect and vermin attack.

These conditions include:

1. Good handling practices on board fishing vessels and at landing sites
   - good hygiene
   - removal of guts and gills (if culturally acceptable)
   - washing and cleaning with good quality water
2. Rapid and effective processing
   - reducing the moisture content of the fish (eg drying, salting, smoking)
   - reducing the temperature (use of ice, shade)
   - cooking (eg boiling, frying)

- lowering of PH by creating acidic conditions (eg fermentation)

3. Protection from insect infestation
4. Good packaging, storage and transport practices

Effective Handling Practice

Raw material quality

Salted, smoked, dried or fermented fish which is of poor quality and unacceptable to the consumer may have been processed by a satisfactory technique. In such cases the quality of the raw material may be at fault. **Poor quality raw fish can never produce a good quality final product.**
The most important factor affecting the quality of a fish product is the freshness of the raw material immediately prior to processing. Processing can only help to slow down the rate of deterioration and using spoiled fish as the raw material can only produce a poor quality product. In many parts of the world, buyers often assess fresh fish quality by feeling and smelling the guts and gills and become suspicious of gutted and cleaned fish because they cannot tell how fresh it is. It might also be the case that consumers prefer to buy whole fish. It is therefore necessary to educate fish processors that the presence of guts and gills accelerates deterioration. However, if gutting and gilling are carried out incorrectly and potable water is unavailable then it is debatable whether these operations are advantageous. It is thus very important that processors can recognise characteristics signalling deterioration in fish. Some of these are listed below.

Freshness Characteristics

	Fresh	Spoiled
Overall appearance	shiny, metallic wet sheen	dull, dry wrinkled
Skin tone	elastic, firm	inelastic, slack, bloated
Smell	fresh, seaweedy odour	sour, off odours
Eyes	clear; projecting	opaque, sunk in head
Gills	bright red/pink colour, fresh smell	dull, brownish in colour, off odours.
Mucous coating on the skin	free-flowing fine lubricant	coagulated mucous (slimy)

Sometimes consumers look to purchase 'ripe' fish for processing as the flavour is considered desirable and, in some cases, used as a delicacy. Spoiled or low quality fish may also be purchased because it is generally lower priced. Fish purchased in this condition may be subsequently preserved by fermentation, if this is acceptable to local tastes.

Appropriate action taken to preserve the fish during the pre-processing stage, which means right from the time it is caught up to the time it is processed in some form, is the best preventive measure against spoilage.

The main factors involved in spoilage during this stage are as follows:

Careful handling

The way that fish are caught and handled is important. Fishing methods can affect the quality characteristics of the fish. The use of gill nets for example may result in some of the catch being landed with spoilage already underway, as the fish may have been in the net for a considerable period. Similarly bruising and rough handling results in tissue damage around which deterioration starts.

Cuts in the flesh will provide an entry point for micro-organisms and insects which will increase the rate of spoilage.

Good hygiene

Immediately the fish are caught, hygiene is of paramount importance. Certainly *cleaned* dead fish stored in a clean place to prevent recontamination will keep in a better condition before processing than those that have not been cleaned.

As soon as the fish dies, internal chemical and bacterial changes which occur begin the breakdown of tissues to cause spoilage. The best way to keep fish as fresh as possible before processing is to keep them alive.

Temperature control

Spoilage of fish is directly related to temperature. The higher the temperature, the faster the rate of spoilage, becoming most rapid between 30°C - 40°C. Therefore any reduction of temperature prior to processing will increase the quality of the fish and any product processed from the fish.

Reducing time intervals

Ultimately, the quicker the fish is processed the better quality the end product will be. This is helped by carrying out fish processing near the landing area.

Effective Processing to Inhibit Spoilage

Drying

Although at first sight drying seems a simple process in fact the manner in which products dry is complex, depending upon the drying conditions and the physical and chemical nature of the commodity. A basic understanding of the principles of drying will prove useful when looking at possible improvements to a system.

Drying requires the transfer of moisture from the product to the air around it. Clearly both the quantity (air flow) and dryness (relative humidity) of the air will effect the way a product dries as well as the nature of the product itself. The relative humidity (RH) of air decreases rapidly with increasing temperature and the water absorbing capacity of dry air of low RH is much greater than moist air of high RH. It can been seen from the table below which shows the effect of heating air on its RH and capacity to absorb moisture, that raising the temperature of air by only 10°C increases its water absorbing power by a factor of five.

°C	RH	Kg of water that can be taken up by each Kg of dry air
20	80%	0.003
heat to 25	falls to 58%	0.008
heat to 30	falls to 25%	0.016

It is important to realise that there are two stages in the drying process: the first removing 'surface moisture'; the second removing 'internal moisture' from within the piece of fish.

The rate of drying during the *first stage* is dependent solely on the ability of the air passing over the fish to absorb and remove moisture. Air flow rate is more important than temperature but in areas of high relative humidity the air may need heating to lower its RH to a level that allows it to absorb meaningful amounts of water. In general air with an RH of 75% or more is not able to effect much drying except in the earliest stages when the fish is very wet.

Once the surface water is removed a *second stage* of drying begins in which water is removed from the interior of the fish.The drying rate in this second stage is dependent on the rate at which moisture can migrate through the tissue to the surface where it evaporates to the passing air. The migration is a slow process so drying rates are lower than in the first stage of drying. The rate of air flow is less important.

The rate of drying in this second stage depends on such factors as:

- the oil content, oily flesh acting as a barrier to water movement and slows down drying rates
- the thickness of the fish, the further the water has to travel to the surface and the slower the drying rate
- the moisture content, the rate of movement to the surface falling as the moisture content of the fish is lowered
- the temperature of drying

During the second stage of drying, depending upon ambient air humidities, some heating of the drying air may be essential to reduce the final moisture content to a sufficiently low level to prevent microbiological spoilage, generally 25% or less depending upon the oilyness of the fish and whether salt has also been used. As a general guide, if no salt is used, lean fish should lose approximately 75% of their weight during drying and oily fish 65% (FAO/

DANIDA (c)). A simple weighing of the fish before, during and after drying is a good quality control check for adequate drying, provided the fish have been periodically turned. For weighing purposes it is perhaps necessary to mention that there are very simple and inexpensive spring balances often available locally.
The surface area exposed is also very important so splitting or opening of the fish will increase drying rates.
One other vitally important aspect of fish drying must be mentioned. If the fish are dried at too high a temperature or when the initial relative humidity of the drying air is too low, during the early stages of drying, the outer layers become 'cooked' or altered so as to be almost impervious to water. This effect is know as 'case hardening'. The fish externally may appear dried but water becomes trapped inside leading to in sufficient drying and spoilage. The onset of case hardening makes it very difficult to obtain a good dry, final product. Drying temperatures during the early stages of the process should as a general rule not exceed 40°C. Case hardening must be avoided at all cost.
In conclusion and taking into account local environmental conditions the factors mentioned above (air flow, temperature, fish thickness) can be manipulated to give a final product that has:

- been evenly dried and is not moist inside
- a moisture level below 25%
- a good shelf life
- good visual and acceptable eating qualities

Salting

The most important effect of salt is the removal of water from the fish flesh to the point where microbial and enzymatic activities are retarded (Duere and Dryer, 1952). Some spoilage bacteria cannot live in salty conditions and a concentration of 6-10% salt in the fish tissue will prevent their activity. A group of micro-organisms known as halophilic bacteria are however salt-loving and will spoil salted fish only. Further removal of water by drying will inhibit these bacteria.
The removal of water, which takes place during the salting of fish, is due to the fact that the salt solution outside the fish is of a higher concentration than the residual water in the fish flesh. As water is removed from the fish flesh, salt will penetrate into it. If the salt concentration outside the fish is equal to that inside the fish flesh, no movement of water or salt will occur. Once this happens, more salt will have to be added to the solution so that salting can continue.
The rate of water movement out and salt movement *in* depends on:

- the concentration of the salt solution
- the fat content of the fish
- the thickness of the fish
- temperature
- the time that the salting is allowed to continue

It needs to be borne in mind that the type of salting operation used will depend on:

- consumer preferences
- availability of salt and costs
- fish type i.e. lean or oily

What type of salt should be used?

Salt is variable in its properties, as it is produced in several ways.

The main types are:

Sea salt from the sea or lake waters, **brine evaporated salts** from under ground sources and **rock salts**. These salts will differ in their chemical composition, their microbiological purity and their physical properties which will affect the salted fish quality.

Apart from contamination such as dust, sand, mud and moisture, salt intended for use on fish should have a low content of magnesium and calcium salts to avoid the bitter taste and toughness imparted by these salts although the whiter colour effect may be a consumer preference. Salt itself can carry halophilic bacteria mentioned earlier and these then can contaminate the fish treated with that salt. Heavily contaminated salt can sometimes be recognised by its pink colour.

Salt comes in different sized crystals or particles depending on whether or not it has been ground and how it has been ground. Coarse grain more suitable (large in size) will not penetrate into fish flesh as quickly as fine grain (small in size), nor will it dissolve in water as rapidly. Although fine grain salt will be suitable for making brines, coarser grain is more suitable for dry salting as a condition known as 'salt burn' may occur if fine grain salt is used. That is, the surface of the fish becomes hardened due to too rapid a removal of water from the fish surface, in a similar way to case hardening. The hard surface then prevents both salt penetration and water removal.

The effectiveness of the salting operation for preservation depends on:

- uniform salt concentration in the fish flesh
- concentration of salt solution and time taken for salting
- whether or not salting is combined with other preservation methods, such as drying.

Smoking

The preservative effect of the smoking process is due to drying, and the deposition in the flesh of natural wood smoke chemicals. During smoking, the smoke from the burning wood contains a number of compounds which inhibit bacteria, while the heat from the fire causes drying and, when the temperature is high enough, the flesh will be cooked, preventing bacterial growth and enzyme activity.

Fish may be smoked in a variety of ways, but the longer it is smoked the longer it will keep. The smoked product owes its storage life primarily to the drying and cooking processes, rather than the preservative value of the wood smoke chemicals.

Two smoking categories can be identified:

- *Cold* smoking where the temperature is never high enough to cook the fish, (ie less than 35°C)

- *Hot* smoking where the flesh is cooked, (above 35°C)

Hot smoking is the traditional method more widely practised in developing countries and requires a lesser degree of control over the process than cold smoking. The shelf-life of the hot-smoked product is generally longer than that of the cold-smoked product, because the fish is smoked until dry. Generally, the hot smoking process consumes more fuel than cold smoking. Hot smoking however, (especially where the fish are tented ie, hung on spits) greatly reduces the oil content of the final product. Modern smoking techniques do not preserve the fish but are merely cosmetic to produce a smoky flavour.

Care should be taken in the selection of the wood used for fish smoking, as some types of wood, for example resinous types like pines, may impart an unpleasant flavour and taste to the final product. Other types such as *Euphorbia* may be poisonous.

In addition to wood, other available ma-

terials eg cowdung, coconut husks and sugar cane trash are also used for fish smoking.
Care should be taken as smoking may also bring about defoliation (the loss of leaves from trees), where smokers are placed in woody areas.

Combined curing methods

Drying, salting and smoking can be used in various combinations to produce a variety of fish products with the long storage life necessary for transport and distribution. Such combined methods are also based on the reduction of water content.

Examples:

Drying - smoking - drying

Brining - smoking - drying

Salting - drying

Salting - drying - smoking

More specific examples of combined methods of preservation can be found in Section 3.

Fermentation

In hot humid climates spoilage is not always arrested by dehydration methods as it is difficult to keep the product dry. Fermentation is a method which inhibits spoilage changes within the fish by increasing the acidity. During fermentation, the use of salt inhibits the action of the spoilage bacteria and allows the fish enzymes or beneficial acid-producing bacteria to break down the flesh. Fermentation can be defined as the controlled action of desirable micro-organisms on food to alter the flavour or texture and to extend the shelf life.
The use of fermentation as a low cost method of fish preservation is more commonly practised in South East Asia, and West Africa.
There are many different types of fermented products and their nature depends largely on the extent of fermentation which has been allowed to take place. Refer to Section 3 for examples.

Boiling and frying

The preparation of boiled fish products is only of significance in South East and East Asia. These products can offer short-term preservation varying from one or two days to several months.
The action of boiling cooks the fish by changing the structure of proteins. Enzymes, which can cause deterioration, are also proteins and therefore become deactivated during boiling. The process also kills many of the bacteria in the fish. Traditionally, salt is usually added during boiling and the amount added along with the duration of boiling, determines the shelf-life of the product. Fish which have been boiled for a short time with little salt should be treated the same way as fresh fish. It is only when the fish are cooked for a long time with plenty of salt that they will be preserved to some extent. The advantage of boiling is that it is a very simple process which can deter fish spoilage in the short term when conditions are unsuitable for drying. The process also helps to reduce the fat content of the product if the fish are removed from the water, thereby decreasing problems of rancidity.
Frying also cooks the fish and dehy-

drates the flesh. Fatty fish can be fried in their own oil.
Both boiled and fried products benefit from effective packaging to prevent re-contamination, and insect attack.

Freezing and canning

Both freezing and canning are relatively expensive operations and are therefore unsuitable for the majority of small-scale fisheries. If either of these operations are to be taken up, it is essential that careful consideration be given to the economics of production, the supply of adequate relevant materials and infrastructure, the market, quality control (particularly health aspects) and consumer acceptance for finished products.

Insect Infestation

Before beginning it is necessary to mention how the term insect will be used within this document. There are many types of insects which affect fish quality and reference will only be made to those types of most significance. These fall into two main groups: blowflies and beetles. Within these two groups there are many species and for identification purposes a specialist entomologist should be consulted.
The main conditions which determine the extent of insect infestation are five fold:

- hygiene
- temperature
- moisture content and relative humidity
- salt content
- degree of protection

Both blowflies and beetles will typically select specific ranges of these conditions for their individual survival (FAO, 1981). In general, tropical conditions wit[illegible] higher temperatures and relative humid[illegible] ties than those found in a temperate c[illegible] mate are more favourable to insect dev[illegible] opment. Blow fly inf[illegible] on occurs early on in the post-harvest chain when the fish is moist. As quickly as one day after the female fly has laid her eggs, they may hatch into larvae which then may complete their development within 3 to 4 days. During rainy weather when drying is slow or impossible, losses due to blow fly infestation may be c[illegible] iderable. In general, the more quic[illegible] the fish is dried, the less the infest[illegible] on.
The adult fly will not [illegible] le to lay eggs on fish adequately p[illegible] d, for example by netting.
Salting is known [illegible] blowfly and beetles but adeq[illegible] salting to protect the fish (9[illegible] salt concentration of processed fish [illegible] ght) may give an unacceptable taste, especially if salted fish is not preferred.
Beetles will select fish with a lower moisture content than blowflies. These insects are typically inhibited by moistures greater than 45% (FAO, 1981), and will thrive on a typical sundried product. The longer dried fish are stored, the greater are the losses due to beetle infestation. These insects will feed and reproduce on dried fish finally reducing it to a powder of waste products.

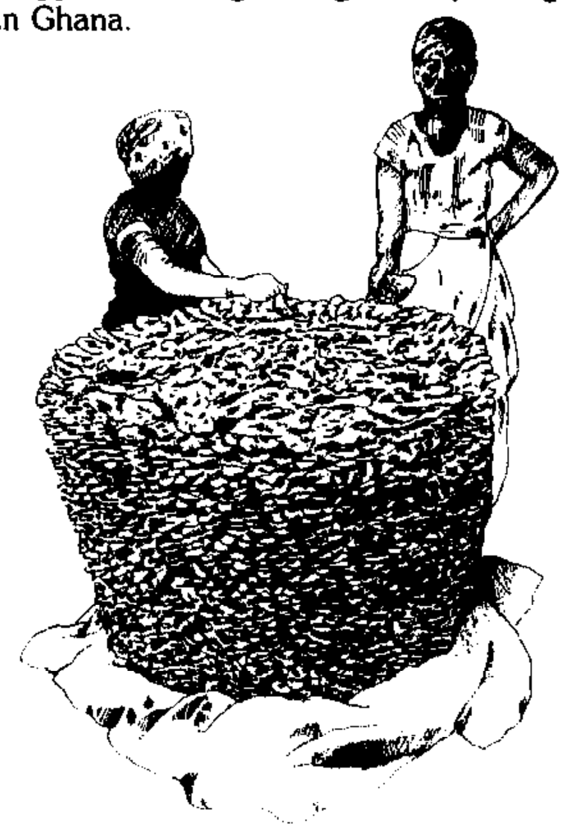
Packaging, Transport and Storage

Small scale fish processing may often occur in localities without good transport and road conditions. Whether the fish is taken short distances on foot or bicycle or longer distances by vehicle, packaging is

important so that the fish product can withstand the rigours of transport without breaking up.
The different types of container traditionally used for packing fresh or processed fish include baskets, boxes, casks, barrels, sacks, cartons, etc. made of bamboo, coconut matting, wood, jute, metal, paper and plastics. Large leaves, like those of the banana or plantain plants, may be used to line the container and pack the fish.

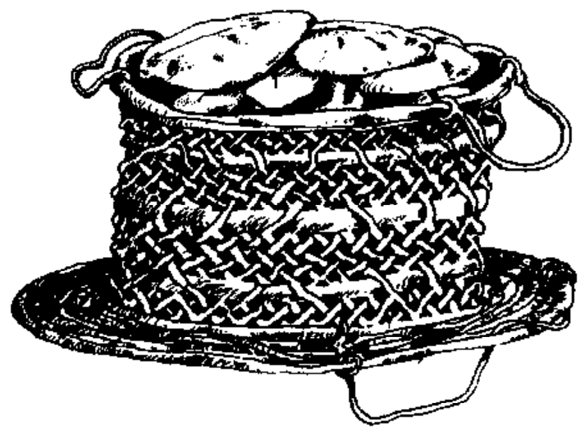
Traditional packing in Kenya

Apart from the suitability of the container to help prevent physical damage, another important consideration is the way the fish are arranged for packing. Traditionally the fish may be stacked very carefully using a particular arrangement to facilitate its transport and distribution. The picture below depicts processed Trigger fish being arranged for packing in Ghana.



Packing of processed trigger fish in Elmina, Ghana

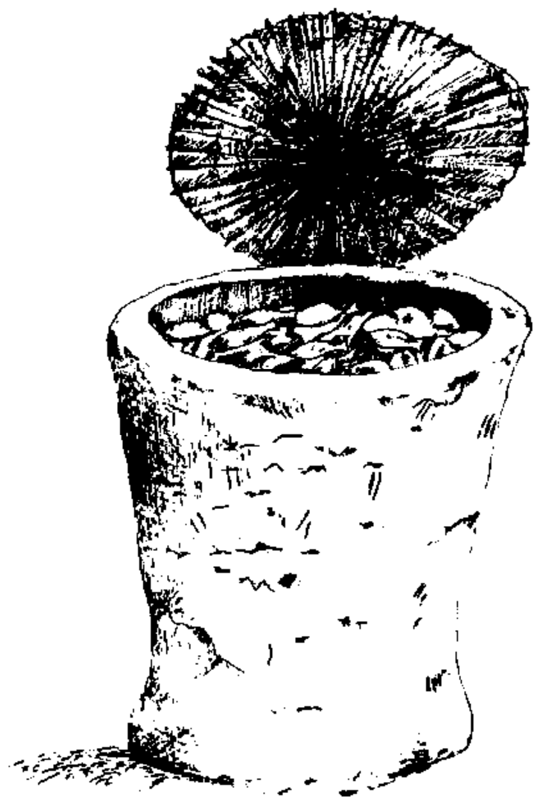
It is also essential that the fish is processed carefully enough to produce a product which can be transported. Damage may be brought about by improper drying and smoking techniques or by insect infestation. The better the quality of the fish product before packing, the less breakage and loss will occur during transport.



Packing to provide sufficient ventilation is also important. Any increase in humidity levels immediately surrounding the fish will cause them to absorb moisture encouraging the growth of moulds and bacteria. Occasional re-drying and re-packing will help prevent such mould attack.
Traditionally fish products are stored in buildings fabricated from locally available materials such as mud and thatch. When no more fish is available for processing, the smoke house may be used for processed fish storage. In Ghana, unused traditional cylindrical smoking ovens are being used for cured fish storage.

[raditional long-term storage of smoked fish

ıttention has to be paid to stored prod- cts because of the problems of beetle ıfestation and reabsorption of moisture n humid atmospheres already de- cribed. Periodic checking of product uality, removal of spoiled fish and re- rying every 3 - 4 months in the dry sea- on and every 3 - 4 weeks in the wet eason to discourage mould and insect ttack are essential quality control mea- ures. The storage area should be kept lean and dry and preventative measures hould be taken to keep predators out.)ften smoked fish is stored in a loft area bove the smoke house where the moke produced during continued pro- essing will drive off insects and keep he products dry enough to prevent eetle infestation. The drying effect of ıe smoking process is more effective gainst insect infestation than the smoke self.



Traditional Fish Processing Methods

Traditional fish preservation methods have been practised for centuries and even though they have been categorised into drying, salting, smoking, boiling and fermentation, it does not necessarily follow that every method fits into one of these groups. In many countries, the methods used are a combination of the above techniques. In addition, two processes termed similarly may involve quite different techniques as applied in different countries. For example "smoking" may mean simply throwing the whole fish onto a pit fire in one locality, whereas in another it may involve salting and drying before smoking.

Indigenous processing techniques evolved because of local environmental conditions, availability of raw materials (fish, fuel, salt, building materials), preferences for taste, texture, colour and smell, social behaviour and economics of production. Each community will most certainly have acquired their art in the first instance by trial and error and perfected a particular process by long experience (FAO, 1970).

This situation has led to processing methods which have been termed sun drying, hot smoking, smoke drying, combined smoke and sun drying; salting, salting combined with sun or smoke drying or smoking; fermentation and boiling combined with smoke or sun drying. In general, smoking tends to be more common in Africa whilst fermenting and boiling are practised more in South East Asia. In Latin America the market for and consumption of cured fish products is fairly limited as, historically, fresh fish has been available to coastal populations and other animal protein sources to inland populations (eg red meat). However, there tend to be localized areas of cured fish consumption such as southern Ecuador, northern Peru, and the valleys of the eastern Cordillera of the Andes in Bolivia. Here fish is salted/dried and consumed with peak consumption during Lent and Easter. Very little control can be exercised over such traditional methods and therefore, the quality of the products varies considerably.

Processing the fish, using traditional or improved techniques, will *not improve* its quality and only serves to help *slow down* the natural spoilage process.

The following section is intended as a brief guide to traditional processing methods, and is essential background for people introducing improved fish processing techniques in order that the merits and limitations of traditional processing can be realised.

Drying

Traditionally, whole small fish or split large fish are simply spread in the sun often laid directly on the ground, or on mats, nets, roofs and sometimes on raised racks. The fish are periodically turned to expose more of its surface for drying. Sun drying such as this does not allow control over drying times, exposes the fish to attack by insect and animal pests and allows contamination by sand, dirt etc.

In Malaysia and Java, local fish processors spread their fish on top of mats laid

on drying racks and when rain threatens, they roll up fish in the mats which can be easily removed.
Being totally dependent on weather conditions, the processors need dry weather and low humidities which are not available in the rainy season. FAO, 1981 reported that a typical sun-dried product has, in general, a drying time of 3-10 days.
Consumer preference also plays a part in processing methods. Dried fish with a moisture content value too high to inhibit spoilage may reflect a preference for moist fish or it may reflect an economic pressure on the fish curer not to over-dry the fish so as to sell a greater weight of water if it is sold by weight and not by piece or volume (FAO, 1981).
Processors may also sprinkle individual fish with salt and sun-dry. In this case, during drying the fish may ferment slightly to impart a desired flavour, but the principal preservation method is drying.

Salting

Salting is a traditional processing method used for centuries world wide, and it has taken two forms:

- Dry salting
- Wet salting

Dry salting

Dry salting is also referred to as 'kench' salting. In this process the fish are mixed with dry crystalline salt, usually by rubbing it into or sprinkling it on the fish surface, and then stacking the fish making the middle higher than the sides. The water is removed from the fish by the action of the salt, and osmotic draining away as brine. (Figure 1)

Another method is to rub or add salt onto the fish and lay them out individually in the sun to dry.
Non-fatty fish are usually dry salted. Large species are split open or filleted. Salting fatty fish in this way will allow for extensive breakdown of oils, giving characteristic rancid flavours and smells, due to exposure to the air, and thus is not recommended.
Kench salting has the advantage that water drains away from the stack of fish so leaving it fairly dry. However, one disadvantage of dry salting is that it may be uneven and that the concentration of salt may be too weak to inhibit mould, bacterial and insect attack.
The fish may not be left long enough for complete salt penetration and if the pile is not re-stacked to allow re-arrangement of the fish, those at the bottom will have been salted to a different degree to those at the top.

Wet salting or salt pickling

Pickling is the term commonly used for wet salting and must not be confused with the use of vinegar. The method used largely depends on whether the product will be further processed by drying or smoking, or preserved by salting alone.
Pickle curing starts as for the dry salting method in that the prepared fish are layered alternately with dry salt crystals. The fluids are not left to drain away as in 'kench' salting but are allowed to accumulate to cover all the fish. Often weights will be placed on the top to keep the fish immersed in the brine, and assist in the removal of water. (Figure 2)
This process is ideal for oily fish, such as herrings, sardines, anchovies, mackerels, especially if the fluids cover the fish quickly, to help inhibit rancidity by ex-

cluding air. A more uniform salt concentration can be obtained by this method giving much less variation in the quality of the product.
The product is often sold in the containers in which it is pickled.

Smoking

Traditional smoking techniques vary widely. At its simplest level fish may be placed in a pit containing smouldering grasses or wood, so cooking and flavouring the fish which is usually charred and has a short storage life. Alternatively, the fish may be laid on racks contained in an oil drum or mud oven, or hung on bamboo sticks in the smoke of the fire. The pit kiln widely used in East Africa and some of the small mud circular and rectangular ovens offer little ventilation for drying as the fish is predominately cooked by the heat and flavoured by the smoke of the fire (Figures 3 and 4). On the other hand, the 'banda' smoking platforms used in, amongst other places, West Africa, may consist of racks raised on poles as in Sierra Leone or racks placed on top of a rectangular mud or flattened oil drum base with openings for the fire (Figure 5). In Peru and Bolivia smoking or "grilling" of split fish is carried out on a wooden framework supported on rocks over an open smouldering fire. All these systems offer more ventilation and drying can take place as well as smoking.
The fish, if small are usually left whole, while larger fish are cut open or cut into steaks and smoked. They may be placed on their side or, in order to increase the holding capacity and flow of smoke, stacked vertically on their heads. Whether or not the fish has been salted or dried before smoking depends on local availability of salt, taste preferences, and the desired storage life of the product. The longer the fish is smoked, the drier it becomes and the more suitable it is for long term storage (several months). The examples of traditional processing methods outlined below in flow diagrams give some idea of the various traditional techniques used in smoking fish.
The most important advantage of simple traditional ovens such as these is their low capital cost. Many disadvantages have however, been reported (Clucas 1982):

- constant attention is required to control the fire and turn the fish. This may involve working through the night
- the operation is both a health and fire hazard
- many ovens are inefficient in their use of fuel and ventilation system
- there is little or no control over the temperature of the fire and the density of the smoke produced
- the construction materials used limit the durability of the ovens
- the open construction of the ovens leaves the fish susceptible to climatic conditions and animal attack
- the fish product is of poor quality due to insufficient cooking of flesh inside and burning and charring on the outside

Probably one of the most important limitations of traditional ovens is the lack of an efficient air-flow system which results in poor economy of fuel wood, and lack of control over temperature and smoke density.

Fermentation

Numerous fermented products are fermented in the presence of salt to prevent putrefaction and are not dried after salting.

In general three types can be distinguished: those in which the fish retain substantially their original texture, those which resemble a paste and those in which the fish have been reduced to a liquid. Many traditional fermented products are of excellent quality and their preparation is very skillful.

In South East Asia, the term fermented fish covers two broad categories of product:

- Fish/salt formulations which include fish sauces and pastes such as 'patis' and 'bagoong' produced in the Philippines;
- Lactic fermented seafoods produced from fish/salt/carbohydrate mixtures such as 'burong isda' and 'balao-balao' made in the Philippines.

Outlines of Traditional Processing Methods

It would be impossible to describe all of the traditional fish processing techniques, but to give the reader an idea of those used in the developing countries, there are some examples, classified by region or country, outlined below. These serve to illustrate how local methods have been applied to particular fish types, and the diversity in the combination of techniques used.

Region	Africa
Countries	Widespread
Product	Smoked/dried fish
Raw material	Fish
Prepared	Small fish are left whole, while larger fish are scaled, gutted and cut up often without washing.
Smoked	Fish placed directly on a trench open fire of dry grass, fibres or sawdust.
Sun dried	Placed in the sun until the product is hard.
Product	Often charred on the outside with the inner flesh only partially cooked. Short storage life. Products become putrid quickly.

Region	West Africa
Country	Ghana

Product	Smoked/dried fish
Raw material	Sardines, anchovies (usually small and medium size fish are used).
Prepared	Washed but not scaled or gutted.
Dried	Laid in the sun for a period between 5-30 minutes.
Cooked	Placed on grills over charcoal fibre inside a shallow circular container.
Smoked	Placed in a smoking oven fuelled by firewood and rearranged periodically for an even cure. Smoking continued until the fish is cooked and dry. Coconut husk and crushed sugar cane are added to the fire towards the end of the smoking process to impart a desirable flavour and colour the fish.
Product	Long storage life.

Source: **FAO, 1970**

Region	West Africa
Country	Ghana
Product	Fermented Fish
Local name	Momone/Bomone
Raw material	Various species of fish are used eg mackerels, grouper, baraccuda, sea bream, threadfin etc.
Prepared	Methods of processing differs from site to site but generally they involve scaling, gutting and washing in either fresh or sea water.
Salted and packaged	Salting with either coarse salt or brine and dried. During salting, the fish is rubbed with salt and packed in layers of solid salt in various types of containers, including wooden or concrete troughs. In certain areas salt is placed inside the abdominal cavity and behind the gills of individual fish before packing. After packing, the containers of fish are covered with old jute bags or polythene sheets. Quantity of salt used is estimated to be 1:9 salt:fish.

Fermented	Salting takes 1 - 7 days during which time the product is fermented.
Dried	The fermented fish is then sundried on the ground for 1 - 3 days.
Product	A dry, but soft and strongly flavoured product is obtained. Bomone is used for flavouring soups and stews.

***Source:* Nerquaye-Tetteh, G. et al, 1978**

Region	West Africa
Country	Ghana
Product	Salted-Dried Trigger fish
Local name	Ewura Efua
Raw material	Trigger fish (*Balistes capriscus*)
Prepared	Gutted and washed
Salted	Salt sprinkled on fish and arranged in wooden or concrete troughs. The ratio of salt is estimated to be in the range of 1:3 to about 1:6. The troughs are covered under shade for half a day to one day.
Dried	The fish is then spread out in the sun to dry completely.
Product	Very dry with tough skin which needs to be peeled off before the fish is used for preparing food. The salt content is sometimes high and the product needs to be desalted before consumption by soaking in water. When well dried salted dried Trigger fish can be stored for a long time (months).

***Source:* Nerquaye-Tetteh, G., private communication**

Region	Africa
Countries	West Africa

Product	Smoked dried fish
Local name	Smoked dried Bonga
Raw material	Fish *(Ethmalosa)*
Prepared	Washed.
Cooked	The fish are laid whole on top of a bamboo rack in alternate layers with sticks until about 5 layers thick. The rack is supported on poles inside a smokehouse constructed of sticks and palm leaves. The fish are cooked for 12 hours over a hardwood fire.
Smoked	The fire is re-kindled and allowed to smoulder to smoke the fish for a following 3-4 days During this time the fish are rearranged each day. The length of the smoking period depends on the product desired.
Dried	The fish are moved to a loft above the smokehouse and placed in an upright position (heads down) for 7 days to dry in the hot air from the smokehouse.
Product	Dark colour, hard texture, heavily smoked and deformed. It has a long storage life if hard dried, though half dried bonga is also produced which has a short storage life.

***Source:* FAO, 1970**

Region	Africa
Countries	The Gambia, Sierra Leone
Product	Smoked marine catfish
Local name	Kong, Ngunja, Catfish
Raw material	Catfish (*Arius*)
Prepared	Cut open ventrally to remove viscera. Any roe is kept separate. Soaked with boiling water and subsequently scrubbed with lime to remove slime.
Smoked	The fish is drained and hot smoked on banda using coconut husk and/or wood.
Product	Golden brown smoked fish.

Note: The roe which are large and round, are washed with salt and lime and then boiled to produce a hard white yolky substance. When in season, they are sold as a snack. This same method can be used for riverine catfish (Clarias sp), which has great potential in aquaculture.

***Source:* Commonwealth Secretariat, private communication**

Region	Africa
Countries	The Gambia, Senegal
Product	Fermented sundried fish
Local name	Gaedja
Raw material	Fish species preferably *(Pseudotholitus)*
Prepared	Fish is washed and split open dorsally, viscera is removed.
Sundried	The fish ferments whilst allowed to dry slowly over several days.
Product	Hard sundried fish that can keep indefinitely once kept away from moisture. Used as a condiment.

Note: The same technique is used for dry salted fish, adding salt prior to sundrying. Gaedja is also eaten with Yate (fermented and sundried marine snail) which forms the basis of the national dish in The Gambia and Senegal.

***Source:* Commonwealth Secretariat, private communication**

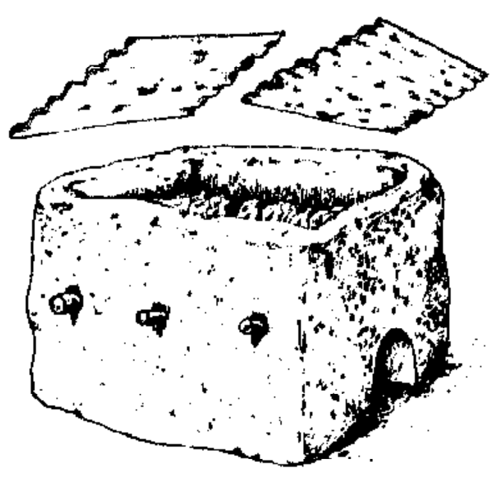
Region	Africa
Countries	The Gambia, Sierra Leone
Product	Wet Salted Fish
Raw material	Demersal species
Prepared	Fish is washed and scaled. Split open dorsally or cut up in steaks and split at the back bone.
Salted	Salt is ground/pounded to fine powder and applied liberally on fish, then stacked. Fish is then covered with jute bag.
Product	Wet salted fish can keep for months once salted well.

Marketing	This technique was extremely popular when trade between The Gambia (fish) and Sierra Leone (dry goods) was at its peak in the 50's and 60's. With the advent of air travel and the withdrawal of passenger lines that sailed Liverpool - Lagos via major West African ports, this trade has diminished.

***Source:* Commonwealth Secretariat, private communication**

Region	Africa
Country	Kenya, Tanzania, Uganda
Product	Smoked fish
Local name	Mbutu
Raw material	Nile Perch. *(Nates niloticus)*
Prepared	Scaled, gutted and split without washing. May be sold fresh or further processed by smoking or frying.
Sold fresh	
Fried/Smoked	The cut pieces are placed on crude trays over an enclosed, rectangular mud oven. The fire is then lit inside the bottom of the oven. Alternatively, the fish may be fried in its own oil.
Marketed	The buyers (women) come to the site and buy fresh, fried or smoked fish to take to markets outside where the fish may be re-fried or smoked before selling.

***Source:* ITDG, private communication**



Traditional 'lungo' rectangular smoking oven at Ragwe, Kenya

Region	East Africa
Countries	Tanzania, Kenya, Uganda
Product	Sun dried fish
Local names	Kapenta (Zambia), Ndagaa (Tanzania), Omena (Kenya)
Raw material	Tilapia, Anchovies, *(Limnothrissa) (Haplocromis)*
Prepared	Small fish left whole, large fish are split.
Sun dried	Laid on the ground or on mats for several days.
Product	Dried fish

Source: **ODNRI, private communication**

Region	North Africa
Country	Egypt
Product	Fermented fish
Local name	Fasikh
Raw material	Small Pelagies
Salted (pickled)	Placed in large margarine type tins in alternate layers of fish and salt.
Fermented	Left to ferment and topped up with fish and salt.
Product	Sold in the tins after the correct length of fermentation has taken place

Source: **ODNRI, private communication**

Region	South America
Country	Peru/Ecuador
Product	Salted fish

Local name	Salpreso
Raw material	Mullet/Mackerel (*Scomber japonicus*)
Prepared	Gutted, dorsal split ('kippered')
Salted	25-30% (wet weight) dry salt in dry (kench) pile
Stacked	In open air/on stones until transported, (several days - 2 weeks)
Product	'Salpreso' (salted fish)
Marketed	Andean towns/villages

***Source:* ODNRI private communication**

Region	South America
Country	Ecuador - Galapogas Islands
Product	Salted dried grouper
Local name	Bacalao
Raw material	Large groupers (eg *Myteroperca olfax*)
Prepared	Dorsally split, gutted and salted on fishing boats - kench piles in wooden boxes stored on deck.
Dried	On black lava (volcanic) rocks, roofs of houses, etc.
Packed	Jute/plastic woven sacks, shipped to mainland.
Market	Lent/Easter and consumed in 'fanesca' soups.

***Source:* ODNRI private communication**

Region	South America
Country	Peru, Chile, Argentina
Product	Salted/fermented fish
Local name	Anchoa

Raw material	Anchovies (*Engraulis ringens*)
Prepared	Whole fresh fish mixed with 35% wet weight dry salt in barrels. Wet pile (salt covers fish). Left for 3 - 4 months or more to mature (fermentation due to enzymes leading to strong odour and red colour).
Marketed	Local and Northern Hemisphere (pizzas), often canned in olive oil for luxury overseas market.

***Source:* ODNRI private communication**

Region	South America
Country	Peru/Chile
Product	Fish marinated in citre acid
Local name	Ceviche
Raw material	Any fish/shellfish. Often sardine, bass, shark.
Prepared	Fresh fish is chopped in to cubes/pieces about 1 - 2 cm. Lime juice is squeezed over cubes to cover and left to marinade for several hours. Often other ingredients are added - chilli, herbs.
Marketed	Local consumption

***Source:* ODNRI private communication**

Region	South America
Country	Peru
Product	Dry-salted fish
Raw material	Hake/shark
Prepared	Head removed and gutted, cut along dorsal side. Two thirds spinal column is removed.
Salted	Fish are salted adding 30% salt concentration. Stacked in alternate salt and fish layers. (Kench pile)

Dried — Dried for 5-6 days, alternating in the shade and sun.

Packed — In jute sacks or polythene bags and put in wooden boxes.

Marketed — For export. At Easter, local consumption of dry-salted fish is a tradition.

***Source:* Reaño, 1986**

Region — South America

Country — Peru

Product — Dried fish

Local name — Dried Ishpis

Raw Material — 'Ishpis' are *small* fish caught in lake Titicaca in the Peruvian highlands.

Dried — Left to dry whole in the sun near the boats. Low relative humidity (45-60%, of the area aids drying.

Product — 'Ishpis' Consumed locally by Indian population. Because of the air drying the product is highly oxidised.

***Source:* Reaño, 1986**

Region — South East Asia

Countries — Indonesia

Product — Prawn/fish cracker

Local name — Keropok

Raw Material — Good quality fish (sardine and dorad species are preferred) or prawns.

Prepared — The flesh of the fish is stripped from the bones, (prawns are peeled), mixed with sago or tapioca flour by pass-

	ing through a mincer, or pestle and mortar. Ratio of fish to flour varies, can be 1:1. Monosodium glutamate, salt, sugar, red colouring (optional) are added.
Pounded	Using pestle and mortar
Rolled	The mixture is rolled into sausages when it begins to gel. Sausages are shaped into rolls.
Cooked	In steam or boiling water until gelatinized.
Sliced	After cooling they are sliced into rounds about 2 mm thick.
Dried	Dried in the sun for about 1 day and then packed into polythene pouches for distribution.
Product	Snack food which can accompany more substantial meals.

Note: The manufacture of Keropok is an important cottage industry, mostly carried out by women. This product is widespread throughout South East Asia.

***Source:* ODNRI, private communication**

Region	South East Asia
Countries	Indonesia, Philippines, Japan.
Product	Salted smoked fish
Local name	Salted smoked Bandeng
Raw material	Fresh milkfish
Prepared	Gutted, cleaned.
Salted	Placed in salt solution (brine) ($1^1/_2$ Kg salt to 20kg fish) for 2 hours.
Drained	
Spiced	Salt and spices are placed in the gut cavity.
Smoked	In vertical smokehouses for 2-3 hours fish are hung

	from frames. Fuel - charcoal sprinkled periodically with wood chips.
Marketed	Stored for 3 days before distribution (ensures salt and spice are absorbed into flesh).

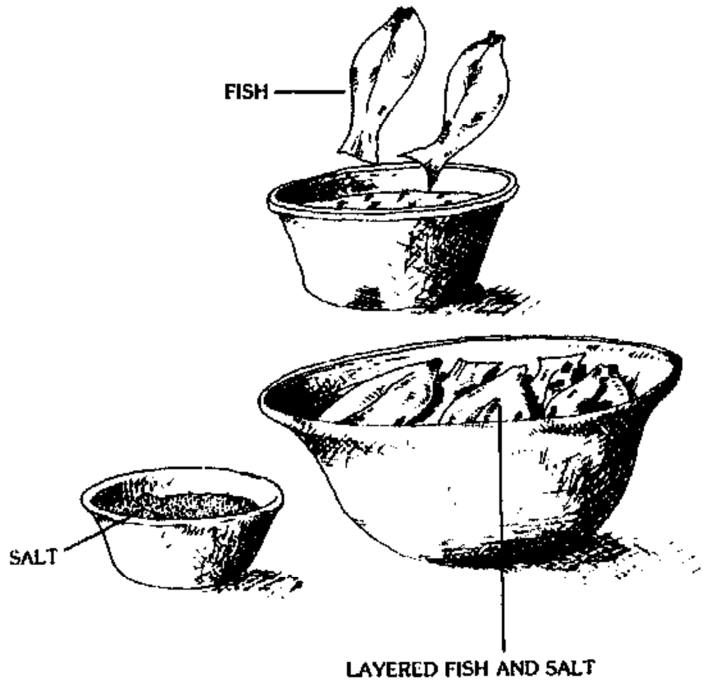
Note: This product is also found in the Philippines and Japan.

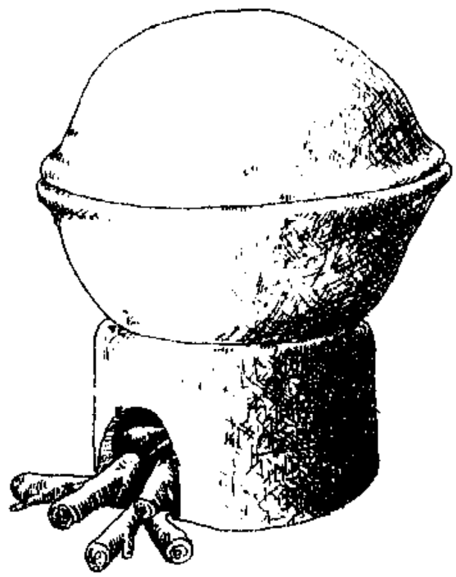
***Source:* FAO, 1970**

Region	South East Asia
Country	Indonesia
Product	Salted boiled fish
Local name	Pindang
Raw material	Milk fish, sardines and herring.
Prepared	Washed, gutted and cut into pieces to fit inside pots or cans.
Salted	Placed inside earthenware or tin containers and layered alternately with salt (the concentration of which varies depending on desired storage life and taste of product).
Add water	To fill the container.
Cooked (Boiled)	Container heated above a fire until fish is cooked.
Re-salted	Most of the water is drained away and more salt is added to the surface fish.
Cooked	Cooking continues until no free water remains in the container.
Marketed	The container is sealed with leaves or paper and distributed. Storage life varies between a few days and a few months.

***Source:* ILO, 1982**

Traditional layering of salt and fish for the production of 'Pindang'





Traditional processing of 'Pindang'

Region South East Asia

Country Indonesia

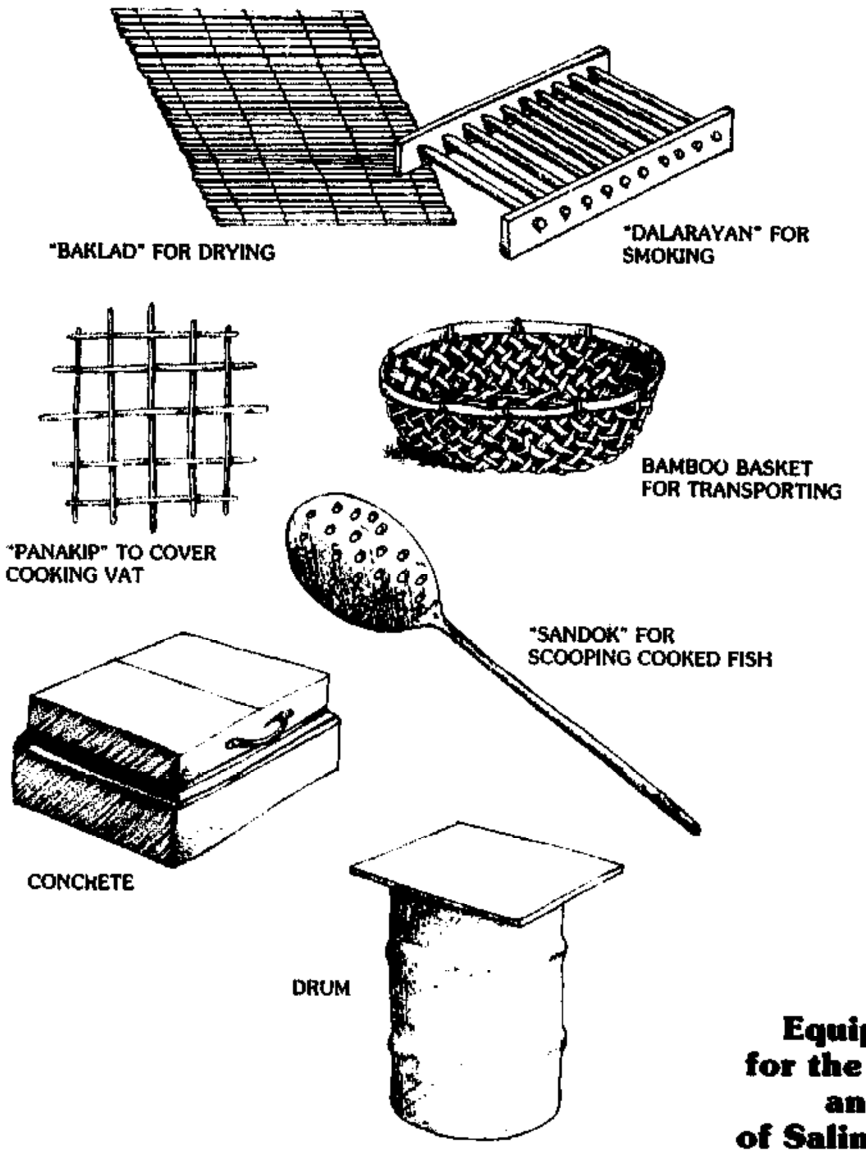
Product Salted-Dried Fish

Local name	Jambal
Raw material	Marine Catfish *(Arius Xhalssinus)*
Prepared	Heads and guts removed. Submerged in water for 24 hours (some fermentation occurs). Removed from water.
Salted	Pickle salted, using solar salt, for 24 hours.
Dried	Sun-dried for 3 - 6 days
Marketed	Sometimes packed in polythene bags

Source: **Humberside College, Private communication**

Region	South East Asia
Country	Philippines
Product	Salted smoked fish
Local name	Tinapa
Raw material	Sardines, milkfish
Prepared	Washed. Large fish are gutted.
Salted	Soaked in saturated brine solution in large tub. The soaking time depends on the size of the fish used.
Boiled (Cooked)	Fish are placed in baskets of wood or bamboo strips and suspended in iron kettles or boilers until cooked.
Dried	In the baskets and left to cool (usually overnight).
Smoked	Arranged in smoking trays inside a furnace heated with charcoal and sawdust. Smoking times vary depending on size of fish and the taste desired. The position of the trays is alternated to provide as even a cure as possible.
Marketed	Cooled and packaged in coarse woven ratten baskets. Storage time from 3-7 days at ambient temperatures.

Source: **FAO, 1970**



Equipment used for the processing and transport of Salinas 'Tinapa'

Region	South East Asia
Country	Philippines
Product	Boiled smoked fish
Local name	Tinapa "Salinas" method
Raw material	Roundscad, milkfish, sardines, mackerel
Prepared	Washed

Sun dried	Sun dried for 2 hours
Boiled	Cooked in saturated boiling brine until the eyes turn white.
Smoked	Sprinkle with water to remove scum and drain before smoking for 30-45 minutes. The smoking kilns used are completely closed except for the opening at the top where the smoking trays are placed.
Product	'Tinapa' cooled and packed in baskets covered with banana leaves.

***Source:* Bulaong, et al, 1986**

Region	East Asia
Country	Japan
Product	Smoked dried fish
Local name	Katsuobushi
Raw material	Tuna
Prepared	Head, guts and fins removed. Washed, filleted and cut into strips. Vertebral column removed.
Steamed	Arranged in shallow flat baskets suspended in kettle above boiling water for 40-60 minutes, until cooked.
Cooled	Once cool, the fish are dipped into tub of water and the skin stripped off to remove fat, ribs and spines. Bones carefully removed.
Smoked	Placed on flat basket and suspended in smoke oven and turned once to smoke 30 minutes on each side.
Moulded	Fish flesh previously discarded is kneaded into place into damaged parts and smoothed down.
Smoked	40 minutes smoking repeated 6 to 10 times during which the temperature is reduced.

Sun dried	3-4 days. Surface scraped and remoulded as before followed by 2 more days sun drying.
Stored	In boxes for 2 weeks to produce a mould on fish surface.
Sun dried	1-2 days after which the storing and drying process to allow for mould growth is repeated 4-5 times.
Product	Storage life is almost indefinite providing each month the product is re-dried in the sun for a day. Eaten as shavings which are scraped off to flavour soups etc.

***Source:* FAO, 1970**

Region	South East Asia
Country	Philippines
Product	Fermented fish
Local name	Bagoong
Raw material	Anchovy, sardines.
Prepared	Washed in clean water.
Salted	Placed in concrete or wooden vat and mixed with salt in a ratio of 3:1, fish to salt.
Fermented	Salt and fish mixture is transferred to earthenware jars or oil drums and covered with cheesecloth for 5 days and then sealed. They are left in the sun for 7 days before transferring the product to 5 gallon cans. These cans are left to stand for 3-12 months to allow further fermentation of the product.
Product	'Bagoong' has a pasty consistency and reddish colour and can be stored for many years.

***Source:* ILO, 1982**

Region	South East Asia
Country	Burma

Product	Fermented fish
Local name	Ngapi
Raw material	Small anchovy
Prepared	Washed in sea water.
Dried	In the sun for 2 days.
Salted	One part salt is added to six parts dried fish in a bamboo basket.
Pounded	To form a paste which is then packed into wooden tubs or boxes to remove all air bubbles.
Fermented	The paste is left to ferment for 7 days.
Pounded & Salted	For approximately 3 hours whilst adding the same amount of salt as previously added.
Dried	Spread in the sun for 3-5 hours.
Fermented	Left to continue fermenting in wooden tubs, for one month.
Pounded	
Product	'Ngapi' has a pasty consistency and can be stored for 2 years in anaeorobic conditions contained in tubs or earthenware pots. Sometimes artificial dyes (which can be toxic) are added to improve colour.

***Source:* ILO, 1982**

Region	South East Asia
Country	Viet Nam
Product	Fermented fish sauce
Local name	Nuoc-Mam
Raw material	Anchovy, Scads

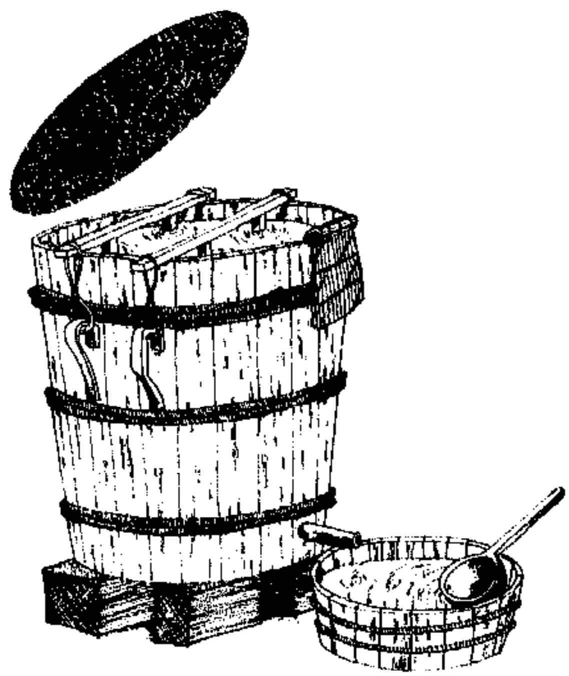
Prepared Washed and kneaded by hand before mixing with salt.

Salted One part salt is added to 3 parts fish in earthenware pots.

Fermented The pots are buried in the ground for a few months.

Product 'Nuoc-mam' is a clear liquid which rises to the top of the fermented product and is decanted off. The residue is used as a fertilizer.

***Source:* ILO, 1982**



Traditional vat for processing of nuoc-mam

Region South East Asia

Country Philippines

Product Lactic fermented fish

Local name Burong-isda

Raw Material Shrimp, milk fish, silver perch, mud fish, cat fish, gourami, tilapia.

Prepared Scaled, gutted, washed and drained.

Salted	10 - 30% salt concentration for 2 - 6 hours, after which the fish is removed from the brine that develops.
Mixed	With boiled rice in the ratio 3 - 5 parts rice:1 part fish. Ginger and garlic may be added.
Fermented	Fish and rice are packed together in a jar and left for 1 to 2 weeks before consumption.
Product	'Burong-isda' is sauted with garlic and onion and eaten with vegetables.

***Source:* Adams et al, 1985**

Region	South East Asia
Country	Philippines
Product	Lactic fermented fish
Local name	Balao-balao
Raw Material	Shrimp
Prepared	The antennae of the live shrimps are removed. Washed and drained.
Salted	15 - 20% salt concentration and left to stand for 3 - 6 hours before draining.
Mixed	With salted boiled rice. The shrimp to rice to salt ratio is 1:4.8:0.2
Fermented	Packed in jars and left to ferment for 7 - 10 days.
Product	Sauted in oil with garlic and onion before serving.

***Source:* Adams et al, 1985**

Region	Asia
Country	South India
Product	Fermented fish

Local name	Colombo Cure
Raw Material	Mackerel, non-fatty sardines.
Prepared	Gutted, gilled and washed in seawater.
Salted	Mixed with dry salt, (1 part salt to 3 parts fish), in concrete tanks. The dried fruit pulp of tamarind (Malabar tamarind) is added to the salt and fish to increase the acidity level of the mixture.
Fermented	Fish are weighed down in the brine mixture with stones on mats and left for 2-4 months. They are then transferred to wooden barrels, packed tightly and kept topped up with pickling solution.
Product	'Colombo cure' is the whole fermented fish which has a fruity odour and firm but flaky flesh and can be stored for over a year. The remaining pickle is used as a fish sauce.

***Source:* ILO, 1982**

Prevention of Insect Infestation

Traditional methods used to deter insects are virtually unrecorded. It has been observed that local village fish processors in The Gambia use chilli sprinkled over the fish while it is drying to prevent blowfly infestation and similarly lime juice is used by Senegalese fish processors. In Malawi sand is applied to the fish to preclude blowflies. However, this may introduce bacteria.

The only reference to a traditional method of preventing beetle infestation is in Mali where the local processors scatter pepper in a ring around fish placed in bundles or, alternatively, the powdered leaves of *Bosia Senegalensis* may be used (ODNRI, private communication).

Recent experimental work at Imperial College, UK, has shown that dried citrus peel subsequently powdered and added to dried fish prevents beetle infestation.

During the wet season, when blowfly infestation is at its peak and fish losses are high, the most effective traditional method used some fifty years ago for insect control by the fishermen was not to fish at all.

It was realized by fish processors that climatic conditions (high relative humidities in particular) were unfavourable for sun drying and hence for the keeping quality of fish. However, in view of the shortage of protein-rich foods, and the consequent pressure put on fisheries to increase the total catch, this effective traditional preventive measure often no longer exists (ODNRI private communication).

Improved Processing and Equipment

When talking of 'improved' fish processing techniques, care must be taken about how the term is applied. Traditional methods have evolved over hundreds of years and are continuing to evolve. In many cases traditional methods are still the best way of processing fish for local markets.

Traditional methods only break down when factors impinging on these activities are changing faster than traditional technical adaptations can cope with. These could be a number of things such as introduced species, an increasing shortage of a convenient and/or inexpensive fuel supply, depletion of stocks through over fishing or changing habits of urban populations.

It is in these cases that improvements can most likely be introduced effectively. Whoever is introducing any improvements, however, must aim to involve the processing community fully in any process of innovation since they will understand much better than any outsider just what will and will not work. The advisor must also have active hands-on involvement in both traditional and improved techniques and equipment in order to be able to appreciate any merits and limitations of the methods. Economics need to be re-considered too. While a piece of equipment may have a good rate of return, the sheer scarcity of capital may mean that what may seem a cheap piece of equipment to an outsider may be beyond any possible risk that a fish processor could take.

This section looks at improved techniques and equipment that have been tried out. It follows the same technical layout as the previous sections. The reader is urged to follow the checklist in Section 5 and the principles in Section 2 before attempting any introduction of improved technology.

Health and safety aspects of any process must not be overlooked. Because fish is a low-acid food, careful and rapid processing following the correct procedures is essential. For example, if insufficient salt is used during salting, or inadequate acidic conditions are produced through reducing fermentation times, then the growth of pathogens such as *Clostridium botulinum* may be lethal. This bacterium produces botulinum toxin under certain conditions and is responsible for the condition botulism which has a 70% lethality in man. Care must be taken to ensure that people receive correct training especially where a new product or process is being introduced.

Preprocessing Aspects

Effective handling practices

It has been mentioned in Section 2 that the quality of raw fish available to the processor depends on the way it has been handled from the point of catch. In general the processor will have little direct control over the way that fishermen capture, handle, prepare and store fish on their boats. However, when fish supplies are plentiful, the merchants can place a demand for high quality raw material, providing there is a market demand.

Consultants should be aware of these aspects and seek mechanisms to improve the quality of the fish available to processors by liason with local fisheries specialists.

As soon as a fish dies spoilage changes commence. The ideal way to keep a fish fresh is to keep it alive. However that may be very difficult to achieve.

If, as is more common, the fish dies after it is caught it should ideally be bled, gutted and gilled before landing, providing the methods used are correct and hygienic. However if fish are sold on a weight basis, fishermen may be reluctant to do this. Hygiene on board the fishing vessel is important; knives need to be cleaned, gutting areas washed down; guts thrown away etc.

To help maintain freshness the catch should be stored in cool, shady areas. The extent to which the fish have been bruised by rough handling, being trodden on, thrown about and moved by using shovels, will also have an effect on their freshness.

The importance of good hygiene continues after landing and here good practices come under the control of the processors. Fish landing sites and processing areas should be kept as clean as possible, waste being removed and disposed of so as not to attract insects and vermin. Unhygienic and insanitary conditions in particular attract blowflies. Fish should be prepared for processing off the ground, preferably on a clean surface. Plastic and metal surfaces are considerably easier to keep clean than wooden ones. If possible processing areas should have access to clean water so that knives, tables etc can be regularly cleaned down. If no water of drinking quality is available use of a small amount of household bleach in water will greatly assist in maintaining hygiene of tables and implements. Fish, before and after processing, should be kept cool and covered to avoid flies landing on them and laying their eggs. Caution needs to be used particularly when large catches are landed during seasonal gluts, when the time interval between landing and processing of fish is invariably increased.

Maintaining fish at low temperatures

The rate of microbiological and chemical deterioration that takes place after the death of a fish is temperature dependent and typical tropical temperatures will accelerate spoilage. Any measures taken to reduce the temperature of the catch by keeping it in the shade, covering with wet sacks or ice will play a significant role in maintaining quality.

Whether the fish are on water or on land, the best way to keep them cool (without sophisticated refrigeration facilities) is with ice. However, in many areas ice may not be available and fish can then be kept relatively cool by other means, including the following:

- keeping the fish in the shade out of direct sun
- evaporative cooling - ie placing clean damp sacking over the fish. This helps reduce the temperature as the water evaporates. The sacking must be kept wet and clean and the fish must be well ventilated. This can be done by laying small sticks across the containers under the sacking or mixing the fish with wet grass or water weeds in an open-sided box so that the water can evaporate and cool the fish. The fish should be kept continuously wet. (Figure 6)

However, fish will generally only keep a few hours unless ice is used.

Use of ice

The use of ice can significantly increase the shelf life of fresh fish both at sea after capture and handling ashore. The water used in ice making should be reasonably clean and sea or brackish water can be used, although there are disadvantages in using sea water.
Ice should be mixed with the fish using a fish to ice ratio adequate to keep the fish at the correct temperature until processing or sale. Often, especially during transport, insulated containers are necessary to prevent the ice from melting faster than the required rate for as long as possible. Therefore, with the use of ice, comes the use of appropriate containers and this may represent a substantial investment for the artisan. However, interestingly, it has been suggested that the cost of ice is the limiting factor for icing fish in tropical countries rather than the cost of the containers. (Lupin, 1985). In addition ice represents an on-going operational cost.
It is probably not as recognised as it should be that, in tropical countries, not only is ice often unavailable but its relative cost compared to the other costs involved in fresh fish handling is so high that its use in small scale fisheries is inappropriate, unless inputs are made in organisation, capital investment and infrastructure. This is reflected in the fact that the final cost of the use of ice for fresh fish could be as much as 20 times higher in tropical and subtropical countries than in temperate and cold weather countries (Lupin, 1985). Further to these economic constraints on the use of ice are the physical constraints, such as: the ice melting more quickly in the higher tropical temperatures; the availability of appropriate containers; and the loss in transportation and storage space available.
Perhaps the final major point to raise is that it is a waste of time using ice if not enough of it is used. The fish to ice ratio represents a mixture of the two by proportions adequate to keep the fish cool enough for the required distribution or storage time. The most suitable containers are those which provide adequate insulation to reduce the melting rate of ice. Another problem is that small vessels used in artisanal fishing often do not have the capacity for containers for ice.
If the use of ice is to be considered as a fish preservation technique then careful planning and organisation is essential. The installation of ice facilities (to provide ice continuously and at the required production levels), and infrastructure must be carefully assessed along with the existing markets for fresh and processed fish and consumer acceptance. It is not uncommon to find resistance to icing as the consumer believes that the reason why the fish is iced is because it is of poor quality. Research institutes, such as ODNRI, London and FAO, Rome have carried out a lot of work in this area and hence have gained valuable experience.

Drying

The heat of the sun and the removal of moisture by movement of air (air speed) are the major factors which cause fish to dry, and these can be utilised to their full advantage by very simple changes in processing. It is more difficult to have any control over relative humidity, except by raising the air temperature.
In general, the optimal drying conditions for tropical fish species appear to be quite well established. (FAO, 1981).

Shade drying

In some cases fish can dry too quickly when exposed to both high temperature

and strong wind, which can lead to "case hardening".
To minimise this fish can be initially dried in the shade. During the initial drying stage, careful drying is necessary at these shade temperatures. Thereafter, when the water is being removed from the fish interior higher temperatures can be applied by moving the fish out of the shade. This reduces the drying time allowing for a more efficient process.

Drying racks

Drying fish on loose ground or at ground level such as on mats or rocks has many disadvantages and the use of raised drying racks (Figure 7) may offer substantial improvements because:

- air flow is increased at a metre or so above the ground as opposed to at ground level
- a greater part of the surface area of the fish is exposed to air currents and temperatures
- the fish is less accessible to predators and some insects; and it is hygienically preferable
- if the racks are sloping, any excess moisture can drain away
- fish can be protected from water when it rains by covering with waterproof material. This is not possible if the fish are laid directly on the ground, as the underside of the fish will still be in contact with water
- choosing a drying site where the wind is strong (ie, increasing airflow) will aid drying (Clucas, 1982).

The same principles apply to drying ropes or poles, which are stretched between uprights on a beach or an open, windy area. The fish are hung or draped, upon the ropes.
A constraint to the introduction of drying racks may be the additional costs incurred in their construction, which may not be realised in terms of the processing time saved or increased prices for the improved product.

Drying platforms

Simple concrete or hard packed clay/earth drying platforms may offer the best alternative to simple drying. These retain thermal energy and if kept clean can be very effective at drying. They are easy and cheap to construct.

Solar drying

There has been a good deal of interest and research in recent years on the development of a variety of solar driers as an improved method of drying fish in developing countries.
Researchers have found that by achieving regular increased drying temperatures and reduced humidities, solar driers can increase drying rates, and produce a lower moisture content in the final products, with resultant improvements in fish quality compared with traditional sun drying techniques.
It has been suggested that solar driers may also offer some protection against adverse weather conditions for example in wet seasons, and afford some protection against attack by blow flies, beetles and other vermin. Temperatures in excess of 45°C may be attained inside solar driers, thereby killing insect pests.
The solar driers evaluated in the field have included:

- the solar tent drier (Figure 8)
- solar cabinet driers (Figure 9)
- solar dome drier (Figure 10)
- solar drier with separate collector and drying chamber (Figure 11).

Information on the principal operating features of these driers together with the basic theories of solar drying is reported in Trim and Curran, 1983; Brenndorfer et al., 1985; and Curran et al., 1985. Although solar drying relies on natural convection and so fuel expense is spared, the initial costs of construction materials and their replacement costs when they wear out need to be considered. The majority of the available designs are not particularly robust (eg in high winds) and may achieve temperatures which are too high, giving high initial drying rates causing fragmentation, case hardening or cooking effects which reduce product quality. Solar driers often have a fairly low capacity and the time needed for their construction may make them unattractive to artisans. Additionally, training must be given to educate local processors in the correct operation of the drier.
For example, insuring air vents are operated correctly to optimise ventilation.
To increase their capacity for holding fish, larger solar driers, such as the solar dome type, have been evaluated (Curran et al, 1985; Bostock et al, 1985). However, problems of inefficient drying rates and blowfly infestation have been encountered when using this drier in adverse weather conditions. The effectiveness of natural convection solar driers in reducing losses due to blowfly infestation is controversial.
Some researchers have had success in controlling blowfly infestation in fish using solar driers, whereas other workers have found that the insects become trapped inside, it is difficult to keep them from entering and increasing the temperatures inside the drier sufficient to kill the blowflies reduces product quality. (Walker, private communication; Curran *et al*, 1985). There is no evidence that these driers are used by artisanal fish processors, the main problem being the large capital investment in the face of competition from other producers.

Artificial driers

In an attempt to address the problems posed by the difficulties of sun drying in developing countries during the rainy season, when traditional drying techniques may be impossible to carry out; various designs of artificial driers typically fuelled by agro-wastes eg., rice husk have been tested. Such designs also have the potential of affording more control over temperature, air flow and thus over the drying process.
The high capital and maintenance costs of these artificial driers compared with traditional techniques, and the additional level of skills and training required for their operation may make them unsuitable or difficult to justify for general use with small scale fish processors.
The following are examples of artificial driers:

- canvas drier (Figure 12)
- tray drier (Figure 13)
- IRRI fish drier (Figure 14)
- low cost fish drier (LCF) (Figure 15)
- UPLB - IDRC fish drier (Figure 16)
- SAM drier (Figure 17)
- Steel drier (Figure 18).

The latter five artificial fish driers are prototypes resulting from extensive research carried out at the Universities of Los Baños and Visayas in the Philippines together with various collaborators. The IRRI drier was a joint effort between IRRI and Philippine-German Fisheries Project; the steel drier was also conceived under the Philipine-German Fisheries Project, and the UPLB-IDRC drier was a collaborative project between University of Los Baños and IRRI.

All of these prototype driers differ in their type of fuel use, construction materials, energy conversion, method of holding fish (hanging or placing on trays) and the design of the drying chamber and chimney. Further information on their construction and operation can be obtained from IRRI, IDRC or the Universities in the Philippines (refer to contacts list).

The IRRI drier has a unique Vortex Wind machine facility to harness wind energy, while the Tray and the SAM (Solar Agrowaste Multipurpose) driers make use of solar energy and can be converted to artificial use when rain threatens.

A lot of laboratory research has been carried out to test these driers (Jeon *et al*, 1986; Roberts, 1986, Sison *et al*, 1983; Villason and Flores, 1983; Orejana and Embuscado, 1983) but it appears that their use has not been tested significantly in the field and their advantages and disadvantages for use by small-scale processors is therefore unclear

Salting

Improved salting involves the application of processing techniques as described in the principles of spoilage and the use of equipment does not therefore feature very strongly.

Proper use of salt

Although salting has long been known and is frequently practiced as a technique for fish preservation when used traditionally, the amounts of salt to fish used are too low to ensure adequate preservation. This may be because of constraints in availability and costs of salt in particular locations, due to lack of adequate knowledge in salting techniques, or due to consumer preference.

Attention should be drawn to possible health hazards caused by inadequate processing. There have been outbreaks of lethal botulism from the growth of *Clostridium botulinum* on fish when insufficient salt has been used, for example, in the preparation of 'Pindang'.

When the correct amounts of salt are used, this is an extremely effective way of preserving fish. Recommended levels of salt usage are 30-40% of the prepared weight of fish. The use of more salt will not improve the process and simply add to the production costs unnecessarily.

Other considerations in salting are the size and type of the salt crystals used. In dry salting, the FAO recommended proportion of small to large crystals is 1 to 2 respectively.

In both wet and dry methods, the salt must be as clean as possible, as impurities present in the salt also effect its penetration rate into fish flesh.

It is acknowledged, however, that it may be very difficult to obtain good quality salt; salt may not be available in different particle sizes and whatever salt is available will have to be used.

Brining

Brining differs from wet and dry salting in that the fish are immersed into a preprepared solution of salt (brine). Brining will *not preserve* the fish unless the correct strengths are used.

The brine is prepared by dissolving crystalline salt in water until no more salt will dissolve. This is termed a saturated solution or 100% brine, and contains approximately 360 g of salt per litre of water.

When the fish are added, there is an exchange of salt from the brine to the fish and water from the fish to the brine so diluting the strength of the brine. Thus when brining it is necessary to check the strength of the brine periodically. Practically brine strength can be ensured by hanging a sack of salt in the brine solution to ensure that the brine remains saturated.

If the quality of available salt or water is poor, the brine could be boiled thoroughly, and any foam on the surface skimmed off. The brine is then allowed to cool before use. Another way is to bake the salt first, before making the brine.

The advantages of brining as a preparative measure is that it allows for a more uniform cure and by varying the concentration of the brine and the period of immersion or curing period, it is possible after experimentation to control the salt concentration in the final product.

A 10 degree brine, for example, which is made up by mixing 1 part of saturated or 100 degree brine with 9 parts water is sometimes used to soak fish before dry salting. Brining is not generally used as a preservation method in itself but can be advantageously used as a preparatory treatment prior to subsequent salting, smoking or drying.

Brining and pressing

An experimental process involving a combination of brining and pressing has been described by Parry (Reilly and Barile, 1986) which seems to have good potential.

Briefly, fish are beheaded, eviscerated and washed, before being immersed in a saturated brine solution in a weighted, closely covered container. The mixture of fish and brine should be stirred and the brine checked daily to ensure it is saturated.

The rapid uptake of salt by the fish ensures microbiological safety and prevents spoilage. The fish remain in the saturated brine until the fish flesh is saturated with salt. This can take up to six days. Following brining the fish are packed in layers in a slatted wooden box and pressed for a period of between 8 to 18 hours; to remove (i) excess moisture and (ii) air spaces between the fish which would encourage rancidity.

The salted fish form a compact block, and can be packed in a polythene carton with a storage life of at least 10 weeks.

This method is experimental and has only been used with small pelagic species such as sardines.

An improved salting method now used in Peru consists of mixing dry salt (at a concentration of 30% wet weight) with small pelagic, gutted fish in a wet pile. Pressing can be carried out if required, otherwise the fish are simply left in the brine pickle.

This will also impede oxidated rancidity. The storage life of the product is 2 to 3 months. Maturing reactions due to fermentation will become evident later (reddening of flesh and fruity odours).

This product is consumed mainly by the Andean Indian population (Bostock *et al.*, 1986).

Smoking

The disadvantages of traditional smoking techniques and equipment have previously been mentioned in this section.

In order to improve smoking techniques some control must be exercised over temperature, airflow and smoke density. Traditional open-type ovens produce non-uniform smoked products because of fluctuations in these factors. It is difficult for fish processors to improve their smoking techniques using traditional oven designs, particularly the pit type. One way is to pre-dry or salt the fish so that its moisture content is reduced before smoking. In order that more control over the smoking process can be exercised attention has been paid to the development of improved smoking ovens. These have focussed on aspects such as:

- increased fuel efficiency
- improvements in product quality and storage life
- provision of increased control over the smoking process to produce a more standardised product
- increased durability of kilns
- more uniform smoke density
- better handling
- better ventilation system.

Efforts to improve smoking kilns, unlike improved drier design, have in general been more successful and have been introduced to small scale fish processors.

Some improved kiln designs are:

- Mud and pole kiln (Figure 19)
- Oil drum (Figure 20)
- Watanabe fish smoker (Figure 21)
- Altona type (Figure 22)
- Adjetey oven (Figure 23)
- Ivory Coast kiln (Figure 24)
- Chorkor (Figure 25)
- Innes Walker smokers (Figure 26).

Again, despite the merits of improved ovens, many new designs have not made any significant impact with artisanal fish processors. This is particularly true of the Altona type and its various attempted versions. Although this closed kiln has, compared to the traditional pit type, an increased capacity, fuel efficiency and better control over temperature and smoke volume, its high initial cost and inappropriate building materials are significant factors affecting its use. Interestingly, a version of the Altona type used in the Tombo project, Sierra Leone, made skilled operators in loading traditional bandas redundant (Beck and During, 1986). Studies in a coastal village in The Gambia (ODNRI, private communication) showed that in order to keep up production levels of 11 tonnes of traditionally dried fish a day, 120 Altona ovens operating at capacities used in Nigeria (250 kilogrammes fresh fish per day) would be needed. Traditionally the fish are stacked vertically along the bandas measuring 40 feet in length by 6 feet wide and this way a large quantity is smoked. The construction and operation costs of Altona ovens compared to traditional bandas would be very unattractive to the artisans.

The construction of the Chorkor or Kagan smoker has been reviewed by Brownhill, 1983. Since its first introduction to West Africa the Chorkor smoker has proved very popular with the local women processors, who produce a better quality product, but has naturally had its disadvantages such as:

- frequent necessary replacement of netting on trays
- recent unavailability of wire netting for fish trays
- reduced 'chimney effect' due to difficulties in operating a large number of trays
- cracking of mud oven base due to higher temperatures reached
- burning of the sides of the trays
- not enough depth in the trays.

The Chorkor oven has been introduced to other countries in West Africa (see case study under Section 4).

Other methods for improvement in smoking ovens generally have been the installation of a smoke spreader to control smoke density; more shelves to increase capacity; separate fire box, smoke accumulators and smoking chamber; and construction for portability; and batch handling.

The two tables shown below taken from Stroud, 1986, give a comparison of the technical performance of different types of traditional and improved smoking ovens.

Summary of the technical performance of different types of smoking ovens Total costs for material and labour, June 1986

Ovens type	Species Smoked	Weight fish smoked (Kg)	Kg fuel used (Kg)	Kg fuel/ Kg fresh fish	Kg fuel/ Kg smoked fish (adjusted)	Process time (hrs)	Cost in $US
Chorkor mud	tuna	226	49.3	0.21	0.26	4.15	94 (10 trays)
	sardinella	180	63.6	0.35	0.42	7.40	
Chorkor brick	tuna	230	56.5	0.24	0.35	3.40	147 (10 trays)
	sardinella	224	65.8	0.29	0.51	8.00	
Oil drum	tuna	71	20.9	0.29	0.28	3.00	100
	sardinella	38	22.4	0.6	1.17	7.30	
Traditional round mud	tuna	61	25.1	0.39	0.59	3.10	17
	sardinella	331	21.2	0.92	1.58	7.60	
Altona	tuna	182	40.1	0.22	0.28	4.30	305.50
	sardinella	184	36.5	0.7	1.13	7.00	
Ivory Coast	tuna	130	45.4	0.35	0.46	4.45	251.60
	sardinella	76	35.9	0.47	0.81	7.00	
Pit	tuna	3.4	4.7	1.38	1.96	1.00	1.00
	sardinella	2.7	7.4	2.7	4.7	5.00	

Source: Stround, G. D. (1986) A technical and economic appraisal of artisanal smoking ovens in Ghana. TCP/GHA/4506 (T). Field Document FAO Fisheries Department, Rome.

Summary of the features of the different smoking ovens

Oven type	Fuel usage	Construction cost	Ease of operation	Control of smoking and drying	Useful life
Chorkor Mud	Good	Low	Good. Well accepted by smokers	By rearrangement of trays	Short, unless covered and well maintained.
Chorkor brick	Good. Less efficent than Chorkor mud	Moderate	As above	As above	Long, but some bricks showing signs of cracking
Oil drum	Tuna-good Sardinella-fair	High	Poor. Disliked by smokers, who have to work over a smoking fire	Difficult. Fire must be removed to rearrange fish	Medium tends to rust
Traditional mud	Poor	Low	Poor As above	Difficult As above	Short, unless covered and maintained.
Altona	Tuna-good Sardinella-fair	Very high	Poor. Awkard to load. Highest trays. Disliked by smokers	By arranging trays	Long
Ivory Coast	Moderate	High	Moderate. Could be improved by providing tray handles	As above	Moderate
Pit Oven	Poor	Low	Good	By rearranging individual fish	Short

Source: Stround, G. D., (1986), A technical and economic appraisal of artisanal smoking ovens in

Potential for storage of smoked product	Quality of product	Temperature distribution	Trans-portable	Capacity
Good	Good	Variable, dependent on wind strength	No	High
Good	Good	As above	No	High
Moderate	Medium tends to burn fish in centre of oven. Fish marked	Variable High centre temperature. Poor insulation	Yes	Mcderate
Moderate	Good. Even drying and good colour fish marked.	Good	No	Moderate
Poor	Good, but surface of product inadequately dried	Vertical distribution good. Horizontal distribution variable	No	Moderate
Good	Medium. Smoke tends to condense on spreader plate. Poor colour of smoked product	Vertical distribution good. Horizontal distribution variable	Possible	High
Not possible	Good	Variable	No	Low

Ghana. TCP/GHA/4506 (T) Field Document FAO Fisheries Department ROME

Fermentation

Because of the nature of fermentation, where enzymatic activity is effectively part of the process, there has been little need for improved fermentation techniques for small-scale production. For larger scale production there have been improvements in accelerating the rate of fermentation but these are not applicable to artisanal processors.

Prevention of Insect Infestation

There are many simple, inexpensive and appropriate ways to reduce insect attack by improving processing techniques: for example, improving salting, smoking and drying techniques which have been mentioned earlier. Some blowflies are able to develop a salt tolerance, for example in West Java, blowflies will reproduce and feed off fish in a pickling solution of high salt concentration, a salt level as high as 35% (salt content in processed fish) is needed before blowflies are inhibited. This may give an unacceptably salty product.

Probably one of the most advanced technological improvements to inhibit insect infestation is the use of insecticides which deserves mention here because of their high demand and widespread use. However, insecticidal use should be regarded as a last resort and improved processing techniques must be considered first.

The first field application of an insecticide to protect fish was carried out in Chad in 1956. Since then, use of insecticides has escalated to a degree that warrants concern over the potential hazards of their indiscriminate use. Because blowflies and beetles can be killed by any insecticide, it is easy for local people to purchase any cheap insecticide not even of food grade quality, (ie those specific for cash crops, for large animals or for household use). This is not only a problem for local fish processors but also for fish technologists playing an advisory role, who may have no background in entomology (the study of insects). For any application of insecticides, specialist advice should be sought.

If the use of chemicals is to be continually abused, (it has been observed that fish processors use DDT, petrol, kerosene etc to combat infestation), then the availability and cost of an insecticide which is safe and easy to use on fish to be consumed, could help prevent hazardous consequences of using non-food grade insecticides.

One such product is pirimiphos-methyl (under the trade name *Actellic*) which was given clearance by WHO and FAO in November 1985 to be used on fish. It is one of the safest food-grade insecticides and is available at a cost similar to that of insecticides already in frequent use. Its effectiveness depends on its application and again, specialist advice should be sought. Trials carried out by ODNRI in Africa have shown that the effectiveness of *Actellic* depends on the size and oil content of fish because these factors affect penetration rates and concentration uniformity.

Case Studies

Women play a vital role in traditional fish processing and marketing. Their efforts have been largely taken for granted and their needs ignored. This may be because any opportunity to voice their needs has not arisen or because someone else has answered for them. Furthermore, with only limited funds to allocate for development, Governments usually place priority on those steps which will produce the greatest immediate gains, such as adding outboard motors to traditional fishing canoes to increase catches of fish. Improving smoking ovens or fish driers provides far less tangible and impressive results. Yet without improvements in traditional processing methods, women continue to slip behind their male counterparts, who fish with modern motors and work in the few modern canning factories. Moreover, increased yields of fish are wasted because the processors are unable to keep pace with the supply (ECA,1984).

It is often assumed that because women have been processing fish for centuries, they are naturally conservative or antagonistic to new ideas or devices. They are naturally mistrustful of new ideas being brought in by outsiders (after all 'development ideas' don't have a very good record) but when they can see clear benefits for themselves they are likely to want to adopt them.

The failure of introduced ideas in these circumstances is much more likely to be in the design of the project than in any innate conservatism. Often, the key constraint facing the women as perceived by themselves was not central to the project. For example, in Togo, the problem affecting processors is shortage of fish rather than firewood, of underemployment rather than lack of capacity.

Secondly, assumptions are made about the willingness of people to organise co-operatively. When no tradition of organisation exists, establishing co-operatives can often lead to recriminations, mistrust and collapse. The Sierra Leone case study amply shows this.

Thirdly, while schemes are shown to be 'economic' no realistic attempt is made to ensure that the improvements are affordable. In many pilot projects, the equipment is given to the beneficiaries and no credit systems are established to enable other groups of women to take up the technology.

Hence, the reason why in Guinea the Chorkor smokers have been taken up by private male entrepreneurs, leaving the women out in the cold.

Fourthly, pilot projects often fail in establishing adequate extension programmes to ensure that other women have access to the technology. Such activities include sensibilisation (creating awareness and motivating people to participate), training of artisans and fish processors in all relevant skills, follow-up support and adequate market research where new products are being introduced. The lack of these facilities has led, for example, to the down-grading of the Chorkor technology in Ghana, where untrained artisans have built sub-standard smokers.

There is potential for introducing im-

provements. The Chorkor smoker proves that, but improvements can only be introduced by involving the women themselves and enabling them to elaborate the social, cultural and economic content of any fish processing activity. Furthermore, design adaptation should be allowed to happen to fit in more closely with the women's own priorities and capacities.
Lastly, and probably most important of all, small changes often bring about the greatest benefits because they initiate a process of development. Large changes often have the effect of removing a process from the hands of those the improvements were designed to help. Project planners should never forget that.

1 Chorkor smoker Nyanyano, Ghana

Compiled by Linda Adams

Summarized from:

Field Report on Post-Adoption Studies (Technologies for Rural Women) ILO/NETH/80/GHA(1), November 1985.

The Chorkor smoker was originally developed in 1969-1971 by the women of Chorkor, Ghana, FAO, and the Food Research Institute, Accra.
The Chorkor smoker has gained wide acceptance in the area by traditional processors and has been popular for the following reasons:

- low cost of construction
- working life of 4 - 15 years depending upon the strength of materials used for construction
- a smoking capacity of up to 18 Kg of fish per tray
- low consumption of fuelwood and higher retention of heat leading to a better quality product
- reduction in labour time.

The Chorkor smoker was designed specifically to address the following problems in traditional processing methods:

- poor quality product due to fish being damaged by difficult handling of the fish on wire nets used to support them over the fire
- loss of smoke and heat, resulting in uneven smoking
- limited capacity of smoking larger volumes of fish
- time consuming in terms of amount of time needed to handle the fish in smoking.

Socio-economic background

Nyanyano is a fishing community 22 miles from Accra, 20 women smoke fish using the 'Chorkor smoker', 80% of these women are married but live away from their husbands.
Participation in polygamous relationships is both socially acceptable and of economic necessity for a woman. It is only through marriage with a man who owns a boat that she can be assured of regular supplies of fish to smoke. In return, the wives are responsible for taking turns feeding the husband with part of the funds she has made from her sales. In this sense, sharing the financial burden with other wives becomes attractive.
Fish smoking is traditionally done on an individual basis or on a family basis composed of 3-4 members which may

include a mother and daughters or group of sisters. Sometimes individuals will break off from these groups once they have acquired the working capital to set up business on their own.

This lack of capital and lack of access to low interest loans is a major constraint to purchasing more fish and therefore taking advantage of the increased smoking capacity of the Chorkor technology.

The fish is purchased from fishermen (their husbands) who demand immediate cash payment for the day's catch which has been allocated to each wife. Lack of cash to purchase increasing amounts of fish also becomes compounded when there is a shortage of petrol, forcing fuel prices up. Given these constraints, it has been difficult for Nyanyano women to maximise the full benefit of the improved oven in order to substantially increase their income.

The system of obtaining bank loans has also created a structural constraint for women fish smokers in that commercial banks prefer loaning to groups, although this is not how they customarily organize themselves for this activity.

The National Council for Women had previously assisted the women in forming fish smoking groups in 1984 by commissioning the initial construction of 15 improved Chorkor ovens. This group subsequently met once a week in order to discuss matters such as acquiring further smokers and various problems encountered including access to credit, fish storage and marketing. Individual contributions were made with the goal of seeking a group loan from the bank. Possibly the concept of group formation was not fully accepted by each member as meetings became irregular when project staff attendance at their meetings declined. The initial goal was never realized and the group disbanded.

Advantages and disadvantages of the technology

The Chorkor smoker has been accepted by individual women constructing these ovens with their own funds. Women who previously did not smoke fish have taken on this activity having had improved smokers constructed for them. Changes in old processing methods have occurred as a result of the introduction of the Chorkor oven. Fish was previously dried in the sand due to a lack of capacity of their traditional ovens; but using Chorkor ovens they are now able to smoke all their fish. Traditional cylindrical mud ovens have assumed a new purpose: storing their smoked fish. It is believed that these traditional ovens would be abandoned completely if improved storage technologies were available.

The new technology has assisted women in relieving them of the most laborious process of arranging the fish in alternate layers using sticks and broomsticks as required in the mud ovens. Trays within the improved ovens have replaced this step thus making the process more efficient and reducing damage done to the fish (which tends to lower the value) in handling. Two smoking ovens were required in the old method of turning whereas one improved oven was sufficient for turning.

The Chorkor oven has also had an effect on marketing possibilities. Fish that is smoked with the improved oven is usually bought first and can demand higher prices. As they have been producing under capacity, for reasons mentioned earlier, fish processors 'mammies' have not been able to take full advantage of this potential increase in income.

Time inputs were examined comparing time spent on fish smoking with the traditional and improved ovens. In the peak season, women can smoke as much as 10 crates of fish (600 kgs) taking the whole day to arrange the fish from one traditional cylindrical oven to the next. Not enough time was available during this period to cook for their children who were instead given money to buy cooked food. The improved smoker required less time for smoking. It could smoke 15 crates of fish a day whereas the cylindrical oven could only undertake 6 crates per day. In addition, the tray system relieves further time as arranging of fish in the old method takes more time than stacking of trays.

The women felt that the 10 trays introduced in one smoking cycle could be increased in order to avoid wasting firewood and increase smoking capacity of the oven. Other problems mentioned were that the improved smoker could not be operated by one person, the medium cross piece of wood dividing the tray into two can catch fire if the flames are uncontrolled and smaller quantities of fish wastes fuel as the design of the oven does not compartmentalize the areas holding the firewood. Some of the ovens introduced into Nyanyano were a modification of the original Chorkor oven (even though they are referred to as Chorkor ovens). The modification included removal of the original middle wall and insertion of two pieces of iron rod fixed to the upper middle part of the oven on which the trays are rested. This caused problems of trays catching fire and making the capacity too large. In the original design the middle wall was put in to prevent the trays catching fire and to be able to smoke smaller quantities of fish by using only one half of the oven.

Reliance on informal money lenders presented a higher risk to women as interest rates from them were high. As mentioned earlier formal commercial bank channels were not accommodating to individual loan applications. Lack of available capital was seen as a major constraint in increasing output and for women who did not participate in the initial group scheme to purchase the new technology. Money relationships between husband (fisherman) and wife (fish processor) put a further financial constraint on her as the spot payment is demanded not giving her any grace period in order to take advantage of storage methods that would allow her to demand higher prices during lean seasons.

The price of fish is expressed in a standard quantity as determined by the base price established each day when the first boat returns from its fishing trip. This set price is often, not surprisingly, open to debate between men and women.

Internal family relationships can also play a positive role in the organization of fish processing. Mothers will usually cooperate with married and unmarried daughters as a team until a daughter has the financial means to form a separate unit. As a team, the mother has full control over the fish, providing initial cash payment of the purchase of fish, organizing the marketing, retaining the profits and finally providing money for cooking meals and expenses incurred by her daughters as a form of repayment.

2 Guinea and Togo

Two contrasting case studies on the introduction of the Chorkor oven. Harmandip Sandhu, UNIFEM.

The Republic of Guinea, with its (300km long) coastline has good resources capable of supporting a mixed fishery. Artisanal fishing accounts for about 26,000 tons per year, of which a large part is processed by smoking, primarily done

by women. However, because the methods used are traditional, they are labour intensive, fuel and time consuming.
In answer to requests from the Republic of Guinea, in 1984 UNIFEM provided funds for a project introducing an improved fish smoking technology. The immediate objectives of the project included regrouping 300 women into cooperatives for the processing and distribution of fish, and introducing an improved fish smoking kiln using technology to reduce women's labour; improve working conditions; and increase productivity and revenue. The project was to construct the smoking ovens in the capital, as well as in 2 villages in the interior of the country, at Boffa, to exploit lake fisheries.
The improved smoking technology introduced was the Chorkor oven originating from Ghana, where it had been widely tested and used. The Chorkor is a rectangular clay brick oven with two openings in the front of the fire. The fish is placed on trays (made of chicken wire) which are stacked on top of the oven. Up to 15 trays can be stacked on the oven with a total of between 100 kg to 160 kg of fish being smoked at a time.
As part of the project a group of eight project personnel including a carpenter and mason were sent to Ghana and Benin in order to familiarize themselves with the Chorkor and be trained in its construction, use and maintenance.

Advantages and disadvantages of the project

It was found that after 2 years the project had obtained certain positive results despite the numerous difficulties it faced. Some of the setbacks included: a change in the political situation of the country which resulted in changes in the economy, notably increases in the cost of living; and materials for the construction of trays were not available in Guinea.
Most of the original members of the cooperative were not traditional fish-smokers. They therefore regarded participation in the project more in terms of salarial employment rather than independent use of commonly owned facilities. This emphasizes the need for careful definition of a criteria for the selection of beneficiaries before a project commences.
The women did not have a regular supply of fish to smoke; in some cases women would pay transport to come to the centre and will not be able to smoke fish. The fishermen, who prior to the political changes had agreed to supply the centre with fresh fish, refused to provide fresh fish or would do so only at exorbitant prices which the women could not afford. Consequently the women have resorted to smoking frozen fish. This in itself presents a contradiction because not only is the fish processed twice but energy is wasted as well.
Although the Chorkor can smoke up to 15 trays of fish it was noted that in most cases women used only up to 4 or 5 trays at a time because there is not a regular supply of fish to warrant the use of more trays. In the interior of the country where fish is obtained from lagoons the problem of availability of fish is due to social reasons. In some cases the fishermen sell the catch to any women who are able to buy even if the women are not their wives. These women then sometimes market the fish fresh. In other instances the fishermen may sell only to their wives, thus women entering into a fish smoking cooperative are at a disadvantage if their husbands are not

fishermen. In a few cases in Guinea, women would supply the fishermen with enough gasoline to pay for one fishing trip; in return the fisherman is obliged to supply the women with the entire catch from that trip.

Additionally there is increased competition among the fishermen with motorized boats and those with non-motorized boats. The latter are unable to get a sufficient catch each time as they can only fish at limited distances, whereas fishermen with motorized boats can provide fish but have to account for the cost of the motor and fuel, thus increasing the price of fish.

In terms of the technical advantages and disadvantages of the Chorkor it is clear that in the Guinean context, the Chorkor is an improved technology. Traditional smoking systems consisted of "open smokers" which were basically a grill over four wooden legs — fuel consumption is considerably higher in these traditional ovens. The Chorkor presents a marked improvement in that it is a "closed system" — the fire is enclosed in a compartment in the bottom of the rectangular oven thus fuel consumption is much less. The trays, however, become heavy once the fish are placed on them and require two women to manipulate one tray. When more than 7 trays are stacked they are very difficult to manage in terms of weight and height. As a result one finds that the women are reverting to their traditional ovens but covering the sides with sheets of metal, corrugated iron or similar material to enclose the fire and thus reduce the amount of wood consumed.

Currently the project staff are working with the women to improve the Chorkor to fit these needs.

From the points mentioned above it is clear that not only is the technology itself important when assessing its relevence, but also the situation into which it is introduced. If the social, economic and political conditions in a village do not allow the women greater access to a supply of fish, then the expense of an oven with greater productivity is not going to outweigh the situation. However, if the oven will reduce the amount of fuel needed, thus reducing costs in a present system then the savings need to be examined. This saving should be examined in terms of women's labour and time. One reason for using the Chorkor was to reduce women's labour constraints. However problems of manipulating the trays prevented this from being realized. While there are still problems with the Chorkor in Guinea, it has proved to be a significant improvement in terms of fuel consumption.

Replication in Togo

In Togo, the Chorkor was introduced in order to increase productivity and revenue and reduce the amount of fuel and labour required. The scale of the project in Togo was much smaller than in Guinea, although the impact was significant. The project initially constructed 12 Chorkor smokers at various villages along the coast. Since then between 50 and 80 additional Chorkor smokers have been built by women individually.

This is an indication that advantages of the Chorkor have been realized. However, like the Guinean women, Togolese women are also suffering from an insufficient supply of fish. This is largely due to the fact that there are no strong fishing traditions in Togo. Consequently the women have to rely on foreign fishermen, usually Ghanaians, and therefore the supply of fish is sometimes irregular leaving the women unable to count on a regular income. Women whose hus-

pendently from men and keep separate budgets. Processing activities are organized by the first wife who owns the banda, buys the fresh fish and sells the smoked fish. The junior wives are involved by washing the fish, transporting them from the beach to banda, watching the fire, and other tasks designated by the first wife.
Processing is very labour intensive. The women spend 12 hours of continuous work processing 600 dozen herring (400 kg) with a typical banda having a capacity of 100-1200 dozen herring. During the dry season, most women will spend up to 75 hours a week on processing for 5 days.
Women control the marketing of food stuffs such as smoked fish. A complex system of long distance trade involving wholesalers, semi-wholesalers, traders, and retailers has developed.
The changing socio-economic structure has affected the women's position within the household. Husbands and senior wives will operate as a team in this whole cycle but still keep separate accounts. Women invest in their husbands fishing operations, providing loans in order to expand fishing activities by purchase of boats, engines, nets etc.
The money earned by women from the sale of processed and marketed fish is the major cash source for the household. The income from their economic activities has provided a cushion for men when fishing has become difficult due to climatic or other reasons.

Tombo village fisheries pilot project

The pilot project was jointly sponsored by the governments of Sierra Leone and the Federal Republic of Germany and initiated in 1981 to last for 5 years. It was a pilot project to be replicated in other fishing villages on the western coast. Under the sponsorship of GTZ, the operating budget was quite substantial at 12.11 million DM (6.5 US$ million). The philosophy of the project was that improvements in fishing techniques should go hand in hand with innovations in processing techniques and marketing strategies, the latter being the special economic domain of women in African fishing communities.
The aim of changes in fishing technologies was to reduce the high operating costs for fishermen via improvements in fishing gear, boat-building, introduction of sails and fuel-saving diesel engines. Any increases in the fish landings would of course affect the women processors in terms of workload.
Improvements in fish processing concerned itself with the introduction of the Ghanaian model of the Altona-type oven. The project staff in consultation with the women modified the design by lowering the height, expanding the width and using trays made of iron. Although these changes increased the price, the ovens were easier and safer to operate. Savings in fuel costs of 60%, a lifespan of almost double that of the traditional banda, decreased processing time (including laying) and the fact that constant supervision of the fish over the fire was no longer required were seen as improvements.
Disadvantages were also observed: handling of the trays required two people, frequent changes in the position of the trays in order to accommodate the temperature gradients within the oven was extra work for the junior wives. Handling of the hot, fully loaded trays could cause dangerous accidents like burns to the stomach.
Of the original dozen Altona ovens that were introduced, ten are still in use by

the original owners. The project felt it needed a visible success in the beginning of its life in order to validate its major presence in the area. The technology was inappropriate within the context of the deteriorating economic conditions in the country. The materials needed to build and maintain the oven such as iron, steel and firebricks (locally made mud bricks could not withstand the high temperatures) proved too costly to replicate after the original dozen were built. In addition, no locally trained mason was capable of building these ovens.

The Altona oven programme ceased and no further ovens were built from 1982-1986. The original 12 individuals who were given the ovens renaged on the project loan and there was no one in an extension role to follow up the case and seek payment.

The Altona oven was seen as useful if there was a small batch of fish to cure but was generally not seen as capable of handling the large volume of fish for processors in this area.

The three plus years generally needed to pay for the oven was seen as too long a payback period in light of the low material investment needed for more traditional ovens. The women processors were purchasing such high volumes of fish to process, that the savings in fuelwood costs were seen as negligible in terms of the investment cost of the Altona oven which would save them fuel costs. The 12 processors have fully accepted the Altona oven and no longer use the traditional ovens.

Fish processing arrangements in Tombo are a socially defined hierarchy within the context of multiple wives involved in handling the fish. The construction of the Altona oven upset this hierarchy. The trays were very heavy with the highest of the 2 dozen trays to be shifted, being 2 metres from the ground. Two women could not shift these trays and only men were strong enough to do this work.

There have been technology adaptations in Tombo resulting in the traditional banda almost disappearing and continuing increases in the production of the Fante banda. The Fante banda is basically a modified traditional oven with built-up sides and increased surface area (up to 12 metres square) to support the higher volume of fish requiring processing. As the capability to catch fish has increased, so has the size of the banda.

In general, the upkeep of these bandas is poor due to lack of materials such as metal grates and concrete to reinforce the mud block. It was under discussion that the project would purchase these materials outside with foreign exchange and set up a store for fish mammies much the same as it has done with making fish gear available to fishermen.

Presently, the project has moved into its consolidation phase and has been extended for 2 years. The initial goal of increasing the volume of protein available in Sierra Leone by large scale introduction of fish gear and processing technologies has been altered to a focus on increasing overall community development. No more new technologies will be introduced, in recognition of the multiple economic and social problems that came under stress with previous technologies. A sociologist has been hired and the present aim of project activities is to expand both women's and community group linkages to the project.

Checklist of Questions

These questions summarize the text.

1. How fresh is the fish when the processor buys it?
2. Is the fish bruised or cut?
3. Who has she bought it from?
   - the fisherman?
   - another trader?
4. Does she always/most often buy from the same person?
5. What factors affect how much the processor pays for fresh fish?
6. What factors determine how much fish she buys?
7. What type of fish is being purchased?
8. Will the bought fish be sold fresh or processed?
9. What is the time interval between when the fish is bought and when it is sold fresh?
10. What happens with any fish which cannot be sold that day?
11. How fresh is the fish immediately processing begins?
12. Is the fish kept cool before processing?
13. Is the fish easily accessible to blowflies?
14. Is the fresh fish prepared before it is processed or sold fresh?

Preparation

15. How is the fish prepared?
    - is it gutted?
    - is it gilled?
    - is it bled?
    - is it washed first?
    - what quality of water is used?
    - is it cut up into smaller pieces?
    - how is it cut up?
16. Is the fish prepared on the ground, on rocks or raised off the ground?

17. Are the preparation area and the implements used kept clean?
18. Is all the fresh fish intended for sale, sold at the end of the day?
19. If not, what happens with the fish which is left over?

Processing

20. What method of processing is practised traditionally?
21. What steps are followed through processing?
22. How long is the fish dried/salted/smoked/fermented/boiled/fried for?
23. Is a combination of processes used? eg. smoke-drying, salting-drying
24. What are the climatic conditions? How do seasonal conditions affect the traditional process?
25. Does the processor perceive what fluctuations in climatic conditions affect product quality?
26. Does the processor use the climatic conditions to her full advantage?
27. What equipment is used?
28. Describe how it is used?
29. Is the operation easy?
30. Are there any safety hazards?
31. How much time is spent operating equipment and by whom?
32. What is the source of energy?
33. What quantity of fresh fish is processed per batch/day?
34. Could this be increased without additional equipment?
35. What percentage of her processed fish is lost from the time it is bought fresh to the time it is sold processed?
36. Does she have to reduce prices of her fish? - Why?
37. Does she have to reject any of her fish?
38. Are there any limitations perceived by the processors, of (i) the traditional processing technique? (ii) the traditional processing equipment?

Drying

39. How much fluctuation is there in temperature, relative humidity and air speed throughout the processing period?
40. Is the fish accessible to insect attack?
41. Is salt used in drying?
42. If not, is salt available to use and would the taste of the product be acceptable?

43. What is the average weight loss of the dried fish?
44. Is shade drying used?
45. Can the fish be protected from the midday sun or hottest time of the day to avoid case-hardening?
46. Is case-hardening a problem?

Salting

47. Where does the salt come from?
48. Why is salt used – for flavour?
    – to deter insects?
    – to increase storage life?
49. Is the salt cleaned to remove foreign matter eg, dirt, mud etc?
50. How much salt is used by weight compared to the fish weight?
51. Is enough salt used to deter blowfly and beetle infestation?
52. Is "salt burn" a problem?
53. In kench salting, are the cut fish stacked in any order ie. skin to skin, flesh to flesh?
54. In kench salting, is the stack re-packed to allow for even salting of the fish?
55. In pickling, are all the fish completely immersed in the solution which forms?

Smoking

56. What is the weight of fuel consumed per kg of fish smoked?
57. Is there scope for improving fuel efficiency ?
58. Is fuel scarce or difficult to obtain?
59. How are the fish arranged for smoking?
60. What happens to other fresh fish which cannot fit onto the smoker?
61. Is the product burnt/charred? Is the interior of the fish still moist after smoking?
62. Is there any control over ventilation, fuel consumption, temperature, smoke density?
63. How great is the variation in these parameters throughout the processing period?

Product and marketing

64. What is the traditional marketing structure?
    – Who sells the processor's product(s)?

- Where is her product(s) sold?
- Who does she sell to?

65. What is the storage life of the processed fish?
66. How long is the period between processing and selling?
67. How/where is the product stored?
68. Is any processed fish rejected after storage?
69. How does the processor pack processed fish for transport?
70. How is the fish transported?
71. Does the processsor, her family or workers travel to sell?
72. Is the processed fish damaged during transport?
73. What determines the selling power of the fresh fish (quality, size, appearance...)?
74. What determines the selling price of the processed fish?
75. Is the processor satisfied with her fish sales?
    - does she sell all her processed production?
    - could she sell more?
76. Does the processor recognise any need for a better quality product?

Socio-economic

77. How much time does the processor spend in processing fish (including buying and marketing)?
78. Is processing a seasonal activity?
    - which season?
    - why (availability of fish; competition with other activity?)
79. How many other people help the processor?
    - who are they (immediate/extended family)?
    - what tasks do they perform?
    - are they paid (cash/kind)?
80. What are the costs to processing?
81. What other economic activity does the processor engage in?
82. How important to the family is income from processing?
    - % total household cash income
    - % total household income
83. Is the processor satisfied with her income from fish processing?
84. How does she think it could be improved?

Improved processing

85. In what way could the handling, processing and storage of fish be improved to:
    - improve quality of final product
    - improve value of product
    - reduce losses
    - reduce costs
86. What experience has she had with new or improved technologies?

As compared to the traditional method

87. Is the improved equipment likely to result in a decreased holding capacity for fish?
88. Will the improved method/equipment reduce labour input?
89. Will the improvement increase production? If so will the roles of the women and/or their households be changed?
90. Will the improvement significantly change the amount of time spent on the process?
91. Would the introduction of improved drying equipment, eg drying racks, improved smoking oven be within the financial capabilities of the processors?
92. Are the construction materials available?
93. Will the improvement require that processors need significant training?
94. Will the improvement require additional raw materials or greater quantities of raw materials than previously used?
95. Are these raw materials available?
96. Will the improvement require previously unused facilities eg clean water, fuel and are these facilities available?

Socio-economic

97. Will the improvement be within the financial capabilities of the processor(s)?
98. If not, is the cost manageable on a community basis?
99. If credit is needed is it accessible? What are the local mechanisms? What are the rates of interest?
100. How would improved processing affect the processor's income?
101. How would it affect costs (capital, operating)?

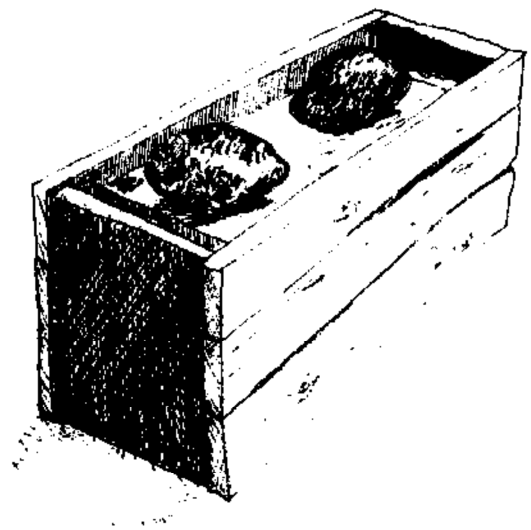
102. Will the women realistically be able to repay the loan?
103. What will the return on the investment be?
104. How long will it take the processors to cover the cost of the improvements?
105. How would it affect the number of workers and the time worked?
106. How would it affect the organisation of processing and marketing?
107. Who would earn the income from the improved process?
108. Will the improvement affect the price of the product on the market?
109. Will the improvement cause a change in the taste, appearance, texture or smell of the product?
110. If so, is this change acceptable?
111. Will the improvement cause a change or introduce new responsibilities for the processor?
112. Will these responsibilities be culturally acceptable? Will the processors be able to cope with any new constraints?

Illustrated Guide

Figure 1

Kench Salting (Dry pile)

The fish are layered flesh to flesh, skin to skin and the top layer of fish are skin side upwards. Weights can be used to press the pile. The brine formed is allowed to drain way.



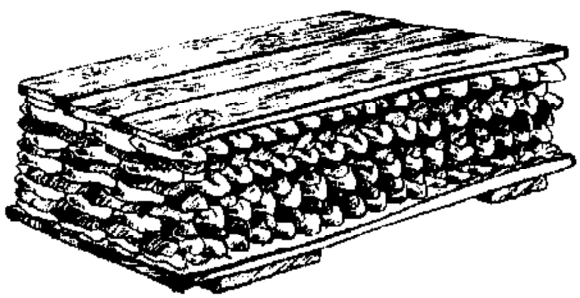


Figure 2

Pickle curing (Wet pile)

The fish and salt are layered (as for Kench Salting) inside a container, (for example a margarine tin), which is then sealed carefully, labelled and left to cure.

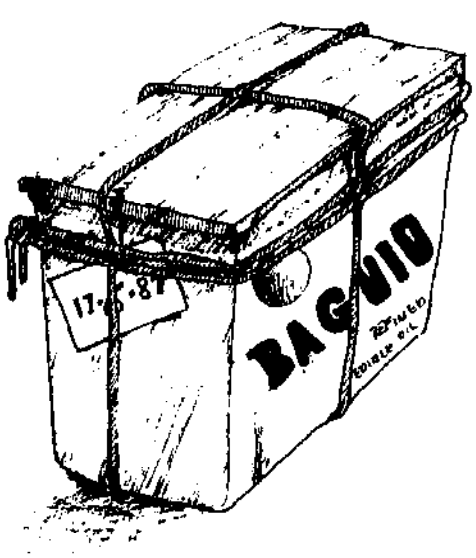
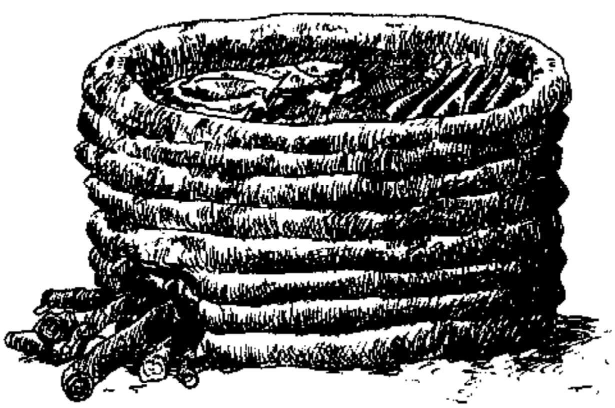


Figure 3

Traditional Smoking Pit in East Africa

Figure 4 (a-b)

Traditional Ghanaian Cylindrical Mud Oven



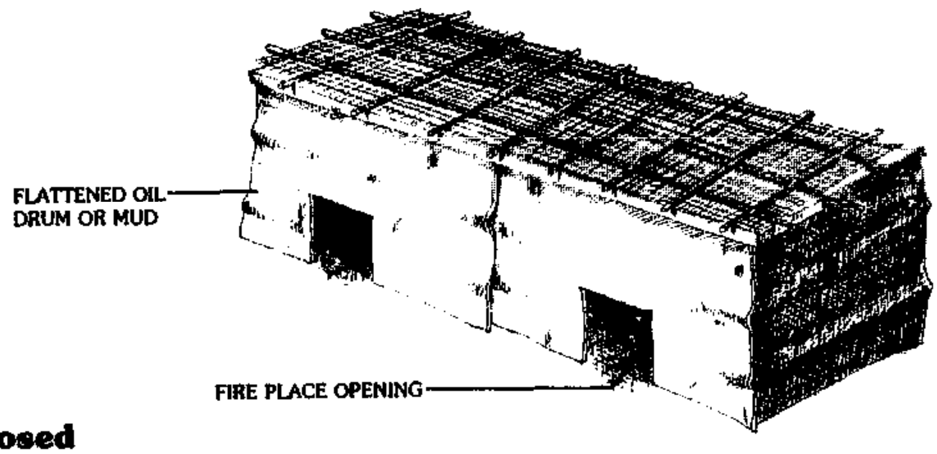
a) Open

b) With Thatched Cover

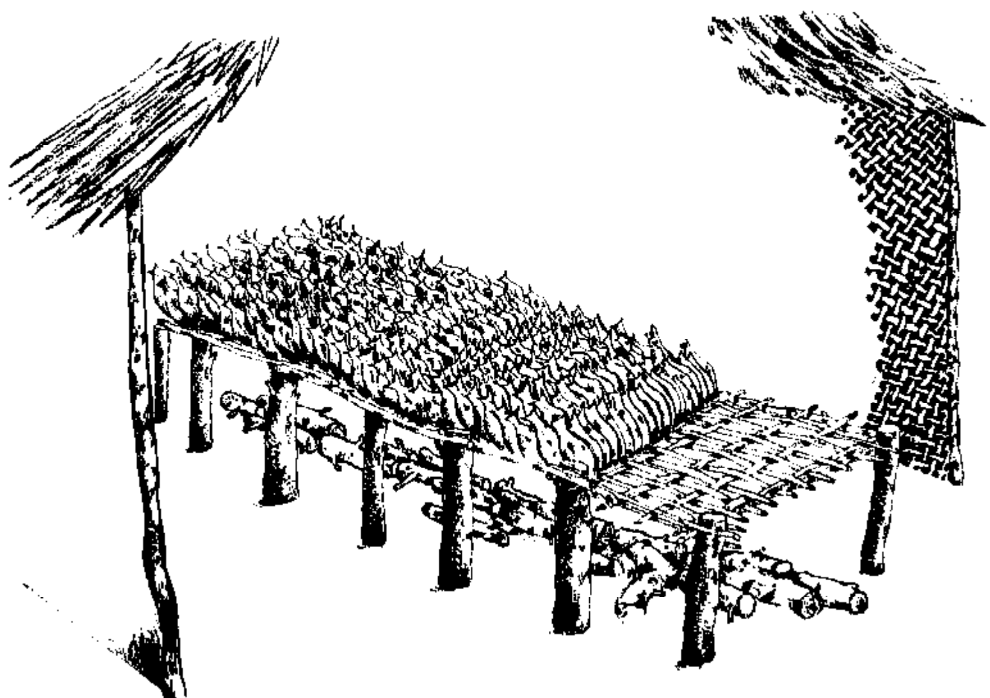
Figure 5

Traditional Smoking Platforms or 'Bandas' in Sierra Leone

The metal sheeting (often made from a flattened oil drum) covering the open sides of the banda helps to conserve fuel.



a) Enclosed

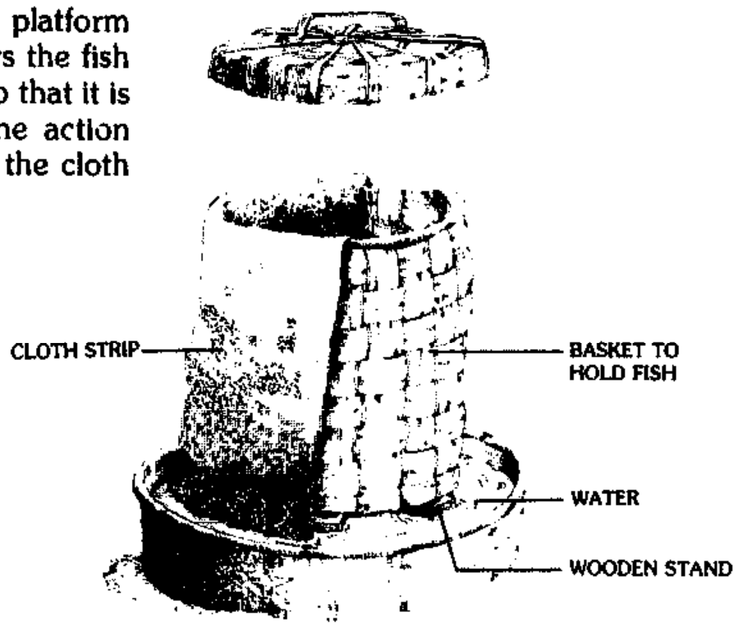


b) Open

Figure 6

Evaporative Coolers

a) The fish is hung or placed on trays inside the open weave container which is stood on a raised platform in water. A wet cloth covers the fish and hangs over the water so that it is continuously re-wetted. The action of water evaporating from the cloth cools the fish.



b) The evaporative charcoal cooler works on the same principle. In this design the water filters down from the top of the cooler. It passes over the charcoal, which is encased in wire mesh, from which the water evaporates to cool the interior of the box.

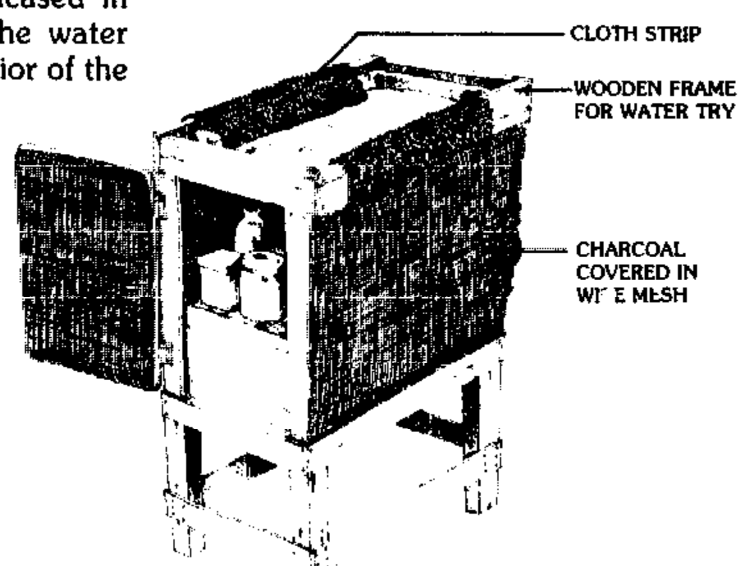


Figure 7

Drying Rack

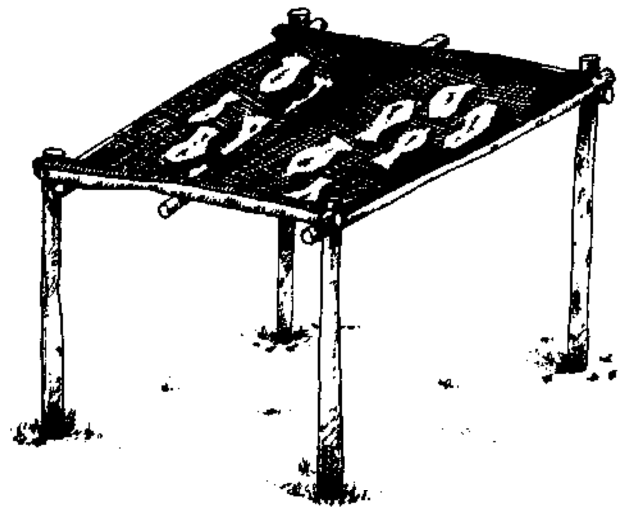


Figure 8

Solar Tent Drier

This drier is awkward to construct and operate.

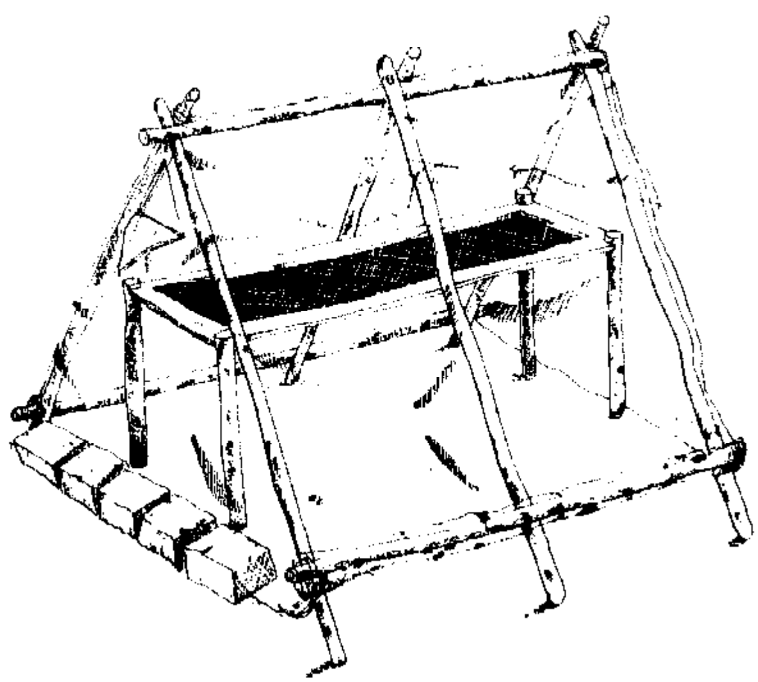


Figure 9

Solar Cabinet Drier

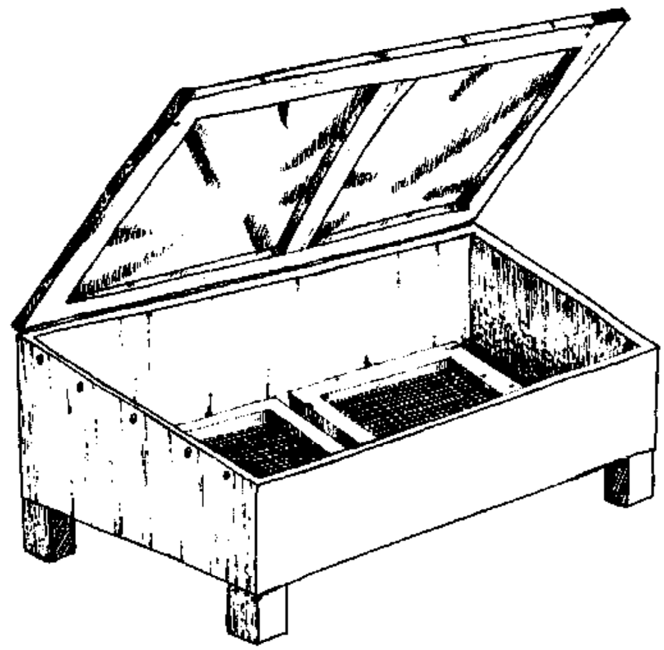


Figure 10

Solar Dome Drier

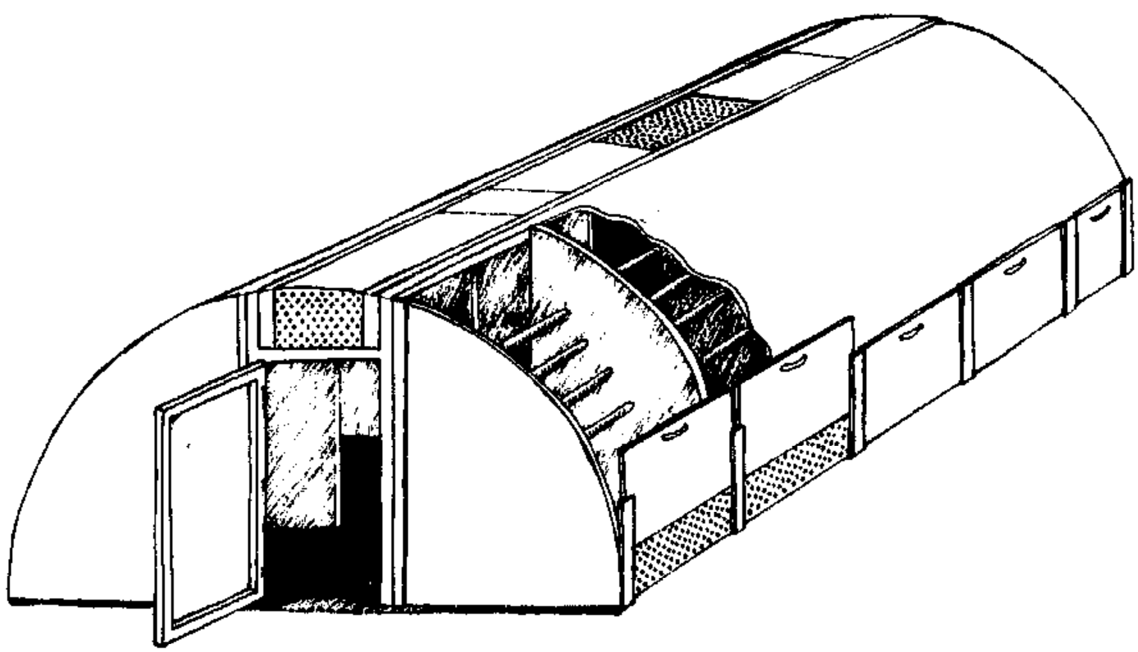


Figure 11

Solar Drier with Separate Collector and Drying Chamber

The chimney is painted black to absorb more heat. This will aid in heating the air up inside the chimney, thereby increasing the air flow through the drier.

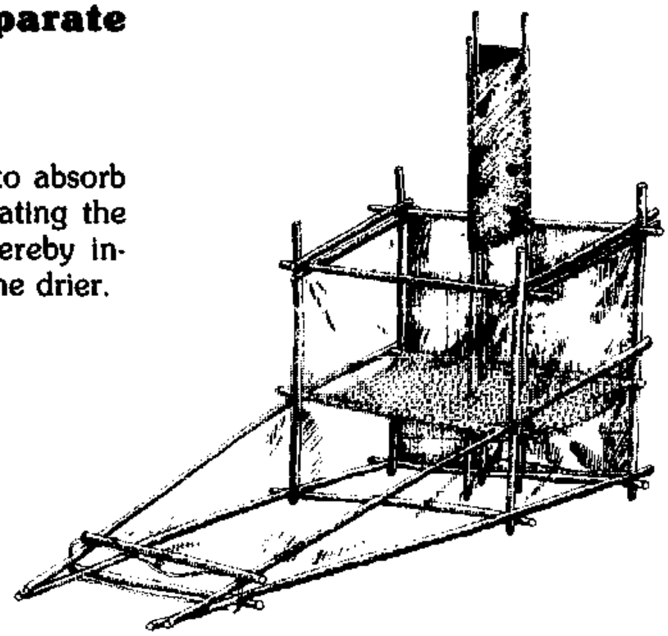


Figure 12

Canvas Drier

This is a direct convection drier constructed from a wooden frame covered by a canvas awning which encloses the drying chamber. The roof and chimney are made from galvanised iron. The dryer is fuelled by charcoal in a fire box or cement pit below the drying chamber.

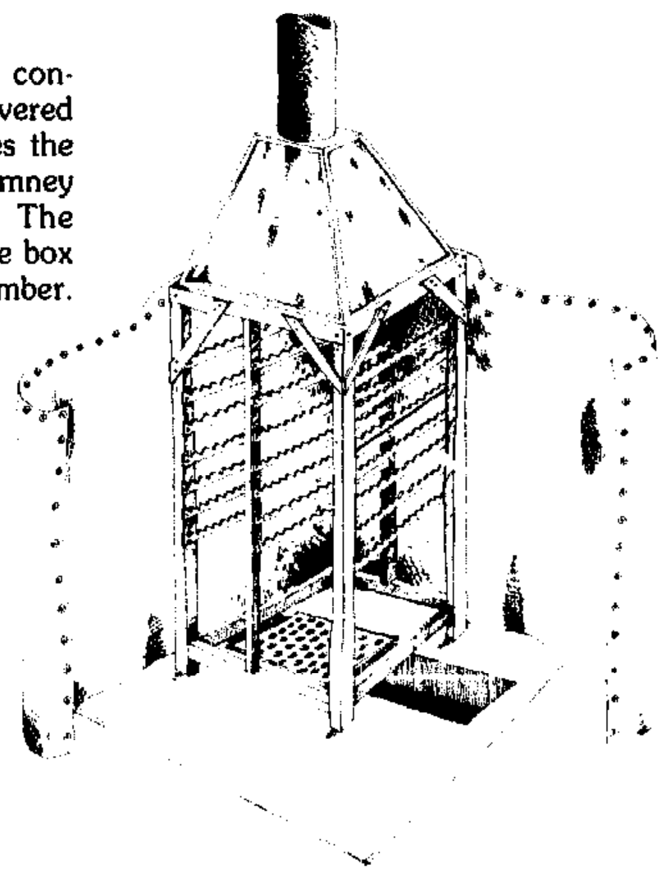


Figure 13

Tray Drier

When rain threatens the trays previously placed to sun dry the fish are assembled on top of each other over a simple heating compartment. A roof and chimney are placed on top and drying continues by direct heating using charcoal.

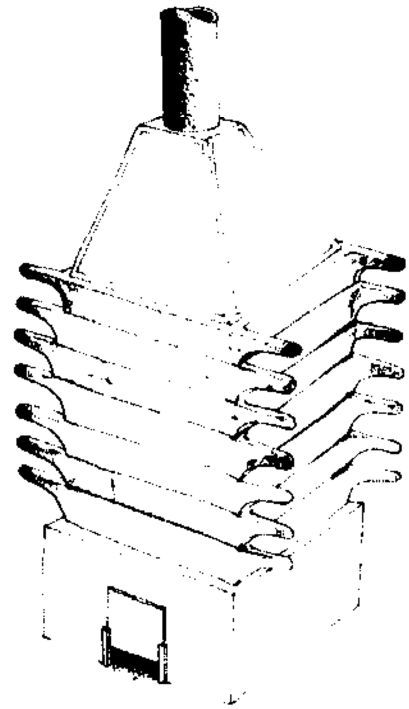


Figure 14

IRRI Vortex Fish Drier

The Vortex wind machine is placed on top of the drying chamber and rotates during windy weather. This causes a draught of air through the drying chamber.

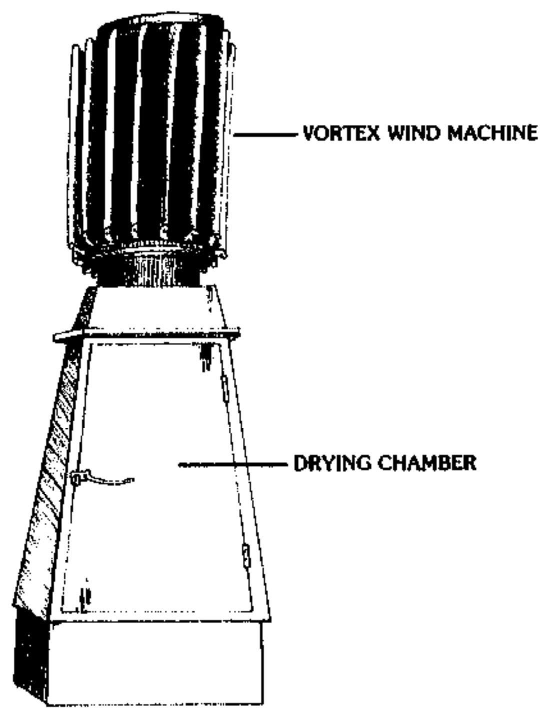
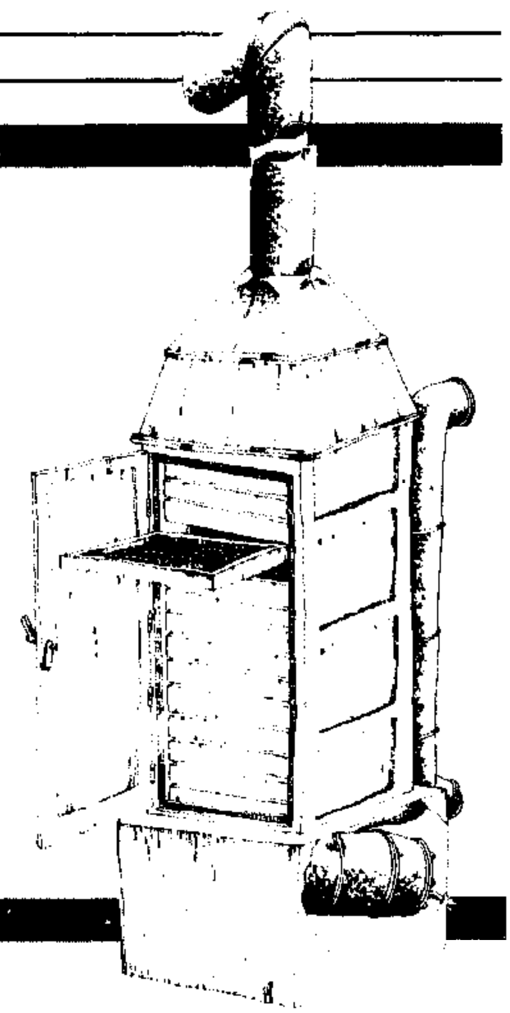


Figure 15

Low-cost Fish Drier



This is a vertical tray drier fuelled by coconut husks, firewood or rice husks. At the base of the fire a combustion chamber made of concrete is located. Attached to one side is the incinerator made of asbestos and metal into which the fuel is placed. A heat exchanger is housed across the incinerator and combustion chamber and heated air passes into the drying chamber. Wooden framed wire mesh trays are positioned centrally within the drying chamber. At the bottom of the concrete chamber there are ten air vents with sliding covers. A chimney with an inverted, L-shaped hood placed on top of the drying chamber increases air flow within the drier.

Figure 16

UPLB-IDRC Drier

This drier is composed of four major parts: a brick furnace, the heat exchanger, the blower and the drying chamber. It is fired by rice husks and an average of 25 Kg of fuel per hour are consumed. Air is heated by the heat exchanger and is sucked by the blower into the drying chamber where the air temperature is in the range of 40 - 60°C. The drying chamber has five compartments and a uniform temperature distribution is achieved by adjusting the exhaust vents on top of each compartment.

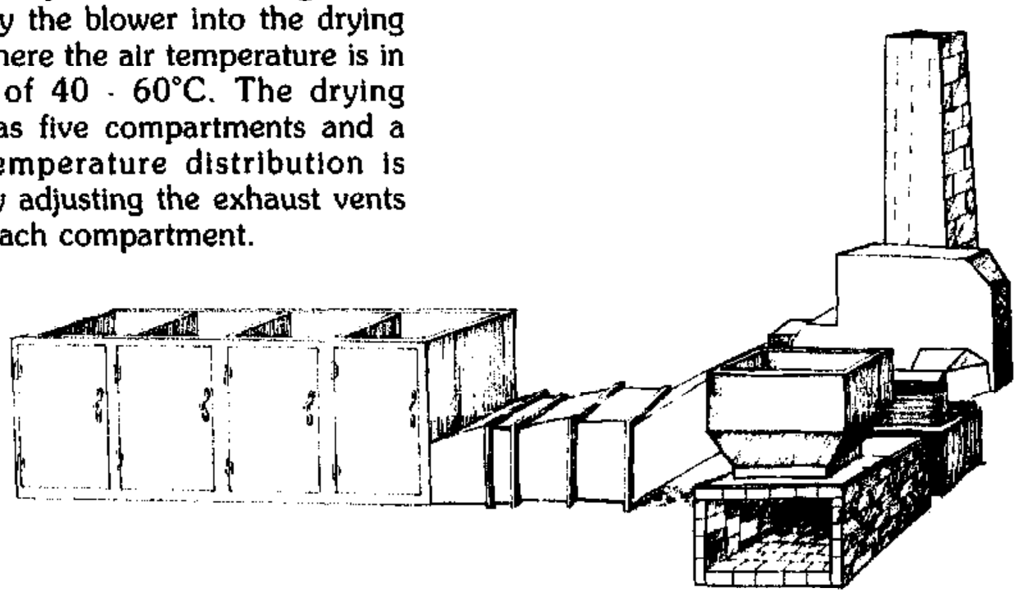


Figure 17

Solar Agrowaste Multipurpose Drier/Smoker

The SAM type drier is a rectangular box made of metal with a tapering roof. The drying chamber holds 12 pairs of trays. The roof, the door and the side facing it are made of polythene sheeting. The chimney attached to the roof is made of metal and air flow through the chamber is regulated by a damper. A furnace is situated below the drying chamber and is separated by a piece of corrugated sheet metal.

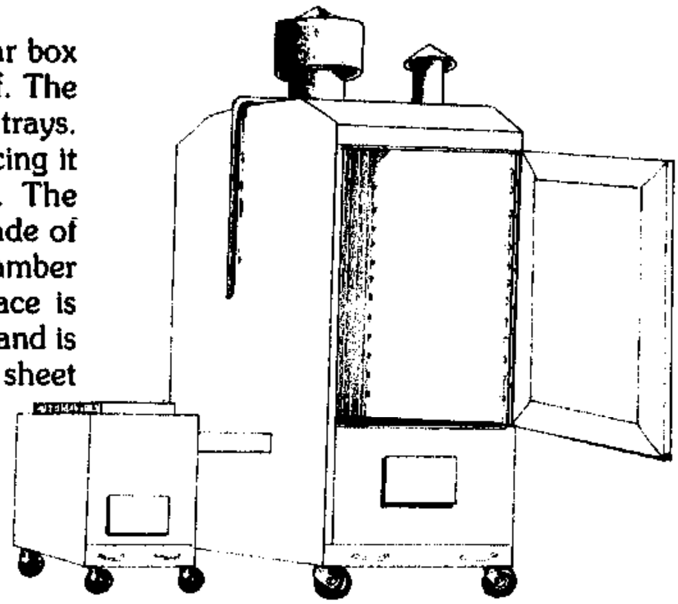
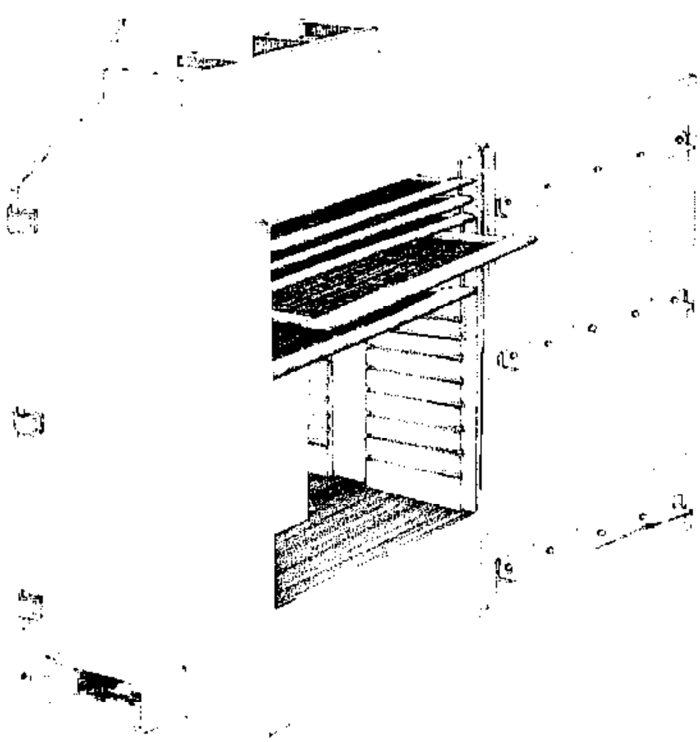


Figure 18



Steel Drier

This drier is constructed entirely of steel and comprises a firebox and flue which passes through the centre of the drying chamber. The furnace is fired by coconut husks, firewood or charcoal. Fish are placed on wire trays positioned either side of the central chimney.

Figure 19

Mud and Pole Smoking Kiln (Clucas, I.)

Designed as a development of the oil drum smoker, the mud and pole kiln is constructed from locally available materials such as bamboo sticks, leaves and mud. There is a separate firebox delivering heat into the smoking chamber via an underground flue or smoke pipe.

Figure 20

Oil Drum Smoker

Cylindrical ovens made by joining two opened oil drums are used by artisanal processors. A stoke hole is cut at the base of the oven in which a fire is made. A perforated metal sheet can be inserted inside the drum just above the fire to act as a smoke spreader. Trays are suspended towards the top of the drum to hold the fish.

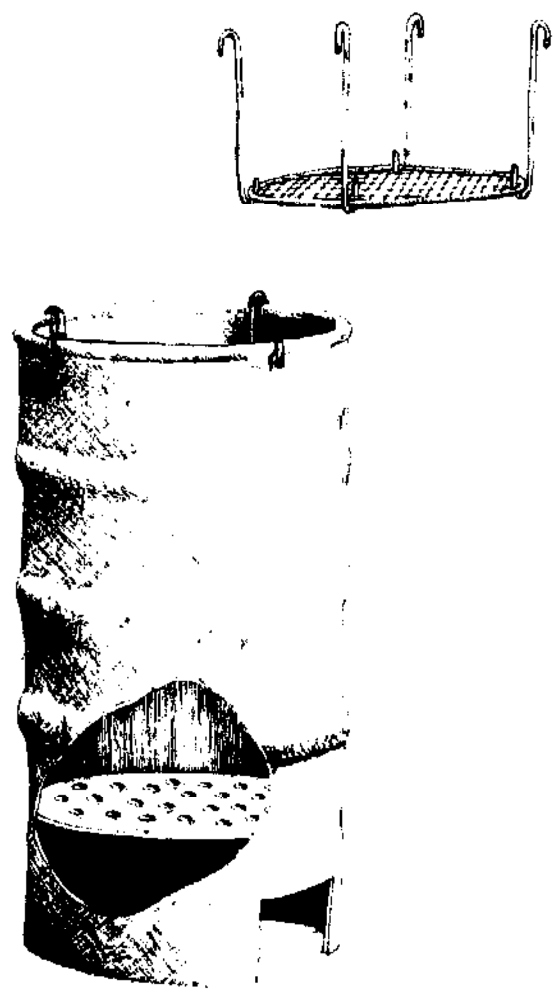


Figure 21

Watanabe Drum Smoker

This smoker is constructed from an oil drum, much like the one in Figure 20, except that there is a separate enclosed fire box and connecting pipe for better control over the smoking process.

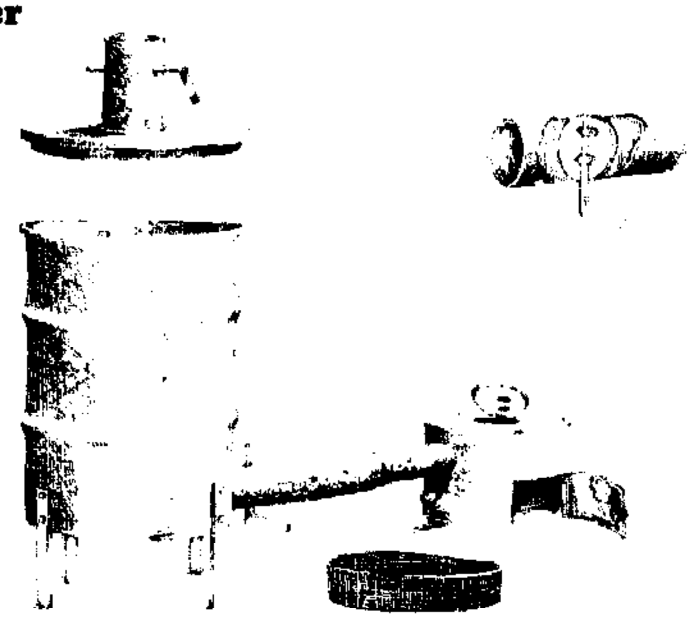


Figure 22

Altona-Type Oven

The simple version of an Altona oven consists of a brick or cement fire box located below a smoking chamber made of metal. The fish are placed on trays which slide into the smoking chamber. Many other versions of this kiln have been constructed using less expensive materials such as mud or fired bricks instead of metal. A more complex design built of cement known as the Rogers Kiln, was introduced into Uganda. However, with both the Altona type and the Rogers Kilns the initial cost of construction makes them unaffordable for artisans. Although the Rogers Kiln was still being used in Uganda some time after its introduction, the fish processors had not built any other ones themselves.

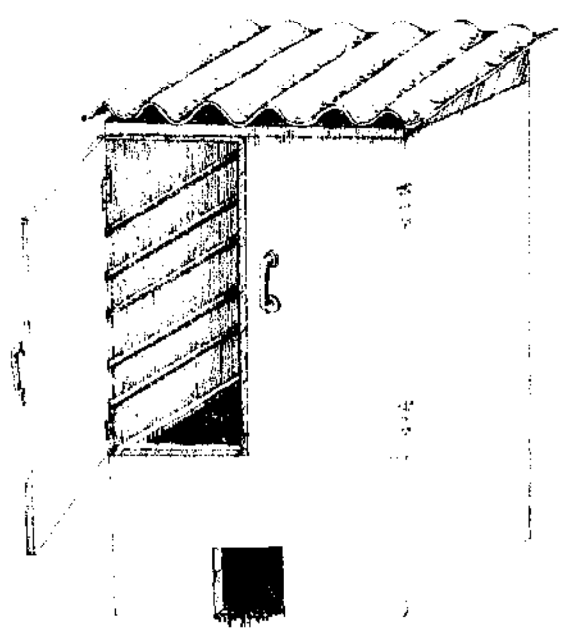
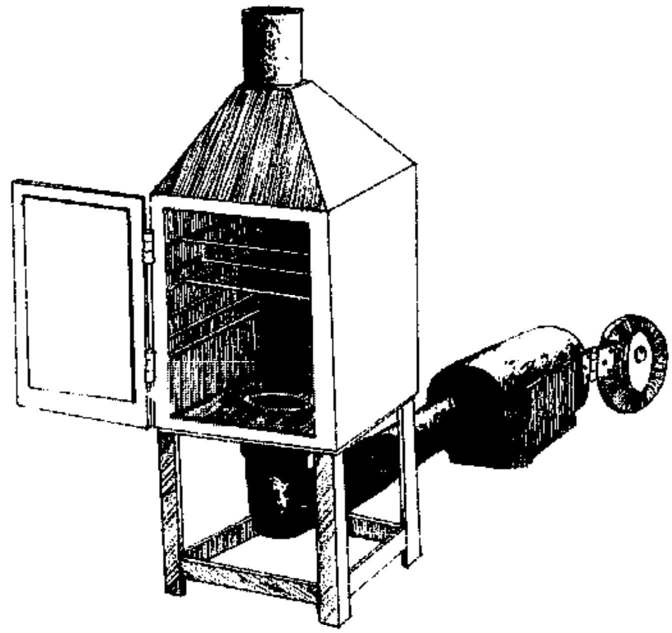


Figure 23

Adjetey Oven



The Adjetey oven was designed in Ghana to overcome two main problems of the traditional cylindrical oven: an increased holding capacity for fish and greater control over the fire. The oven is made of iron and consists of a stand, a smoking chamber and a fire box. The oven is fired indirectly and a metal tube connects the fire box to the smoking chamber. The oven is rectangular with an inverted conical top providing a vent at the top, equipped with a simple damper to regulate air flow.

Figure 24

Ivory Coast Kiln

First introduced into the Ivory Coast, this smoker can be made easily from locally available materials. The trays of fish are stacked on top of a base made from sheet metal (flattened oil drum) or asbestos roofing sheet. A fire box and a smoke spreader are enclosed in the base.

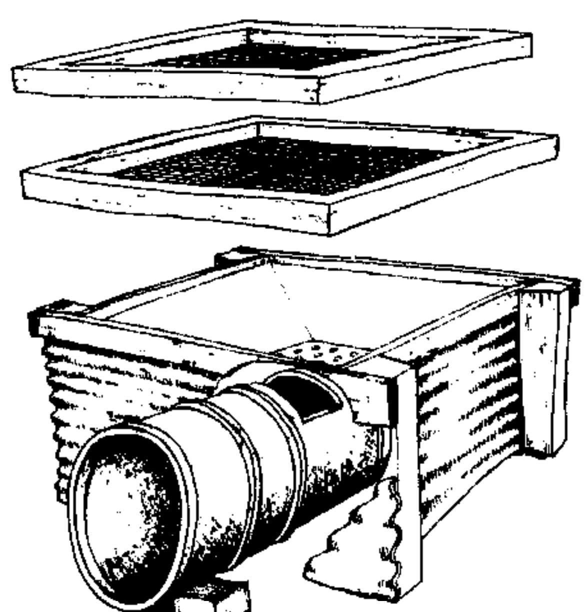


Figure 25

Chorkor Smoker

Originally designed in Ghana to resemble the traditional rectangular smoking kilns, the Chorkor smoker contains two stoke holes along one of its sides. Wooden trays fitted with wire mesh are stacked on top of the rectangular base and can be alternated during smoking.

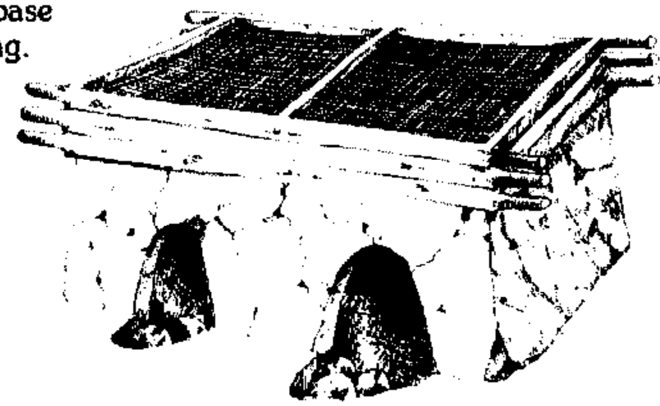
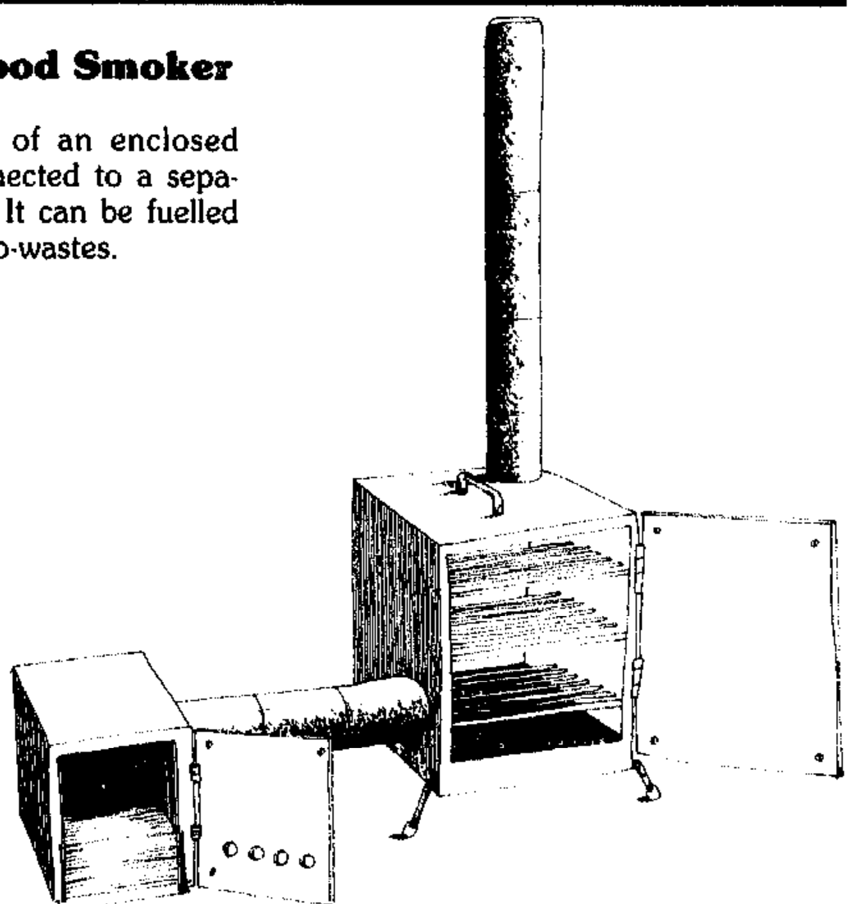


Figure 26

Innes-Walker Food Smoker

This smoker consists of an enclosed smoking chamber connected to a separate enclosed fire box. It can be fuelled by locally available agro-wastes.



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CONTACTS

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ITDG
Intermediate Technology Development Group, Myson House, Railway Terrace, Rugby CV21 3HT, U.K.

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University of Science and Technology
Faculty of Agriculture, Department of Engineering, UST, Kumasi, Ghana

Innes Walker (Food Smokers)
Midton of Fulwood, Stewarto, Ayrshire, KA 5JZ, U.K.

School of Food Studies, Humberside College of Higher Education, Nuns Corner Grimsby DN34 5BQ, U.K.

FPRD
(Food Production and Rural Development Division), Commonwealth Secretariat, Malborough House, Pall Mall, London, U.K.

FAO
Food and Agriculture Organisation of the United Nations, Fishery Industries Division, Via Delle Terme Di Caracalla, 00100 Rome, Italy.

UPLB
University of the Philippines in Los Baños, Laguna, Republic of the Philippines.

University of the Philippines in The Visayas Diliman, Quezon City, Republic of the Philippines.

FRI
Food Research Institute, P.O. Box M20, Accra, Ghana.

IRRI
International Rice Research Institute, P.O. Box 933, Manila, Philippines.

RIFT
Research Institute for Fishery Technology, Jalan K. D. Tuban, P.O. Box 30, Palmerah, Jakarta, Indonesia.

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Department of Food Science and Technology, P.O. Box 1 Kensington NSW 2033, Australia.

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