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Projectleader: Dr.ir. G.A. Kleter

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Control and prevention of contamination and spoilage in the traditional production of smoked fish in Ghana

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G.A. Kleter

Business Unit Safety and Health
Cluster Databases, Risk Assessment and Supply Chain Management

RIKILT - Institute of Food Safety
Bornsesteeg 45, 6708 PD Wageningen, The Netherlands
P.O. Box 230, 6700 AE Wageningen, The Netherlands
Tel. +31 317-475400
Fax. +31 317-417717
Internet: www.rikilt.wur.nl

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MAILING LIST

EXTERNAL:

Dr. G.T.P. Ruivenkamp, Wageningen University, Netherlands

G. Frempong, MSc, STEPRI, Ghana

M. Ottah Atikpo, scientist, FRI, Ghana

Prof.dr. P.L. Howard, Wageningen University, Netherlands

Dr.ir. M.J.J. Kotterman, RIVO, Netherlands

Ir. C.H.J. Aalberts, RIVO, Netherlands

Ir. M.A.A. Heselmans, scientific reporter, Netherlands

Ir. I. Dijkslag, teacher, Netherlands

Mrs. M.A. Cortellino, FAO Photo Library, Italy

Dr.ir. M.H. Thijssen, IAC, Netherlands

Ir. W. Schoustra, Ministry of Agriculture, Nature and Food Quality, Netherlands

Participants Tailor Made Biotechnologies (TMBT)-RIKILT debate, May 22, 2003

Scholars TMBT-IAC course, May-June 2004

TMBT-Wageningen UR contact group

ABSTRACT

There are various food safety issues related to the traditional production of smoked fish in Ghana, especially with regard to the safety requirements of importing nations. These issues include mercury and histamine contamination, smoke and microbiological safety. This paper discusses the methods that can be used in the field or in the laboratory to test for food safety, as well as the feasibility of implementing quality assurance in fish production. Since fish smoking in Ghana is the domain of women, gender issues linked to the introduction of new technologies for smoking fish are taken into account.

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1 INTRODUCTION

In fish producing countries, this product is a valuable asset not only as an important and cheap source of food and animal feed, but also with respect to fish quotas and fish exports. In addition to conventional fishing practices, aquaculture is receiving increased interest as a means to produce protein-rich food. In developed countries, the favourable health benefits associated with fish consumption are both understood and appreciated. In addition, the 'exotic' fish trade in affluent markets creates additional opportunities for fish exports.

However, fish is highly perishable and thus contamination and subsequent spoilage need to be prevented to ensure its safety for consumption. Well-known artisanal fish conservation methods are salting, hot smoking, fermentation and sun drying, and combinations of these methods. More recently, deep-freezing freshly caught fish has become common practice among commercial enterprises. Cold smoking processes have been developed that impart the characteristic smoke flavour to fish as an alternative to heat smoking, but in this case additional steps are required to preserve fish from spoilage. To ensure the safety of fish and other food products, laws are enforced with regard to, for example, fish processing conditions and the levels of microbial and biochemical contaminants and of pathogenic microorganisms in the fishery products to ensure they meet acceptable and recommended international limits and standards.

In May 2003, Dr Frempong of the Ghanaian partner institute STEPRI gave a presentation on fish smoking in Ghana during a workshop organised by Tailor Made Biotechnologies and RIKILT - Institute of Food Safety in Wageningen. In particular, he discussed the practices of artisanal fish smoking in Ghana, which is carried out by fishermen's wives, and the impact of EU food safety regulations on Ghanaian exports of smoked fish to the EU. In order to facilitate compliance with EU standards, a Ghanaian-Dutch project developed a new type of smoking oven that has been widely adopted by Ghanaian artisanal fish processors. Statistics showed that the number of companies exporting fish to the EU had substantially declined since the introduction of EU Directive 91/493 on fish processing procedures.

Local producers must be able to comply with the food safety legislation of importing nations. This implies, for example, that they must test for spoilage, pathogenic microorganisms and contaminants during fish production. The experts attending the workshop gave their views on this issue. Since sophisticated laboratory methods cannot be applied in all situations, alternative methods need to be explored. These alternatives should be both easy to carry out and cost-effective. Examples of such assays are immuno-strip tests (which are similar to pregnancy tests) and methods that are considered outdated in modern laboratories but are still valuable in local situations. A combination was envisioned of rapid and easy infield assays to identify potentially problematic lots of products that should be further analysed in a dedicated or accredited laboratory. After the presentation, Dr Frempong indicated that he would like to have assistance in analysing mercury, histamine, smoke and microbiological contamination in Ghanaian fish.

This paper explores the possibilities to assist the Ghanaian partners in introducing rapid field tests, minimally elaborate procedures for local laboratories and official methods for national and/or larger

laboratories. It also takes into account the EU legal requirements for the given contaminants/spoilage, as well as gender issues related to fish processing and especially fish smoking, since in Ghana this is the domain of women.

2 ISSUES IN SAFETY OF SMOKED FISH

The safety of foods, including the hygiene of fish products, is regulated through the Dutch Commodity Act. In addition, the Fish Product Board - the national sector organisation for fish processors and traders - has formulated a regulation for the control of imported fish. This regulation requires that every lot of imported fish must be tested for organoleptic properties (taste, smell). If the fish does not meet the criteria for organoleptic quality, it must be retained and tested for chemical and microbiological properties. The Product Board has also developed a hygiene code for fish sales, to facilitate compliance with EU regulations on this issue.



*Figure 1 Ghanaian woman smoking fish
(Photograph: FAO/18380/P. Cenini)*

2.1 Mercury in fish

The organic compound methylmercury is formed from inorganic mercury and taken up by fish and other seafood organisms. Whereas metallic mercury itself may not be a particular concern when ingested with food because of its low absorption from the gut, methylmercury is well absorbed from food and may be toxic to consumers due to its effect on the neural system. In addition, methylmercury is classified as a possible carcinogen (class 2B) by the International Association for Research on Cancer. A well-known example of the toxicity of methylmercury in fish is the Minamata disaster in the 1950s, when many people living around Minamata Bay (Japan) suffered neural system damage as a result of eating fish contaminated with mercury derived from industrial waste.

In Ghana, mercury (including methylmercury) contamination of fish may be a particular concern given that artisanal gold-mining activities release mercury into Ghanaian waterways. In these activities, mercury is used to separate gold from crushed ore in an aqueous solution by a process called amalgamation. The mercury-gold amalgam is subsequently separated from the water and the mercury is released as a vapour from the amalgam by heating. These practices lead to contamination of the environment (sediment, groundwater and river water) around the gold-mining site, and subsequently to the contamination of fish both at the site and downstream of it (Adimado & Baah, 2002; Babut et al., 2003).

EU legislation establishes maximum permissible levels of mercury in fish, and these have been implemented in the Dutch Commodity Act. These maximum levels are 0.5 mg of mercury per kg of fresh weight (fw) of fish, except for a maximum level of 1.0 mg/kg fw for fish on a certain list (e.g. eel, halibut, swordfish and tuna). During studies on mercury contamination of fish in Ghana, these threshold levels were exceeded by part of the sampled fish (Adimado & Baah, 2002; Babut et al., 2003).

The analysis of total mercury and methylmercury in fish can be done in various ways, such as by means of the official methods described by the Association for Official Analytical Chemists (AOAC; Horwitz, 2002, Ch. 9). No specific method is required by EU (or Dutch) legislation, except that the method should be validated and must comply with specific performance criteria (detection limit, quantification limit, variability, etc.; see EU Directive 2001/22). The Dutch Inspectorate for Health Protection and Veterinary Public Health (Jonker, 2000), for example, applied cold vapour atomic absorption spectrometry (CV-AAS) in one of its studies. In this method, a sample is digested with acidic solutions (HNO_3 and HClO_4), and subsequently the total mercury (inorganic and organic) in the sample is reduced by reagents to metallic mercury. The mercury is then released as a vapour and measured by its absorption of light at a characteristic wavelength. In RIKILT's laboratory, microwave-mediated, temperature- and pressure-controlled digestion by HNO_3 is carried out to ensure that the digestion is complete. Standard addition of mercury is carried out to correct for fluctuating concentrations of HNO_3 in the samples caused by the matrix, which otherwise result in a seemingly too high mercury content.

Other laboratory methods may be easier to adopt for the measurement of total mercury in a wide range of samples without much pretreatment. One of these methods is very similar to artisanal gold-mining itself: after combustion, the mercury released from a sample is taken up in an oxygen stream and deposited on a gold wire (amalgamation). When the wire is heated, the mercury is released and measured by atomic absorption (Willford et al., 1973). Apparatus which carry out this process fully automatically are available on the market.

Another example of a laboratory method, one which has been used at RIKILT, is gas chromatography coupled to mass spectrometry (GC-MS). This technique allows for the separation of methylmercury (present in an extract of a given food) in a gas stream running through a capillary tube, and for its subsequent measurement with high precision instruments/equipment. Methylmercury is the organic form of mercury. The GC-MS method therefore does not include measurement of inorganic mercury, unlike the methods for the detection of total mercury (organic and inorganic) described above.

As far as we are aware, methods for the infield measurement of mercury levels in foods have not been described. Examples of screening methods for mercury in environmental samples are enzyme-linked immunosorbent assays (ELISA) in tubes (EPA, 1998a), and hand-held X-ray fluorescence detectors (EPA, 1998b). These methods would require adjustment to and validation of the conditions of food analysis. The ELISA assay for mercury is based on the conversion of all mercury-containing compounds by acid reagents into mercury ions (EPA, 1998a). These ions subsequently form a complex with proteins. The addition of antibodies reveals the presence of the complex by producing a colour reaction. ELISA assays can also be further developed into strip tests, much like the well-known pregnancy tests, which can be used with few requirements (e.g. water-soluble sample).

It would benefit strip test development were ELISA producers to make their antibodies against mercury available for this purpose. In the absence of such antibodies, they should be produced in-house (e.g. by RIKILT), which will add to the development costs but save on the purchase costs. It should be borne in mind that strip tests are generally less sensitive than ELISA and therefore their ability to assure compliance with legal thresholds for the compounds that are detected needs to be checked.



*Figure 2 Unloading fish at the Ghanaian port of Tema
(Photograph: FAO/6999/F. Botts)*

2.2 Histamine

The compound histamine can be formed by microbiological activity from its precursor histidine in fish tissues. Some fish types - such as scombroids (e.g. mackerel) - are particularly susceptible to this kind of spoilage. Histamine causes allergy-like reactions, which can be severe or even fatal, in consumers. Sub-optimal fish storage and processing conditions can contribute to histamine formation.

The Dutch Commodity Act requires fish of certain species to be analysed for the presence of histamine. The average level of histamine in all samples may not exceed 100 mg per kg of fish, while individual samples may not exceed 200 mg/kg. In fish that has undergone preservation by salting, the levels may be twice as high. The Act does not describe a reference method for the analysis of histamine.

Official methods for histamine analysis in fish described by the AOAC include (Horwitz, 2002, Ch. 35):

- Extraction of a fish sample, separation of histamine from the extract over an ion-exchange column, reaction of histamine with ortho-phthalaldehyde, and measurement of fluorescence.
- Extraction, separation over a column, reaction with a diazonium reagent, and measurement of light absorbance.
- Extraction with dilute acidic solution, neutralization and addition to a piece of guinea-pig intestine attached to a kymograph, measurement of intestine response (movement).

The first two methods describe low-pressure column chromatography for the separation of histamine from extract. In the literature, alternative, modern chromatographic methods have been described - such as high-performance liquid chromatography (HPLC) - which allow for the automation and scale-up of the analysis for histamine. In fact, the Netherlands Institute for Fisheries Research (RIVO) has adopted an HPLC method in which an extract from homogenised fish tissue is separated over an apolar (reverse phase) HPLC column (largely as described by Veciana Nogues et al., 1995). The histamine that is separated over this column is subsequently detected as a fluorescent compound formed by a post-column on-line reaction of histamine with ortho-phthalaldehyde.

An alternative laboratory assay that requires less equipment is a modification of the Lerke assay (Rodriguez Jerez et al., 1994). In this assay, a two-step enzymatic reaction is used to quantify histamine, in which hydrogen peroxide is formed from histamine and subsequently disintegrates in the presence of a substance, which develops a measurable colour correlated with the level of histamine. This reaction could be exploited in strip tests used for infield assays (Hall et al., 1995).

An alternative, easy-to-use method may be specific ELISA kits, a number of which are offered by commercial suppliers (see comparative test in Rogers & Staruszkiewicz, 2000). These methods would be suitable for use in small-scale laboratories and would also allow for the further development of strip tests (if such are not yet available), based on the same principle of measurement. Similar to what is described above for mercury, the development of strip tests for histamine depends on the availability of antihistamine antibodies.



*Figure 3 Preparing firewood for fish smoking in a Chorkor oven
(Photograph: FAO/18297/P. Cenini)*

2.3 Smoke

One particular phenomenon that may occur during fish smoking is the formation of polycyclic aromatic hydrocarbons (PAHs) as a result of the incomplete combustion of organic material. High levels of PAHs are associated with the dark discolorations in intensively heated products. In addition, some (but not all) of these compounds are cancer-causing compounds; for example benzo[a]pyrene, which serves as an indicator for PAHs in food analysis.

Research has shown that the formation of benzo[a]pyrene can be influenced by the smoking conditions. Modern smoking ovens allow for the control of these conditions, for example by controlling the level of smoke present in the oven (Karl & Leinemann, 1996).

The Dutch Inspectorate for Health Protection and Veterinary Public Health (2003) maintains a threshold of 1 ug benzo[a]pyrene per kg for products in general. During a study on traditionally smoked foods from Nigeria, benzo[a]pyrene levels in all samples [n=9] ranged from 8.7 to 34.8 ug/kg (Ogbadu & Ogbadu, 1989). These samples therefore exceeded the threshold.

Analytical methods to measure PAHs commonly are based on the separation of these compounds in liquid media over apolar chromatography columns, followed by the detection of the fluorescence of these compounds. Also gas chromatography with mass spectrometry is a commonly employed method. For both these methods, the PAHs have to be pre-purified by extraction and possibly distillation. These methods are therefore suitable only for large-scale laboratories

For small-scale laboratories, an alternative technique that does not necessarily require sophisticated equipment is thin-layer chromatography. With this technique, samples are spotted onto one side of a layer of silica or cellulose attached to a glass plate or aluminium foil. Fluid is subsequently allowed to enter the layer from the side closest to the applied spots, and while the fluid moves through the layer by capillary action, the compounds within the spot will be dissolved (or not) and carried by the fluid through the layer. After separation, the layer is dried and the separated compounds appear as separate spots.

Thin-layer chromatography of benzo[a]pyrene in smoked meat has been described and could therefore be adapted to smoked fish (Grimmer & Jacob, 1987). We are not aware of operational infield assays for benzo[a]pyrene and other PAHs in smoked foods. The characteristic fluorescence of these compounds is exploited for their rapid identification in environmental samples using a field-portable device employing either a cuvette or an optical fibre, which can measure the fluorescence in a range of wavelengths and requires a laptop for data processing (EPA, 1999). A similar but even more simplified version can be envisioned (and may be developed with the support of RIKILT), namely a hand-held LED device that emits light and measures the sample fluorescence at distinct wavelengths.



Figure 4 Fish market near Chorkor, Ghana
(Photograph: FAO/18305/P. Cenini)

2.4 Microbiology

Apart from histamine production caused by microbiological activity in badly preserved fish, some bacteria themselves may be a health hazard because they are human pathogens (e.g. *Salmonella*). In the Dutch Commodity Act, no specific microbiological criteria have been specified for raw, untreated or processed fish (criteria have been established only for boiled bivalves and gastropods). Smoked fish should therefore comply with general microbiological criteria for foods defined by the Dutch Commodity Act.

A report on the Dutch national fish sanitary control system notes that samples are analysed for *Listeria monocytogenes*, for which a legal threshold of zero bacteria per 0.01 g or ml for all ready-to-eat foods has been established (FVO, 2001). The bacterium *L. monocytogenes* can grow during cold storage. This may be a problem particularly for smoked fish, because it is commonly consumed immediately after storage without heat treatment, which might remove contamination with *L. monocytogenes*. However, in Ghana the high temperature at which food is cooked may eliminate such hazard. Another report by the Dutch Inspectorate for Health Protection and Veterinary Public Health describes a coordinated action carried out in 2000 to measure the microbiological quality of smoked fish. Analyses were performed for total counts of mesophilic bacteria, *Enterobacteriaceae*, *Staphylococcus aureus*, sulphite-reducing *Clostridia*, *Clostridium perfringens*, *Escherichia coli*, *Bacillus cereus*, *L. monocytogenes* and *Salmonella*. It was concluded that a large proportion of the smoked fish was of unacceptable quality when stored until the 'best before' date. The results also indicated that fish had undergone unhygienic treatment and storage at too high temperatures (Jonker et al., 2000).

Listeria and known spoilage organisms, as well as the total numbers of bacteria (for which thresholds have also been set), are commonly measured after their growth in a culture media in a temperature-controlled incubator (commonly 37°C). Culturing bacteria and subsequently identifying and counting them may take days. Polymerase chain reaction (PCR) techniques for the detection of specific bacterial strains facilitate the identification of pathogenic bacteria, but still require the pre-culturing of bacteria in media (Feng, 2001). National and other large-scale laboratories may well be able to carry out these types of analysis, for example because they can install equipment for the culture of bacteria and the preparation of media under sterile conditions. Small-scale laboratories could benefit from commercial rapid tests with ready-to-use reagents and consumables for detection of food pathogens, such as

Petrifilm, Vidas and diagnostic kits. In most cases, these rapid tests still require the pre-culturing of the bacteria on a medium, which may take anything from 4 hours to 1 day (Feng, 2001). Additionally, culturing and detecting bacterial pathogens requires specific laboratory safety measures. Interestingly, a commercial diagnostic kit recently introduced in southern Africa for the detection of *Salmonella*-specific DNA does not require the pre-culturing of *Salmonella* (Gopo et al., 2003).



Figure 5 Ghanaian fish vendor
(Photograph: FAO/6124/P. Johnson)

2.5 Quality assurance

Quality assurance is the combination of measures applied to assure the quality and safety of a product, and ideally involves the stakeholders from all stages of the production process. One well-known and important example of such a measure is Hazard Analysis Critical Control Points (HACCP), which is required by EU legislation for food production in and imports into the EU (Directive 93/43). With HACCP, food producers and processors identify the health hazards for consumers of their products and define the points at which these hazards can be controlled and their magnitude measured ('critical control points', CCPs). For example, a flow diagram of the production processes showing the CCPs is drawn up. If the values of measurements at the CCPs exceed a certain threshold value, the product is considered unsafe and appropriate corrective actions have to be undertaken. In addition, records of the controls must be kept to facilitate monitoring, while audits are carried out regularly to verify compliance with the HACCP principles (see e.g. Ward, 2002).

To promote the compliance of fish smokers with HACCP, a number of prerequisites need to be fulfilled. For example, personnel must be trained to carry out controls, keep records and perform audits. In addition, HACCP commonly represents an extension of previously implemented 'good manufacturing practices' (GMPs). HACCP requirements may also differ from one importing nation to another.

Quality assurance in Ghanaian fish smoking would have to be adapted to the local traditional circumstances of production. To this end, researchers of the Ghanaian Food Research Institute made an inventory of the hazards involved with the traditional production of smoked *Sardinella* and anchovies in Ghana, and then reviewed the production stages, namely the catching, handling, smoking, storage and distribution of the fish. The main hazards identified were microbial pathogenic contamination and

spoilage, as well as contamination with histamine, insect infestation of stored fish and over-deposition of smoke products on the fish. The proposed measures included freezing the fish until it is processed, applying sufficiently high temperatures during smoking, protecting stored products from harmful external influences, and implementing good hygienic practices. In keeping with the limited analytical capacities, the researchers proposed controlling the procedures by both visual inspections (for freshness, smoke and mould infection) and tactile inspections (for dryness) (Plahar et al., 1999).



*Figure 6 Preparing fish for smoking in a Chorkor oven
(Photograph: FAO/18298/P. Cenini)*

3 GENDER ISSUES

As mentioned, traditional fish smoking is commonly carried out by women. Any change in the production methods for smoked fish will likely affect the role and status of the women involved. Women generally take care of the fish after it has been landed on the beach; their activities include drying, salting, smoking, storing and selling the fish. Compared to men, women have fewer financial resources and less physical mobility (ability to travel). In addition, they have multiple responsibilities within their families, such as child-rearing and caring for the household (see e.g. Horemans & Jallow, 1997).

Many small enterprises in Ghana are a one-person business run by a woman and comprise such activities as fish and vegetable processing. These businesses commonly have very little start-up capital, are season-bound and labour-intensive. For example, fish smoking requires women to spend a great deal of the day collecting firewood, while at the same time wood supplies are dwindling as a result of deforestation. In addition, women are exposed to the unhealthy fumes created while smoking fish in traditional ovens.

To decrease wood fuel requirements and to create healthier working conditions for women, the UN Food and Agriculture Organisation (FAO) has successfully introduced the Chorkor oven in Ghana and other African countries. This oven - which is named after a suburb of Accra, the capital of Ghana - consists of one or two rectangular burning chambers with a conical hole for wood fuel surrounded by walls made of brick, cement and/or clay, with one stoke hole per chamber. Up to 15 rectangular trays, consisting of a wooden frame and wire mesh, holding the fish can be placed on the burning chambers, acting as a kind of chimney allowing for the efficient transfer of heat and smoke from the fire to the fish. The Chorkor oven uses approximately 30 percent less fuel wood (and reduces the labour and costs entailed by fuel wood procurement) and reduces direct labour requirements for smoking by 30 percent, signifying major gains for women. In addition, the Chorkor oven prevents smoke from getting into the eyes of the processors, which is one of the problems associated with traditional ovens (Brownell & Lopez, 1986; UNDP, 2001b). Women have been actively involved in the dissemination of this technology. For example, ten female fish smokers who operate year-round were selected from each community to manage one oven, in part by supplying mud, water and labour for its construction. The costs of additional labour and materials required for oven construction - such as nails, wooden lats and wire mesh for the trays - were borne by technology transfer projects. In addition, at least one mason and one carpenter per community were trained to construct additional ovens within their community using locally available materials, if needed (FAO, 2003). Given that the oven does not profoundly change existing smoking techniques, training users in the new technology typically takes only three or four one-hour sessions. The technology transfer projects also developed extension materials, for example a 'how to' manual and a training video (Brownell & Lopez, 1986).

A survey of women using the Chorkor oven in Ghana showed that the transfer of the technology had been successful in terms of, for example, increased knowledge, product quality and marketability (Baryeh et al., 1999). Important constraints were the availability of credit that might enable women to implement the technology, as well as the high input costs. While most individual women relied on informal and/or quasi-formal sources for credit, members of women's groups were able to obtain loans

from financial institutions. The formation of women's cooperatives therefore increases their access to credit sources. In addition, this and other reports showed that illiteracy among female fish smokers is high. To deal with credit institutions, most women therefore have to rely on their literate spouse, who subsequently uses most of the credit himself (see e.g. FAO [2001]). The survey also showed that most women had heard about the new technology from fellow processors, and that only a few had learned of it from extension agents. The lower frequency of knowledge transfer through extension agents might be because most agents are male and are therefore unable or reluctant to interact with women (Baryeh et al., 1999). The employment of female extension agents would improve the effectiveness of technology transfer to female fish smokers. Interestingly, a fish oven project in Nigeria employs women to demonstrate a new oven and to train other women to smoke fish with it (UNDP, 2001a).

Community Fisheries Centres in the Gambia are another example of the coordinated introduction of a new fish smoking technology in West Africa. The aim of these centres, the first of which was opened in 1979, is to facilitate the objectives of the Artisanal Fisheries Development Project, namely to increase fishermen's income, fish consumption and economic diversification. The establishment of these centres includes the development of infrastructure and facilities, for example fuel wood plantations and informal credit schemes. Within the centres, various users groups - including women fish smokers - are organised into associations, which are represented on the centre's management committee. The centres have introduced, for example, the Gambian bonga oven, which is a variation of the Chorkor oven (bonga fish are a popular food in West Africa). The bonga oven has not only reduced fuel wood usage by 40 percent, but has also reduced fish loss and fire damage (Njie & Mikkola, 2001).

A recent example of women's participation is that of a pilot project for another new, more hygienic oven developed by the Ghana Regional Appropriate Technology Industrial Service (GRATIS) for the UN Development Fund for Women (UNIFEM). This oven runs on liquefied petroleum gas (LPG) rather than wood, while smoke (for flavour) is generated by burning coconut husks, crushed sugar cane or other appropriate agricultural waste materials. This oven therefore saves wood that would otherwise have been used for fuel and smoke generation. In addition, loans with favourable conditions have been provided to the women's cooperatives, as has training to operate the oven and to further process the fish. Besides obviating the need for laborious fuel wood collection and the exposure of women to harmful fumes, the new technology allows smoked fish to be produced in line with international requirements, which extends the market, adds value to the produce and potentially raises the women's income (Mensah, 2001).

Other issues should also be taken into account with the introduction of such new technology as the LPG oven. For example, LPG is considered to be a 'clean' fuel as opposed to biomass fuels (such as wood), which may be 'dirty' due to incomplete combustion. However, LPG is also explosive and therefore its transport, storage and handling require precautionary measures to prevent serious accidents. The acceptability of the use of a different type of smoke to impart flavour to the fish should also be tested, especially because the export markets include African expatriate communities (e.g. in the EU) for which the organoleptic characteristics of traditionally smoked fish may be an important attribute.

In addition, sophisticated fish smoking equipment may have to be installed and used in centralised, dedicated facilities, in contrast to the local traditional (and Chorkor) smoking ovens which are located close to or within women's homes, allowing the women to carry out their other duties, such as child

rearing. Women operating in such centralised facilities would spend more time away from their family; if they have no access to childcare this could have negative implications, for example, for elder daughters who might be withdrawn from school for this reason. Young mothers might therefore have difficulties operating under such conditions, while other women might have more time available as a result of the lower need for labour in fuel wood collecting and fish smoking. On the other hand, if such activities are well remunerated, men may take them over, displacing women - who are already more materially disadvantaged - from their traditional fish processing business and depriving them of the income needed to support themselves and their families.



*Figure 7 Preparing fish for smoking on a Chorkor oven
(Photograph: FAO/18367/P. Cenini)*

4 DISCUSSION

There is a need for validated quantitative methods that can be applied by certifiable national laboratories to test the quality of Ghanaian smoked fish, both that for export and that for domestic consumption. There is also a need for rapid, qualitative or semi-quantitative methods that can be used locally to sort out the potentially problematic lots that should be further checked.

With regard to the first type of assays for certifiable laboratories, many of the routine analyses of methylmercury, histamine and benzo[a]pyrene will probably entail extraction, chromatographic separation and detection of the compound. The routine microbiological analysis will entail standard microbiological techniques, possibly coupled to PCR DNA-identification methods. These techniques are commonplace in such laboratories as RIKILT, which could offer Ghana assistance in the form of training personnel, setting up laboratories, and developing and optimising methods.

For the second type of analysis (for small-scale laboratories and infield measurements), immunoassays for compounds such as mercury and histamine can be used. Small-scale laboratories, for example, could use ready-to-use kits, such as ELISA microtitre plates with small wells, in which colour changes can be measured with the eye (where dedicated apparatus is not available). Such commercial kits are currently available for histamine. The immunoassay for mercury is used for environmental samples, and should be adjusted to the analysis of fish. For infield use, strip tests - which are based on the same principle as the ELISA plate tests, but require minimal sample treatment - would be very suitable given their ease of use and low cost per analysis. RIKILT can aid in the development of appropriate immunoassays, including strip tests, and support the training of the instructors for the local controllers.

As noted, the second type of analysis could serve to identify production lots of smoked fish that may be problematic and therefore require further analysis in dedicated laboratories. Conversely, the first type of analysis could also be used to carry out surveys to identify specific attributes associated with a higher probability of food safety concerns of the smoked fish. Such attributes could include, for example, geography, biology, the environment, processes or facilities. These attributes could be used to focus on the second type of analysis on certain points in smoked fish manufacture that carry these identified attributes.

The analysis of benzo[a]pyrene as an indicator of PAHs formed during smoking may be done by thin-layer chromatography in small-scale laboratories. RIKILT can help to explore the feasibility of a rapid, infield assay of PAHs, which as far as we know is currently not available.

The rapid analysis of microbiological quality can be done in small-scale laboratories using ready-to-use kits. For the rapid infield analysis, organoleptic analysis (smell, taste of samples) could provide a first indication of spoilage. In some cases, however, spoilage may occur without affecting organoleptic quality. It should therefore be combined with an infield assay for histamine, which is both toxic and an indicator of microbial spoilage.

Besides the analysis of smoked fish products for their safety, quality assurance could ensure that the smoked fish produced in Ghana is safe and of good quality. It should be kept in mind that in traditional

smoking facilities, new safety and quality improving measures should be realistic and achievable, such as the visual and tactile inspections proposed by Plahar and colleagues (1999). In addition, improved smoking technologies, such as the Chorkor oven, have previously been introduced successfully through a participatory approach. Given that fish smoking in Ghana is the domain of women, gender-related issues are important and the role of women in ensuring that smoked fish production complies with safety standards needs to be taken into account. Experience with technology transfer of the Chorkor oven has shown that women consider credit availability as one of the most important constraints on gaining access to improved fish smoking technology. Most women who smoke fish are married and illiterate, and credits provided to them may be exploited by their literate male spouse for purposes other than fish smoking. In addition, the introduction of new, profitable technologies may cause a shift in gender roles, with the men taking over the women's business.

Compliance with export standards may lead to requirements being imposed on smoked fish production beyond what is needed to improve local living standards. For example, the proposed quality assurance by tactile and visual inspections may not be sufficient to ensure compliance with export standards. If additional analytical tests are required at the local level, these should be cost-efficient, impose low technical requirements and be easy for local fish smokers to learn to use. Immuno-strip tests may have the advantage that women are likely to be acquainted with these tests, which are sold in the marketplace for other purposes (pregnancy tests). In addition, strip tests do not require laboratory facilities and are competitively priced. Implementation of quality assurance and analytical tests may be further facilitated by organisational measures, such as scale-up of women's businesses into companies or cooperatives in which specialised members take care of these items on a routine basis.



Figure 8 Extension worker educating Ghanaian villagers about improved techniques for fish smoking (Photograph: FAO/18422/P. Cenini)

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