HEALTHYFOODAFRICA PROJECT REPORT (2022)

CSIR-FOOD RESEARCH INSTITUTE TEAM

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INTRODUCTION

The Healthy Food Africa (HFA) project is a European Union (EU) Horizon 2020 collaborative research funded by the European Union, Horizon 2020 Grant Agreement No. GA 862740.
The project, themed *'Improving nutrition in Africa by strengthening the diversity, sustainability, resilience and connectivity of food systems'*, is working with multi-stakeholders and value chain actors to co-generate, co-develop strategic roadmaps; and co-design analytical frameworks labeled Food System Labs (FSLs) to develop a sustainable food ecosystem for the country. The project has 17 partners and is coordinated by the Natural Resources Institute Finland (Luke). These partners are in Europe (Italy, Netherlands, Norway, and Portugal) and Africa (Ghana, Benin, Ethiopia, Kenya, Uganda, and Zambia).

The Council for Scientific and Industrial Research (CSIR) Food System Lab (FSL) also referred to as FSL-Accra (FSL-AC)/CSIR is represented jointly by the Water Research Institute and the Food Research Institute. The CSIR-Food Research Institute is actively participating in Work Packages 2, 4, and 6 and is also the lead for WP6. This report, therefore, outlines activities undertaken during the period at CSIR-FRI.

KEY ACTIVITIES AND ACHIEVEMENTS

WP2 Activities

Data collection from the four different communities

Data collection from the four different communities has been completed. The second phase of activities focuses on the analysis of the preliminary results. Data were collected in four zones: west, east, south, and central zones along the coastal belt. Two communities from each zone were purposely selected; one from urban/peri-urban and one from rural, to capture geographic differences. In the third stage, a simple random sampling technique will be employed to select 103 households/individual subjects within each of the selected zones. In each district, the first day was used for field mapping and household enumeration. The enumerators with the help of the local liaison had called the households in advance to book appointments and arrived at the specific households at the scheduled time to conduct the survey. To ensure ease of accessibility when seeking consent from the participants and explaining the study objectives to the households, surveys were conducted in local languages where necessary. The whole survey involved interviewing the respondents to get background information on the household and conducting 24-hour dietary recalls. After each data collection day, the enumerators sent the electronic forms to the server from where the researchers were able to pick them up and check data to correct any mistakes and clarify uncertainties with the enumerators. Translation of the qualitative data was also carried out. A total of 534 households across target communities have been surveyed for the cross-sectional study to date. Respondents were aged 18- 87 old with the majority (58%) of the respondent being female. Socio-demographic descriptors of baseline respondents showed that the majority of respondents were married with an average family size of 4.47±3.84. The distribution of respondents across economic sectors showed that the majority were in agriculture-related services. Household economic activity disaggregated by Gender and economic sector showed most of them were self-employed. The data analysis is still ongoing.

Nutrition stakeholder engagement workshop

A stakeholder engagement workshop that sought to mobilize consensus on Social Behaviour Change Communication (SBCC) around nutrition and fish consumption was held in partnership with Work Package Leaders from Kenya. The FSL-AC HFA WP2 aimed at evaluating the impact associated

implementation of national strategies and their primary outcomes and identifying the SBCC key messages that can be employed to tackle malnutrition in the opinion of actors in the nutrition-related sectors of Ghana. The activity also sought to draw on the consensus between stakeholders from all levels of decision making and implementation to develop nutrition message recommendations and catalogue best practices in SBCC. To do this the team undertook a two-day workshop in Tomreik Hotel Accra with representatives of stakeholders between 22nd and 23rd November 2022. In all, forty key stakeholders were in attendance representing mainly independent academic/research professionals or health experts (n=5) and governmental organisations (n=18), local non-governmental organisations (n=5), food industry (n=7) and international non-governmental organisations (n=6) participated.

Summary of inferences from the workshop

The general point of convergence was that investing in nutrition education is critical and cannot be over-emphasized. Nutrition education and SBCC potentially help to achieve not only public health impact but results in the creation of social safety nets, growth of agribusiness, to reduce the cost of health (present and future), and ultimately achieving the SDGs. From the discussions. The following themes emerged:

- Innovative research: Micronutrient survey was viewed as a step in the right direction. Additional Research was seen as fundamental to evaluate the shortfalls of past nutrition strategies, adapt current strategies to the ever-changing Ghanaian nutrition landscape as well as help in the development and implementation of more resilient future nutrition strategies for Ghana. Research that will extend to providing guidelines and best practices for all nutrition activities carried out by international and national level actors. This is very important in nutrition surveillance. Research is also required for national early warning systems and nutrition emergency preparedness to ensure nutrition security for the citizenry.

- Nutrition education and nutrition/health promotion: At least two out of every four stakeholders interviewed reiterate the importance of nutrition education's influence on the success of any nutritional strategy. Nutrition education is essentially for promoting consensus between stakeholders, influencing policy design, and changing consumers' behaviour and nutritional environment. Participants opined that nutrition education/promotion will be improved if the following actions were implemented:

 Establishment of national guidelines/legislature that creates an enabling environment for nutrition education to able influence public policies and programming. Research-informed guidelines that promote access to a variety of nutritious local foods, address the barriers to nutrition, and move beyond individual behaviour change advocacy and information transmission as the only approach, but extend to environmental supports, organisational change, advocacy, and policy/legislature that work collaboratively across sectors and with social networks.

 A centralised national administrative (intersectoral multiagency) task force that will develop national nutrition messages and vet all national nutrition education and behaviour communication messaging to ensure coherent, persuasive messages with National Nutrition Policy and National Nutrition Action Plan. There should also be a national system of identifying, reporting misinformation and correcting wrong nutrition messages, especially in hindsight of the impact of nutritional misinformation during the Covid -19 pandemic.

 Institutionalising knowledge of the nutritional value of foods and awareness of the importance of nutrition in health by

- Early incorporation of comprehensive nutrition as a subject/course in national basic primary school through reviewing and revision of the curriculum.

- Incorporation of nutrition-related information at various levels throughout the secondary school academic environment. Teaching and learning methods employed should reinforce scientific evidence relating to the food quantity, quality, safety, and nutritional content.

- Adding nutrition to the essential curriculum courses required in the training of professionals in teaching, agriculture, food, environmental, health, and medical education.

 Behaviour change campaigns must adopt innovative communication, interactive teaching and learning strategies, and technologies that are creative to guide the design, development, and dissemination of innovative and useful messages; especially communication technology which includes both mass media, small media, folk media, and person-to-person

• Gender: Stakeholders recognized that women are extremely important contributors in food and agricultural systems and nutrition sectors. Yet very often political, sociocultural, and traditional norms often result in women having limited decision rights at national nutrition strategies decision-

making levels (generally controlled by men) and are often relegated to the implementation level of nutrition programming. The belief is that there are opportunities to do more to understand the basis for the power imbalances at the national and identify the current status of women and women's organisations in decision-making, (existing institutional policies demanding female involvement in decision-making and the progress made) and invest in targeted action to promote women's leadership that strengthening women's roles in decision-making. For women to garner some power and thrive, stakeholder organizations need to elevate an agenda that caters to women's agency and autonomy.

Perception of integrated strategies:

In Ghana, the integrated approach within the national stakeholders interviewed has not been without its shortfalls. However, stakeholders seem optimistic that integrated strategies are the way forward for nutrition programming in Ghana and the need to look at it from a multisectoral food system approach that requires a combination of preventive and curative strategies (package of nutrition-specific and nutrition-sensitive interventions). Reversing these current shortfalls is not impossible, and can be achieved with a systematic analysis of the broader spectrum of nutrition drivers (socio-economic, biophysical, technological, political, demographical, cultural resources) and linking these drivers to more immediate factors (water supply, sanitation, hygiene, gender equity, dietary preference, and household food distribution behaviour) affecting food affordability availability, accessibility, and safety at the national, regional and household level. To adequately do this, will require stakeholder engagement and joint efforts from various sectors including but not limited to agriculture, health, social welfare, education, and finance to harmonise efforts at various stages of programming: from creation/inception and policy design to implementation, monitoring, and scaling up.


Nutrition Education Strategies
for Improving Nutrition
and Health in Africa Workshop

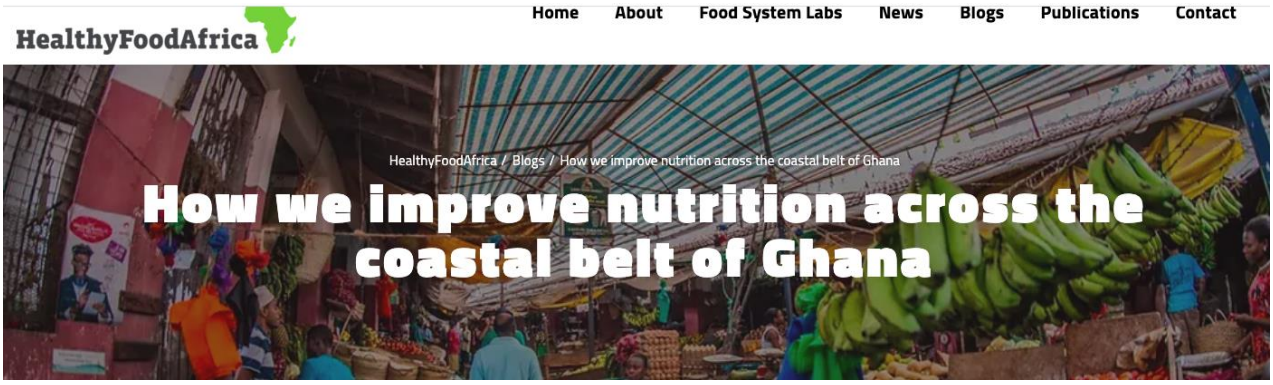

NUTRITION DEPARTMENT
BACKGROUND OF THE NUTRITION DEPARTMENT

Nutrition stakeholder engagement workshop

Blog post

Three (3) blog post were published on line.

Blog. 1

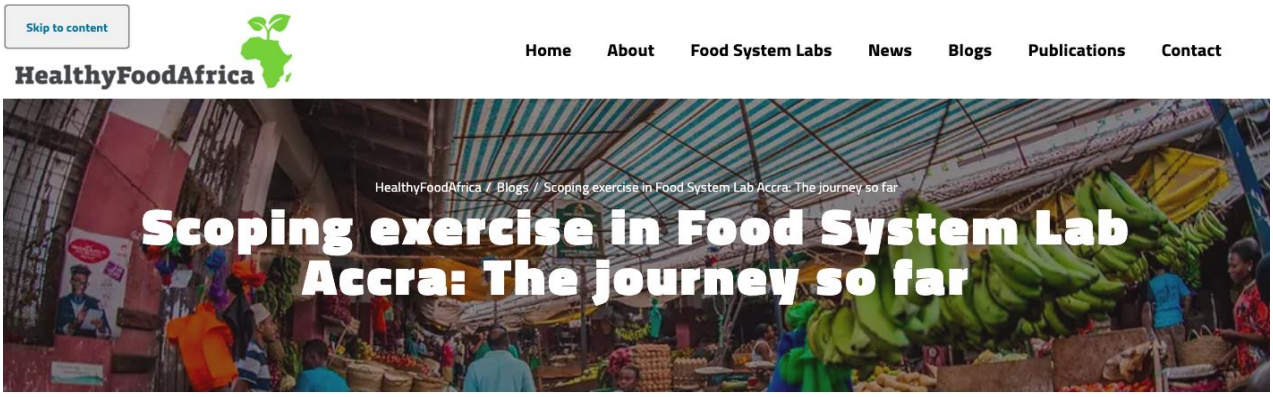


The blog elaborated on HealthyFoodAfrica's Accra Food System Lab's activities designed to address nutritional challenges. It provides insight into the HFA FSL-Ac's ultimate strategy and provides a platform for the dissemination of nutritional knowledge to the local population and increasing access to research-informed food products. The strategy explores the use of baseline dietary patterns information from selected communities along the coastal belt of Ghana to enhance and streamline current national nutritional efforts and messaging approaches that seek to increase, affordability, accessibility, and utilization of local foods through evidence-based knowledge transfer.

Link: https://healthyfoodafrica.eu/blog/how-we-improve-nutrition-across-the-coastal-belt-of-ghana/

Blog 2

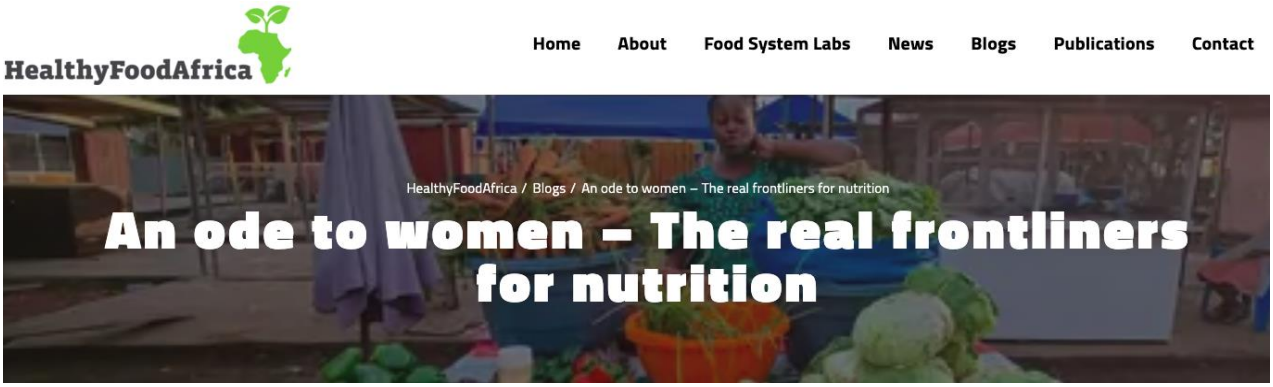
This blog was focused on discussing the activities HealthyFoodAfrica Food Systems Lab Accra's scoping exercise. The scoping exercise deliverables were geared toward ascertaining the overall picture of the food system in selected coastal communities a with special focus on fishing communities.



In doing this, we engaged stakeholders along the fish value chain at the household and community levels, identified any possible shortfalls in the current food systems, design innovative ways to improve food utilisation, consumption, and improve nutrition. This activity aimed at providing nutritional surveillance and evidential data for future nutrition programming. The hope was that the evidence gathered will form the basis for developing behaviour-changing communication strategies and tools that will enhance nutrition knowledge and general dietary intake in the study communities.

https://healthyfoodafrica.eu/blog/1325/

Blog 3



This blog was a discussion of baseline photo journal and shines light on a few of the unique experiences and realities of the women change makers we encountered who were. helping to address some of the food and nutrition consequences of the post COVID-19 pandemic.

https://healthyfoodafrica.eu/blog/an-ode-to-women-the-real-frontliners-for-nutrition/

WP4 Activities

Assessment of Food Safety Knowledge and Practices

The study revealed that out of the total sample of 206 fishermen and fish farmers interviewed, 124 (60.2 %) were from the Eastern region and 82 (39.8%) were from the Greater Accra region. The demographic characteristics of fishermen and fish farmers showed interesting results. Sixty-five participants (31.6%) were fishermen only, 65 (31.6%) were fish farmers only, and 76 (36.8) were both fishermen and fish farmers. The fishermen and fish farmers were mostly males, with the majority of participants interviewed aged between 20 and 29 years. Based on the data obtained the estimated mean age of the respondents was 33 years. Considering the educational level, almost half were educated to the JHS level and had 1 to 5 years of working experience as fishermen and/or fish farmers. Also, more than 60 % have had some formal food safety training while the rest had no formal training in food safety and hygiene.

Food safety knowledge of fishermen and fish farmers showed that majority of the respondents agreed with the assertion that water is the major source of transmission of diseases. Furthermore, they were aware that it was necessary to stay away from lakes or farms when they were affected by diseases like diarrhoea, dysentery, and cholera. They were also aware of the need to their wash hands with soap after using the toilet, and the necessity to wash and disinfect fishing and farming equipment. Generally, the fishermen and fish farmers had good knowledge of food safety and hygiene. This may be due to most of the respondents receiving food safety training.

Evaluation of the food safety practices of fishermen and fish farmers revealed that a high majority of them always wash their hands before eating, after using the toilet, and after handling fresh fish. The food safety knowledge of the fish handlers showed that generally, knowledge among the participants regarding key food safety issues was encouraging but whether they practice it is another issue altogether.

Waste Quantification and Oil Extraction

Nile tilapia (*Oreochromis niloticus*) waste quantification and oil extraction from the guts were carried out at selected sites in the Greater Accra and Eastern regions of Ghana. Sampling locations for these activities were Joma, Ashaiman, Weija in the Greater Accra region and Kpong, Akosombo in the Eastern region. Tilapia sampled for these activities comprised those from the

wild and culture systems (cages and earthen ponds). The waste quantification and oil extraction activities are outlined below:

Waste quantification

A web-based cross-sectional consumer survey was conducted using a semi-structured online questionnaire with 246 participants. The questionnaire was designed to assess which parts of the tilapia consumers considered edible or useful and which parts they considered as inedible or waste and administered online. Based on this, a total of 24 batches of fresh Nile tilapia samples were purchased from wild and culture systems. A known weight of tilapia was sampled and for each batch, the head, fins, scales, gut, gill cover, and bones were separated for weight estimation. Whilst some were carried out on-site, the majority of the experiment was carried out in the fish processing laboratory. The sampled tilapia comprised different sizes (weight: 300-500 g; length 22-29 cm; width: 10-14 cm) to churn out results that are close to representing a quantitative overview of tilapia waste. The data has been analysed and the write-up is ongoing.

Sample collection

Fish separation for waste quantification

Oil Extraction

It is common knowledge that lipids can be found in multiple regions of tilapia fish. This experiment, however, mainly targeted semi solid fats from the guts which are not readily visible. Ten (10) samples of Nile tilapia from ponds and wild sources were used. For each sample, guts were collected in a plastic bowl, and upon the addition of clean water and vigorously shaking the guts, creamy to white semisolid fats appeared on the surface of the water. These semisolids were collected, scooped/sieved off, and washed several times. The washed fats were boiled with water for 25-35 min to remove all the water (by evaporation) thereby leaving the oil. Generally, it was observed that per equal weight of guts from wild tilapia and cultured tilapia especially that of the

cage, higher volumes of oil were extracted from the latter. Five (5) ml of each of the samples were sent (via DHL on 6/7/22) to the Department of Food and Nutrition, University of Helsinki (Dr. Hanna Koivula)) for Tocopherol and Percentage (%) of total fatty acids analysis after receiving EU authorization for the shipment. The commodity code received was III 1504 20. The duplicate samples are being analysed at CSIR-FRI Moisture, acid value, free fatty acid (FFA), copper, iron, phosphorus, and zinc (CSIR-FRI).



Gut Extraction


Manual agitation of guts in water to force semisolid fats on the surface and scooping of fat on the water into a container.



Scooped fat is boiled for 25 - 35 min to remove water by evaporation thereby leaving the oil which is allowed to cool and poured into a bottle.

Extraction of Gelatin from Scales

The study was conducted during the dry (February 2022) and wet (July 2022) seasons for comparison. Nile tilapia samples obtained from Weija Lagoon (wild) in the Greater Accra Region and Akosombo in the Eastern Region (cage cultured) were descaled, iced, transported, and stored at -20 °C prior to usage. Before extraction, they were thawed and pre-treated by washing with water and soaking in 0.5M NaOH for 30 min (3x). Separate weights of cultured and wild tilapia scales were digested using acid (0.9 % H_2SO_4) for 20 min and base (0.7 % NaOH) for 40 min (3x). The scales were washed under running water until neutral pH was obtained. The final extraction was carried out in distilled water to obtain the fish gelatine extract. The extract was filtered, and it was observed that the yield from the cultured tilapia scales was more than that from the wild tilapia scales. Also, the cultured scales appeared lighter/clearer/less turbid than the wild scales. The filtrates were freeze-dried at 50 °C for 24 h, weighed, and milled. The total quantity of gelatin obtained for the dry season cultured and wild respectively were 158 g and 39.25 g which represented a yield of 7.9 and 2 % respectively for the dry season and 7.95 and 1.98 % for the cultured and wild gelatin during the rainy season. The viscosity, emulsifying capacity, proximate (pH, yield, protein, moisture ash, fat), and physical characteristics (colour, turbidity, gel strength, structural studies (X-ray diffraction, FT-IR). SDS-PAGE (Sodium dodecyl sulfur-polyacrylamide gel electrophoresis) to determine molecular weight and α/β ratio of gelatin was conducted but the

outcome was not positive. Gelatin is a colourless and flavourless food ingredient, commonly derived from collagen (a protein found in connective tissue, skin, bone, cartilage) taken from animal body parts. It is brittle when dry and rubbery when moist. It is commonly used as a gelling and thickening agent in foods, beverages, medications, drug or vitamin capsules, photographic films, papers, and cosmetics. The data has been analysed and the draft manuscript is under preparation.

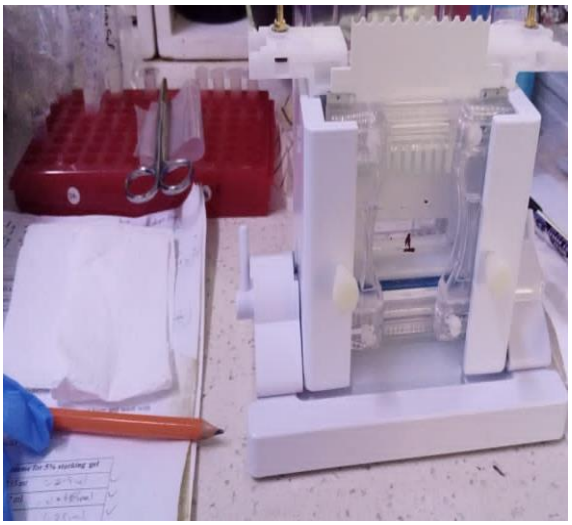
Nile tilapia scales

Digestion of scales by acid/alkali

Purified scales are filtered

Extraction of gelatin in water bath

Freeze-dried gelatin products



SDS-PAGE (Sodium dodecyl sulphur-polyacrylamide gel electrophoresis) experiment

Microbial Studies

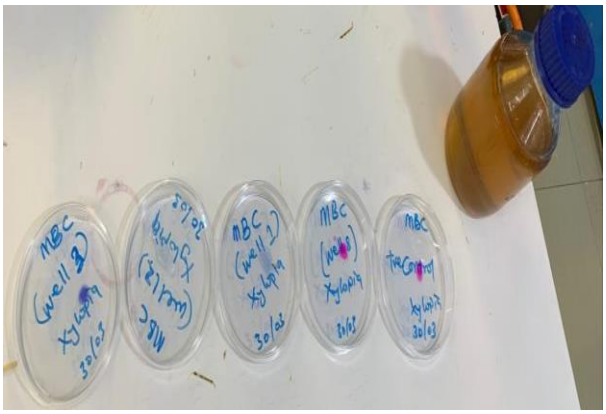
Determination of Minimum Inhibitory Concentration and Minimum Bactericidal Concentration of the spices against selected pathogenic (*Clostridium perfringens*, *E. coli*, *Salmonella* spp, *S. aureus*) and spoilage (*Pseudomonas*) bacteria of fish is completed. The results indicated varying degrees / extent of inhibition with the test pathogens.

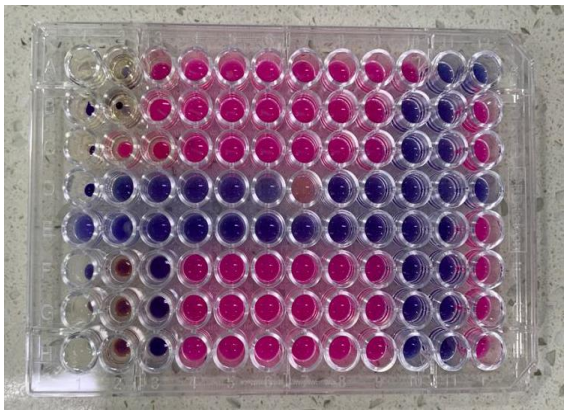
Essential oil-treated tilapia fillets spiked with one pathogenic (*C. perfringens*) and one spoilage organism (*Pseudomonas aeruginosa*) for Microbial Challenge Study has been completed. The treated fish fillets were packaged under vacuum and stored at 5º for and monitored daily for 5 days. The treatments appeared to be effective in combination with vacuum packaging as there was a decline in bacterial counts with time.

Efficacy of spice extracts on tilapia fillets under fresh and chilled conditions completed. A consumer acceptability study has been completed using a panel of 55. Data analysis is completed. Generally, the control sample was preferred over the essential oil-treated samples because the panelist had not associated the strong aroma with fish.

Investigation of the survival of pathogenic bacteria (*C. perfringens*) and a spoilage bacterium (*P. aeruginosa*) spiked on tilapia fillets (control) and essential oil treated tilapia fillets under chilled (4ºC) and abuse temperature (10, 15, 25 ºC) conditions in high-density polyethylene packaging is

completed. The treatments appeared to be effective in combination with vacuum packaging as there was a decline in bacterial counts with time.





Microbial studies

Package treated fish fillets

Sample preparation and sensory studies

WP6 Activities

Commissioning of Renovated Fish Processing Facility by Director General of CSIR

The outgoing Director General of CSIR on his final visit to CSIR-Food Research Institute on 15th February 2022, toured and commissioned the Healthy Food Africa renovated fish processing hall. His entourage included Directors from the Head Office, immediate past and acting Directors of CSIR-FRI, and the Interim Management Committee of CSIR-FRI. He congratulated the project team and expressed his excitement about the range of products developed, the renovated facility, and his desire to see most of the products on the Ghanaian market. He encouraged the project team to execute the project objectives effectively to lift the image of CSIR. He also suggested that the institute could support the potential up-takers with the CSIR-FRI logo on the products and charge a token from their proceeds to generate income for the institute.

DG of CSIR and his entourage touring the HFA fish processing hall

Multi-Stakeholders Workshop

A multi-stakeholder workshop was held at CSIR-Food Research Institute on Wednesday, 17th February 2022 to validate the improved stove/smoking oven performance survey report. The stakeholders included governmental agencies, Research, Development and Academia; Civil Society Organizations; Non-governmental organizations (NGOs); Fish Processing Associations and other relevant agencies in the value chain. In his opening remarks, Dr. Seth Agyakwah, Principal Investigator on the project delivered the opening remarks. He was optimistic that technical knowledge would be shared by experts from CSIR-FRI/WRI and other institutions present who have dedicated time and resources to address issues leading to improved 'Ahotor' oven performance. The Acting Director of the CSIR-Food Research Institute, Prof. Charles Tortoe delivered the welcome address. He indicated that the activities of WP6 of the HFA project were in line with the mandate of the Institute. He expressed his appreciation to the stakeholders for their support and was hopeful their contributions at the workshop would be towards the improvement of the existing ovens and the value addition of fish in general.

Mrs. Amy Atter, Co-Project Investigator and WP6 lead at the CSIR-FRI presented an update on work done on the project. Her presentation covered the thematic focus and goal of the project; an overview of tasks and activities, work carried out in WP6 and activities yet to be carried out by CSIR-FRI. She indicated that based on the preferred products that will be selected at the WP level

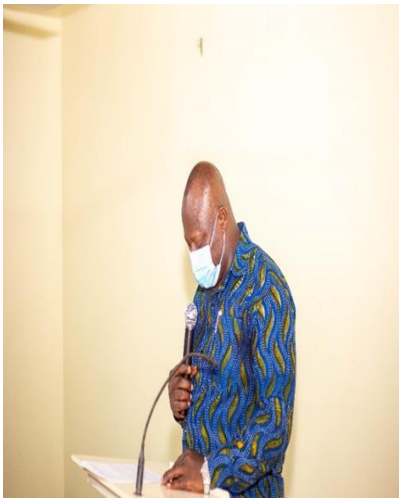
and by local up-takers, sensory, microbial, chemical/nutrient and shelf life studies will be conducted on them for Food and Drugs Authority certification to ensure sustainability. She also reported that about 100 different microbes (both good and bad) were identified in tilapia samples obtained from selected fish farms and the data is being analysed. Nutrient profile, pesticide, and heavy metals will be carried out with some already started. Fish smoking, salted tilapia drying, and catfish canning experiments (microbial, molecular, physicochemical, value addition to catfish oil, sensory, etc) will also be carried out and results disseminated within selected communities the FSL is working in. A food fair is also expected to be held later.

Mr. Steven Nketia presented a detailed report on the survey conducted on improved stove performance evaluation. He said questionnaires were developed taking into consideration, the existing stoves and were administered to processors in the areas where the stoves were deployed. The draft report was sent to all members on the platform to peruse before attending the workshop. Some of the observations made during the survey according to him were that some of the beneficiaries were using the stove effectively, some had done some changes to the ovens and some had ideas to help improve the ovens. He indicated that it was a good experience to have women's voices heard and would be incorporated in the improvement of the Ahotor oven.

Mr. Emmanuel Kwarteng, the Ph.D. student on the project (WP6) indicated that the development of Ahotor was to address issues such as reduction in PAH, temperature, the effect of the fat droppings on the galvanised material when heated, etc. He stated that, in 2020, the Fisheries Commission conducted an evaluation of the 250 installed Ahotor ovens in different parts of Ghana, and the survey yielded some interesting findings. Most of the women were not interested in the use of the Ahotor ovens in their current state. This was mainly because the ovens could not smoke a lot of fish, the fish processing time was longer compared to the Chokor oven and the other available ovens and they did not receive any form of training on the use of the Ahotor oven. However, they stated that should the modified Ahotor meet their needs of smoking a lot of fish they will adopt it.

There was extensive discussion on the report by stakeholders who also shared data their organisations already have on the Ahotor oven. They all agreed the improvement was very necessary and proposed HFA should focus on:

- Ahotor oven with the use of Liquefied Petroleum Gas (LPG)/ charcoal or fuelwood as a fuel source (3 in 1 oven)
- Ahotor oven with a fat collector using charcoal alone as a fuel source
- Ahotor oven with fat collector using fuelwood alone as fuel a source;
- Chorkor smoker with a fat collector using fuelwood alone as a fuel source
- The construction of FAO-Thiaroye technical (FTT) for comparison study was also agreed upon.





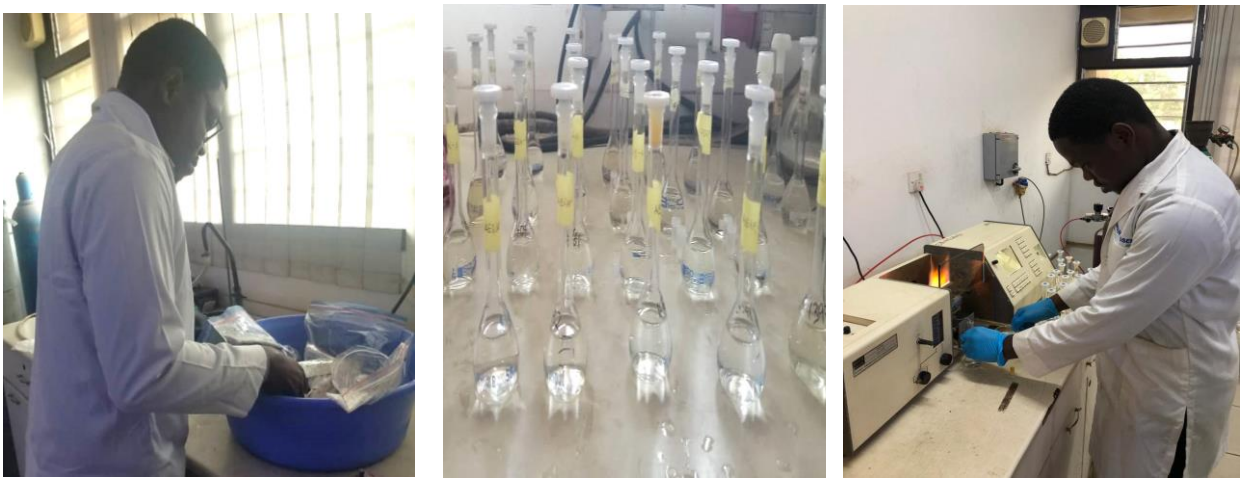



Stakeholders touring the HFA fish processing hall

Chemical Contamination in Water Bodies and Nile Tilapia Fish

Chemical contaminants (pesticides and heavy metals) in selected water bodies and Nile tilapia fish (*Oreochromis niloticus*) samples from the Greater Accra, Eastern, and Western Regions were analysed. Pesticides were determined using Varian CP-3800 Gas Chromatograph while heavy metals concentrations were measured using the Atomic Absorption Spectrophotometer (AAS). Determination of organophosphate, organochlorine, paraquat, and synthetic pyrethroid in the Volta Lake, Whine River, Weija lake, waste from the Weija treatment plant, as well as the muscle,

bone, and gills of Nile tilapia fish samples. Heavy metals such as mercury (Hg), lead (Pb), Cadmium (Cd), arsenic (As), Nickel (Ni), Zinc (Zn), Iron (Fe), Aluminum (Al), Copper (Cu), Chromium (Cr), Selenium (Se), and Vanadium (Vn) were determined in Volta Lake, Whin River, Weija lake, waste from the Weija treatment plant, as well as the muscle, bone, and gills of Nile tilapia fish samples. Bifenthrin concentration was detected only in the Weija Lake sample which was below the guidelines set by the EU. Chlorpyrifos concentrations were detected in Recycled Waste, Weija Lake, Whin River, and Volta Lake respectively but were below the guideline level set by WHO. With the exception of aluminum and vanadium, ten (10) heavy metals (As, Hg, Cr, Fe, Zn, Cu, Se, Cd, Pb, Ni) were detected in both the water and the Nile tilapia fish muscles, bones, and gills samples. Chromium (Cr) metals analysed in Nile tilapia fish muscles, bones, and gills samples obtained from Eastern Region were above the guideline set by WHO. Generally, chromium levels in samples obtained from farms in Eastern and Western Regions were above the WHO recommended levels and may therefore pose a threat to aquatic wildlife and human health. The thesis write-up was completed by Mr. Emmanuel Osei, perused by supervisors, and submitted to CSIR College of Science and Technology (CCST).



Preparation of samples and chemical contaminants analysis

Technology Improvements on Existing Technologies

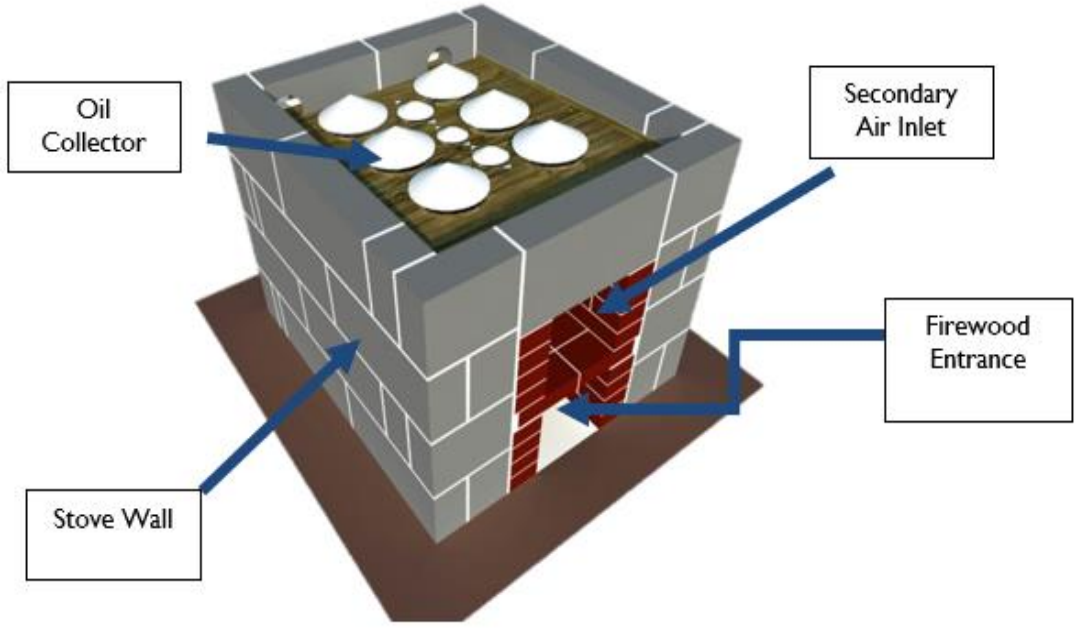
A consensus was reached on the improvement necessary on the existing Ahotor oven during the multi-stakeholders 'workshop held at CSIR-Food Research Institute on 17th February 2022 to validate the improved stove/smoking oven performance survey report and discussions among

multi-stakeholders. Based on this, the Ahotor oven was redesigned to improve and address major concerns such as increasing the range of adoption by different end users, increasing energy efficiency, capacity, time efficiency, technological cost, ease of operation, emissions, and PAH levels. The combustion has been modified to include a chamber for charcoal briquettes as well as a built-in LPG gas 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. The Chorkor oven has also been modified to improve the PAH levels and hygiene. FTT unit has also been installed to allow for comparative testing and analysis. The fieldwork on stakeholder analysis and gender audit revealed a fish processors' revision of the two-roomed fuel combustion chamber to a single room and a remark that cooking time has decreased.

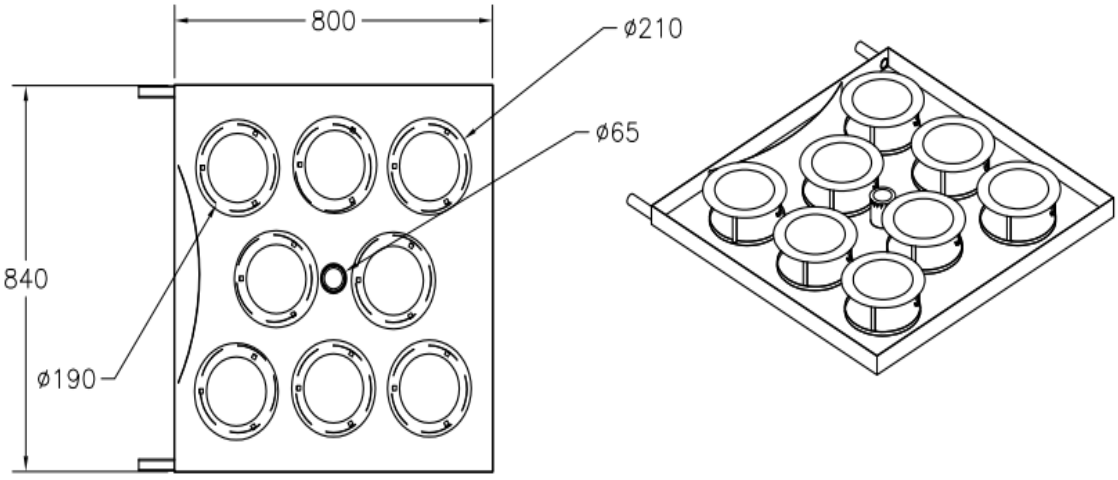
The Ahotor Oven

The Ahotor Oven is made up of a combustion chamber that is fitted centrally to a chorkor-like outer shell, with fish processing trays above, just like a traditional oven. Above the combustion chamber, a fat/oil collecting tray (as shown in the next figure) is fitted that allows the hot gases to flow up through to the fish while preventing any fat from dropping down onto the fire. A primary air inlet supplies oxygen into the combustion chamber to enhance the efficient combustion of fuelwood.

The secondary air inlet located on top of the fuelwood entrance introduces cool air into the smoking chamber to meet with hot gases from the combustion chamber to enable evenly circulation of air and heat in the smoking chamber. The grate located in the combustion chamber improves combustion by reducing smoke emissions. For the purpose of this research, three different designs of Ahotor ovens were produced.



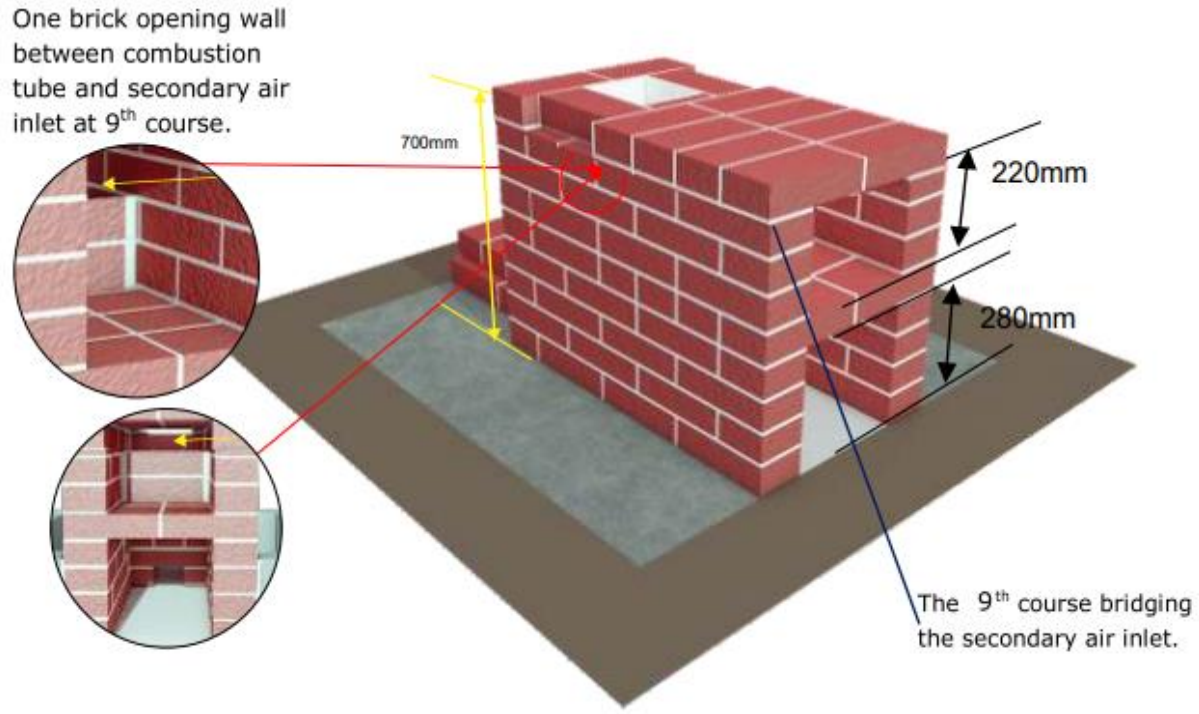
The Ahotor oven design



The fat/oil collector design

The Ahotor oven with increased combustion chamber size

The Ahotor oven has been redesigned based on end users' feedback. The design is expected to address two major concerns from the survey and stakeholder engagement – time efficiency and the capacity of production. The dimension of the combustion chamber and combustion tube has been increased by a factor of 0.25 to accommodate more fuel and ensure increased transmission of heat for rapid cooking and increased capacity. The impact of these two performance parameters on emissions, energy efficiency, ease of operation, and PAH levels will be evaluated.



***Ahotor oven with 3 (*Gas, Charcoal & Fuelwood) fuel source design**

The gas, charcoal and fuelwood type Ahotor oven

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 LPG gas 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 what the end user wants, a fuel mix option could be used to improve the taste and texture preference.

A unit each of 1) Charcoal and 2) Fuelwood alone

Gas, charcoal and fuelwood combined Ahotor oven

The modified Chorkor oven

The Chorkor Oven was developed and introduced in 1969 by FAO and the CSIR-FRI. Although it was originally designed for use in Ghana, the Chorkor oven has since gained widespread

adoption in most Western, Central, and Eastern African countries. The Chorkor oven became popular because of low construction costs, durability, large production capacity, and uniformity of smoked products due to ease of operation. To date, the Chorkor oven is the most dominantly used fish smoking technology in Ghana.

Under this project, the Chorkor oven has been 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. The design maintained the original dimensions and materials of the technology. The performance parameters of the new design will be tested both microbiologically and chemically. A successful outcome of the test will significantly improve safe fish production in Ghana since over 80% of fish processors in Ghana process their fish using the Chorkor oven.

Modified Chorkor oven with fat collector

Installation of FAO-Thiaroye Technical (FTT) oven

FAO-Thiaroye technical (FTT) is designed to conduct manufacturing operations for smoked fishery products more reassuring for public health. The technology aims to reduce post-harvest losses, add value to finished products, and promote environmental protection by utilizing agricultural biomass and natural resources such as firewood. It helps save the environment by

focusing on the reduction of wood as fuel, especially since the addition of stone reduces by about 50% the required quantity of coal. FTT mainly solves the problem of chemical contaminants from the smoked fish, particularly Polycyclic Aromatic Hydrocarbons (PAHs), and implements all the documentation relating to the management of the quality of the smoked products on the domestic market and, in particular, Europe (Bomfeh, 2020).

As part of this project, one FTT unit was installed to allow for comparative testing and analysis. In comparison to existing smoking technologies, the model will be tested for emissions, energy and time efficiency, ease of operation, capacity, and PAH levels. Fish smoking experiments to validate the improvements in these fish smoking technologies will be conducted in the next phase of the work. Good outcomes may complement efforts to optimise Ghana's production of healthy and safe fish.

A unit of FFT installed at FRI

Nutrient Profile of Fresh Nile Tilapia

Analysis carried out on nutrient profile studies of fresh Nile Tilapia samples included moisture, fat, ash, fibre, mineral, Vitamin A and E content, and amino acid profile. The moisture content of fresh filleted wild, pond, and cage-cultured tilapia ranged between 76.9 – 80.6%, 75.9 – 77.8 % and 68.5-74.7 % respectively. Wild fish (filleted) sampled from Greater Accra Region had

significantly higher moisture content while cage-cultured tilapia from the Eastern region recorded the lowest moisture content. The protein content of cage-cultured fish was higher than pond-cultured tilapia and wild tilapia. There was no significant difference in the fat content of wild tilapia (filleted) samples from the Greater Accra and Eastern regions of Ghana. The ash content of tilapia from the Eastern region was lower than the others. The crude fibre contents of the tilapia samples were diverse. It was also observed that the tilapia samples analysed as a whole had higher moisture, protein, fat, ash, and fibre contents compared to their respective filleted counterparts.

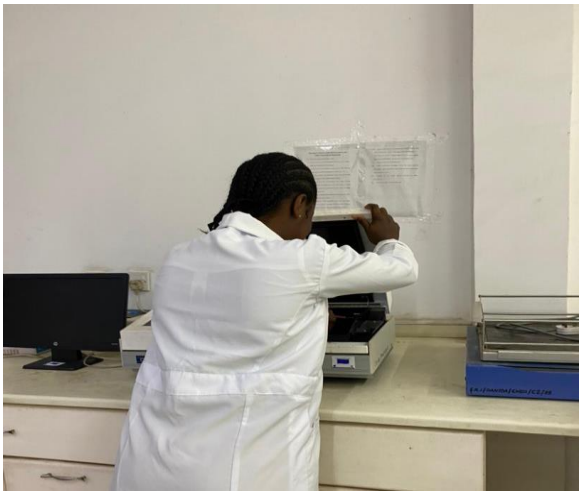
The mineral tested for were calcium, sodium, potassium, zinc, and magnesium. The wild tilapia (filleted) samples from the Eastern region recorded higher calcium contents as compared to the wild tilapia (filleted) sample from the Greater Accra region. Pond-cultured (whole) sample from Greater Accra recorded the highest sodium content. Besides, potassium levels for all wild tilapia (filleted and whole) samples from the Eastern region were higher than the wild sample from the Greater Accra region. There was no significant difference in the level of Zn in most samples, although the pond-cultured (filleted) sample from the Eastern region recorded significantly higher zinc contents. Also, the wild tilapia from the Greater Accra region had the highest magnesium content.

The vitamin A content of tilapia ranged between 0.03 - 0.63 mg/100g with the wild tilapia (whole) sampled from the Eastern region recording higher content. There was no significant difference in the vitamin E levels in all samples tested.

For the amino acid profile, lysine, leucine and aspartic acid were the most abundant amino acids. Generally, it was observed that the samples analysed as a whole had higher contents of each amino acid compared to their respective filleted counterparts. Also, lower levels of amino acids were recorded for wild tilapia (filleted) samples from the Greater Accra region.

Filleting of tilapia

Extraction of minerals and vitamins



Measuring the absorbance

Salted Dry Nile Tilapia (Koobi)

Aerobic mesophilic count, *Enterobacteriaceae, Escherichia coli, Coliform, Staphylococcus aureus, Bacillus cereus, Clostridium perfringens, Salmonella spp, Listeria monocytogens* and *Vibrio* spp were the microorganisms analysed to evaluate the microbial quality of ten (10) market retailed salted dried Nile tilapia (koobi) samples from the Greater Accra and the Eastern Regions. Six freshly harvested Nile tilapia samples taken from the cage (2), pond (2), and wild (2) sources were hygienically processed into koobi by degutting live fish, salting, fermentation, and

mechanical drying. These samples were tested before and after processing for their microbial and chemical safety. The retailed samples recorded aerobic mesophilic counts ranging from 10^2 to 10^6 CFU/g. Even though *E. coli, Enterobacteriaceae, Staph. aureus,* and *B. cereus,* were present in some of the samples, generally, most of the pathogenic microorganisms tested for were absent or not detected in the retail market samples. *C. perfringens* were however present in most of the samples. Some level of reduction in the microbial counts was observed in the hygienically processed koobi which may be attributed to hygienic preparation and the mechanical drying method used. The moisture, ash, fat, protein, carbohydrate, energy content, and formaldehyde of salted dried Nile tilapia (Koobi) were also analysed. The samples with acceptable microbial counts and proximate results from the different sites were used in the development of koobi in olive oil for the consumer acceptability test. Sensory evaluation of the sensory attributes of the salted dried Nile tilapia was conducted using 50 panelists The samples were assessed based on the following attributes: aroma, texture, taste, mouthfeel, and overall acceptability based on a 9-point hedonic scale with the degree of likeness expressed as 1 - dislike extremely, 2 - dislike very much, 3 - dislike moderately, 4 - dislike slightly, 5 - neither like nor dislike, 6 - like slightly, 7 - like moderately, 8 - like very much and 9 - like extremely. The results are being analysed. Molecular detections of other food safety pathogens are yet to be carried out on other market samples.

Degutting, salting and fermentation process



Oven drying of salted Nile tilapia


Steaming of koobi and other ingredients for product development

Trial koobi in oil for and sensory evaluation

Labeled koobi in oil

Report on Sensory Evaluation of Developed Products

Development of fruity soy pancake mix, ready-to-use frozen vegetables of okro / ademe (jute) leaves, fish chips, fish sausage, koose (black eye pea) mix, and the ready-to-eat cereal mix (maize, millet and combination of maize and millet) were carried out. Sensory studies (consumer acceptability) on these products were conducted to assess the level of acceptance of the products. A total of 50 to 75 panelists consisting of staff from CSIR-Food Research Institute were used for the evaluation of the sensory attributes. The assessments were based on attributes including aroma, texture, taste, mouthfeel, and overall acceptability. Assessors rating were based on a 9-point hedonic scale with the degree of likeness expressed as 1 - dislike extremely, 2 - dislike very much, 3 - dislike moderately, 4 - dislike slightly, 5 - neither like nor dislike, 6 - like slightly, 7 - like moderately, 8 - like very much and 9 - like extremely. Minitab Statistical Software was used for the analysis of the data obtained. Statistical differences were obtained using analysis of variance (ANOVA). Statistical differences among the sensory attributes were established using Tukey pairwise comparison at 95% confidence level.

Some panelists accessing some of the developed products

CONSORTIUM MEETING

HealthyFoodAfrica Project Consortium Meeting was held in Accra, Ghana from the 29 Nov. to 1 Dec. 2022 at the GS Plaza Hotel. Participants arrived on Mon. 28th Nov. 2022. The objectives of the Consortium Meeting were given by Mila Sell who joined via zoom and the chairperson's remarks were given by the Director General of the CSIR (Council for Scientific and Industrial Research) Professor Paul Pinnock Bosu. The first day had presentations from the different Work Package (WP) and Food System Labs (FSLs) leads on updates on activities and their respective innovations. Presentations on 'Quantification and Utilization of Nile Tilapia (Fish) Waste' and 'Baseline Fish Farming Characteristics and Practices in FSL Accra' were presented by the CSIR (Amy Atter and Seth Agyakwah). Discussions centered on 'Reflections on WP and FSL Presentations and Takeaways'. A welcoming dinner was held with music provided by the Ghana Police Band. The second day focused on the innovations from the different FSLs and WPs. A study tour to CSIR-Food Research Institute was made by the consortium team to familiarize themselves with ongoing HFA activities. The Director of the Institute, Prof Charles Tortoe supported by the Deputy Director, Dr. Charlotte Oduro-Yeboah welcomed the team. They had the opportunity to tour the test kitchen, sensory laboratory, and fish processing laboratory. They also tasted the different products developed under WP6 including fish chips, koose, fruity soy pancake, smoked fish (using the improved Ahotor oven), etc. They also had some packaged products for takeaways. Some WP6 potential up-takers also exhibited their products. HFA Partners visited Selasie Farms

and Groceries, producers and exporters of processed foods including Hausa koko powder, banku powder, and ready-to-eat cereal mix at North Legon-Accra, and a Small Scale Aquaponic Farm at East Legon the following day. The third day focused on the impact pathways for FSLs and WPs the project should be working towards. Reflections and recommendations on the Progress of HFA were presented by a representative of the Project Advisory Group (PAG). The next steps were discussed and the meeting officially closed with a farewell dinner. The meeting was ably moderated by Dr. Jolene Nyako. Below are some pictures from the meeting activities.

Address from the Director General of CSIR

Statements from the Deputy Directors of WRI and FRI


Healthy FoodAfrica
Improving nutrition in Africa by strengthening the diversity, sustainability, resilience and connectivity of food systems
ACCRA FOOD SYSTEM LAB (FSL-Ac)


Healthy FoodAfrica
FRUITY SOY PANCAKE MIX
Healthy eating for nutrition and good health


Healthy FoodAfrica
ACCRA FOOD SYSTEM LAB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Healthy FoodAfrica


UITY SOY
NCAKE MIX


Healthy
FoodAfrica


Healthy
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ACCRA FOOD SYSTEM LAB (FSL-Ac)
Healthy nutrition
Food packaging and
safety
Food chain
governance
Innovative food
products


Healthy
FoodAfrica

Presentations by FSL and WP leads

Bilateral discussions


CSIR - COLLEGE OF
SCIENCE & TECHNOLOGY
(CCST)


Healthy FoodAfrica


ACCRA FOOD
SYSTEM LAB
ACCRA FOOD
SYSTEM LAB

Visit to CSIR-FRI

Visit to Selasi Farms and Glossaries

Visit to an aquaponics farm

Wrap ups

Meeting moderator

Facilitation team


Healthy FoodAfrica
FRUITY SOY
PANCAKE M


FRUITY SOY
PANCAKE MIX
Healthy eating for nutrition and good health


Healthy
FoodAfrica
ACCRA FOOD SYSTEM LAB

Other FSL-Ac core and non-core team members in attendance

Some group photographs

Snacks and lunch sessions


Welcoming and closing dinners