Processing Fish: Nigeria

Summary

Artisanal fishing in Africa, historically dominated by fishermen in canoes and boats who set out to sea from small coastal fishing villages in search of bonga, sardinella and other pelagic fish, has provided a nutritious source of food often cheaper than meat. **As** a result, fish has been consumed by large portions of the population and has become a diet staple.

Today, however, some African fisheries, including the bonga ***(Ethmalosa fimbriata),*** which is widely harvested and eaten by west Africans, suffer from periods of excess harvest or glut, particularly during the peak season between November and May. Because most fishing communities do not have ice-storage facilities, the daily catch is either sold fresh or smoke-dried before it spoils. Traditional ovens and kilns, with low-batch capacities and long smoke-drying times, are no match for the heavy landings of bonga and other fish that occur during the peak season. Furthermore, traditional ovens and kilns produce fish of uneven quality; use fuel inefficiently; and often pose work-related health risks (the absence of chimneys or smoke barriers creates dangerous levels of smoke, which is inhaled by the laborers who rotate the fish).

With these long-standing problems serving as a backdrop, in 1989 the African Regional Centre for Technology *(ARCT),* in collaboration with the Nigerian Institute for Oceanography and Marine Research, launched its fish kiln project. The project focused on:

- Socic–economic studies of fishing communities.
- Strategies that drew on existing knowledge and resources in fishing communities as a prerequisite for developing appropriate and acceptable new technologies.
- Efforts to improve equipment, especially through the construction of a pilot demonstration unit.
- Local training to advance the use and management of the technology.
- Demonstrations of the technology in rural areas and at trade fairs.
- Continual assessments of the project's impact.

Advances in the design and operation of fish kilns have had a lasting impact on the communities' harvests and marketing of fish. The industry, which is dominated by women, has become more efficient, especially during the peak season when, historically, many fish have spoiled before they could be consumed or processed. The following are some of the technical highlights of the project.

- Use of reflectors as an integral part of the design has helped to distribute the heat generated within the kiln more evenly. **As** a result, drying and smoking now take place without the danger and drudgery associated with constantly rotating the fish — a nec-

essary practice in traditional kilns.

- The heat distribution mechanism created by the reflectors can be adapted to other kilns to improve their performance. Such adaptability will help ensure widespread distribution of the new design.
- The kilns are designed to be built in segments. This allows processors to fit the size of the oven to the size of the catch, thus saving labor, time and money.
- Construction of chimneys not only minimizes smoke inhalation but conserves energy by ensuring a more intense fire.

Most importantly, the redesigned kiln has shortened drying times from some 30 to three hours.

Such startling improvements have been achieved through the use of appropriate technologies that rely on the existing resources of fishing communities. Rapid distribution of the kilns, among both firms and families, has not only increased worker safety but curbed the adverse environmental impacts associated with fish processing. In particular, the industry's impact on deforestation, a major problem along the west coast of Africa, has been reduced thanks to the greater energy efficiencies of the new technologies.

Background and Justification

Smoke-drying is one of the most common preservation methods used by fish processors. Such drying has often taken place in round mud or extended-drum ovens (crested by joining two open-ended drum ovens), or even on galvanized iron sheets supported by planks.

Each of these technologies comes with significant drawbacks. For example, although extended-drum ovens are simple to construct, workers must be present all the time to rotate the fish and monitor the flames' intensity to ensure that the drying of the fish takes place evenly. Because smoke-drying in traditional ovens may take up to 30 hours, monitoring can prove a formidable task. Meanwhile, mud ovens, although cheaper to construct and more fuel-efficient, also fail to dry the fish evenly. Moreover, mud ovens are cumbersome — and potentially dangerous — to operate because workers must labor over *an* open fire to rotate and remove the fish. Galvanized iron sheets, on the other hand, are both inefficient and fragile. And the thick tar deposits that they often leave on fish reduce their quality and value.

Despite the problems inherent in all traditional smoke-drying technologies — from lengthy drying periods to low capacities to poor quality to inefficient energy use — local and regional fish smokers have continually rejected improved kiln designs introduced by national and international agencies. What accounts for this reaction? Without exception, the designs have failed to consider critical socio-economic and cultural factors. For example, some of the designs proved to be too expensive; others were too complicated to operate or repair; and still others altered the appearance and taste of the smoked fish in ways that did not

conform to traditional community expectations or tastes.

Small-scale fisheries in Africa, in general, and western Africa, in particular, play a vital role in fish production and are therefore responsible for supplying a large number of people with affordable high-quality animal protein. Fisheries also offer stable employment in communities where jobs are often scarce. And they serve as the foundation for a way of life that has enabled many coastal communities in western Africa to enjoy both a rich heritage and a distinct identity.

Yet, the fishing industry, despite its importance, suffers from enormous post-harvest losses, which are estimated at 35 to 40 percent of landed weight. These losses often have a profound adverse impact on fishing communities in general and rural women in particular, whose status and income often depend on post-harvest activities.

Smoke-drying is one of the most common and popular methods for preserving and/or adding value to the fish harvest. At its simplest level, fish are placed in open pits containing smouldering grasses or wood. Such drying methods char the fish, which diminishes their flavour and shortens their shelf-life. Along the west coast of Africa, fish may also be laid on racks set in an old drum or mud oven, a practice particularly common in Nigeria. Although such traditional ovens are cheap to build, they carry many drawbacks, including:

- Need for constant attention to control the fire and turn the fish to ensure even drying.
- Serious health and fire **risks.**
- Little or no control over the temperature of the fire and density of the smoke.
- Poor product quality owing to uneven cooking that chars the outside flesh but often leaves the inside of the fish under-cooked.
- Inefficient energy use and high levels of air pollution caused by charring and poor ventilation systems.

Moreover, more advanced kiln designs, which both Nigerian governmental agencies and international aid organizations made available to fishing companies and families during the 1970s and 1980s, failed to have much impact on the nation's small- and medium-scale fish processing industry despite the advances in technology that were inherent in these new designs.

Why did communities turn their backs on equipment that would likely boost their income and make their work safer and more efficient?

First, the newly designed kilns cost too much. Second, they seemed to produce a product that tasted substantially different from fish smoked in more traditional kilns. Most importantly, however, the designs were developed without the involvement of the end users, many of whom were women continuing the trade of their mothers and grandmothers. Failure to tap this deep rooted local and regional knowledge made it seem as if these new designs were being imposed from the outside. More importantly, it meant that the designs were not sensitive to critical cultural and social forces within fish-processing communities — fac-

tors that would ultimately determine whether the technology was accepted or rejected.

In light of this failure, a new project was launched in 1989 by *ARCT* in collaboration with the Nigerian Institute for Oceanography and Marine Research (NIOMR). The objective was to design new kilns that would minimize the drawbacks of traditional models yet be affordable and cultural acceptable.

Through their new fish kiln designs, researchers sought to address one of the most significant shortcomings of traditional designs; the constant rotation of fish on trays to ensure even drying. They accomplished this goal through the introduction of reflectors that, in effect, recycled what had previously been waste heat. By capturing this heat, these new "reflective"designs were more efficient, safer and required less attention from fish processors. The ovens, moreover, were designed to be built in segments, which enabled processors to erect their kilns near the catch, and then dismantle and clean them easily. That, in turn, has made their work safer and more efficient. At the same time, segmented kilns have allowed processors to heat a small section of the oven when there is only a small batch of fish to smoke. With traditional designs, they had to heat the entire oven regardless of the size of the batch. Such improvements have not only saved time but have raised the levels of energy efficiency.

As mentioned earlier, researchers had not only to address key technical issues in terms of design but they also had to devise strategies that would encourage local communities and individuals to accept the new designs once they were completed. The unacceptability of previous kilns, despite the technical advances they offered, taught researchers a valuable lesson: Proven laboratory advances in technology are not enough if you hope to introduce new equipment and procedures that people and communities will embrace and use. For these reasons, researchers were attentive to design features that:

- Gave processors increased control over the smoke-drying process in ways that would enhance the quality of the product. In other words, the process was designed not only to lengthen the shelf-liie of the fish but to improve the taste.
- Relied on local materials so that the processors could easily replicate the kilns.
- Reduced drudgery so that workers would feel that the technology carried direct personal benefits that went beyond greater efficiency.
- Paid strict attention to reducing fire and health hazards.

Description

In many rural fishing communities, the infrastructure for post-harvest processing and preservation of fish, especially during peak fishing seasons, is inadequate. As a result, losses reach 40 percent of total catch by weight. Such losses not only have a detrimental impact on the socio-economic life of fishing communities but reduce the amount of animal protein available to large segments of the population. Because

fish are a diet staple throughout much of the developing world, such losses have direct impacts on the nutrition of millions of people.

One prime method of fish preservation — smoke-drying fish in traditional kilns — has proved to be inefficient in several ways. Traditional kilns provide uneven heat, consume vast amounts of wood, and pose health and safety risks for workers. Perhaps most importantly, with capacities of less than 30 kilograms and lengthy drying periods that extend beyond hours into days, traditional kilns often cannot keep pace with the catch, especially during the peak harvest season.

Several efforts to improve the designs of kilns, spearheaded by national and international agencies, have met with little or no success. They either failed to take account of the socio-economic and cultural backgrounds of the users or were designed in ways that could not **be** adapted to traditional ovens. As a result, fish processors ignored them.

Between 1989 and 1993, *ARCT* and NIOMR jointly developed a fish smoking kiln that addressed many of the problems associated with the traditional ovens.

The effort began with discussions with members of coastal fishing communities in Nigeria, followed by comprehensive socio-economics studies. Information and data gathered from the discussions and surveys formed the basis of a conceptual design for a new fish smoking kiln. This design sought to increase batch capacity from 30 kilograms to 90 kilograms, reduce drying time from days to hours, eliminate the need to rotate the fish, and lower the levels of smoke emitted into the atmosphere. Equal attention was paid to the kiln's form and function. The goal was *to* create a product that potential users would welcome and not find strange.

Once a design was agreed upon, researchers built and then demonstrated the new kiln. Demonstrations took place in a fishing village designated by NIOMR for just that purpose. The kiln, in effect, was brought to the community instead of the community being brought to the kiln. Again, the concept was to make potential users feel as comfortable as possible with the new technologies that were being offered.

Beyond the demonstration activities, several training sessions were developed on the use, maintenance and repair of the kiln. These sessions were designed to provide processors with the knowledge and skills they would need to ensure that "their" kiln had a long and useful life.

The kiln's technical profile is as follows:

- Batch capacity: up to 90 kilograms depending on model.
- Batch process time: three to four hours.
- Operating temperature: 60° to 150° C.
- Overall ground size: 1.4 square meters.
- Height excluding cover: 1 to *2* meters.
- Number of compartments: two.
- Maximum number of trays: *six.*

The project resulted in a new kiln that combines the merits of traditional kilns with improvements devised by scientists,

technologists and fish processors. On a more general level, the project has increased the technological capacities of the institutions and individuals who are involved.

Publications

- NIOM/ARCT (1990). ***Report on the Phases; Pilot and Demonstration Unit for Fish Processing Equipment.***
- ***Proceedings of the Workshop on Pilot and Demonstration Unit for Fish Smoke-Drying Equipment,*** organized by NIOMR in collaboration with ARCT 24-27 May 1994.
- Promotion of Women in the Use of Food/Energy Technologies: Training Workshop organized by NIOMR and ARCT using the fish smoking kiln, 1997.

Patenting and Commercialization

Following several training and demonstration sessions, the design was patented on 29 October 1993 under Patents Decree No. 60 of 1970 of the Federal Republic of Nigeria. Since 1993, about 20 of these fish smoking kilns have been manufactured and sold. Several additional requests are now under consideration.

Partnerships

In pursuing this innovation, partnerships were forged mostly with the public sector, notably NIOMR the Federal College of Fisheries and Marine Technology; Lagos State Fisheries Department; and the Federal Ministry of Science and Technology Raw Materials Research and Development Council in Nigeria. To advance the commercialization process, partnerships were also initiated with the private sector — for example, NOVA Technology, Shell and Basic Finance and Commerce Ltd, all of which are based in Nigeria.

At the outset of the project, partnerships were forged with the United Nations Development Programme (UNDP), which was a major project sponsor, and United Nations Economic Commission for Africa (UNECA), which served as the project's administrative agency. No partnerships have yet been arranged with other countries, but project operators would welcome such initiatives, particularly with African nations.

Replicability

This innovative experience may prove relevant to other developing countries, especially those in which fisheries still play an important role as a prime source of nutritional and economic well-being. When it comes to fisheries, countries along the west coast of Africa all face similar situations. In most cases, women have long been involved in the smoking or drying of fish. And mud or extended-drum ovens, or traditional smoking platforms, historically, have served as the most popular means of smoking fish.

Project researchers sought to draw on the merits of traditional ovens while introducing new technologies and procedures that would make smoke-drying operations more efficient and productive and less burdensome and hazardous. Moreover, the raw materials used in the construction of the kiln, including wood, iron, bricks and

aluminum, can be found in countries throughout the region, which should help the new technology achieve widespread distribution.

So, what are the policy implications that may be drawn from this experience?

- Fish processors should have easy access to credit and low-interest loans. Such access is particularly critical for women who often make up a majority of the fish smokers in communities throughout western Africa. Project researchers discovered that commercial banks often prefer to lend money to groups — a practice that could impede the ability of individual women to obtain the capital they need to purchase the newly designed kilns.
- Fish processors should be able to move freely from one country to another to familiarize themselves with the new technologies and to receive the necessary training to ensure that equipment is operated at optimal levels of efficiency. By the same token, fish kiln design and manufacturing companies must be able to display their wares across national boundaries. Freedom of travel will help ensure that processors are exposed to the best equipment and most advanced training at the lowest prices.

lessons learned

Researchers faced a host of obstacles that were cultural, socic-economic and technological in nature.

Culturally, project researchers had to recognize that in western Africa women play a dominant role in most post-harvest fish activities. The knowledge and skills they possess have been passed down through generations and should not be ignored. At the same time, it had to be acknowledged that the popular mud oven was cheap to build and that all of the materials used in its construction came from local sources. The construction of the kilns, moreover, was done by the women themselves. Previous efforts which failed to account for these economic and cultural factors were doomed to failure. Project operators were determined not to make the same mistakes.

That's why project researchers worked hard to discover why earlier redesigned kilns, despite their superior properties, had met such stiff resistance. One factor that had to be addressed head-on was the communities' deep-seated "attitude of rejection" towards innovation. For this reason, researchers decided to live and work with members of the fishing community for extended periods. During this time, they gathered extensive information ranging from the work habits of processors to the taste preferences of local residents. They also tried to uncover the circumstances under which processors might be willing to invest in new technologies.

While working on more general community issues, project researchers also discovered that they had to convince men in the communities that the enhanced earnings enjoyed by women who used these more efficient and effective tech-

nologies would be good for their families and the whole community. Another critical issue that demanded quick and constant attention was how to lower the social and cultural barriers between researchers and residents. Building confidence and mutual respect may have been the most important prerequisite for the project's success.

Once the intangible bonds between the researchers and residents were firmly established, it was important to provide demonstrations of the benefits inherent in the technologies that were being offered. This required:

- Undertaking practical trials that compared the new existing technologies with existing technologies.
- Devising a strategy by which processors, not outside researchers, were responsible for conducting and assessing these trials. Similarly, processors were given responsibility for overall evaluations of the technologies in terms of batch capacities; product quality; taste, texture and appearance preferences; energy efficiency; and convenience of use.

After a number of practical sessions, trainiig sessions for additional participants were organized in which women fish processors served as the demonstrators and, in effect, trainers. The technology was also exhibited at several national trade fairs. During the fairs, fish smoked in the newly designed kilns were offered to those in attendance, who were asked to voice their opinions and assessments.

Impact

This innovative experience, which drew upon disciplines ranging from engineering to food and material science to economics, proved both rewarding and satisfying for all those involved. Institutions learned to work together for the mutual goals of advancing knowledge and transferring technology from classrooms and laboratories to local rural fishing communities. The "traditional" knowledge of fish processors added new dimensions to the thinking of scientists, engineers and technologists involved in the project. Such interactions helped improve the design of the kiln and make it more acceptable to processors.

Sustainable development, as defined by the World Commission of Environment and Development (WCED), is development that "meets the needs of the present without compromising the ability of future generations to meet their needs." Concerns over sustainability and development in developing countries, in general, and Africa, in particular, have focused on environmental deterioration — for example, deforestation and desertification — largely caused by pressures imposed by poverty, unemployment and population growth. That's the bad news. The good news is that many observers — from both the scientific community and the general public — believe that humans now have the capacity, through applications of innovative science and technology, to halt and even reverse such environmental damage.

The improvements made in the design of the fish kilns created an oven that is more

efficient and requires less fuelwood than its earlier counterparts. Furthermore, the new design can also use gas as a source of energy. All of this means that fewer trees will be felled to process fish in the future, a trend that will have a positive impact on the environment and, more generally, on efforts to devise systems that promote long-term environmental sustainability without undermining short-term activities to improve the economic and social well-being of people.

This innovative experience is sustainable for many reasons. It evolved through close collaboration between researchers and residents and, as a result, led to strategies that combined research findings with more practical, on-the-ground experience. The strategy, moreover, was designed to encourage the community to contribute its time, resources and energy to the effort. This not only allowed people to offer their ideas but it also gave them a sense of ownership in the project's success. The community, in fact, "bought into" the project and displayed an enthusiasm and commitment that the researchers could never have matched on their own. Through a series of training sessions on the use of the new equipment, a network of "smoking kiln associates"or advocates has emerged. The project's growing success has led the Family Economic Advancement Programme (FEAP) of Nigeria to choose it as one of a few that will be cited throughout the nation not only for its direct contribution to the fish processing industry but for its innovative methods of administration and management.

Future Plans

Plans to improve and expand the project are under way. For example, research efforts have been launched to finetune the design to fit particular needs in terms of capacity and available energy sources (such as charcoal or gas). Furthermore, research will be conduced to improve the heat retention capacity of the kiln. This work will be done in collaboration with the Federal Ministry of Science and Technology Raw Materials Research Development Council of Nigeria.

As for expanding the project, *ARCT* is currently managing two major subregional food- and energy-related projects that use the kiln as one element in a broader range of activities. These projects involve several countries in western Africa, including Ghana, Nigeria, Sierra Leone, Benin and Senegal. Two major project objectives are to determine the appropriate socio-economic and technical conditions for establishing small- and medium-scale agro-food enterprises and to promote the use of technology among women working in the food and energy sectors.

In addition, contacts have been made with potential investors and programs are being developed aimed at disseminating information about the **kiln** as widely as possible. Finally, results of this innovative experience will be shared with organizations and countries through publications, training workshops and joint research initiatives.

Profile of Implementing Institution

The African Regional Centre for Technolo-

gy (ARCT) is an inter-governmental institution launched in 1977 (operations began three years later) under the aegis of the United Nations Economic Commission for Africa (UNECA) and the Organization of African Unity (OAU). Broadly stated, ARCT objectives are to:

- Enhance regional technological capabilities.
- Assist in the formulation and implementation of technology policies.
- Disseminate information concerning applications of mature technologies for sustainable development.

Within the framework of these objectives, *ARCT's* research efforts focus on such key issues as agricultural commodities, energy supplies and information technologies.

ARCT's most noteworthy scientific achievements relate to breakthroughs in the post-harvest processing of two food commodities of critical importance to Africa - cassava and palm-oil.

Cassava ***(Manihot esculenta crantz)*** is both a major source of food and a vital source of energy for millions of people living in humid and sub-humid Africa. Cassava's ability to be cultivated under many different farming systems (shifting cultivation, rotational fallow and intercropping), combined with its multiple uses, have made it an indispensable commodity in efforts to advance food security throughout Africa. But cassava's value to society is always at risk because it is highly perishable. In fact, cassava often begins to deteriorate only one or two days after harvest.

For all these reasons, efforts to process cassava into more stable and storable forms carries great importance. Scientists and technologists working on lengthening cassava's storage life have also sought to reduce the toxicity sometimes associated with its processing, create products more convenient to prepare and increase the available options for its use and consumption.

Gari — fermented, roasted and granulated cassava — is the most important cassava product in such African countries as Ghana, Nigeria, Benin, Togo and Cameroon. Despite gari's widespread use, technologists have identified several problems related to traditional processing methods.

In a joint project with Ghana's Council for Scientific and Industrial Research's (CSIR), the Food Research Institute (FRI) and the Industrial Research Institute (IRI), ARCT has devised new processes and designed new equipment that have eliminated some of these processing problems and minimized others. This research ultimately led to the construction of a pilot demonstration unit in Ghana for processing cassava not only into high-quality gari but into flour and starch. (For a more detailed description of *ARCT's* efforts to improve the processing of cassava, see Cassava to Gari).

Palm-oil, a product of the oil palm ***(Elaeis guineensis Jacq)***, is a critical part of the diet of many west Africans. In addition to its widespread use as a cooking fat, it is a rich source of beta carotene, a precursor of vitamin A.

Processing palm fruits into palm-oil involves several steps, including sterilization, threshing, milling, pressing and sepa-

rating the palm-oil from the water (the latter process is sometimes referred as clarification). Traditional processing methods used by small-scale producers are lengthy, laborious and unhygienic. Moreover, these methods often produce oil that contains more than 3 percent high free fatty acid and 1 percent water. Such percentages mean that the processed oil can easily turn rancid. That, in turn, causes oil to have a short shelf-liie.

In collaboration with Guinea's University of Conakry and Senegal's Rural Expansion Centre, ***ARCT*** established a pilot demonstration unit in the Casamance region in southern Senegal. The unit, which relies on both new equipment and new processes, not only improves the quality of palm-oil by reducing its free fatty acid and water contents, but eliminates some of the drudgery associated with traditional processing methods. As an added bonus, by-products and effluents are recovered and converted into biogas and fertilizer, which minimizes the adverse environmental impacts of palm-oil production.□

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Implementation Period five years

costs:

Government (NIOMR)	US$26,950
Foreign sources	US$65,000
Total	**US$91,950**