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RESEARCH ARTICLE

ASSESSMENT OF THE MICROBIOLOGICAL QUALITY OF SMOKED FISH IN TRADITIONAL AND IMPROVED OVENS IN TOGO

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ABSTRACT

The development of new processing technologies should make it possible to obtain good quality products that meet the required sanitary standards compatible with good consumer health. To this end, the general objective of this study is to evaluate the impact of improved smoking processes on the safety of smoked fish in Togo. The study compared the traditional and improved smoking system introduced in Togo within the framework of an agricultural sector support project in order to determine the microbiological quality of smoked fish and to assess the impact of the new smoking technologies for the benefit of the target beneficiary groups and consumers. This is a cross-sectional study conducted among women processors through a process survey and microbiological laboratory tests. The data show that fish smoking is done by women, the majority of whom are between 25 and 30 years old. The women processors use several types of combustible during smoking. With regard to microbiological quality, of the five (05) germs tested, compliance with the standards was only found for "coagulase positive staphylococci". The results of the microbiological tests were unsatisfactory for the "FMAT" germs. As for the hygiene control and spoilage germs "faecal coliforms", 38.5% of the results were unsatisfactory. The presence of FMAT, CTT indicates that the smoking and cooling process was poorly conducted, these germs can remain and proliferate in the smoked fish after smoking. The non-observance of good hygiene practices and the unsanitary environment of the production workshops would be at the origin of the post-smoking microbial contamination.

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INTRODUCTION

Enhancing food safety is a prerequisite for minimizing the burden of foodborne diseases, reducing poverty and contributing to the achievement of Millennium Development Goals 1, 4 and 8. However, recent events have highlighted the importance of food safety in the African Region. An unprecedented number of foodborne disease outbreaks have been reported recently, including salmonellosis, enteric *Escherichia coli* haemorrhagic disease (EHEC), hepatitis A and acute aflatoxicosis (WHO, 2012). Togo, a West African country, bordered to the south by the Atlantic Ocean, is dependent on fishery products for the nutrition of its population, including fish. Fish has been an important source of human food since ancient times and contains proteins, vitamins, essential minerals and high quality omega-3 fatty acids (Degnon et al., 2009; Gang, 2013). It is a foodstuff of high nutritional value and also one of the most perishable of all fishery commodities because shortly after death, fish starts to putrefy (Annune, 1993; Agbon et al., 2002). Its conservation, especially in tropical or hot countries, is difficult because of the lack of adequate conservation infrastructures and because of the climatic and environmental conditions that contribute to its degradation in a few hours (Anihouvi et al., 2005). The transformation processes used in Togo for fish conservation are smoking, salting, drying, frying and fermentation. Smoked fish represents more than 60% of the total annual fish consumption in Togo (Abotchi, 2010). In recent years, fish safety has become a public health issue, as the pathogens present in smoked fish pose serious threats to the health of consumers (WHO, 2003). Thus, in order to improve the sanitary quality of fishery products, the Agricultural Sector Support Project (PASA) is building the capacity of actors involved in post-capture activities. Indeed, 300 women have been trained in hygiene, good fish processing and conservation practices. A FFT-Thiaroye fish processing platform was built for the benefit of the women fish smokers of the Union of Women Fish Processors' Groups (UGFTRAPO) of Katanga/Lomé fishing port and 63 improved ovens were built for the benefit of the women fish smokers of the Lonlonyo scoop of Lake Nangbéto. The implementation of these new technologies should make it possible to obtain good quality products that meet the required health standards. It is in this sense that this study was carried out, the general objective of which is to evaluate the impact of PASA actions and improved smoking processes on the sanitary quality of smoked fish in Togo. Specifically, it was first of all a question of determining the microbial

contamination flora that are the pathogenic flora, the total aerobic mesophilic flora, the total coliforms and the sulphite-reducing anaerobic bacteria of fish smoked by the traditional and improved method; then the socio-demographic characteristics of the respondents and their influences on the perception of the importance of hygiene and salubrity.

MATERIAL AND METHODS

Setting and period of study: This study was carried out in Togo, especially in the Maritime and Plateau Regions from 10 May to 11 June 2017. The first study area was in the Maritime Region, more precisely in the locality of Katanga. It is a fishing village where a processing platform (Improved oven Thiaroye FTT) was built for the women fish smokers of the Union of Women Fish Processors Groups (UGFTRAPO) of Katanga/Lomé fishing port. The locality of Nangbeto located in the Plateaux Region was the second study area where 63 improved ovens (58 Chorkor improved ovens, 05 Banda improved ovens) were built for the fish smokers of the Lonlonyo scoop of Lake Nangbeto. The food microbiology laboratory of the National Institute of Hygiene (INH) in Lomé, Togo, was used for the various microbiological tests.

Study population: The study was carried out among 300 women fish processors in the Kantaga and Nangbeto areas.

Material

The material consisted mainly of smoked fish from traditional and improved ovens (FTT Thiaroye, Chorkor and banda).

Methods

Survey and sampling methods: The survey was carried out exhaustively, taking into account the 300 fish processors who use the ovens. Samples of smoked fish were taken from fish smokers using traditional and improved ovens. Samples were taken at three sites around Lake Nangbeto and at the processing site in Katanga (Table 1). These surveys were carried out using survey forms over a period of 30 days. Among the smokers, some used only improved stoves, while others used both improved and traditional stoves.

Methods of microbiological analysis: Microbiological analysis is based on the techniques of isolation, identification and enumeration of the various germs.

Preparation of the stock solution (SM) (NFV 08-010 March 1996): 25 grams of the surface and deep parts of the smoked fish were aseptically removed and introduced into the sterile STOMACHERND bag. Then, 225 ml of previously sterilised buffered peptone water (BPW) was added to obtain a total mass of 250 grams. This mixture was homogenised with STOMACHERND for 30 seconds. The resulting solution, called the stock solution, was left to stand for 30 minutes to ensure the revival of germs stressed by the homogenisation and the shock exerted during the grinding. The dilution of this solution is 10^{-1}.

The concentration of this stock solution is obtained by taking the ratio of the weight of the feed to the total volume (diluent + feed). Moreover, for highly hydrated foods, their density is considered to be close to 1, and therefore 1g of food is equivalent to a volume of 1 ml.

Decimal dilutions: One millilitre of the stock solution was taken and added to a test tube containing 9 ml of buffered peptone water (BPW) to obtain a 10^{-2} dilution solution. One millilitre of the 10^{-2} solution was again removed and added to another tube containing 9 ml of Buffered Peptone Water (BPW) to give a dilution of 10^{-3}. This operation continued until dilutions of 10^{-4} and 10^{-5} were reached, especially for the total aerobic mesophilic flora.

Enumeration and calculation method: After the incubation period mentioned in the specific standard for each germ, the characteristic colonies were counted for each box containing less than 300 colonies and at least 15 colonies or any other number indicated in the standard. The number N of germs present in the tested sample and considered as a weight average of successive dilutions was determined by the following formula:

$$N = C_1 + C_2 / V (n_1 + 0.1n_2) d$$

C_1+C_2= sum of the characteristic colonies on the two boxes selected
V= volume of inoculum applied to each box
d= dilution rate corresponding to the first dilution selected
n_1 = number of box retained at the first dilution
n_2 = number of box retained at the second dilution

4.2.4. Investigation and enumeration of total anaerobic mesophilic flora (FMAT) (ISO 4833, February 2003)

1 ml of each dilution (10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}) is taken and aseptically placed in single-use Petri boxes. 15 ml of melted PCA (Plate Count Agar) medium cooled in a water bath at 45°C was added. The mixture was homogenised by circular movements of the boxes. After solidification, 5 ml of PCA was added. This second layer was used to avoid the invasion of the plate by germs which could make the reading difficult. The plates were then incubated at 30°C. The characteristic colonies appear whitish. The count was made after 72 hours of incubation.

Faecal coliform (FC) detection and enumeration (ISO 4832, February 2006): The medium used for isolation by the double layer method was VRBL (Crystal Violet, Neutral Red Bile and Lactose Agar). Indeed, 1ml of the 10^{-1} and 10^{-2} dilutions were introduced into the single-use Petri boxes and two layers of VRBL were poured. After incubation for 24 hours at 30°C, the faecal coliform colonies appeared dark red.

Search and enumeration of presumed pathogenic staphylococci (SPP) (NF V08-057, 1 January 2004). 0.1ml of the stock solution and 0.1ml of the 10^{-2} dilution were surface-seeded into Petri boxes in which BP (Baird Parker) medium had been poured beforehand. The plates were incubated at 37°C and read after 24 hours. Characteristic colonies were marked on the back of the box and incubated again for 24 hours at the same temperature. After this second incubation, 03 characteristic or uncharacteristic colonies were collected for further steps (catalase test, heart-brain broth (HBM) culture, coagulase test).

Research and enumeration of sulphite-reducing anaerobic bacteria (SRB) (standard NF V 08- 061 May 2005). 0.1ml of the 10^{-1} and 10^{-2} dilutions were inoculated into tubes containing 10 ml of TryptoneSulfite Agar (TSC) selective medium. These tubes were then incubated at 37°C. After 20 hours of incubation, characteristic colonies were counted.

Salmonella detection and enumeration (ISO 6579/A1, July 2007)
The search for and enumeration of Salmonella used several culture media (Rappaport, Selenite cystine, Hecktoen, nutrient agar, API 20 E gallery) and was carried out in several stages:

Pre-enrichment: **The 10^{-1} dilution stock solution was incubated for 20 hours at a temperature of 20°C.**

Selective enrichment: After this first step, 0.1ml and 2 ml of the stock solution were taken and introduced into two test tubes containing 10 ml of Vassiliadisrappaport (RV) and 20 ml of cystine selenite respectively. The tubes were then incubated for 24 hours at 42°C (rappaport tube) and 37°C (cystine selenite tube).

Isolation: The rappaport and cystine selenite cultures were seeded separately in sterile Petri boxes in which Hecktoen medium had been poured and solidified. The plates were incubated for 24 to 48 hours at 37°C.

Identification and Purification: Characteristic colonies were isolated on nutrient agar and cultured at 37°C for 24 hours.

Biochemical confirmation: **One colony from the nutrient agar was plated onto the API 20E gallery and read after 24 hours incubation at 37°C.**

Method of interpretation of the results: **The interpretation of the results was done according to a 3-class plan for total aerobic mesophilic flora, thermotolerant coliforms taking into account the criteria (Table 2).**

- A sample was qualified as being of satisfactory microbiological quality (SMQ) if the flora (F) was less than or equal to 3 m;
- A sample was qualified as acceptable microbiological quality (AMQ) if F is between 3 m and 10 m ;
- A sample was qualified as unsatisfactory microbiological quality (UMLQ) if F is greater than 10 m; m being the microbiological criterion indicated in Table 2.

For Salmonella, Anaerobic Sulphite Reducing Bacteria (ASR) the interpretation will follow a 2 class scheme. The presence of Salmonella and ASR will indicate that the sample is QMNS. The sample will be QMS if they are absent.

Statistical analysis of the data: The data were entered and processed in Excel 2007 and analysed using IBM SPSS Statistics 20 software with a statistical significance level of 5%.

RESULTS

Socio-demographic characteristics of respondents

Distribution of respondents by age and gender: One hundred percent (100%) of the respondents were women, and the 35-55 age groupswere the most representative for this activity (Table 3).

Distribution of women processors by marital status and level of education: Fifty-five 55% had no education, 34% had primary education and 11% had secondary education (Table 4).

Results of microbiological analyses

Pathogenic flora: This flora includes Salmonella, presumed pathogenic Staphylococcus and Listeria monocytogenes, but 2/3 of these germs were investigated in our study. For coagulase-positive Staphylococci at 37°C, all the samples taken, regardless of the smoking method used, were contaminated with Staphylococci, but the contamination rate was lower than the norm.
For Salmonella spp, only the smoked mackerel taken from the Katanga site were contaminated by these pathogens.

Total aerobic mesophilic flora at 30°C (FMAT): All the samples taken, regardless of the smoking method used, are contaminated with total germs. The level of contamination of the smoked fish collected is well above the standard (Table 5).

Total coliforms at 30°C: All samples taken regardless of the smoking method used were contaminated with total coliforms. 38.5% of the samples analysed had a level above the standard (100 germs per gram of product) and concerned both traditional and improved smoking (Table 5). 60% of the contaminated samples were from traditional and improved smoking. These 60% are from the samples from Atchinedji.

Anaerobic sulphite-reducing bacteria at 37°C (ASR): All the samples collected, regardless of the smoking method used, were contaminated with sulphite-reducing anaerobes (Table 5). 15.4% of the samples had a level of contamination above the standard (100 germs per gram of product) and concerned the sites of Yoromè and Katanga (traditional smoking).

Microbiological quality of fish according to germs: Of the five (05) germs tested, conformity to standards was observed only for "coagulase positive staphylococci" germs. Unsatisfactory results for the pathogenic germs "salmonella and sulphite-reducing anaerobes" were found at the Katanga and Yoromè sites for traditional smoking. The microbiological results were unsatisfactory for the hygiene control germs and FMAT spoilage germs. As for the hygiene control germs and "faecal coliform" spoilage germs, 38.5% of the results were unsatisfactory.

DISCUSSION

Assessment of the results of the survey: The evaluation of the microbiological quality of smoked fish allowed us to assess their microbiological quality and the general hygiene level of artisanal smoking. In our survey, 100% of our respondents were women. This percentage was found by Abotchi et al. (2010) when conducting the same studies in Togo. Thus, the artisanal smoking sector in Togo is dominated by women. The majority of these women, 54.54%, were illiterate, just as the results of the work of Abotchi et al. (2010) in Togo showed, but at an even higher rate of 80.95%. This low rate of schooling could compromise the ability of these women processors to understand the impact of microbial contamination on the quality of fish products and, moreover, on consumer's health.

Assessment of the microbiological quality of smoked fish on the different ovens

Spoilage flora: For the total aerobic mesophilic flora, all the samples taken (100%), regardless of the smoking method used, were contaminated with total germs. The level of contamination of the smoked fish sampled was well above the standard, i.e. $3.3x10^5$ CFU/g of finished product (smoked fish) regardless of the oven used. This result is similar to the results of other authors whose percentage of contamination by FMAT was 100% for the raw material and respective averages of $5.95x10^5$ germs per gram of fresh product and $7.69x10^5$ germs per gram of finished product (Abotchi et al., 2010). Oulaï et al. (2007) also observed a significant rate of contamination (97.61%); this difference in microbial load between fresh and smoked fish would be due to the contamination of products after smoking following the various manipulations. This difference in microbial load between fresh and smoked fish is due to the contamination of the products after smoking as a result of the various manipulations. In fact, most of the fish processors do not apply the basic rules of hygiene and good hygiene practices (GHP). The average of the total mesophilic flora of the smoked fish was lower than the average of $5.4x10^5$ germs per product obtained by Djinou (2001) whose samples were taken from units that apply good hygiene and manufacturing practices in their production process. It is lower than that of Oulaï et al. (2007) who found $3.1x10^7$ germs per gram of product working on 150 samples from traditional fish smoking in the Ebrié Lagoon in Côte d'Ivoire. Our results are different from those of Seydi (1991), Thiam (1993) and Dione (2003) who obtained respectively $2.8x10^7$; $3.4x10^8$ and $5.26x10^8$ germs per gram of product on braised-dried fish. In view of the results, FMAT was responsible for 100% of the non-compliance of the samples with the standards against 5% found by Abotchi et al. (2010); 6.09% found by Djinou (2001) and 0.6% by Gouen (2006). For braised-dried fish, it was the cause of 90% of the unsatisfactory quality according to Dione (2003). The enumeration of the total mesophilic flora was useful in that it allowed the definition of deviations from good manufacturing practices, particularly delays in the preparation of products (Ababouch, 1995). Its presence in large numbers indicates product spoilage. These germs do not have a great impact on the health of the consumer, but they do cause significant economic losses because of the deterioration of the products.

Thermotolerant coliforms: All samples taken regardless of the smoking method used were contaminated with total coliforms. 38.5% of the samples analysed were above the standard and concerned both traditional and improved smoking. This result is different from that of other authors who have observed contamination rates and therefore unsatisfactory microbiological quality of smoked fish samples amounting to 2.1% (Djinou, 2001), 0.78% for Gouen (2006), 48.75% (Abotchi et al., 2010).

Table 1. Distribution of samples by quantity and sampling sites

Sampling site	Number of samplesFT/ weight	Number of samples FA/weight	Species
ATCHINEDJI (AT)	-	03 (10kg)	Various
YOROME (Y)	02 (4kg)	01 (3.5kg)	Various
ODE (O)	01 (4kg)	02 (7kg)	Various
KATANGA (KT)	05 (9.2kg)	-	Sardinella, flying fish, half-beak fish, mackerel
Total	08 (17.2kg)	06 (20.5 kg)	

Table 2. Criteria for microbiological interpretation of results

Types of products	Microorganisms (CFU/g)				
	FMAT	Salm	S. P.P.	CTT	ASR
Fresh or frozen fish	10^4	Abs/25g	10^3	10	Absence
Smoked products: end of production	10^5	Abs/25g	10^2	10	Absence
	Jouve 1996	Jouve 1996	Jouve 1996	Jouve 1996	AFNOR 1996
Sources					UE 2005

Table 3. Distribution of respondents by age and sex

Respondents	[15 to 35]		] 35 to 55]		] 55 and more [		Total	
	N	%	N	%	N	%	N	%
Male	0	0	0	0	0	0	0	0
Female	92	30.7	162	54	46	15.3	300	100
Total	92	30.7	162	54	46	15.3	300	100

Table 4. Distribution of women fish processors by marital status according to their level of education

Marital status	Level of education							
	None		Primary		Secondary		Total	
	N	%	N	%	N	%	N	%
Married	138	46.03	93	30.95	30	10.11	261	87.09
Widow	26	8.51	9	3.15	4	1.25	39	12.91
Total	164	54.54	102	34.10	34	11.36	300	100

Table 5. Microbiological results for the five germs tested

Batch code	Searched parameters				
	FMAT UFC/g	CT UFC/g	STAPH UFC/g	ASR UFC/g	SALM UFC/g
01/YFA	$>3.3x10^5$	$6.0x10^{1(a)}$	$<1.0x10^2$	<40	Absence
02/YFT1	$>3.3x10^5$	$2.2x10^{3(b)}$	$<1.0x10^2$	$8.0x10^{1(a)}$	Absence
03/YFT3	$>3.3x10^5$	$1.6x10^2$	$<1.0x10^2$	$2.1x10^2$	Absence
$01/ATFA_1$	$>3.3x10^5$	$>1.7x10^4$	$<1.0x10^2$	<10	Absence
$02/ ATFA_2$	$>3.3x10^5$	$>1.7x10^4$	$<1.0x10^2$	<10	Absence
$03/ ATFA_3$	$>3.3x10^5$	$>1.7x10^4$	$<1.0x10^2$	<10	Absence
$01/OFA_1$	$>3.3x10^5$	$4.0x10^{1(a)}$	$<1.0x10^2$	<10	Absence
$02/OFA_2$	$>3.3x10^5$	5.9	$<1.0x10^2$	$7.9x10^1$	Absence
03/OFT	$>3.3x10^5$	1.8	$<1.0x10^2$	<10	Absence
$01/KTFT_1$	$>3.3x10^5$	<10	$<1.0x10^2$	<10	Absence
$02/KTFT_2$	$>3.3x10^5$	<40	$<1.0x10^2$	<40	Absence
$04/KTFT_4$	$>3.3x10^5$	$>1.7x10^4$	$<1.0x10^2$	$>1.7x10^4$	Absence
$04/KTF_5$	$>3.3x10^5$	<10	$<1.0x10^2$	<10	$>3,3.10^4$
Standard: Order n°86/08/MAEP/CAB/SG/DEP	1.10^6 C=2 ; n=5	M=100 C=1 ; n=5	M=1000 C=2 ; n=5	M=100 C=2 ; n=5	Absence in 25g

FMAT: Total mesophilic aerobic flora at 30°C: *Escherichia coli* at 44°C; TC: Total coliforms at 30°C; STAPH: Coagulase positive Staphylococci at 37°C; SALM:*Salmonella spp ;* ASR: Anaerobic sulphite-reducing bacteria at 37°C; n = number of units in the sample c = maximum number of results that can have values between m and M for the number of samples n performed.

Our results are different from those of Oulaï et al. (2007) who found an average of $4.8x10^4$ germs per gram of product for a percentage of 27.3%. They are also contrary to the results obtained by Thiam (1993) and Dione (2003) on braised-dried fish which found respectively 132.9 germs per gram of product and 56.98 germs per gram of product. The difference observed would be due to incomplete sterilisation of the product during smoking to which contamination germs were added or to significant contamination after smoking. Thermotolerant coliforms are a sign of poor hygiene conditions, in this case the hygiene of the personnel. Indeed, they are hosts of the digestive tract of humans and animals. Their presence is due to contamination of faecal origin.

Smokehouses do not have hand washing and disinfection facilities. Thus, the requirement to wash hands before each work shift was not observed. In addition, as these plants do not have fences, stray animals can leave faeces on the site and contaminate the smoking equipment and products.

Anaerobic sulphite-reducing bacteria (ASR): For sulphite-reducing anaerobes, all samples taken regardless of the smoking method used were contaminated with sulphite-reducing anaerobes. 15.4% of the samples had a level of contamination above the standard (100 germs per gram of product) and concerned the sites of Yoromé and Katanga (traditional smoking).

Our results were less satisfactory than those of Abotchi *et al* (2010) who found in their work that sulphite-reducing anaerobic germs were responsible for 3.75% of contamination and therefore for samples of unsatisfactory microbiological quality. According to the same authors, only smoked fish were contaminated at a rate of 1.25 germs per gram of product for a percentage of 3.75% of contaminated products. Thiam (1993) in a similar study found an average of 43.26 germs per gram of product on braised-dried fish. Gouen et al. (2006), in Côte d'Ivoire, found even more satisfactory results of 0.88%. In fact, these are bacteria of the genus Clostridium characterised by a heat resistance. These germs secrete enterotoxins that are responsible for serious toxic infections, which mean that they must not be present in foodstuffs intended for human consumption.

Salmonella, *Staphylococcus aureus:* Salmonella spp. were only found in smoked mackerel collected at the Katanga site on the traditional oven. For coagulase-positive staphylococci, all the samples taken regardless of the smoking method used were contaminated, but the contamination rate was below the threshold (1000 germs per gram of product). Our results are unsatisfactory compared to those of Abotchi et al. (2010) whose results revealed the absence of these germs in fresh and smoked fish; and also to those of Oulaï et al. (2007) who detected neither Salmonella nor Listeria in cold smoked fish. They differ from those of Thiam (1993) and Dione (2003) who found in braised-dried fish in Senegal 79% and 90% respectively. Less satisfactory results were found for smoked fish, i.e. 0.5% and 0.16% respectively by Djinou (2001) and Gouen (2006). The absence of pathogens such as Salmonella, Staphylococcus could be explained by the high temperature of smoking and low water activity of smoked fish due to dehydration.

General assessment of the microbiological quality: In sum, for the microbiological quality of the five (05) germs investigated, compliance with the standards was only noted for the "coagulase positive staphylococci" germs. The results of the analysis do not comply with the hygiene control germs and FMAT alteration germs. As for the hygiene control and spoilage germs "faecal coliforms", 38.5% of the results were non-compliant. The presence of FMAT and CTT indicates that the smoking and cooling process was poorly conducted, as these germs can remain and proliferate in the smoked fish after smoking. The lack of compliance with good hygiene practices and the unsanitary environment of the production workshops would be at the origin of the post-smoking microbial contamination. The smoking trays were sometimes placed on the floor. This non-compliant practice and the heat-resistant nature of RSA would explain the presence of RSA in smoked fish. The smoked fish are packaged in basins or baskets previously lined with paper or cardboard that has already been used to package the fish. This could also be a source of contamination of the finished product. All these contaminations could be controlled by implementing a number of actions.

CONCLUSION

This study has enabled us to take stock of the methods and techniques of artisanal fish processing and to familiarise ourselves with the different methods for assessing the microbiological quality of smoked fish. This study allowed the comparative analysis of traditional and improved ovens (Banda, Chorkor and FTT Thiaroye); three types of fish smoking systems that were introduced in Togo during the Agricultural Sector Support Project (PASA). This comparison was assessed on the basis of microbiological quality, which revealed a higher level of contamination in the samples from traditional smoking. In addition, the improved FTT-Thiaroye ovens have economic advantages as they require less fuel consumption and therefore appear to be the most cost-effective for fish smokers. In addition, the improved ovens facilitate the working conditions of women in the smoking sector by reducing the health risks associated with exposure to heat and smoke in the work area, as is unfortunately the case with traditional ovens. Women processors in the fish smoking sector should be sensitised on the advantages of improved ovens, especially FTT ovens, over traditional ovens to promote the use of this improved technology.

In the light of the results obtained, it would be important to carry out regular sensitisation of women processors on good hygiene and production practices, and to initiate training to upgrade the skills of women fish processors on good smoking practices and techniques.

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