9310003/62

PN-AAM-912
ISN-27434

Good reference article!

Postharvest Food Losses in Developing Countries

Prepared under Contract AID/csd-2584,
Task Order No. 23

Board on Science and Technology
for International Development
Commission on International Relations
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C.
1978

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This report has been prepared by an ad hoc advisory panel of the Board on Science and Technology for International Development, Commission on International Relations, National Research Council, for the Office of Agriculture, Bureau for Development Support, Agency for International Development, Washington, D.C., under Contract No. AID/csd-2584, Task Order No. 23.

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

Chapter 6

Postharvest Losses of Fish

Postharvest loss in the production of fish[11] is unique among the staples examined in this study. For no other class of food is there both so much evidence of serious loss at every stage from harvest to consumption and so little precise knowledge of the overall proportion of losses to the potential harvest or to the fish finally consumed.

In this discussion of postharvest fish losses, attention is focused particularly on artisanal fisheries which are small scale, poor, dispersed, and unorganized.

The following aspects of fishing and fish consumption are not considered:

- Commercial fisheries carried out by large vessels on the high seas;
- Fish meal and fish oil industries; and
- Fish caught but not consumed as a result of religious or ethnic preferences or taboos.

These excluded areas, although of great importance in terms of losses, are not central to the focus of this study. Previously, we have said that nonutilization or underutilization of commodities not recognized as acceptable food is not loss. However, for fish we need an expanded definition of postharvest food loss that includes, among other things, non-use of edible species.

[11] In this study "fish" is used for all aquatic animal produce.

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Specifically, postharvest losses of fish should include fish discarded at sea as by-catch in the harvest of other species, such as shrimp; this seems justified not only because the by-catch frequently represents a multiple in weight of the principal--and economically more valuable--harvest, but also because the discarded harvest often contains a large proportion of locally acceptable food fish, because the loss could be identified, and because research and development could be applied to reduce this loss.

By extension, the loss definition should include food fish that is locally unutilized or underutilized for any reason except for religious or ritual grounds, again not only because this potential food is quantitatively identifiable, but also because an effort should be made to determine by research special handling and preservation requirements that might exist for these species.

Because fish harvesting differs in many ways from the land harvests of the other food commodities in this study, an overview of fishing and fish consumption will be helpful as a prelude to further discussion of postharvest fish losses.

General Aspects of Fish Harvest and Consumption

Fisheries

Fisheries (as opposed to fish farming) involve the greater proportion of worldwide fishing activities, and those on the high seas represent probably the most dangerous and demanding of food-providing occupations.

Although there are significant regional differences, preference on shore and in the market place in most developing countries is for whole fish. Under the usually prevailing primitive conditions of preservation and distribution, only small harvests can be rapidly disposed of. As a result, most ocean fishing in developing countries is carried out by fleets of many small fishing boats

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skippered by individualistic, competitive captains, each acting according to his own lights and laws, trying to make the best living he can.

The fishing trade is doubly hazardous: once because of the dangers inherent in harvesting, and then, because of the perishability of a commodity whose consumers demand that it be fresh. It requires a great deal of perseverance and capital to weather the vicissitudes of fish supply and demand. The fishermen who sell their catch to tradespeople--who in turn operate on the open market--have since time immemorial had to use all the tricks of the trade to avoid being left with large amounts of unsold and inedible catch. The special vulnerability that has forced many fishermen and fish-traders to resort to sharp practice in selling their goods has led fishtrading to be placed, in many countries, at the very bottom of the hierarchy of desirable professions.

Consumption

Of the 20-25,000 species of fish known to exist in salt and fresh waters, only a few dozen species are utilized at present on any large scale, though more are probably used on a small scale in specific locations.

Experience with toxic species or those traditionally believed to be poisonous has compelled consumers, especially in warm climates, to demand that fish remain whole to permit identification of species and inspection for freshness. It has also generated local traditions that only particular fish species are acceptable for human consumption; species that are desirable in one place may for a number of reasons be quite unacceptable in others.

In 1976, of the worldwide catch of about 70 million tons of fish--in the general sense of food of aquatic origin--about 35 percent was used for the manufacture of feed material for animals (almost all used in developed countries); about 40 percent was consumed "in the round" fresh or frozen, 10-15 percent was

dried and cured; although in some developing countries consumption of cured fish is disproportionately higher; and 8-10 percent was canned, with the rest being used in miscellaneous ways. Here again, regional variations in the forms in which the fish is consumed cannot be overemphasized. Fermented fish products, such as those in Southeast Asia, for instance, are locally consumed in very large quantities and should be studied much more intensively to determine their nutritional contribution to consumers' diets. If unutilized or underutilized species such as capelin, krill, squid, and other major groups of aquatic animals could economically be harvested, processed, distributed, and marketed, the total aquatic food resources would be increased by as much as tenfold.

James (1977) summarizes the information regarding the costs of expanding existing fisheries to meet the demand, particularly in developing countries. He points out that the investment in equipment, manpower, and technical development required simply to double production from the present level would be of the order of $30 billion, or about $500 per additional tonne.

Importance as Food

All available evidence indicates that fish has been used as human food since long before recorded history. At present fish provides about 17 percent of the world's animal protein intake (Table 6:1).

Fish is unique insofar as it is the only universal staple that inhabits a medium potentially hostile and dangerous to man. This seems to have endowed it with attributes and powers more varied, colorful, and deeply engrained than those associated with perhaps any other food. The need to select nontoxic species from the harvest and to devise methods to avoid spoilage has provoked strict preference and avoidance patterns, with the development of severe criteria for safety and precise eating habits and taboos.

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About 60 percent of the world's edible fish catch goes directly to consumers in the round, reflecting their desire to inspect the raw fish carefully for freshness. In countries where Japanese and other Far Eastern fish sausages and sauces are unknown, the only fish products in which the original identity is not preserved are products similar to fish sticks and gefilte fish, but these represent only a very small proportion of fish consumed.

TABLE 6:1

ESTIMATED WORLD VEGETABLE AND ANIMAL PROTEIN PRODUCTION, 1975[1]

Protein Source	Amount of Protein (Million Tonnes Per Year)		
	Available to Man	Fed to Livestock	Total
Cereals	57	38	95
Legumes	24	6	30
Other Vegetables	5	1	6
Livestock	30	3	33
Fish[2]	6	3	9

[1]From Pimentel et al. (1975).

[2]Fish includes all seafoods harvested from the ocean and for 1975 is estimated at 66 million tonnes (based on FAO figures) that contain an estimated 14 percent protein. A reduction from 17.5 to 14 percent in total fish protein is included for cleaning the fish consumed by man. An estimated 33 percent of the fish harvest is fed to livestock.

Fish thus represent close to 17 percent of man's direct animal protein intake; in certain regions they make up the bulk of a nation's animal protein fare.

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It is noteworthy that in spite of the wide availability of fish resources, the recognized nutritional value of fish, and the important economic contributions that fisheries have made everywhere, fish is still largely consumed as in was ancient times and with the exception of canning and mechanical refrigerated freezing no basic technological advances have been made in its preservation. These observations are significant in that they do not apply to the consumption or preservation of any other staple food and reflect the general, long-term, stubbornness of the consumer intent on dealing with fish in a special way. This pervasive attitude continues to influence the nature of the fishing, fish processing, and fish marketing industries. It also affects the possibility of estimating postharvest losses in developing countries since fish spoil rapidly and are mainly preserved by drying (with or without salting and smoking.)

As fishery resources available to the subsistence fisherman are very limited because of these attitudes, and in many cases they are exploited at or above their maximum potential, it is therefore essential to make better use of what is landed and to preserve its economic value.

Postharvest Losses

FAO estimates for fisheries in some countries place fish losses among the highest for all commodities. There are very few documented studies to support this; one carried out on Lake Chad indicates that fish losses there may be as high as 50 percent.

James (1977) roughly estimated losses of dried fish due to insect infestation at 3 million tonnes per year (25 percent of 12 million tonnes produced); discarded edible by-catch from shrimping alone at 5 million tonnes (5 times the total shrimp catch); and due to spoilage at 2 million tonnes (i.e. 10 percent estimated spoilage loss of the 46 million tonnes used for direct human consumption, of which 20 million tonnes is estimated to be consumed fresh).

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These rough conservative approximations give a loss figure of 10 million tonnes a year--20 percent of the total catch now going to direct human consumption.

These figures are highly speculative, since there are no reliable data for any developing country on either postharvest losses or the unregistered harvests caught by unchartered and uncontrolled individual fishermen. In general, however, it seems clear and can easily be documented that:

- Serious postharvest food losses begin immediately after harvest on board ship because of the lack of means to preserve the catch until landed;
- Important losses are caused by enzymatic spoilage and insect infestation as the catch is landed, is processed on the beach, and awaits transportation to market; and
- Further heavy losses are caused by primitive methods of handling, preservation, transportation, and exposure at market.

Moreover, the entire marine fisheries industry in developing countries is so fractionated by local customs and cultures, and is controlled by so many individual entrepreneurs from harvest to the consumer, that losses occur simply as a consequence of frequent handling and transfer of the variously processed food from one middleman to another. It seems, therefore, fair to say that no reliable figures for overall postharvest losses are available at present for any one region.

The committee recommends that, in view of the present situation and since loss assessment must be an integral part of loss reduction intervention, efforts should be concentrated on a) initiating a number of specific projects, particularly in Southeast Asia to assess losses in relation to local socioeconomic conditions; b) to understand the technological and social organization of artisanal fisheries in different regions; and c) to improve the handling and processing techniques in those stages where the most important losses occur and

where the greatest loss reductions can be achieved--preservation on board boat, drying, transportation, and marketing.

Despite the difficulty in establishing global or even regional loss figures, there is probably merit in developing methods for loss measurement, or at least informed estimates in specific fisheries or geographic areas. Some concrete figures, even if used only as examples, would help persuade governments to commit funds for prevention. Selected studies in Southeast Asia and Africa may well strengthen the case for intervention.

Food losses in the artisanal fisheries industry are related to the various steps of the postharvest system as it leads from the initial catch to the consumer's table.

Fresh Fish

The extent of postharvest losses on board the fishing vessel is unknown, but is likely to be considerable because of spoilage due to lack of refrigeration; actual losses are camouflaged, however, because even stale or spoiling raw fish is processed. This results in economic loss, since the price for the fresh and poor-quality dried product is often the same per unit weight, while the fresh fish is five times the weight of its dried equivalent.

Traditionally Processed Fish

Major losses occur with traditionally processed products, particularly with smoke-dried and dried or salted-and-dried fish. Although these are very different products that are often specific to a region, it is possible to refer to them are as <u>dried products</u>.

Drying

The simplest, and most widely used, technique for preserving fish is sun drying, in which the landed fish are spread on the beach or on a mat and allowed to dry in the sun.

The wet fish are subject to attack by blowflies, mainly Chrysomyia spp., whose larvae burrow into the fish and cause damage and spoilage. Apart from physical damage to the fish and the enhanced spoilage, the blowflies are a dangerous carrier of pathogenic organisms particularly since the beaches they infest are widely contaminated with human feces as a result of limited public sanitation facilities.

Dried fish is also subject to attack by Dermestes beetles. If this infestation is allowed to proceed, the beetles consume the fish.

A wide range of other insect pests and mites attack drying and dried fish.

Salting

Preliminary salting is often used to enhance the quality and acceptability of naturally dried fish. Salting either by stacking the split fish with dry salt between the layers or, preferably, by immersing the fish in brine, speeds up the removal of water from the flesh and reduces the time necessary for air or sun drying. In the case of oily fish such as sardines, prolonged drying leads to discoloration and rancidity; a 15-minute immersion in saturated brine may reduce drying time by half. Waterman (1976) reports that presalted dried fish kept in fair condition for 6 months, while unsalted controls were rotten or moldy.

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Salting is also a chemical method of bacterial and insect control. Flies will not attack fish that has been brined before drying, and the rate of attack by beetles is inversely proportional to salt concentration (James, 1977). One of the most difficult problems with salted dried fish is to control reabsorption of moisture from humid atmospheres after processing. For this purpose, proper packaging is required.

Smoking and Smoke Drying

Smoke drying is widely used in Africa for a variety of foodstuffs, many of which spend some time suspended over cooking fires as a means of deterring insect infestation. In the Lake Chad area, fish may be partially dried in the sun and then covered with grass or papyrus, which is set on fire and the fish scorched and charred to form a hard, protective outer surface. Some fish may be smoked over a grid or fire, or simple kilns may be employed.

These methods, however, offer little protection against insects and may result in additional loss from charring and burning. The insect pests lay their eggs in the flesh before and during drying. During smoking of thick-bodied fish, they are deterred by the heat and smoke, but the larvae already present penetrate the deeper parts of the fish where the heat and smoke cannot reach. Products attacked by insects range from those with high water content and a storage life of 1-2 days to hard-dried products with shelf lives of several months.

A certain amount of spoilage results from storage of improperly processed products, which causes direct losses. Improved quality-control procedures and market incentives will alleviate these losses. Traditional processing may be responsible for a loss of nutritional value as high as 15 percent (Hoffman et al, 1977).

Storage and Distribution

After losses to insects, the most important physical and economic losses result from crumbling during storage and distribution. Poorly dried fish is a fragile product that, if roughly handled or vibrated on overloaded trucks on poor roads, will crumble to a powder. Prior insect attack weakens the structure and can result in a mixture of pieces and a powder of fish and insect frass. With poor packaging, there can be direct physical losses and, although fish powder also has a market, there are always economic losses. Inadequate protection is recognized as an area in need of study

Strategies for Loss Reduction

With an industry as fractionated, little-organized, independent, and subsistence-oriented as capture fisheries in a developing country, the obstacles that must be overcome to bring about change are enormous. To effect social change, there are basic requirements of cultural and economic appropriateness, political compatibility, and sound promise of economic or other benefits that must be met. Cooperation with members of the food-fishing industry--the men and women who harvest, process, sell, buy, preserve, store, package, transport, and purchase fish in the marketplace--involves the same basic considerations as cooperation with those who deal with and consume the farm commodities discussed in this study. Requirements for successful intervention in a traditional postharvest system, adapted here to the fishing industry, include:

- A communication link between the fishing people and the rest of the community;
- Incentives for loss-reduction efforts;
- Government support;

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- Knowledge of locality-specific social and cultural patterns; and
- Knowledge of locality-specific preference for, and avoidance of, certain fish species.

In the case of fish, locality-specific patterns and preferences are especially important. All suggested postharvest conservation strategies must be appropriate--that is, must fit into the system technologically, culturally, and socially. For example, the idea of comminuting fresh fish with cereals or tubers in simple meat-grinding machines to manufacture inexpensive "intermediate moisture products" (which are stable because of the low moisture content of the product) should only be proposed if such fish-cereal mixtures are known and accepted by the community in question.

There are also, of course, unique characteristics of the fishing industry that must be considered in planning for reduction of postharvest loss. For example, in an industry that consists typically of one-man operations with very small boats, it is essential that appropriate scale not be overlooked in the design of conservation technology. Other problems which must be considered include the small space available on a fishing boat, the large number of boats, and the small batch sizes of fish that must be processed and protected after they are landed at dispersed coastal locations.

The rest of this chapter deals with specific characteristics of the fishing industry as they relate to postharvest food losses: the locations at which intervention may be most effective in reducing loss; new technologies; and training and organization.

As in grain and perishable losses, the initial step in planning loss reduction is to pinpoint stages at which intervention appears to be needed and promises to yield substantial benefits.

Aboard Ship

The most effective intervention at the immediate postharvest stage is improvement of storage conditions to reduce deterioration of fish prior to landing. However, each situation must be looked at separately for cost effectiveness, and many potential improvements may be beyond the resources of the artisanal fisherman. There is need for research and development in this area. Low-cost cooling devices would be particularly helpful and, though ice would be better, even seawater cooled by several degrees can greatly retard spoilage of certain species.

On Shore

Insect infestation of wet fish with Chrysomyia (blowflies) followed on dried fish by Dermestes (beetles) cause losses that are measurable (though with difficulty), but these vary so much from one area to another or from season to season that accurate measurement is difficult and expensive. As an example, in the rainy season in Malawi losses due to blowfly larvae varied from 2 percent to 40 percent (Meynell, 1978). These losses can be significantly reduced by dipping boxes of small fish in an inexpensive insect-repellent solution.

A variety of technologies, old and new, have been developed to improve on simple sun drying to reduce blowfly and beetle infestation. These methods are discussed in an FAO publication "The Production of Dried Fish" (Waterman, 1976), see Note VI-1.

It should be stressed that the following techniques should be considered in the context of local circumstances and that introduction of these technologies to new or different areas are likely to require adaptive research and development. Waterman's treatment of the principles of drying

is highly recommended to anyone interested in acquiring a detailed basic knowledge of the subject.

Preparation of the Fish

In preparing simple, naturally dried fish products, with or without supplementary salting or smoking, the basic preparation and hygiene of the conditions with which the fish is handled are crucial to the quality of the final dried product.

Although drying is often seen as an alternative for unsold fresh fish, and although the characteristic flavor of dried fish may to some degree mask the flavor of stale raw fish, poor quality fresh fish makes poor quality dried fish. To the extent that the fish can be cleaned thoroughly and, if possible, chilled before drying, the better the product and the less likely the occurrence of losses.

Drying, Salting, and Smoking

Once drying has been decided upon, the first step is to keep insects away from the fish and reduce the drying time by raising the fish off the ground. Simple racks constructed from local materials work very well. It is also desirable to be prepared to cover the drying fish in case of rain (as an alternative to moving them under cover from the racks), and plastic sheet is cheap, effective, and generally available. In Zambia and in West Africa, this kind of drying fresh-water sardines is combined with a period of drying in a smoking oven. Salting is also used to speed up the drying and preserving process. The availability at reasonable cost of plentiful, good quality salt is an important aspect both of technology and of government policy directly related to conservation.

New designs of smoking oven have been developed by a number of workers and are slowly being introduced (see, for example, Clucas, 1977).

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The strong-tasting smoke-dried product is popular and in demand and will probably continue to be competitive with fresh and frozen fish products. A disadvantage in many countries is the increasing scarcity and cost of wood and charcoal, although the new oven designs are much more efficient than the traditional ones.

Solar Heating

Heat treatment of fish to kill insects and their larvae and eggs is well established. In Bangladesh, Doe (1977) using a simple solar dryer constructed in the form of a tent from polyethylene plastic sheet and sticks killed all stages of blowfly in 20 hours at 45°C. The temperature was achieved with clear plastic facing the sun, black plastic behind; vents were provided at top and bottom.

Chemical Control of Tropical Insect Infestations

The literature contains a number of suggested chemical treatments for both short- and long-term infestation. However, it stresses at the same time the inherent limitations of the technology imposed by the potential hazard to the consumer. There is as yet no chemical means of control of insects that may be recommended and applied on a commercial scale without this health hazard. Cautious use of chemical control is vital in developing countries where different insecticides are produced, transported, distributed, and used by many people who have little knowledge of their hazards. Moreover, there is a lack of coordination between scientists working on experimental control and health authorities, so that work to improve the safety of certain compounds may be academic because of a ban on their use.

The use of contact insecticides should be considered only as a last resort, where:

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° No other means of coping with the pest infestation is as practical or economic;

° The techniques employed are simple and foolproof; and

° The treatment uses insecticides of low mammalian toxicity at dosage rates that leave residues within FAO/WHO tolerance limits.

Some examples are given in Note VI-2.

Systems that include insecticides generally call for a combination of physical methods (drying racks, etc.) with chemical, using insecticides to control insects by treating fish containers or places where fish is handled rather than the fish itself. These techniques, used in a w , that minimizes potential contact of the fish with residues, should be used with physical methods wherever possible before resorting to direct contact methods.

More research is needed and new products of low toxicity must be developed before direct treatment with insecticides can play a more important role in insect control in fish. The focus should be on the extension of effective and safe methods to the producers. Dried fish production is generally carried out by small, widely scattered, and conservative groups who would be reluctant to adopt new methods even if trained extension agents were available to convey them. Aggregation of production through centralized collection and processing by large-scale mechanical dryers requires high capital investment, and the standardized product may not have market appeal.

Refrigeration and Ice

Because of the expressed preference for whole, fresh fish, there is major interest in using refrigeration and ice to extend storage life. With ice, tropical species (i.e., those actually living in warmer water,

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rather than those living in cold water in tropical regions) generally keep longer, on average, than cold water species. Shelf lives up to 45 days have been recorded for some species, and 20-30 days is common. This probably results from the effect of the greater temperature difference between ice and warm-water fish on spoilage microorganisms and tissue enzymes.

There appears to be little if any advantage in deheading and gutting tropical species for cold or chill handling. The further handling creates additional hazard, and the intact fish is commonly preferred in the local market.

With a number of exceptions, apart from a small percentage of urban markets the use of refrigeration is still limited, although it is expected to increase (James and Krone, 1976). Where refrigeration does exist, postharvest losses associated with refrigerated storage and transportation are likely to be so minor compared with other postharvest losses that they can be overlooked here. An excellent account of the use of refrigeration technology for fish preservation can be found in the FAO report Ice in Fisheries (1974).

Solar- and wind-powered cooling and ice-making equipment is still relatively young. Research in this, as in other aspects of renewable energy source utilization, should be encouraged. Application of renewable energy to the particular needs of developing countries should also be encouraged, perhaps through cooperative research and development projects at a regional level between universities and governmental organizations in developed and developing countries.

New Technologies

Recent developments for preserving fish as fish silage, fish cheese, and low-salt fermented fish (using added cereal "ragi" in Southeast Asia)

are discussed in the proceedings of a conference organized by the Tropical Products Institute in London in 1976 (Tropical Products Institute, 1977).

Traditionally, fermented fish has been widely used in Southeast Asia as nuoc-mam, but its high salt content has limited its use, particularly by young children, as a source of protein in the diet. The development of low-salt fermented fish offers the possibility of extending the protein supply wherever this variety of marine product--one in which the source species is unidentified--is acceptable.

New Methods of Drying

Drying racks, improved smoke-drying ovens, and design and introduction of better solar driers can contribute to loss prevention.

Training and Organization

Extension links are weak throughout the third world, although extension services exist on paper in many countries. It is vital to demonstrate to young, developing-country men and women that technical extension can be a rewarding career. Many of the solutions to postharvest loss can come from extension work, particularly that resulting from socially oriented research projects with women. In some areas, particularly in Africa, women are the economic power in the fish business and extension work is unlikely to succeed unless this is recognized and women extension officers trained. Osuji (1976) makes the following points about the need for extension in the dried-fish industry, for instance:

Extension services are necessary in order to increase the awareness on the part of fishmongers as well as consumers of the considerable economic and nutritional losses incurred through insect damage. Such campaigns would attempt to destroy the traditional belief in most places that the beetles are part and parcel of the dried fish, or that "dried fish must have beetles." Attention should be drawn to the fact that beetle infestation is not spontaneously generated within the fish. Infestation can, on the contrary, be prevented or reduced to a minimum by the application of simple measures including better sanitation and the inexpensive modification of existing techniques.

The principle loss of value to the fisherman for his fresh fish results from inability to hold fish in the expectation of better markets. Containerized chill stores, supplied with ice from central locations, can be established reasonably cheaply. These can be used to test the economic feasibility and acceptance by the fishermen before permanent (e.g., ferrocement) stores are built. Community storage can also be organized for dried fish--making adequate disinfestation and protection possible.

Marketing and Infrastructure

Fishermen, because of the nature of their trade, are particularly vulnerable to pressures exerted by middlemen who often exploit the situation. However, experience has shown that it is dangerous for external assistance to be directed to supplanting the middleman or woman. The general improvement of social and economic conditions of the community as

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a whole is important to create larger and more prosperous markets for fish and fish products.

The adoption of new technologies through extension programs is bound to be unsatisfactory unless there is also provision for improvement of the infrastructure. Economically feasible projects successfully implemented on a small or local scale need to be multiplied by substantial investments. These investments are also required to improve the general quality of rural village life. They include provision of port and landing facilities, fish marketing and storage, water supply with improved sanitation and sewage disposal. Upgrading road or water transport can also substantially reduce postharvest losses.

Each of these areas--technology, extension, and infrastructure--contains a critical maintenance component to which both governments and technical assistance agencies should be particularly sensitive as this is generally the weakest part of improved technology applied to economic development.

Chapter 6

Notes

Note VI-1.

As Waterman points out:

> There are hundreds of different dried fish products in the world, and a great number of ways of making them. Some of the products are highly prized, some are tolerably pleasant, while others are barely acceptable except as an alternative to starvation. The intention here is not to persuade producers of dried fish to make standard products; the raw material, the climatic conditions and the markets are all so different in different regions that uniformity is neither possible nor desirable.

Furthermore:

> Of the many accounts of regional methods on record, it is unfortunate that all too often the essential details are missing that make all the difference between haphazard procedure dependent largely on luck, and a controlled reproducible method. This is rarely the fault of the recorder; in all probability the process times and temperature, brine strength, water content and other factors have never been measured, let alone set down on paper.

Note VI-2.

For wet fish, short immersion in pyrethrum solution (0.125 percent w/v) with 1.25 percent w/v piperonyl butoxide has been recommended for short-term fly control prior to drying (McLellan, 1963). This was not effective against dermestids, which requires a further immersion of the dried fish in a water emulsion containing 0.018 percent w/v pyrethrins and 0.036 percent w/v piperonyl butoxide. Provided the fish was properly dried before and drained after treatment, it did not become too moist for storage nor unacceptable to consumers (Proctor, 1972 and 1977). This method of control is reported to be effective for 8-12 weeks. Recent work in Malawi (Meynell, 1978) has shown that dipping or spraying boxes of fish with a solution of pyrethrum (0.02 percent) synergized by piperonyl butoxide (0.04 percent) reduced losses from blowfly by 10 percent at a cost of 0.1¢ per pound.

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Chapter 6

Recommended Reading

It is difficult to suggest background reading material solely related to postharvest fish conservation. The interested reader is advised to peruse publications in the wider field of handling, processing, and distribution of fish. From these it is possible to identify problem areas where losses are apparent and, in many cases, where means of prevention are defined. A recent FAO bibliography extracts the major monographs and journal articles in the postharvest area.

A number of the FAO technical papers and reports listed below are readily available and should be consulted.

However, the most concise and recent materials are the Proceedings of the Conference on Handling, Processing, and Marketing of Tropical Fish (Tropical Products Institute, 1977), and the forthcoming Proceedings of the Symposium on Fish Utilization, Technology, and Marketing in the IPFC Region, Manila, Philippines, 8-11 March 1978.

FAO. 1974. Ice in fisheries. FAO Fisheries Report No. 59, Revision 1. Food and Agriculture Organization of the United Nations, Rome. 57 pp.

_____. 1977. Freezing in fisheries. FAO Fisheries Technical Paper No. 167. Food and Agriculture Organization of the United Nations, Rome.

_____. 1977. Selected publications on the technology of fish utilization and marketing. In English, French, and Spanish. FAO Fisheries Circular No. 136, Revision 1. Food and Agriculture Organization of the United Nations, Rome. 57 pp.

TPI. 1977. Proceedings of the Conference on the Handling, Processing, and Marketing of Tropical Fish. Tropical Products Institute, Ministry of Overseas Development, London, July 5-9, 1976. 511 pp.

Waterman, J.J. 1976. The production of dried fish. FAO Fisheries Technical Paper No. 160. Food and Agriculture Organization of the United Nations, Rome. 52 pp.

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