



CSIR-FOOD RESEARCH INSTITUTE

TRAINING MANUAL FOR HYGIENIC HANDLING AND SMOKING OF FISH



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INTRODUCTION

Smoking is another method of preservation for fish that is often used in African countries. It accounts for about 70 to 80% of the most common fish preservation and processing methods in Africa which enables long storage and trading to other markets. Smoking has been described as the penetration of volatiles produced from the thermal destruction of wood into fish products. Wet-hot smoking and dry-hot smoking are the forms it takes with both taking place at temperatures high enough to cook the fish. The type of fish, the required storage period, and its intended usage determine which form to apply. For wet-hot smoking, the fish is smoked for about 2 hours to a final moisture content of about 40-50% and can be stored for 3 days. In the dry-hot smoking method, on the other hand, fish is smoked for about 18 hours and can have 10-15% moisture content. This gives the fish a longer storage life of up to about 9 months. The heat is produced from the burning of fuel which includes hardwood, sawdust, coconut shell, husk and other local sources of fuel. The incomplete combustion of these fuel sources generates smoke which also contains gases, chemical and flavour compounds. The smoking is carried out in indigenous earthen kilns, bricks, and metal/oil drums with single or multiple platforms above the combustion chamber on which the fish is loaded. A very popular one is the Chorkor oven from Ghana.

Smoked fish is nutritious and as such its consumption is necessary to alleviate the micronutrient deficiencies in Africa. The smoking process improves the sensory attributes of the fish, increases shelf life and utilization. The high smoking temperatures can inhibit microbial growth ensuring food safety. Denaturing of protein may also occur and phenolic compounds slow down oxidation of fish lipids. The degree to which the fish is coloured and flavoured is correlated with the amount of smoke intake. Smoking may also lead to the production of carcinogenic substances like polycyclic aromatic hydrocarbons (PAHs) in the fish.

The Food and Agriculture Organization introduced the FAO-Thiaroye Technology/FAO-Thiaroye Processing Technique (FTT) oven as an intervention oven which uses fully-lit charcoal mixed with heat retention stones for fish smoking. It can mitigate most of the negative effects of traditional ovens. Low PAH (benzo(a)pyrene (BaP and PAH4) levels are recorded from fish smoked in this oven meeting the EU regulatory limits. The Ahotor (comfort) oven was also introduced in Ghana to achieve similar outcomes as the FTT but has some challenges (including a slow rate of smoking, and low turnover time) and hence requires further improvement.

Under the Healthy Food Africa project, some modifications have been carried out on the Ahoto oven (CSIR FRI/MA/AA/2024-002). The improvement work focused on increasing the range of adoption by different end users. The combustion has been modified to include a chamber for charcoal briquettes as well as a built-in Liquefied Petroleum Gas (LPG) system, allowing fish processors to use a variety of fuel alternatives. This is also expected to significantly reduce PAH levels as cleaner fuel options are provided. Depending on end-user preferences, a fuel mix option could be used to improve the taste and texture of the final product. The Chorkor oven was also modified to improve upon the PAH levels and hygiene. The oven has been redesigned with the introduction of a fat collecting system aimed at reducing fat drippings in the fire during smoking. The fat collector introduced is expected to channel all forms of drippings out of the oven and thereby reduce smoke production and emissions. Therefore, this document addresses the hygienic handling of fish, smoking in the modified, improved ovens, and packaging, to produce fish that is safer and nutritious. The use of these techniques may enhance the patronage of smoked fish and expand its local and export markets.

GOOD HYGIENIC PRACTICES

Good hygiene practices (GHPs) are fundamental measures and conditions applied at any step within the food chain to provide safe and suitable food (FAO and WHO, 2023). GHPs control numerous food-related risk sources that have the potential to contaminate food products. These include workers who handle food during harvest, production, and preparation; suppliers of raw materials and other ingredients; upkeep and cleaning of the work area; and storage and even display. While all GHPs are significant, some are more so in terms of their effect on food safety. For instance, cleaning walls and ceilings is not as important as cleaning equipment and surfaces that come into contact with ready-to-eat food. This is because improper cleaning of surfaces that come into contact with food can directly contaminate food. Every processor should be conscious of the risks associated with the work and the key controls needed to appropriately manage such risks. Some of these key controls include:

- a. control of water quality – minimizes the presence of many potential hazards (e.g. biological, chemical, physical);
- b. control of faecal contamination – minimizes the potential for contamination with many foodborne pathogens such as *Salmonella*, *Campylobacter*, *Yersinia*, pathogenic strains of *Escherichia coli*;
- c. control of food handler practices and hygiene – prevents many potential communicable diseases that could be foodborne; and
- d. control of food contact surfaces by cleaning – removes bacterial contaminants, including foodborne pathogens, and allergens (FAO and WHO, 2023).

Some personal hygiene mistakes by processors can cause pathogens or germs to be transferred to the fish being processed (FAO, 2012-Fish handling, quality and processing: training and community trainers manual (<https://openknowledge.fao.org/handle/20.500.14283/az083e>)).

These include:

- a. Failure to wear clean, protective clothing;

- b. Failure to cover wounds;
- c. Failure to wash hands after using the toilet;
- d. Failure to wash hands before handling fish;
- e. It is improper to spit, cough, or sneeze;
- f. It is improper to allow fingernails to grow long;
- g. It is improper to smoke;
- h. It is improper to eat or drink while handling fish;
- i. Fish handling when ill (vomiting, diarrhoea, skin infections) is improper;
- j. Wearing jewellery, such as bracelets, necklaces, earrings, watches, and rings is improper.

Additionally, the following World Health Organization's (WHO) 5 Keys to Safer Foods, which focuses on the five fundamental messages that explain the principles of good hygiene, offers detailed information on how food hygiene must be taken into account to improve the quality and safety of foods including fish and must be applied where applicable (WHO 2006).

Table 1: WHO 5 Keys to Safer Foods

<p>Keep clean</p> <ul style="list-style-type: none"> ✓ Wash your hands before handling food and often during food preparation ✓ Wash your hands after going to the toilet ✓ Wash and sanitize all surfaces and equipment used for food preparation ✓ Protect kitchen areas and food from insects, pests, and other animals 	<p>Why?</p> <p>While most microorganisms do not cause disease, dangerous microorganisms are widely found in soil, water, animals and people. These microorganisms are carried on hands, wiping cloths and utensils, especially cutting boards, and the slightest contact can transfer them to food and cause foodborne diseases.</p>
<p>Separate raw and cooked</p> <ul style="list-style-type: none"> ✓ Separate seafood, raw meat, and poultry from other foods ✓ Use separate equipment and utensils such as knives and cutting boards for handling raw foods ✓ Store food in containers to avoid contact between raw and prepared foods 	<p>Why?</p> <p>Raw food, especially meat, poultry and seafood, and their juices, can contain dangerous microorganisms which may be transferred onto other foods during food preparation and storage.</p>
<p>Cook thoroughly</p> <ul style="list-style-type: none"> ✓ Cook food thoroughly, especially meat, poultry, eggs and seafood ✓ Bring foods like soups and stews to boiling to make sure that they have reached 70°C. Ideally, use a thermometer ✓ Reheat cooked food thoroughly 	<p>Why?</p> <p>Proper cooking kills almost all dangerous microorganisms. Studies have shown that cooking food to a temperature of 70°C can help ensure it is safe for consumption.</p>
<p>Keep food at safe temperatures</p> <ul style="list-style-type: none"> ✓ Do not leave cooked food at room temperature for more than 2 hours 	<p>Why?</p> <p>Microorganisms can multiply very quickly if food is stored at room temperature. By holding at</p>

<ul style="list-style-type: none"> ✓ Refrigerate promptly all cooked and perishable food (preferably below 5°C) ✓ Keep cooked food piping hot (more than 60°C) prior to serving ✓ Do not store food too long even in the refrigerator ✓ Do not thaw frozen food at room temperature 	<p>temperatures below 5°C or above 60°C, the growth of microorganisms is slowed down or stopped. Some dangerous microorganisms still grow below 5°C.</p>
<p>Use safe water and raw materials</p> <ul style="list-style-type: none"> ✓ Use safe water or treat it to make it safe ✓ Select fresh and wholesome foods ✓ Choose foods processed for safety, such as pasteurized milk ✓ Wash fruits and vegetables, especially if eaten raw ✓ Do not use food beyond its expiry date 	<p>Why?</p> <p>Raw materials, including water and ice, may be contaminated with dangerous microorganisms and chemicals. Toxic chemicals may be formed in damaged and mouldy foods. Care in the selection of raw materials and simple measures such as washing and peeling may reduce the risk.</p>

(Adapted from CSIR-FRI/MA/AA/2021/001; WHO Permission request ID: 373210)

PROCESSING OF SMOKED FISH

Characteristics of fresh and spoiled fish

A fish processor must know the characteristics of fresh fish and spoiled fish. The difference between fresh and spoiled fish which the processor or consumer may use as a guide in buying fish is key. With this guide, the processor or consumers would be able^{to} to decide if the fish displayed for sale should be accepted or rejected as shown in Table 2.

Table 2: Difference between Fresh and Spoiled Fish

	FRESH FISH	SPOILED FISH
EYES	Bright, bulging, pupil velvet black, cornea transparent	Dull, wrinkled, sunken pupil dull black, cornea opaque
GILLS	Bright red, covered with clear slime; odour under gill covers fresh	Dull brown or grey, slime cloudy; odour under gill covers sour and offensive
FLESH	Firm, body is stiff, an impression made by fingers do not remain; slime present is clear	Soft and flabby; an impression made by fingers remains
BELLY WALLS	Intact	Often ruptured; viscera protruding
MUSCLE TISSUE	White	Pinkish, especially around the backbone
VENT	Pink, not protruding	Brown, protruding
ODOUR	Fresh, fishy odour	Stale, sour, or putrid
COLOUR	Bright	Faded

Adopted from: <https://www.fao.org/3/ac061e/AC061E34.htm>

Steps in the processing of smoked fish

Hands, contact surfaces, utensils and equipment must be washed with soap and potable water before the start of activities in the facility. Staff must be appropriately dressed. The steps involved in processing smoked fish are shown in the flow diagram below.

**RECEIVING/
STORAGE
(CONTROL
POINT)**



PROCEDURE

When the fish arrives in boxes/ containers/bowls, they are examined to ensure the raw fish is infused in ice or iced.

The fish is inspected as a Control Point (CP) to make sure it is free of any undesired materials.

Then the fish are sorted based on the following quality checks:

1. Bad smell or fish smell
2. Impaired eye refractive index i.e. dull eyes.



3. Pale or Green gills, which are slimy.
4. Softness of the fish tissue
5. Damaged or injured fish.

It's then processed further OR the fish can be packaged, labelled, and frozen until ready to use. Keep fish from staying longer than necessary via the principle of "first in, first out." This storage temperature is a CP to prevent or eliminate a food safety hazard. Frozen fish can be thawed at room



temperature or in the open for a few hours hygienically. A batch code has to be generated for every batch received. It should include the initial of the supplier, the date of receipt, and the time for processing. It should be well affixed on the package.

FIRST WASHING



The fish must be thoroughly washed to eliminate the majority of any possible waste materials, dirt, and bacteria that may have been associated with any sand or dirt.



that may have been on its surface. Use potable water (potable running water or stored potable water) to wash each fish separately to ensure that there is no foreign material or sand in its gills and other parts. Defrosted fish must be washed severally to get rid of any leftover ice.

**GUTTING AND
GILLING
(OPTIONAL)**



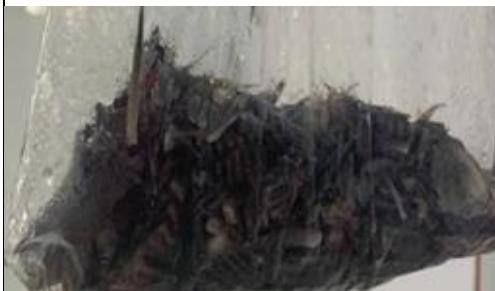
Make an incision directly beneath the fish's belly with a clean, sharp knife to open it. Physically remove all the stomach contents thoroughly.



Additionally, remove all gill covers by taking them out of the operculum with the knife. Clean the fish with potable water.

NB: This applies only to fish types that require gutting and gilling.

SCALING AND BEHEADING (OPTIONAL)



Take off all of the fish's scales from both sides using a knife to remove every last one from the fish skin into a bowl. The removal of the heads from fish may also be carried out by pressing the knife up against the fish's

	 	<p>head or gill cover, the head is then cut off from the body. The fins may also be removed.</p> <p>NB: This applies only to fish types that require the removal of scales, head and fins.</p>
2ND WASHING	 	<p>Wash the descaled fish in/under potable water to get rid of all of the fish skin's loose scales.</p>

**3RD
WASHING
(Control Point)**



Use 10% clean edible salt water in a bowl to wash for 3-5 min. This is critical to prevent biological pathogens' growth during smoking/drying and histamine formation (in histamine-susceptible species). It can also prevent and enhance the texture, flavour and overall taste. Dripping and drying follows immediately after.

**OVEN
READINESS**



Prepare the oven for the smoking process by sprinkling ash on the fat-collecting trays.

**SMOKING
(CRITICAL
CONTROL
POINT)**



Arrange the fish on the trays, set/light the fire and smoke for the amount of time needed to coagulate the proteins. Insert a probe to check the internal temperature of the fish (it should be around 80 °C) for the required duration based on the fish size and moisture content. That is, about 2 h to a final moisture content of



about 40-50% for wet-hot smoked fish and 18 h to a final moisture content of about 10-15% for dry-hot smoked fish or depending on the specification of the buyer). The smoking stage is a Critical Control Point (CCP). This is a stage critical for biological pathogens' growth to be prevented or eliminated. At the end of smoking, quench the fuel source/fire.

NB: There is a need for moisture and water activity monitoring at this stage.

COOLING (CRITICAL CONTROL POINT)		<p>The fish is allowed to sufficiently cool on the oven at room temperature depending on the size (maximum overnight). Cooling is critical to prevent condensation in packaging materials which promotes microbial growth. Cooling must not be too long as pathogens can grow on them.</p>
PACKAGING AND LABELING (CRITICAL CONTROL POINT)		<p>Depending on the suitability, fish is weighed and packaged in food grade clean brown paper-lined boxes, baskets or appropriately labelled polythene/</p>



polyethene bags hygienically indicating the appropriate temperature for storage, handling, and shelf life.

Packaging maintains the product's integrity and helps avoid contamination.

Vacuum packaging can also be done for longer shelf life but *Clostridium spp* check may be required.

NB: Customers feel more confident when they see labels on the product.

STORAGE (CONTROL POINT)



Pathogens can grow in warm temperatures so must be stored and transported hygienically. Wet-hot smoked fish can be stored e.g in the freezer while dry-hot smoked fish can be stored at room Temperature.

CP/CCP: essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Instructions for use

Add the desired quantity of smoked fish to stews and soups.

Heat and use as accompaniment.

Serving size

It contains a significant amount of proteins, but the fat and other nutrient content can change depending on the fish species. Serving size may differ from person to person but about 6 ounces cooked for a 160-pound/73 kg adult.

Raw material sources

All raw materials are obtained in the traditional open market and fish landing sites.

Packaging

Different types of packaging are used for smoked fish in Ghana. The most common being cane baskets lined with brown paper with nets put around the

baskets to keep the fish in place. For the formal markets, smoked fish is packaged in boxes, normally sealed pouches and vacuum packaging. Since vacuum packing keeps out oxygen, it delays the development of rancidity in fatty fish. The packaging material must be of a food grade and clean. The packaging has a critical role in determining the shelf life of fish. It must limit odour permeation, minimize bacterial and chemical deterioration, suppress fat oxidation, and dehydrate the product under normal conditions. Fish that has cavities, is dehydrated, is discoloured, is rotten, and has some black or red patches are signs of low quality.

Storage period and condition

Generally, the shelf life of smoked fish products varies based on several factors, including the fish species, quantity of salt, fuel type, level or duration of drying/smoking, storage temperature, storage condition, and type of packaging material. A well dry-hot smoked fish can store for up to 9 months while a wet-hot smoked fish can store for up to 3 days at room temperature. They are however expected to last longer in the frozen state.

CONCLUSION

It is important to maintain the hygienic processing of smoked fish to protect the public's health as well as the reputation of the fish processing sector. We can reduce the risk of contamination and maintain the end product's quality and safety by adhering to good hygienic practices from start to finish of the production chain. Good hygiene practices must be implemented to prevent the growth of harmful microorganisms and the formation of toxins. These include thorough cleaning and disinfecting equipment and facilities, handling and storing raw materials properly, and routinely checking on key control points. In addition, it is imperative that staff members engaged in the processing of smoked fish get continual training and education to establish a culture of food safety and guarantee adherence. By keeping up with emerging technologies and best practices, we can reduce the risk of foodborne illness outbreaks. Finally, prioritizing good hygienic practices during the processing of smoked fish protects customers, boosts market competitiveness, and fosters trust and confidence in the products. Maintaining the highest standards of food hygiene and safety is a shared obligation of all stakeholders in the industry, protecting the public's health and encouraging the sector's sustainable growth

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