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UNDERSTANDING FISH PRESERVATION AND PROCESSING

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PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Bill Jackson as editor, Suzanne Brooks handling typesetting and layout, and Margaret Crouch as project manager.

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VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers.

UNDERSTANDING FISH PRESERVATION AND PROCESSING

by Volunteer Richard T. Carruthers

I. INTRODUCTION

The purpose of processing and preserving fish is to get fish to an ultimate consumer in good, usable condition. The steps necessary to accomplish this begin before the fishing expedition starts, and do not end until the fish is eaten or processed into oil, meal, or a feed. Fish begins to spoil as soon as it is caught, perhaps even before it is taken out of the water. Therefore, the key to delivering a high quality product is close attention to small details throughout the entire process of preparation, catching, landing, handling, storage, and transport.

Fish that becomes spoiled or putrid is obviously unusable. Fish that is poorly cared for may not be so obviously bad, but it loses value because of off-flavors, mushy texture, or bad color that discourage a potential purchaser from buying. If customers have bought one bad fish, they probably won't buy another. On the other hand, if you consisitently deliver good quality at a fair price, people will become loyal customers.

Spoilage proceeds as a series of complex enzymatic bacterial and chemical changes that begin when the fish is netted or hooked. This process begins as soon as the fish dies. The rate of spoilage is accelerated in warm climates. The fish's gut is a rich source of enzymes that allow the living fish to digest its food. Once the fish is dead, these enzymes begin digesting the stomach itself. Eventually the enzymes migrate into the fish flesh and digest it too. This is why the fish becomes soft and the smell of the fish becomes more noticeable.

There are countless bacteria naturally present on the skin of the fish, in the gills, and in the intestines. Normally, these bacteria are not harmful to a living fish. Shortly after death, however, they begin to multiply, and after two to four days they ingest the flesh of even a well-iced fish as enzymatic digestion begins to soften it. The bacterial load carried by a fish depends on its health, its environment, and on the way it was caught. Healthy fish, from clean water, will keep better than fish dragged along the bottom of a dirty pond in a trawl net.

Both enzymatic digestion and bacterial decomposition involve

chemical changes that cause the familiar odors of spoilage. Oxygen also reacts chemically with oil to cause rancid odors and taste. The aim of fish processing and preservation is to slow down or prevent this enzymatic, bacterial, and chemical deterioration, and to maintain the fish flesh in a condition as near as possible to that of fresh fish.

Whenever fish must be kept for several hours or longer before being consumed, they must be treated in some way to prevent spoiling. These are the basic means for preserving fish:

o Cooling and icing

o Salting and pickling

o Pastes and sauces

o Canning and bottling

o Air drying and smoking

o Kiln drying

The basic task of every fishery is to get the catch to the consumer in good, usable condition. The first fish caught were probably eaten raw, on the spot. Communities grew up near enough to productive fishing grounds so the fish could be consumed the day it was caught. The earliest preserved fish was probably accidentally overcooked, and some observant fisherman saw that

dry cooked fish kept for a period of time without spoiling. Traditionally, air drying, salting, and smoking (or some combination of these three) preserved fish for the short periods required by the fishermen. Fish preserved in these ways is often tough and stringy, the quantities produced are small, and success is uncertain. Few people will eat fish preserved this way, if they have an alternative. Over time, other, better methods of preservation came into being.

II. VARIATIONS AND ALTERNATIVES

Before fishing begins, make sure that all equipment is clean. If a sterilizing rinse is available, use it to clean both the tools and the place where the fish will be processed. Make a clean, cool place to put the freshly caught fish. At the least, shield the fish from direct sun, and use wet cloths spread over the fish for evaporative cooling, which in addition will prevent it from drying out.

Fishermen sometimes tend to get careless and rushed about how fish are handled at the catching stage. But care taken at that point will pay off handsomely at the market. Insofar as possible, handle the fish gently. Bring them aboard carefully without banging them against things, walking on them, or dropping them. If you use any sort of pugh or fork, be careful to stick the fish in some unusable part (like the head).

Fish waiting to be processed should not be walked on. Batches of fish should proceed through the handling process without being

mixed up with fish from another batch. The fish should be washed at once with plenty of clean water. It isn't easy to wash fish. The wash water should be directed away from the fish in such a way as not to contaminate previously washed fish. Large fish can be handled separately, but quantities of smaller fish, expecially flat fish, need some sort of rotating washer for a really good job. You are trying to reduce the bacteria load by washing away the slime. Tossing a bucket of water over a pile of fish is not a substitute for a thorough washing. Many later problems, in any of the processes to be described, can be avoided by keeping the fish clean and cool in the early stages.

Cooling and Icing

The first and simplest method to both preserve and process fish is to keep it cool. Cool fish keeps longer than uncooled fish, although both will spoil in a matter of hours.

If the market is only a few hours away, and if the fish will be sold promptly, evaporative cooling might suffice. All that is required is some coarse cloth--enough to completely cover the fish--and enough water to keeps the cloth damp. The movement of air over the water causes it to evaporate, and thus keeps the fish much cooler and fresher than fish directly exposed. Wrap the fish completely in the cloth. Any portion that is exposed to the air will dry and become warm enough to support the rapid growth of bacteria. Splash water on the wrapped fish, keeping the cloth wet but not soaked. How well this will work depends on too many variables to predict, but it is a distinct improvement over

uncovered fish.

Most fish caught are preserved with ice at some stage in their processing. Trained taste panels are usually unable to distinguish well-iced fish kept less than six or seven days from fresh fish, and storage life can be extended somewhat if antibiotics are added to the ice. Ice works in two ways: it reduces the growth rate of bacteria by reducing the temperature of the fish; and it also washes the bacteria and slime away as it melts. Because of this, it is important to keep melt water drained away from the fish.

Fish are usually gutted and stowed mixed with ice. Small flat fish are stowed without gutting. An active fish like salmon is gutted and the belly cavity is packed with ice as it is stowed. Fish can be iced in bulk, in large quantities, or they can be boxed. Boxing produces a better quality product for several reasons: the bottom fish are not crushed by the weight of the fish on top; and the melt water is better able to drain away. In addition, it seems to be human nature to take better care of a small box than of a pile of fish.

Ice is expensive and begins to melt immediately, so the fishermen are faced with a loss before they even begin. The temptation to get away with as little ice as possible must be avoided. Within limits, the more ice the better. The box should be lined with ice so the fish does not touch sides or bottom of the box. Layer the fish, avoiding overlaps, and ice each layer as it is boxed. If the catch is large enough that the boxes must be stacked, try to

channel the melt water away from the bottom boxes. Keeping the boxes covered with wet cloth will dramatically increase the life of the ice.

There is a wide range of icemakers on the market, ranging from small flake ice machines that produce a couple of tons a day to huge machines that make many tons. They all require electricity and a certain level of technical expertise to operate. The newer machines are built with the small operator in mind, however, and are practically unbreakable. With these machines, it is possible for small operators to make their own ice.

Salting and Pickling

Salting and pickling, along with various kinds of drying, are the traditional methods for preserving fish. Indeed, Egyptian tomb paintings illustrate fish being prepared for salting and drying, and the process must be many years older than that.

The bacteria that spoil fish need moisture to grow. If the moisture in the fish can be reduced to about 25 percent of its normal level, bacterial activity will cease. Some bacteria are killed at these levels, while others simply go dormant. The fish will keep for several years as long as the moisture level is not allowed to increase beyond 25 percent. Salt replaces a portion of the water naturally present in the fish, and so reduces the moisture content below the point where bacterial spoilage can occur.

The several salting methods vary mainly in the amount of salt the

fish are allowed to take up. "Dry salting" is used to preserve non-fatty fish such as cod. The split fish are completely buried in salt, and the brine liquid that emerges is allowed to drain away. The fish are finally dried. In the "pickling" process, used for fattier fish such as herring, the fish are packed in salt in airtight containers. Bacterial decay is reduced or prevented when the salt has replaced enough of the moisture in the fish to inhibit the growth of fish spoilage bacteria.

A combination of coarse grained salt (like rock salt) and a fine grained salt is used. The coarse grains keep the fish separated so as to drain, and the fine grains dissolve quickly into the flesh of the the fish. Salt may be mined from prehistoric deposits, manufactured from partly concentrated brines, or "manufactured" by solar evaporation of shallow ponds of salt water. Any of these may be available to you, as well as salt that is produced expressly for use in salting fish.

Some of the flavor of the finished product depends on the kind of salt used. Impurities in the salt, such as magnesium or calcium, if present at too high a level, impart a bitter taste to the final product; these impurities also interfere with the absorption of salt into the fish. Some common impurities readily reabsorb moisture from the air, so if the curing salt contains enough of these compounds the fish will become damp again and grow bacteria. On the other hand, small amounts of these same impurities give the salted fish a whiter appearance that is more attractive to some consumers. For all these reasons, it is important to know what kinds of salt you are using, and what their

effects will be.

The fish to be salted are cleaned, and the guts and gills and sometimes heads are removed. Larger fish must be split so they can be opened up and laid flat in the salt. In general, a layer of salt is placed in the bottom of a container and a single layer of fish is placed on it, flesh side down. The first layer of fish is then covered with more salt and another layer of fish is added. The layers of smaller fish like herring are crisscrossed. The process is continue until the container is full.

The same cautions as to cleanliness and care in handling apply. Avoid reintroducing a bacterial load. Use clean processing equipment and keep the work area clean. Keep guts and offal away from the processed fish and dispose of it in an area removed from the cleaning area and water supply.

If drying is the ultimate goal, the water that is withdrawn from the fish by the action of the salt is allowed to run off, and the fish are restacked at frequent intervals, rotating the fish from the top to the bottom of the pile to equalize the cure. The fish can remain stacked for several months in a cool climate before being dried, but this is not possible in termperate countries. Fish can be air dried in Norway or Iceland, but in most areas some sort of dryer is generally required.

If the fish is to be pickled, it is packed in the same way, in a container that can be sealed. As the fish shrink, the barrels are consolidated, putting fish from the same day's catch together.

After about ten days, half of the replaced water is drained off, the container is packed full again with fish from the same batch, and the spaces between the fish are filled with the water that was drained off earlier. The container is then sealed and stored.

Salting is a simple process. It does not require much equipment or manpower, but the product has a limited life unless it receives some sort of additional processing such as canning or freezing. Drying, which is explained in the following section, is an alternative to freezing.

Air Drying and Smoking

Even the most heavily salted fish will begin to spoil after a few weeks at warm temperatures. Some additional processing is required to preserve fish in any but the coldest climates. Moreover, although salt alone will protect against the growth of some bacteria, salt-loving bacteria continue to flourish. A combination of salt and reduced moisture, or salt and no air, will allow fish to be kept for several years. Bacterial activity ceases when the moisture content is reduced below about 25 percent. Mold will no longer grow at a moisture level of about 15 percent. Fish dried to this level will last several years if not subsequently moistened.

Air drying and kiln drying reduce the moisture content of fish to the point where bacterial action ceases. Smoking dries the fish, and also adds bacteriacides that are present in the smoke. The process varies from a mild cure that will keep several weeks if

chilled, to a hard smoke that will keep indefinitely if not moistened.

Fish preserved by air drying tends to be tough and stringy. Most people will not eat fish preserved this way unless they must. If the weather is dry, fish may be air dried. Take care to keep the fish in shade, exposed to breeze. Keep flies and insects away! Air drying of fish is an uncertain undertaking. Since it requires a low relative humidity to achieve the necessary degree of dryness, the fish will keep only so long as it is kept dry. On the other hand, it requires a minimum of equipment and no technology. It is primarily suitable for small quantities for personal use. With a minimum of investment solar dryers can be constructed for the drying of fish. Solar dryers made from plastic on a wooden frame eliminate contamination by insects and can increase ambient temperature to accelerate drying. They also reduce storage of fish when rain storms interfere with sun drying.

Kiln or tunnel drying of fish is a more complex process, and the final product is much more palatable than natural air dried fish. It requires careful control of many variables, such as relative humidity, air temperature and velocity, and rate of drying. The product will have to be stored in some sort of cold storage because it also will draw moisture and putrify. In kiln drying, the fish is hung on racks in a tunnel. Dry inlet air is heated, circulated through the tunnel, reheated, and recirculated. A portion of the moisture laden air is vented off and replaced with outside air. Control of the humidity inside the kiln can be

accomplished by venting off more or less of the moisture laden air from the kiln. Midway through the process the kiln is unloaded and the position of the fish is reversed to equalize the drying rate.

With technology that could be easily adapted to other areas, women in the coastal regions of Ghana have built up thriving businesses in smoked fish. With the help of the United Nations Food and Agriculture Organization and UNICEF the women have designed fuel efficient smokers that allow processing of fairly large amounts of fish at a time. The smoked fish are packed into large baskets and taken to markets as far as a day's drive inland. The method the women use produces a very palatable product that can be eaten as is, by people working in the fields all day for example, or made into tasty soups and stews. It can also be made into meal to serve as a high protein weaning food or additive to other dishes.

Fish Sauces and Pastes

In areas where a rice diet predominates, a number of fermented fish products have been developed. If a fairly fixed procedure is followed, the product has a more or less consistent flavor and texture. In areas in which dried or salted fish is impractical because of the high humidity and temperature, fermented sauces or pastes may be an acceptable or preferable alternative.

Small, ungutted fish are mixed with salt (four to five parts salt to six parts fish) and sealed in vats or pots. In a process that

requires several months, the fish dissolves and ferments. The result is a clear "pickle" with good keeping properties that is used as a condiment for flavoring rice dishes. Fresh or salt water fish can be used, as well as shrimp. The processes vary as widely as the kinds of fish used. The somewhat standardized Nuocmam has been studied extensively and is representative of most of the Southeast Asia products.

Fish paste is made from cleaned fish, which is mixed with salt (one part salt to three parts fish) and allowed to digest. Sometimes fermented rice, roasted grains, or bran are added. The manufacturing methods are complicated and vary considerably from area to area. As a result, the product is seldom standardized. Tastes vary from area to area, so local knowledge is imperative.

Bottling and Canning

The bottling and canning of fish requires more precision and expense than the aforementioned methods of preservation. Many nations during their lean fishing seasons import large amounts of canned fish to supply a source of protein. In such a case, perhaps domestic canning is a viable option.

The canning or bottling of fish requires a high quality product at the onset. It should not be employed as a last resort for unsold fish. Consumption of such fish may cause severe illness. Bottled fish is usually prepared for personal consumption. The bottled fish is usually cooked, boned, and put in a pickling solution, then stored in sterilized jars with rubber sealed lids.

Canning, on the other hand, entails placing the fish in a tin can with a lid, removing the air within the can through heat treatment, sealing the lid entirely, and then heating a second time to a specified degree.

The two most important considerations of this method are the availability and expense of the cans or bottles and strict quality control of the product.

Other Methods of Preservation

There are several other methods of preserving fish, most of them requiring sophisticated technologies that are probably not applicable in this context. It is, however, worth mentioning them briefly: Freeze drying involves the use of a vacuum to draw water out of the fish. Irradiation can be used to kill the microorganisms in the fish; however, this technology is still experimental. Another method of preserving fish, pouch technology, is advanced but may be usable in some locations.

There is a level at which the best information is available from the manufacturer of the processing equipment; if you are interested in these advanced preserving techniques, the job becomes one of choosing a reputable local agent.

III. DESIGNING THE SYSTEM RIGHT FOR YOU

The systems described range from very simple to very complex,

from cheap to costly, and so forth. In making your decision about which to use, study each method carefully. Contact equipment manufacturers, talk to specialists, read books and magazines. Ask for help from organizations like VITA or your local fisheries agents.

Use locally available materials wherever possible. They will probably be less expensive and will do as good a job or better. The trick is to achieve the desired outcome with as little outlay as possible. To do this you must focus on what you are trying to accomplish, rather than the method someone might suggest. For instance, petrol tins would serve as "fish boxes" if they were thoroughly cleaned and kept insulated in some way--a woven basket would do as well or better than a plastic box. Many naturally and locally available materials will keep sun off fish. Locally available salt may make a more acceptable product than that which you purchase.

Economies of scale make the cost of processing less per unit as volume increases. Suppose one person, who must be paid for a day's work, can butcher 100 or 1,000 fish in a day. It would be better to try to maintain your volume at 1,000 fish a day than at 100. On the other hand, 1,001 fish would exceed that one person's capacity, and so require hiring another person. Lowest unit production costs occur at multiples of 1,000 fish. Generally, you should always consider the volume you can sell in relation to the volume you can economically process, and try to keep the two in balance. Overloading your capacity always results in higher unit costs and lost or ruined product.

The classic error that novice manufacturers make is to imagine what is called a "ghost market," a market that only exists in the mind of the manufacturer. The manufacturer focuses on the product and imagines that everyone will want to buy it. They won't. Some successful enterprises do start big and keep getting bigger, but most start small and grow slowly, step by step, cementing each step as they go.

The most effective way to research a market is to try to sell to it on a small scale. Choose a neighborhood or small area that is representative of the whole market you want to reach, and see if the people in it will try your product. Then see if they want more, enough to absorb your entire production. Suppose there are 100 people in the area you have chosen, and 20 of these are willing to try your product. Of the 20 who tried the product, five indicated they wanted more. If your whole potential market is a city of 10,000 people, you could expect that 2,000 would try your product and 500 would repeat their purchase. If 500 people will make your enterprise successful, you have created a business. You have every right to expect that your customers will tell their friends that you make a good, usable, consistent product, and business will increase. If 500 customers is not enough to make your business a success, and if you are sure your product is a good one, then you must decide if you can afford to lose some money while you wait for your customers to tell their friends.

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