COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH • GHANA •

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CSIR – FOOD RESEARCH INSTITUTE

ANNUAL REPORT 2022

CSIR – FOOD RESEARCH INSTITUTE

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ACRONYMS

CRP	C-Reactive Protein
DAES	Directorate of Agricultural Extension Services
FAO	Food and Agriculture Organization
FDA	Food and Drugs Authority
FTT	FAO-Thiaroye Technical
IGF	Internally Generated Funds
LPG	Liquified Petroleum Gas
MMDA	Metropolitan, Municipal and District Assemblies
MoFA	Ministry of Food and Agriculture
NAFTA	North American Free Trade Agreement
NaOH	Sodium Hydroxide
NARS	National Agricultural Research System
PAH	Polycyclic Aromatic Hydrocarbons
QDA	Quantitative Descriptive Analysis
RE	Routine Expansion
RT-PCR	Reverse transcription-polymerase chain reaction
SBCC	Social and Behaviour Change Communication
SDG	Sustainable Development Goal
WP	Work Package

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FOREWORD

The CSIR-Food Research Institute during 2022 pursued its mandate to conduct applied market-oriented research into problems of food processing and preservation, food safety, storage, marketing, distribution and utilization, and national food and nutritional security in support of the food industry and to advise government on its food policy. Emphasis was placed on its overall goal of assisting in poverty reduction by creating opportunities that can generate and increase revenues within the micro-small – medium and large-scale agro-food processing industries as well as contribute to food security, foreign exchange earnings and the application of cost-effective food processing and preservation technologies that are environmentally sustainable. Interestingly, our mandate and overall goal addresses the Sustainable Development Goals 1, 2, 3, 9 and 12.

The Institute is grateful to the Almighty God for the progress chalked during the year. The Institute progress had been achieved by the excellent contribution of all staff comprising of senior members-core, senior members non-core, senior member technologists, senior staff, junior staff and contract staff. This is well appreciated and acknowledged. The leadership role presented by the Internal Management Committee and all other Committees culminated in the successful implementation of good management processes and procedures, good cooperate governance, adherence to all statutory requirements, implementation of best practices on its accounting and internal controls in the Institute.

In 2022, the 2nd CSIR-Food Fair and the World Food Day 2022 with the theme ‘Leave no one behind: Better production, better nutrition, a better environment, and a better life’ was organized in collaboration with the Food and Agriculture Organization of the United Nation. CSIR institutes, the universities, Small-scale Medium Enterprises and the public attended the event. I am thankful for the sponsorship from Ghana Gas Company Limited, Cocoa Touton Company Limited, Cocoa Processing Company Limited, CSIR-Water Research Institute, Bel-Aqua Company Limited, Kasapreko Company Limited, GCB Bank Ghana Limited and others.

I am grateful for the support of the Ministry of Environment, Science Technology and Innovation (MESTI), Ministry of Food and Agriculture (MoFA), Food and Drugs Authority (FDA), Ghana Standards Authority (GSA), Association of Ghanaian Industries (AGI) and Chamber of Agribusiness-Ghana (CAG). Further, I acknowledged the timely sponsorship from our foreign partners for our research, technology and developmental programs, including European Commission for Horizon 2020 HealthyFoodAfrica and SmallFish, CABInternational for Pesticides in Vegetables Project, Bill and Melinda Gates Foundation for GC Fermented Foods Project, African Union (AU) for SafeFish Project, Canadian Embassy, Natural Resources Institute (NRI) United Kingdom, Alliance for a Green Revolution in Africa (AGRA), DANIDA, Forum for Agricultural Research in Africa (FARA), Food and Agriculture Organization (FAO) and World Food Programme (WFP) of the United Nations,

On behalf of the Internal Management Committee of the CSIR-FRI, I express my sincere thanks to all our stakeholders for their wonderful support, staff of the Institute for their dedication to work and the Almighty God for His goodness in 2022 and look forward to a progressive year in 2023.

Thank you.

EXECUTIVE SUMMARY

As an affiliate institute of the Council for Scientific and Industrial Research, CSIR-Food Research Institute has since its inception provided technical and scientific assistance to satisfy the needs of the private sector and other stakeholders for the socioeconomic development of Ghana. Over the years, the Institute has developed into the premier organization for food research and post-harvest management technologies that are targeted at supporting the food sector by carrying out its mandate of conducting applied market-oriented research. The CSIR-FRI's operations are deliberately focused on developing skills, building capacity, and conducting studies and interventions related to nutrition. These are key areas targeted at curbing food insecurity related issues in the country.

Through programs, workshops, and other activities aimed at increasing capacity, particularly in rural communities, on various processing technologies, numerous initiatives under FRI's R&D program had an impact on society. These included giving community organizations access to drying platforms and enhancing small fish drying through training in the quality and safety of small fish processing. Some communities were also trained on fruit juice processing in order to reduce post-harvest losses in fruits and the use of orange-fleshed sweet potatoes (OFSP) to add quality and diversity to product lines, such as fortifying gari and creating baked products.

Under the auspices of the SmallFish project, CSIR-FRI constructed wooden raised platforms and forty (40) drying racks were also modified for the Ningo-Ahwiam community. This modification was based on feedback received from processors during the monitoring and evaluation visits. The MAG project organized an Investor's Forum on parboiled plantain chunks technology in a bid to create a common platform for investors, entrepreneurs, processors, farmers, research scientist and financial institutions to expose them to frozen plantain chunks technology and products for uptake and commercialization to reduce postharvest losses of plantain.

The Institute generated a total amount of $ 196,093.75 as IGF; it also received $ 140,468.65in research grants under various projects.

Within the year, the Institute had a staff strength of one hundred and sixty-seven (167) comprising forty-four (55) Senior members, seventy-six (76) Senior staff and thirty-five (35) Junior staff. The Institute churned out sixty-five (65) publications comprising of thirty-six (36) Journals papers, thirteen (13) Technical reports, seven (7) Consultancy Reports, one (1) Manual, one (1) Flyer, three (3) Conference abstracts, one (1) book chapter and three (3) blog posts.

INTRODUCTION

The Food Research Institute was founded in 1963 by the Government of Ghana with the purpose of conducting applied market-oriented research to address problems with food processing and preservation, food safety, storage, marketing, distribution, and utilization as well as to provide advice to the government on its food policy. In 1965, it was integrated into Council for Scientific and Industrial Research (CSIR). The Institute's primary mission is to provide scientific and technological support for the growth of the food and agricultural sectors of the national economy in line with corporate prioritisation and national objectives and secondly, to provide technical services and products profitably to the private sector and other stakeholders. With a cadre of highly qualified and motivated employees for timely delivery of high-quality services and products to clients, CSIR-FRI conducts business in a congenial and transparent working environment to fulfil its goal.

The Institute envisions to be acknowledged at the national and international level as an S&T institution playing a key role in the transformation of the food processing industry and to be internationally competitive with particular reference to product safety, quality and presentation.

CSIR-FRI operates under three (3) pillars: Research and Development, Commercialization and CSIR-College of Science and Technology (MPhil in Food Science and Technology). The R&D component functions under four (4) key thematic areas, these include Root and tuber products program; Cereal, grains and legumes products program; Meat, fish and dairy products program; Fruit, vegetable and spice products program. Commercial activities include analytical and technical services, technology business incubation, contract productions, sale of research developed products, advisory services, trainings and consultancies etc.

Products and Services

- Internationally certified Analytical Services (Microbiological, Physical, Toxicological & Chemical Analyses).
- Technical Services (Collaborative research and Consultancies, Wet and Dry milling, Blending & Packaging).
- Mushroom production (Sales and Training in edible & medicinal mushroom production).

- Fabrication of Food Processing Equipment (Fabricating strong & reliable food processing equipment and industrial dryers).
- Food Processing (Processing of high-quality natural food products and Contract productions).
- Extension Services (Technology transfer, Business incubation, Hiring of conference facilities etc.)

RESEARCH AND DEVELOPMENT

Assisting with food storage, distribution, food quality and safety, enhanced nutrition, maximizing the use of underutilized food commodities, and other initiatives, CSIR-FRI helps to increase food security and reduce poverty. In sub-Saharan Africa, food insecurity continues to be one of the serious challenges that contribute to poverty. Different interventions along the food value chain are needed since not all Ghanaians can always obtain an adequate supply of food that is safe and nutritious. There are still parts of Ghana where a sizable portion of the population is at risk from food insecurity. The institute also oversees the development of the food sector as a whole as well as the post-harvest handling capabilities of various actors. Project initiatives on management of post-harvest loss management are among the Institute's interventions.

MODERNIZING AGRICULTURE IN GHANA (MAG)

Oduro-Yeboah, C., Obodai, M., Kongor, E., Ameyaw, G., Akonor, P.T., Dzomeku, M., Buckman, E., Baffour, C.L., Arthur, W., Padi, A., Boateng, C., Ampah, J., Acquah, I.N-N.

Duration: 4 years

Introduction

CSIR-FRI is among the Council for Scientific and Industrial Research (CSIR) institutes participating in the Modernizing of Agriculture in Ghana (MAG) Project. The aim of the MAG project is for the research institution like CSIR-FRI to address the constraint identified through the Regional Extension linkage Committee (RELCs) system at the regional and districts levels using existing technologies developed over the years. The technologies are transferred through training of trainers' programs organized in collaboration with the district offices of Agriculture for AEAs, District Agriculture officers (DAO), processors and farmers. The technologies transferred by CSIR-FRI are mostly value addition to agricultural produce to reduce postharvest losses and improve the income of the beneficiaries. The trainings are entrepreneurial in nature and beneficiaries can venture into businesses to yield profits.

Key Activities and Achievements

Training workshop on transfer of technology on composite flour from cassava and plantains

The training workshop took place in the Municipal Assembly building of Prestea Huni Valley, Bogoso, Western Region. A total of twenty-six (26) participants attended on the 3rd of March, 2022. The participants included; Agriculture Extension Services (AES), Bakers, members of Appiatse community, Caterers, MoFA officials and Research Scientists. The participants were made up of eleven (11) males and fifteen (15) females representing 42.3% and 57.6% respectively. The practical session was led by Mrs. Alice Padi. Drop doughnuts, chin-chin and bread were products developed using composite flour from wheat, cassava and plantain.

Theoretical Session lecture on production and value addition to plantain and cassava flour

Practical session, using HQCF and plantain flour in product development.

Participants with composite flour products and drop doughnut prepared from sweet potato, HQCF and plantain flour.

Training on aflatoxin management in tiger nut tubers

Twenty-one (21) farmers, marketers and processors, six (6) Agric extension officers including the Director of Agriculture for the Aduamoa District were trained on Aflatoxins management in tiger nut tubers which took place at the Aduamoa Pentecost worship center. The training was facilitated by three (3) trainers from CSIR-FRI. Participants were made up of 70% females and 30% males.

Participants practicing how to sort and perform sampling.

Lateral flow devices, centrifuge tubes and solvent buffers for rapid extraction of aflatoxins

Results from rapid testing of aflatoxins

Training workshops on business development along the mango value chain for selected farmers

The training was facilitated by Modernizing Agriculture in Ghana (MAG), CSIR secretariat and CSIR-Food Research Institute at the Conference Hall of Ministry of Food and Agriculture (MOFA) in Sunyani, the Bono Region and in the Savannah region. The training covered both lectures and practical session. Competent facilitators with expertise in the respective areas of Mango production, Agribusiness, food processing and drying handled the theory and practical sessions to meet the needs of trainees. In the Savannah region, farmers and Agriculture extension officers were trained on reducing postharvest losses of mango and watermelon as these were the major fruits cultivated.

Practical session with participants in the Bono Region

Practical session with participants in the Bono Region

Investors' forum on parboiled plantain chunks technology

The Council for Scientific and Industrial Research-Food Research Institute (CSIR-FRI) organized an Investors' Forum at the Directors' Conference Room, CSIR-Food Research Institute, Accra on Tuesday, 9th August, 2022. The theme for the forum was, "Towards sustainable postharvest management of plantains". The day forum was attended by four (4) Research Scientists, eleven (11) processors, two (2) MoFA Officers, eight (8) Administration Officers, two (2) DAEs, four (4) scientists from CSIR-MAG Secretariat, one (1) Principal Technologist, four (4) Senior Technologists, and three (3) Technician. A total of thirty-seven (37) participants attended the Investors' Forum organized by CSIR-FRI under the MAG project. The purpose of the forum was to expose participants to frozen plantain chunks technology and products for uptake and commercialization to reduce postharvest losses of plantain. It was aimed at creating a common platform for investors, entrepreneurs, processors, farmers, research scientist and financial institutions.

Opening address delivered by Prof. Charles Tortoe, Director of CSIR-Food Research Institute.

A presentation on MAG project by Dr. Charlotte Oduro-Yeboah, MAG Focal person

A presentation on Research work on parboiled plantain chunk technology by Dr. John Edem Kongor.

Presentation on Business Development and Marketing of plantain chunks by Mr. Stephen Nketia

Products developed from frozen parboiled plantain and normal parboiled plantain.

SMALL FISH AND FOOD SECURITY (SMALLFISHFOOD): TOWARDS INNOVATIVE INTEGRATION OF FISH IN AFRICAN FOOD SYSTEMS TO IMPROVE NUTRITION

Atter, A., Owusu, M., Ampah, J., Andoh-Odoom, A. and Akonor, P. T.

Duration: 3 years

Introduction

The small fish industry in Ghana serves as a source of food security, nutrition and employment for fishermen and fish processors, the SmallFishFood project, an interdisciplinary project, sought to improve production processes to achieve

better quality fish with longer shelf life. Small sun-dried fish is a popular fish consumed in Ghana. This fish is usually dried on the bare ground at the mercy of dirt, dust and other contaminants. This practice could cause significant risks to its safety. Concerned about the possible effects and implications of such practice, the CSIR-Food Research Institute team delivered some interventions that improved fish quality and safety, as well as presented the opportunity for diversification in fish products.

The final symposium for the dissemination of SmallFishFood project activities and findings was held at the CSIR-Food Research Institute from 7th to 10th June 2022. Partners from Norway (University of Bergen, Institute of Marine Research); Netherlands (Wageningen University, University of Amsterdam); Germany (German Federal Institute of Risk Assessment); and Ghana (University of Ghana, CSIR-Food Research Institute). The theme for the workshop was, "Small Fish and Food Security: Towards innovative integration of fish in African food systems to improve nutrition".

Key Activities and Achievements

A hundred and five (105) participants drawn from research institutions, academia, regulatory bodies, governance agencies, fish processors, policymakers, related projects, media, and other key stakeholders in the small fish value chain in Ghana as well as the SmallFishFood partners participated in the workshop.

Presentations by work packages

Work Package 1:

This presentation was made by Prof. Francis Nunoo of the University of Ghana. He indicated that the fish supply in Ghana is from multiple sources i.e. large importer of fish, mostly small pelagics, small and growing aquaculture sector, mostly tilapia. Also, a significant inland fisheries sector has much uncertainty in terms of the actual volume of landings and finally, the marine capture fishery altogether supplies the average Ghanaian with 25-35 kg of fish per year, one of the highest in the world. He mentioned that small fish are gotten from industrial trawlers, of which about 76 trawlers have been licensed, semi-industrial (Ghana boat) has about 350 boats, and artisanal has over 14,000 canoes which were the focus of their work.

He added that semi-industrial and artisanal produce small fish which is approximately 200 000 tons and industrial produce small fish of approximately 75 000 tons. He mentioned that their research study focused on the marine pelagic species which comprise the bulk of the catch such as sardinellas,

anchovies, chub mackerel, Atlantic bumper, moon fish and round scad, and other small fish from other species. From their study, they were able to develop a value chain for canoe fishery in Ghana. It moves from fisher, intermediary trader (comprising consumers and fish meal), processor, trader (wholesaler, retailer, consumer, and others). According to him, the value chain begins from the fisherman/woman to the intermediary trader to the processor to the trader, wholesale, retailer to consumers. He explained that according to the research there is a value added to the fish as it moves along the value chain. He stated that using anchovy for instance at the Tema landing area, the value of fresh fish is very low with the fisher but increases slightly at the intermediary fresh fish trader who also earns very little per kilogram and further increases with the processor and trader who earn more by trading.

In his conclusion, he indicated that there has been a shift from the consumption of sardinella to anchovy in recent times. There is high labour intensity for each canoe, ranging from 27 – 47 workers up the value chain from fishers to processors/traders. Processors/traders and boat owners obtain the highest profit in the chain and not the workers, especially during the high season.

Prof. Francis Nunoo presenting to participants.

Work Packages 2&3

The key finding from the survey was presented by Mrs. Amy Atter of the CSIR-Food Research Institute. The study focused on improving the processing of small fish as food. It was realized from the study that Ghana has a strong distribution and marketing system of fish, and fish caught in Accra is easily transported to every part of the country. The small fish is readily available, affordable even for the rural and urban low-income groups, very nutritious, can be used in most foods, and contributes to food and nutritional security in general. However, quality loss emanating from improper handling of fish, poor storage conditions, and many

other bad practices reduce its nutritional quality as well as the cost and value of fish. The study also identified the quality and safety issues in the value chain (harvest, processing, storage/transportation/trading), and the possible cause of contaminations. She mentioned the value chain from harvesting where there is possible contamination from different chemicals including heavy metals, microorganisms, and parasites; processing where there is the reduction of nutrients, microorganisms, and contamination by processing by-products; storage/transportation/trading where there may be a reduction of nutrients, contamination and growth of microorganisms of which certain moulds may even produce aflatoxins; and food preparation where there may be insufficient heating, destruction of vitamins, and contaminants.

She indicated that their study revealed that the quality of processed small fish is rich in proteins and micro-nutrients and significantly contributes to a balanced diet directly or as a fortifier. However, the nutrient composition depended on fish species so advised participants to consume different varieties of small fish. She added that market samples of smoked small fish showed high levels of Polycyclic Aromatic Hydrocarbons (PAH) above the recommended limit in most samples. There were also high microbial counts of processed samples of small fish obtained from some markets in Ghana. There is a need to improve hygienic practices and conditions, smoking methods, and ovens. She indicated that another area of their study was improvements in the sun-drying of small fish through the introduction of wooden platforms and netted racks. She added that the team trained women fish processors and sellers on best hygienic practices, processing practices, packaging, and product development (value addition) in four (4) selected fishing communities in Ghana.

In concluding, she gave some recommendations recognising the importance of small fish in the food system for food and nutrition security. She added that the nutrient content of small fish was shown to be higher than in some big fish species like tilapia. For that reason, people should not look down on them but value them and increase their consumption as they significantly contribute to a balanced diet when eaten directly or as a fortifier in other foods, especially carbohydrate-dense foods. She also recommended inclusive and collaborative technology improvements needed such as smoking ovens, hygienic practices, and support for the value chain actors especially women with suitable training and infrastructure.

Mrs. Amy Atter making her presentation.

Work Package 4

Prof. Joseph Yaro bemoaned the risk of policy bias against small fish in Ghana. He stated that emphasis on small fish is absent in the following national policies: Fisheries and aquaculture sector development plan 2011-2016; Ghana Fisheries Act 2002 (Act 625); Ghana Fisheries Amendment Act 2014; Ghana Fisheries Amendment Regulations 2015 (LI 2217); Ghana Fisheries Regulations 2010 (LI 1968); National Fisheries Management Plan 2015-2019; Ministry of Fisheries and Aquaculture Development. Medium Term Expenditure Framework: 2019-2022; Food and Agriculture Sector Development Policy (FASDEP II) 2007; and National Nutrition Policy 2016.

He indicated that there is a policy silence on small fish benefits because of the risk of artisanal fishers targeting small fish getting delegitimized; policy bias against small fish harvesting because of the risk of women fish processors' infrastructure & viability being neglected; and policy push for aquaculture growth because of risk of small fish diverted to fishmeal. He indicated that by so doing, there will be fewer fish for lower-income groups and more fish for the rich since small fish are more affordable, more nutritious, easier and cheaper to process, transport & store and have strong consumer preference.

He concluded by recommending that there is a need to recognize the benefits of small fish in fisheries, aquaculture, health, and social and economic policies. Explicit food security and nutrition policies that promote the consumption and utilization of small fish, especially among low-income groups. Facilitate infrastructure and technology required for sustainable harvesting, processing, and marketing of safe and nutritious small fish. Avoid an implicit institutional focus on aquaculture at the cost of small fish. Pre-emptively prevent small fish to

be used in fishmeal for animal feed. Effective collaboration and communication among stakeholders in the small fish value chain.

Prof. Joseph Yaro presenting to participants.

Discussions and Contributions

According to Prof. Yaro, Institutions have failed in organizing available human resources for work. He indicated that for the past 10 years, the country has been moving in circles and institutions are working independently in implementing policies and strategies while they could collaborate with other Institutions for better implementation and impact. He said the Metropolitan, Municipal, and District Assemblies (MMDAs) have lots of workers in the markets of which Institutions such as the Fisheries Commission (FC), Food and Drugs Authority (FDA), etc. could work with to help implement their programs. He indicated that if Fisheries Commission should train fish traders on how to handle fish in the markets but does not involve the MMDAs workers such as city guards whose work is in the markets to ensure that the traders are practicing what has been taught, the impact of the training program will not be felt. He called on institutions to do more collaboration and work together to achieve their objectives. On the issue of technologies developed, he indicated that there should be timelines in upscaling technologies and there is a need to find synergies between the innovations developed and how effective they can be employed to solve problems. In doing so, he said local craftsmen in the districts and municipalities should be involved in the development and production of the technologies. He concluded that no institution could execute its mandate if it does not have a broad-based human resource who will support them.

There were further discussions and contributions on the key findings of the project as presented and participants asked questions and made contributions to the presentations.

- The statement “which of the small fish should be caught and which of them should not be caught” was food for taught for the gathering.

- On food safety issues, a participant who had observed that some fish traders sprinkled or waxed oil on smoked fish displayed for sale to make it look fresh whilst others lighted mosquito repellents to ward off flies; and enquired if those practices were acceptable. A representative of the National Fish Processors and Traders Association (NAPFTA) told participants that such practices were not acceptable, and NAPFTA has been educating its members to desist from such practices. The sprinkling of oil (waxing) was explained that after fish had been exposed to the sun and dust, the traders sprinkle the oil just to make it look fresh. Even though she admitted that there are health issues, she called on stakeholders to help educate the traders on food safety practices. She added that educating and helping to certify fish processors were part of the mandate of the association and was certain fish processors and traders involved in unacceptable practices may not be members of the association or a few bad nuts among NAPFTA members. Another processor indicated that the sprinkling of oil on the fish is an indigenous technology for preserving the fish. She indicated that the practice should not be condemned totally but it is done in the interest of the consumer. The buying of fish that is subjected to these practices remains the choice of the consumer. A representative from Food and Drugs Authority (FDA) informed the participants that the Authority has been educating traders on food safety practices and assured participants of continued education to the traders. She disclosed the FDA is propagating safer food for safe health.

- A member of the Tema Fish Processors Association told participants that the association does not receive any support from fish projects in Ghana even though many of them visit them and assure them of some support that never materialise. She called for platforms for learning and other intervention programs for fish processors.

- A participant bemoaned that there is no representative of Fish Processors at the National level where policies and strategies are formulated. This she said is a worry to the associations since their sentiments and problems do not get to the National level even though they have national executives and therefore called on stakeholders to ensure there is a representative of the National Association. A participant indicated that the associations have promoted dialog between members and have improved on their activities.

- A processor from Ningo-Ahwiam compared the technology learned from the implementation of the SmallFishFood project which has helped them a lot; drying of fish is now done on a rack which prevents it from dust and other forms of contamination. He said new products such as fish powder and doughnuts have been developed. But her concern was the absence of a market for their newly developed products. A participant from FDA indicated that they have registered a lot of new products developed from fish. She informed her about the procedures to go through to get the product to the formal markets.
- On technology dissemination, a participant informed the gathering that technologies have been developed without the involvement of local artisans and end users. She cited the Ahotor smoking oven which the majority of the beneficiaries have abandoned because of challenges they encountered in their usage. She appealed to researchers to work closely with the beneficiaries for maximum impact and use of technologies. She appealed to the researchers and NGOs again to reconsider the improvement of the Ahotor oven and address its challenges for the processors.

Exhibition of products developed under the SmallFishFood project.

As part of the program, products developed by the SmallFishFood project were exhibited and tasted by partners and participants. These were hygienically processed and packaged fish, fish powder, fish sauce (shito), and fish-fortified foods including porridge, apapransa, biscuit, doughnuts, mpotompoto, yakeyake.

Products developed from small fish (shito, fish powder from anchovies)

Participants sampling products developed from small fish.

SmallFishFood Team.

HEALTHY FOOD AFRICA (HFA) – IMPROVING NUTRITION IN AFRICA BY STRENGTHENING THE DIVERSITY, SUSTAINABILITY, RESILIENCE, AND CONNECTIVITY OF FOOD SYSTEMS.

Atter. A, Blessie E.J, Nketia. S, Andoh-Odoom. A, Nyako. J, Owusu. M, Akonor P. T, Ofori. H, Ampah. J, Bugyei. K, Obodai. M, Amoa-Awua. W

Duration: 4 years, 6months

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. 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 (4) different communities

Data was collected in four(4) 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 each district, the first day was used for field mapping and household enumeration. The survey involved interviewing the respondents to get background information on the household and conducting 24-hour dietary recalls. A total of five hundred and thirty-four (534) households across target communities have been surveyed for the cross-sectional study to date. Respondents were aged 18 – 87 years old with majority (58%) of the respondent being female. Socio-demographic descriptors of baseline respondents showed that majority of respondents were married with an average family size of 4.47±3.84. The distribution of respondents across economic sectors showed that 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 HealthyFoodAfrica 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 2-day 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. In all, forty (40) 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.

Nutrition stakeholder engagement workshop.

Nutrition stakeholder engagement workshop.

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 (2) out of every four (4) stakeholders interviewed reiterated 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 to 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 strengthen women's roles in decision-making. For women to garner some power and thrive, stakeholder organizations need to elevate an agenda that caters for 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.

WP4 Activities

Assessment of Food Safety Knowledge and Practices

The study revealed that out of the total sample of two hundred and six (206) fishermen and fish farmers interviewed, one hundred and twenty-four (124) (60.2 %) were from the Eastern region and eighty-two (82) (39.8%) were from the Greater Accra region. The demographic characteristics of fishermen and fish farmers showed interesting results. Sixty-five (65) participants (31.6%) were fishermen only, sixty-five (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. 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 wash their 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).

Waste quantification

A web-based cross-sectional consumer survey was conducted using a semi-structured online questionnaire with two hundred and forty-six (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 cultured 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.

Sample Collection

Fish separation for waste quantification

Fish separation for waste quantification.

Oil Extraction

Lipids can be found in multiple regions of tilapia fish however, this experiment 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.

Gut Extraction and extraction of fat

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

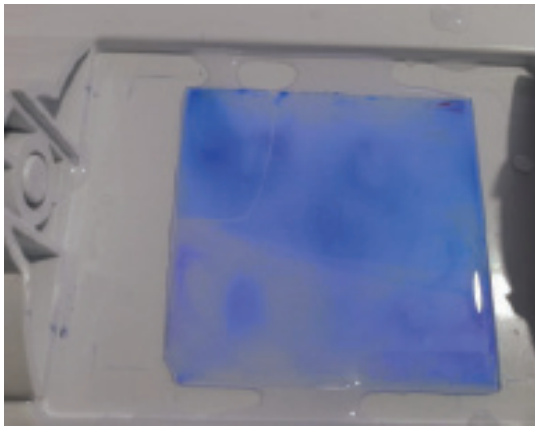
The study was conducted during the dry (February 2022) and wet (July 2022) seasons for comparison. Nile tilapia samples obtained from Weija Lagoon (wild) in the Greater Accra Region and Akosombo in the Eastern Region (cage cultured) were descaled, iced, transported, and stored at – 20 °C prior to usage. 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 gelatin 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 hours, 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.

Nile tilapia scales

Digestion of scales by acid/alkali

Filtered purified scales.

Freeze-dried gelatin products



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

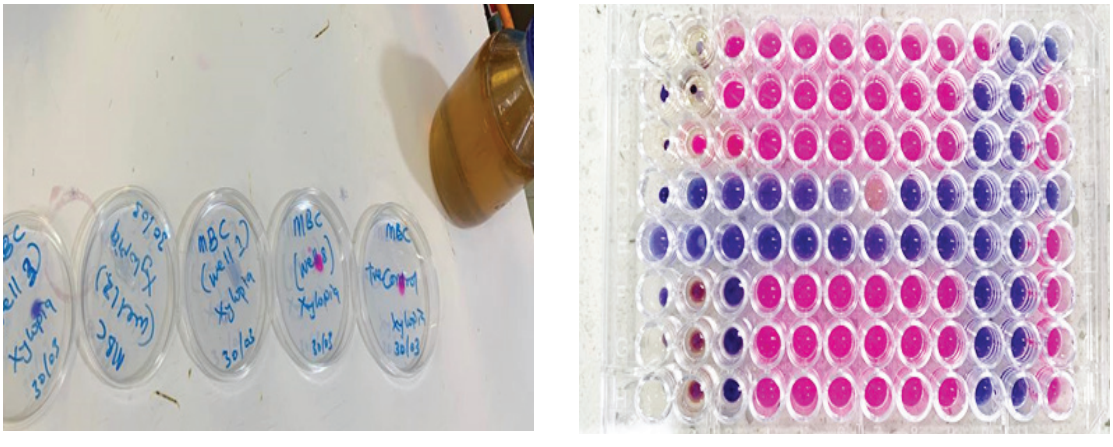
Microbial Studies

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 5° 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 was completed. A consumer acceptability study has been completed using a panel of fifty-five (55). 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 (4°C) and abuse temperature (10, 15, 25 °C) 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

Packaged 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.



Touring of Renovated Fish Processing Facility

Technology Improvements on Existing Technologies

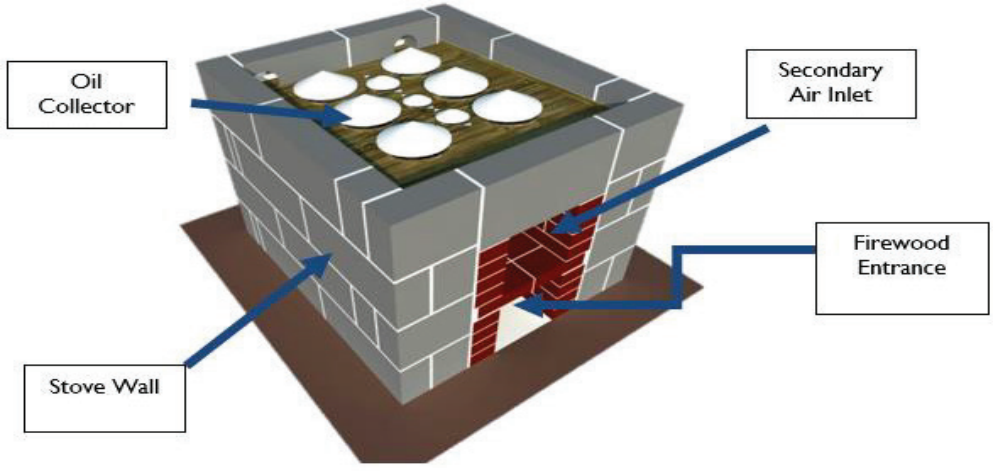
A consensus was reached on the improvements necessary on the existing Ahotor oven during the multi-stakeholders 'workshop held at CSIR-Food Research Institute on 17th February 2022 to validate the improved stove/ smoking oven performance survey report and discussions among multi-stakeholders. Based on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

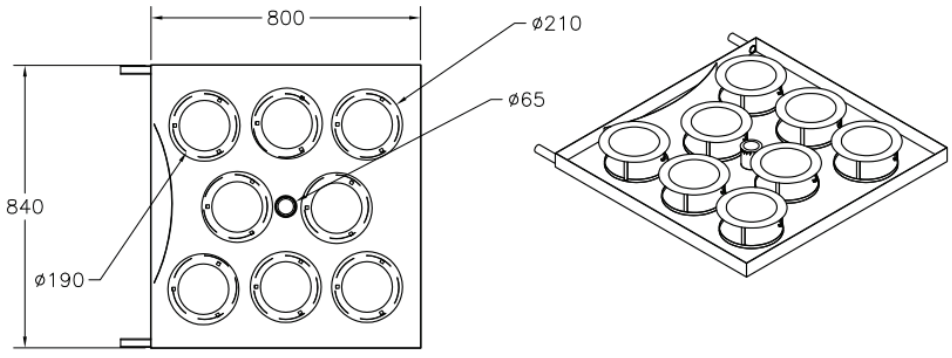
The Ahotor Oven

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 fuel wood.

The secondary air inlet located on top of the fuel wood 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(3) different designs of Ahotor ovens were produced.



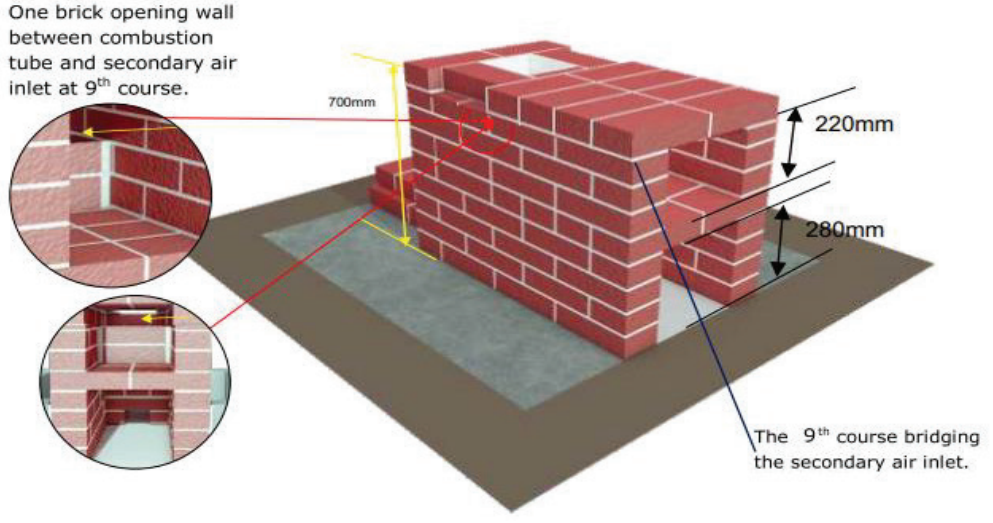
The fat/oil collector design



Ahotor oven 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(2) 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.

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.

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 (6) 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 102 to 106 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.

Degutting, salting and fermentation process.

Oven drying of salted Nile tilapia.

Steaming of koobi and other ingredients for product development

Labelled koobi in oil.

GC FERMENTED FOOD – FERMENTED SOYMILK-BURKINA IN GHANA. EFFECT OF SOYMILK-BRUKINA INTAKE ON GUT MICROBIOME AND NUTRITIONAL STATUS OF GHANAIAN WOMEN.

Glover-Amengor. M, Kyereh. E, Blessie. E, Agbemafle. E, Darko Otchere. I and Glover. R. K. Duration: 18 months

Introduction

In recent times, consumers are expressing a clear demand for healthier and more sustainable food. Embracing the tradition of microbial fermentation to transform locally available foods into naturally vitamin-fortified, toxin-free, flavorful, and shelf-stable product could empower local communities to mitigate the impact of COVID-19 on supply chain/food security and improve health and nutrition of mothers and children in most vulnerable settings. Historical advances in food processing have largely employed strategies that involve supplementation with micronutrients and additives to improve nutritional content and stability, but these approaches require highly centralized supply chains.

Food fermentation plays a key role in the diet of numerous communities in the world especially in Sub-Saharan Africa (SSA) where most of the populace still live in an environment that resembles that of Neolithic settlement. It is an ancient practice through which locally-sourced food substances can be transformed naturally by environmentally occurring microbes. These processes are thought to be intricately intertwined with human biology, and it is hypothesized that our primate ancestors adapted to natural fermentation processes millions of years ago. While many fermented foods (e.g., yogurt, cheese, coffee and alcohol) remain popular, certain types of fermentation are a dwindling art in many settings, representing a loss of cultural heritage and a natural way to improve the qualities of foods across several distinct axes. However, beyond many of the well-known examples of microbial fermentation, the vast majority of fermentation processes around the world remain uncharacterized and their potential human health benefits are unknown. These ancient practices may hold the key to impactful and locally targeted nutritional interventions that combine tradition and science to tackle malnutrition.

The GC fermented project aimed at investigating the impact of the intake of soymilk-brukina, a novel Ghanaian indigenous fermented milk and millet beverage (smoothie), on the gut microbiome and nutritional status of women of reproductive age (15-49 years) living in the Hohoe Municipality. This project replaced cowmilk which is one of the main ingredients in “brukina smoothie” with a plant protein. Soymilk offers a healthful nutritional profile, including flavonoids that exert antioxidant, anti-inflammatory, and cardioprotective

properties. Soymilk substitution will therefore enhance the nutritional and health benefits of brukina. Besides its lower environmental impact compared to livestock rearing for milk, the used of soymilk in brukina production will ultimately boost the soybean market, which is being currently vigorously promoted, to enhance livelihood of local farmers in Ghana.

Key Activities and Achievements

The GC-Fermented food project is divided into four (4) phases. The first phase of the project concerns the soymilk-brukina fermentation and standardization, whereas the second phase of the project is on MALDI-TOF mass spectrometry identification of bacteria species in the product. The third and final stages of this project concerns the human intervention studies and the gut microbiome section respectively. Besides these phases, lots of activities needed to take off to ensure a successful execution of the deliverables.

Omics Laboratory Space

The Omics Laboratory was needed as an ideal space to help execute phase four (work package 4, WP 4) of the GC fermented food project. The Omics lab will house all the gut microbiome activities under this project and future studies. This space will ensure all biological samples are sorted, stored and analyzed without contamination. This facility is equipped with Qubit 4.0 fluorometer, beadbeater, thermos scientific Megafuge 16 centrifuge, – 20 freezer and a host of other equipment required for molecular analysis. Besides, planes are underway to further bring on board equipment such as the sequencer, microarray, RT-PCR etc to further strengthen FRI capabilities and competitive in research areas such as genomics, transcriptomics, proteomics and metabolomics.

Renovated Omics Laboratory Space

Soymilk-Brukina Fermentation and Standardization

GC fermented food project started with development and standardization of the fermented and unfermented drink for the student participants. One hundred percent soymilk-brukina was formulated at 3 levels of steamed millet agglomerate and fermented soymilk with constant brix. Various formulations was assessed in-house for sensory attributes (taste, colour, flavour, aftertaste) and overall acceptability on a 9-point Hedonic scale by semi-trained adult panellists.

After the establishment and standardization phase at CSIR-Food Research Institute, production of soymilk-brukina began for the study in Hohoe Municipality. The production of soymilk-brukina is in four(4) stages. The first stage is the production of the soymilk. The second stage is using the soymilk produced to make yogurt. The third stage is the production of the steamed ground millet. The fourth stage is the combination of the steamed ground millet and the yogurt into a single product (Soymilk-brukina).

Steeping and mashing of soymilk for soymilk-brukina drink

Preparation of soy yogurt for Soymilk-brukina.

Bottling soymilk-brukina drink with millet flakes.

MALDI-TOF Mass Spectrometry Analysis of Bacteria

Sampling of the soymilk-brukina were done at identified critical control points (CCPs) during production of soymilk-brukina. The collected samples were immediately subjected to microbiological analyses. Bacteria colonies from the microbiological analysis were sub-cultured by streaking on pure agar until pure isolates were obtained for identification using MALDI-TOF mass spectrometry identification.

Result Overview

Sample Name	Sample ID	Organism (best match)	Score Value	Organism (second-best match)	Score Value
A1 (+++) (A)	1 (standard)	Pichia kudriavzevii	2.15	Pichia kudriavzevii	2.08
A2 (+++) (A)	2 (standard)	Kluyveromyces marxianus	2.16	Kluyveromyces marxianus	2.13
A3 (-) (C)	3 (standard)	Clavispora lusitaniae no peaks found	2.06 0.00	Clavispora lusitaniae no peaks found	0.00
A4 (+++) (A)	4 (standard)	Clavispora lusitaniae	2.16	Clavispora lusitaniae	2.09
A5 (+) (B)	5 (standard)	Clavispora lusitaniae	1.99	Clavispora lusitaniae	1.88
A6 (+++) (B)	6 (standard)	Enterobacter bugandensis	2.10	Enterobacter kobei	2.05
A7 (+++) (A)	7 (standard)	Bacillus megaterium	2.19	Bacillus megaterium	2.13

Result overview table—continued on next page

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Overview of some identified bacteria strains in the soymilk-brukina drink

Human Intervention Studies

The randomization of study participants was done under this work package. One hundred and twenty (120) women were recruited for each arm of the study (control and intervention groups). The control group were served with unfermented millet-soymilk blend while the intervention group received the fermented soymilk-brukina. Each participant was served and encouraged to consume one bottle (330ml) of control or soymilk-brukina daily for eight (8) weeks. Anthropometric, blood and urine samples were taken from the participants for biochemical analysis such as stool RE, malaria parasitemia, full blood count, ferritin, soluble transferrin receptor, zinc protoporphyrin, serum albumin, iron, zinc, retinol, CRP.

Participant assisting volunteers with bio-data.

Field volunteers distributing soymilk-brukina to study participants.

Some field volunteers distributing soymilk-brukina to study participants.

Gut Microbiome Studies

In order to evaluate the impact of soymilk-brukina on gut health of the study participants, stools were sampled from study participants using OMNIgene-gut (OM-200) stool sample collection kits. Stool microbial DNA were isolated using QIAamp DNA stool kits and the samples were shipped to University of Minnesota Genomic center for sequencing.

OM-200 stool sample collection kids.

Project research assistants assisting in stool DNA isolation.

PROCESS DEVELOPMENT AND PRODUCT CHARACTERISTICS OF BEETROOT DARK CHOCOLATE USING THE MELANGER IN AN ALTERNATIVE CHOCOLATE PRODUCTION TECHNIQUE

Kongor, J.E., Owusu, M., Oduro-Yeboah, C., Kyei-Baffour, V., Tawiah, E., Amey, N.K.

Duration: 30 Months

Introduction

Dark chocolates are semisolid suspensions of fine solid particles from sugar and cocoa in a continuous fat phase, mainly cocoa butter. The quality characteristics of dark chocolates are influenced by ingredient composition and processing methods and must be controlled to obtain high-quality chocolate. There is a dynamic change in the chocolate industry with a drive towards high cocoa content in chocolates due to the high polyphenol content in cocoa beans which has been found to have beneficial effects on human health. However, the high cost of cocoa beans on the international markets significantly adds to the cost of chocolates with high cocoa content. There is a need to incorporate a food ingredient into dark chocolates that are economical, rich in nutrients and has health-promoting properties. Beetroot (Beta vulgaris) is receiving increased recognition as a health-promoting food due to the presence of essential components such as vitamins, minerals, phenolics, carotenoids, nitrate and betalains and provides the opportunity for the development of functional foods. Despite the high nutritive and medicinal value of beetroot, it is under-utilized in Ghana, and consumed only as juices and smoothies. There is also no information on the use of beetroot in dark chocolate manufacture. Incorporating beetroot in dark chocolates will improve the health-promoting properties of dark chocolates and contribute to the good health and well-being of consumers. This should also contribute to diversifying its utilization and reducing post-harvest losses.

Conventional chocolate manufacture consists of the following processing steps: mixing, refining, conching and tempering. These steps are carried out separately, requiring equipment with huge investment costs, operational space and the use of skilled personnel. The use of the alternative technique for chocolate production is thus, gaining attention mainly due to the lower investment cost, maintenance and multi-functionality of the equipment. The melanger is one of such piece of equipment found to have great potential in alternative small-scale chocolate manufacture. Studies on the use of the melanger for chocolate production have however, focused mainly on particle size reduction during refining and conching. The extent to which mixing, refining and conching could be carried out simultaneously in the melanger and how this influences the quality characteristics of dark chocolates remains unknown. With a national

unemployment rate of 4.51% in 2020, a more cost-effective technique for chocolate production will provide decent employment and economic growth, especially for women and youth chocolate processors and retailers, who dominant small-scale chocolate value chain in Ghana, and contribute to eradicating poverty. The main goal of this project is to develop beetroot dark chocolate using the melanger as an alternative chocolate production technique and study the effect of beetroot powder concentration and processing time on the physicochemical, nutritional, bioactive compounds compositions, antioxidant capacity, particle size distribution, hardness, microbial safety, sensory profile (mouthfeel, aroma, taste), consumer acceptability and shelf life of the product.

Key Activities and Achievements

Production of beetroot powder.

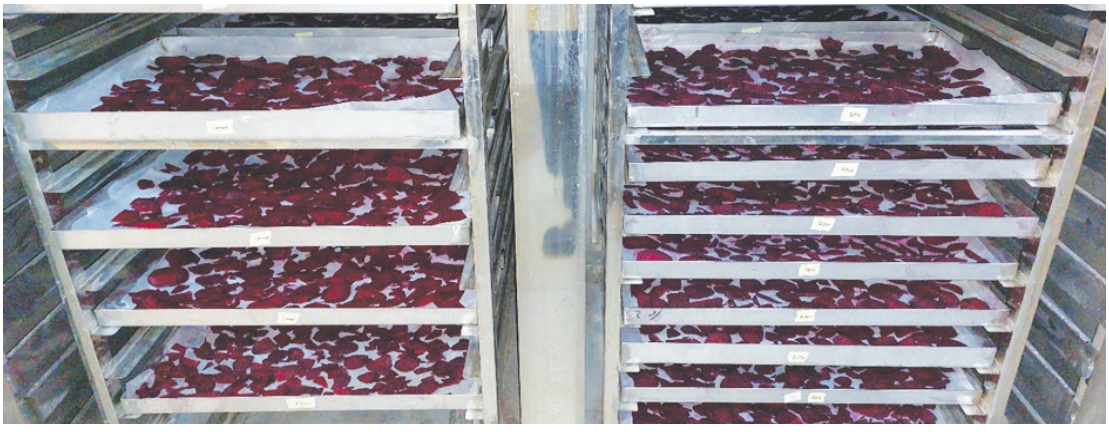
Beetroot powder was produced from fresh beetroots. Fresh beetroots were sorted, washed, and peeled. The peeled beetroots were sliced (1 mm thick) and dried in a mechanical dryer (ZF100 series hot air circulation cabinet, Jinan Keysong Co. Ltd., China) at 60°C for 7 hr. The dried beetroots were then milled using a Panasonic super mixer grinder (MX-AC220, Panasonic Appliances, India) and sieved by passing through a 60-mesh sieve (250 µm). The beetroot powder produced was analyzed for physicochemical, nutritional composition, bioactive compound composition, antioxidant capacity, and microbiological safety.

Washing of the freshly harvested beetroots

Peeling of the washed beetroots

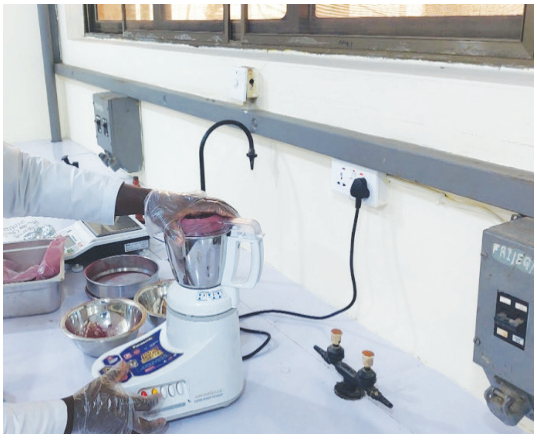
Slicing of the peeled beetroots

Arranging the sliced beetroot on trays



Beetroots arranged on trolleys and placed in the mechanical dryer.

Dried beetroots after 7 hr of drying in the dryer at 60°C



Milling of the dried beetroots into powder using a super mixer grinder

Sieving the milled beetroot powder through a 60-mesh sieve (250 µm)

Beetroot powder

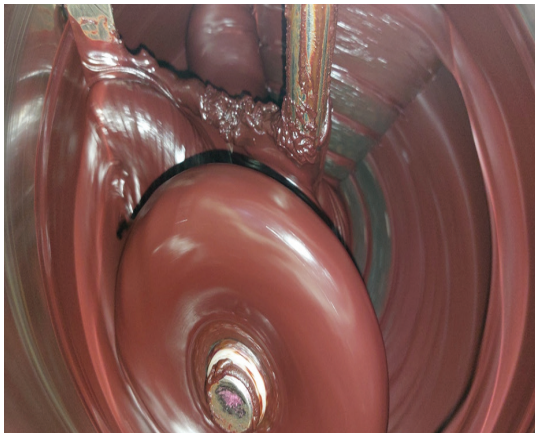
Production of Beetroot dark chocolate

Dark chocolates (ca. 70% cocoa) were then produced on a 1 kg scale with a melanger (CocoaTown Melanger ECGC-12SLTA, Roswell, USA) using the formulation in Table 1. Beetroot powder was incorporated into the dark chocolates, substituting sugar, while the cocoa content remained the same in all formulations. Three (3) chocolate processing steps (mixing, refining, and conching) were combined and carried out simultaneously as a single processing step in the melanger. The ingredients (cocoa liquor, sugar, and beetroot powder) were weighed, mixed, refined, and dry conched by the action of the double conical granite stonerollers of the melanger. Cocoa butter and lecithin were added to the mixture 30 minutes before the end of each batch to begin the wet conching phase. At the end of each processing time, the molten chocolates were manually tempered and moulded into bars. After de-moulding, the chocolate bars were stored in a refrigerator at 20 °C prior to analyses.

Ingredient	Mass (%)		
	Formulation 1 (Control) (0% BDC)	Formulation 2 (15% BDC)	Formulation 3 (30% BDC)
Cocoa liquor	64.65	64.65	64.65
Pre-broken sugar	30.00	15.00	0.00
Beetroot powder	0.00	15.00	30.00
Cocoa butter	5.00	5.00	5.00
Lecithin	0.35	0.35	0.35
Total	100	100	100

Table 1: Recipe for the formulation of beetroot dark chocolate

Adding beetroot powder to the cocoa liquor in the melanger during chocolate production



Processing of the chocolate mix in the melanger.

Tempering of molten beetroot dark chocolate

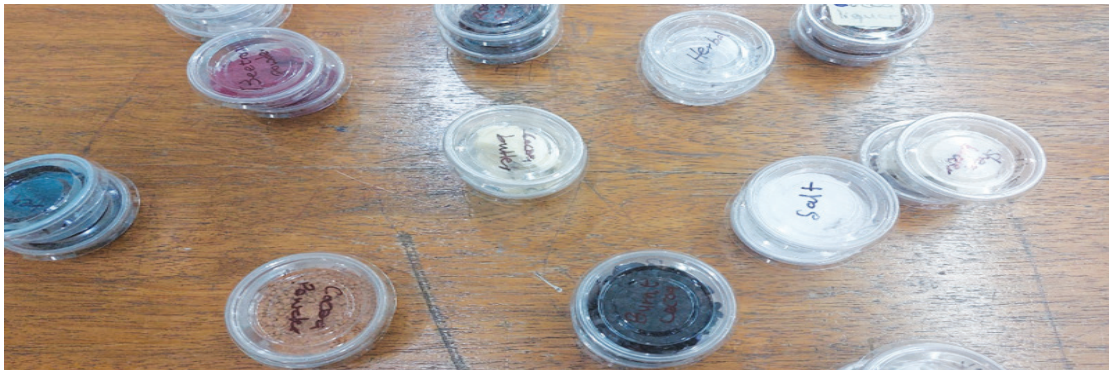
Tempered beetroot dark chocolate molded into bars and heart shapes.

Sample Analysis

The chocolate samples were then analyzed for physicochemical properties, nutritional composition, microbiological safety, bioactive compounds and antioxidant capacity. A manuscript on the bioactive compound composition and antioxidant capacity has been submitted to the Journal of the Science of Food and Agriculture and is currently under review. To evaluate the sensory profile of the chocolate samples, 13 panellists were trained in Quantitative Descriptive Analysis (QDA). The trained panellists then developed sensory descriptors for the chocolate samples and evaluated the intensities of each descriptor on a line scale.

Explanation on the use of reference compounds in a QDA

Panellists evaluating the chocolate samples to develop descriptors



Reference compounds used for the QDA.

Panelists comparing the reference compounds with the chocolate samples to aid in developing the descriptors and their intensities.

ABSTRACTS FROM PUBLISHED PAPERS

Performance Evaluation of a Centrifuge Type Grain Cleaning Machine and its Effect on Chemical and Microbial Quality of Sorghum and Millet Grains.

Nketia, S., Ampah, J., Anyebuno, G., Appiah, F., Amoa-Awua, W., Kyei Baffour V., Tettey, E. A., Bempong, O.

Cleaning is an important unit operation in food processing. However, cleaning of some cereal grains including millet and sorghum prior to processing is tedious due to their small sizes. In this study, the cleaning efficiency of a locally fabricated centrifuge-type grain cleaning machine was tested and compared to the traditional method of cleaning. The centrifuge cleaning machine consists of an outer main frame which is stainless steel, cylindrical drum with a hundred percent opening discharge pipe on the lower side, an inner 250 µm perforated stainless steel cylindrical sieve, a motor-powered transmission stirrer unit with two bats placed adjacent at ninety degrees to each other. Color measurement of grain samples was done with a Lovibond Tintometer Colorimeter. The microbial load – enterobacteria, coliform, Escherichia coli, aerobic mesophiles, yeast and Staphylococcusaureus was analyzed using the AOAC (2012) methods. HPLC was used to quantify the aflatoxin levels – aflatoxins B1, aflatoxins B2, aflatoxins G1 and aflatoxins G2. The time and cost which initially took 8 h using two laborers at a fee of GHC100.00, was reduced to 3 h with just one laborer costing GHC50.00. Skinning damage to millet and sorghum caused by locally fabricated machine was determined to be 2.1% and 4.6% respectively. The results of the study showed that the cleaning machine could be adopted for small scale washing of millet and sorghum grains for foods such as fura.

Performance Characterization of a Locally Developed Fish Smoke-Drying Kiln for Charcoal and Briquette

Amponsah, S.K., Asare, H., Okyere, H., Owusu-Asante, J.O., Minkah, E. and Ketemepi, H.K.

Performance characterization of a locally developed fish smoke-drying kiln (10 kg capacity) was conducted using charcoal and briquette as fuel materials. Samples of fresh African Catfish (Clarias gariepinus) weighing1.03±0.24 kg, charcoal of tropical hardwood (Anthonotha macophylla) and briquette produced from a combination of saw dust, rice husk, coconut husk and palm kernel shell were procured and used for the study. A completely randomized design (CRD)

with three replicates was employed for this study and LSD among treatment means determined at $p \leq 0.05$. Data was collected on moisture content of smoked-dried fish, smoke-drying time, drying rate, energy expended, specific fuel consumption and energy efficiency of kiln. Results showed that the energy efficiency of kiln was 97.02% and 98.45% and specific fuel consumption was 2.57 and 4.20 for charcoal and briquette, respectively. The energy expended by charcoal and briquette fuel materials were 206 MJ and 249.6 MJ, respectively. The energy expended, energy efficiency and specific fuel consumption were higher for briquette than charcoal. The use of charcoal offered higher moisture removal and drying rate for smoke-drying process than briquette but no significant difference was observed. Conversely, using briquette fuel material required almost two extra hours to smoke-dry 1kg of catfish sample compared to using charcoal. Breakeven with charcoal as main fuel material for custom hiring of the smoke-drying kiln occurs at 952 hours vis-à-vis 998 hours when briquette is used. Economically, briquette compares closely with charcoal, and could be considered a good alternative fuel material for smoke-drying of fish. Future research should conduct organoleptic assessment on fish smoked with charcoal and briquette to ascertain consumer acceptability of the final produce.

A review of lentil (Lens culinaris Medik) value chain: postharvest handling, processing, and processed products.

Oduro-Yeboah, C., Sulaiman, R., Uebersax, M. A.

Lentils (Lens culinaris Medik.) are grown worldwide in diverse agroecological regions with significant global production and trade. Since early 2000s, lentils production and consumption have been growing beyond its traditional areas of production and utilization, notably in USA, Canada, Australia, UK, and many European Union countries. Lentils are a rich source of protein, minerals, and many bioactive compounds. Therefore, lentil-based products can offer a healthy food choice for all consumers, including those who are vegetarian or vegans, and/or looking for meat protein alternatives due to health and/or environmental concerns. In order to avail all the benefits that lentils offer, a quality maintenance approach is essential across value-chain operations of postharvest handling, storage, and value-added processing. In recent years, lentils have been used increasingly in a variety of value-added products and cuisines in the developed countries. Different processing methods, for example, cooking, autoclaving, extrusion, baking, roasting, fermentation, and sprouting, significantly improve protein bioavailability, total digestibility, and overall nutritional and organoleptic quality. A number of traditional and innovative processing techniques also have been used to produce lentil-based end-products or ingredients for various food applications. Overall, lentils are well positioned as a food legume crop to cater to

emerging trends among consumers, especially those looking for healthy food choices, an alternative plant-based protein for global food security, and foods that are produced in environmentally friendly and agriculturally sustainable manner. Significant production and consumption trends for lentils clearly demonstrate enhanced value for consumers and further impact in contributions to a nutritious global food supply.

The socio-economic impact of mitigating the challenges at the artisanal palm oil mills in Ghana

Sarpong, F., Dery, E.K., Danso, I., and Oduro-Yeboah, C

There has been tremendous demand for palm oil globally due to it varied used in the food, biofuel, and oleochemicals. Ghana is a net importer of palm oil despite producing some best yielding varieties. This is ascribed to operation of palm oil artisanal mills, which account for close to 80% of palm oil production. Artisans are bedeviled with enormous challenges in their processing activities but possess the key of increasing palm oil production by 6%, which is translated into 210,800 tons per annum. This review, being mindful of net importation reduction, focused on the efforts in addressing some of challenges at the artisanal mills in Ghana to achieving some sustainable development goals (SDGs) and placing emphasis on the social-economic impact. An average free fatty acid and oil extraction ratio for Ghana was 15.55% and 9.55%, respectively. This paper revealed that through policy, research and extension service most of these challenges could be mitigated. Top among the challenge facing artisans were oil extraction ratio and quality of oil production, which demonstrated a positive correlation with a better access to premium market and working conditions, an increase in income and purchasing power, achieving food and energy security and prevention of ecosystem depletion.

Market women's skills, constraints, and agency in supplying affordable, safe, and high-quality fish in Ghana

Overå, R., Atter, A., Amponsah, S., and Kjellevold, M

In Ghana, the role of female informal traders ("market women") in making low-cost smoked and dried fish available in urban and rural marketplaces is the key to explaining the high consumption of fish in the country. However, market women's contribution to food security and nutrition (FSN), as well as to fish quality and safety is underrated and poorly understood. Fish marketing requires proficient distribution and preservation skills, economic and sociocultural competence, and a high degree of mobility. Fish traders face numerous constraints related to fish supplies, credit access, hygiene, storage

facilities, transport, and market governance, all of which affect their incomes and may affect the quality and safety of fish. The article, which is based on semi-structured interviews with fish traders and fish consumers in coastal and inland markets in Ghana, documents how traders operate and exhibit agency to deal with constraints by activating a range of skills in their profit-making and their fish quality and safety enhancement strategies. The authors argue that policies grounded in knowledge about fish traders' activities, skills, and working conditions, with budgets that prioritize investment in public infrastructure that caters for market women's professional and personal needs, can further enhance their ability to supply affordable, safe, and high-quality fish to Ghana's population.

Oxidative stability mechanism of coconut oil as substitute to cocoa butter in chocolate

Sarpong, F., Dery, E. K., Asiamah, E., Darfour, E. K., Oduro-Yeboah, C., Amissah, P. A., & Gyedu-Akoto, E.

To appreciate and explore the potential use of coconut oil as substitute in chocolate this research was conducted. In achieving this, three different chocolates were formulated using varied amount of coconut oil (5–15%) as cocoa butter substitute. The formulated chocolate samples and a control were stored for 21 days to evaluate the kinetic reaction of oxidative stability and phenolic and flavonoid content, color and sensory properties. Results revealed that characterizations of oxidative reactions were dependent on coconut oil which had a positive correlation with free fatty acids, saponification and peroxide. Based on statistical tools such as coefficient of correlation (0.9879–0.9976), root mean square error (0.0176–0.3620) and reduced chi-square (1.5 × 10–4– 0.1310), second-order polynomial model accurately predicted kinetic evolution of oxidative stability during storage. In conclusion, coconut oil could be used as cocoa butter replacer in chocolate formulation, however only 5% is recommended based on better mouthfeel, appearance and taste and enhanced polyphenolic content

Aflatoxin M1 exposure in a fermented millet-based milk beverage 'brukina' and its cancer risk characterization in Greater Accra, Ghana

Kortei, N. K., Annan, T., Boakye, A. A., Essuman, E. K., Tettey, C. O., & Kyei-Baffour, V.

Brukina is a millet based fermented milk product which is consumed as a beverage in Ghana. It is however prone to aflatoxin M1 (AFM1) contamination, which is a serious health challenge for low and middle-income countries in

subtropical regions. This study aimed at evaluating AFM1 levels and cancer risks associated with brukina (n = 150) sampled from different locations of the Greater Accra Region of Ghana. AFM1 were measured with High-Performance Liquid Chromatography (HPLC) connected to a Fluorescence Detector (FLD). Cancer risk assessments were also conducted using models prescribed by the Joint FAO/WHO Expert Committee on Additives (JECFA). Out of the 150 samples analyzed for AFM1, 80/150 (53%) tested positive between the range 0.00 ± 0.001–3.14 ± 0.77 µg/kg. Cancer risk assessments of AFM1 produced outcomes which ranged between 0.64 and 1.88 ng/kg bw/day, 0.31–9.40, 0.0323, and 1.94 × 10–3–0.06 for cases/100,000 person/yr for Estimated Daily Intake (EDI), Hazard Index (H.I), Average Potency, and Cancer Risks respectively for all age categories investigated. It was concluded that the consumption of brukina posed adverse health effects on the majority of the age categories in the different locations of Greater Accra Region since the calculated H.Is were greater than one (>1). Therefore, contamination of brukina with AFM1 should be considered a high priority in public health and Ghana's cancer risk management actions.

Enzymatic modification of fish gelatin and beet pectin using Horseradish peroxidase

Asiamah, E., Aboagye, D., Zaky, A. A., Asakiya, C., & Blessie, E. J. S.

The Fish Gelatin (FG), a good alternative for unhealthy and limited socio-cultural mammalian gelatin appears to possess endogenous structural limitations. The goal of this work was to use enzymatic crosslinking to modify cold-water Fish Gelatin (FG) with Beet Pectin. Reaction conditions were optimized by a single factorial experiment and covalent crosslinking was measured by ultraviolet (UV)-Vis spectroscopy at 340 nm to indicate Horseradish Peroxidase (HRP) catalyzes Beet Pectin (BP). At 50 °C for 4 h, the highest weight ratio of heterologous adducts between FG-BP was 1:3, with HRP and Hydrogen peroxide (H2O2) of 2 µg/mL and 0.067%, (v/v), respectively. Intermolecular cross-linking was found between treated samples using ATR-FTIR and Sodium Dodecyl Sulphur and Polyacrylamide Gel Electrophoresis (SDS-PAGE). The heterologous product, control FG, and BP as well as a mixture of untreated FG-BP had a β-sheet of 41.14%, 39.65%, 39.9%, and 40.0%, respectively. The maximum reduction in elution was obtained in heterogeneous FG-BP complex. Furthermore, a schematic mechanism for Cold-water Fish Gelatin and Beet Pectin was proposed. Overall, peroxidase crosslinked BP was able to modify cold-water Fish Gelatin. The use of Horseradish peroxidase on Fish Gelatin could provide a practical way of building the FG-BP complex as a basis for understanding the FG functionalities comprehensively.

Handwashing knowledge, attitudes, and practices in Ghana

Omari, R., Zotor, F., Baah-Tuahene, S. and Arthur, W.

Introduction Handwashing has been recognized as a convenient, effective, and cost-effective means of preventing communicable diseases. However, many people overlook the importance of handwashing when engaging in activities that require handwashing due to various factors. The objectives of this study were to assess the level of handwashing knowledge, attitudes, and practices and determine their relationships and how they are affected by sex, educational background, and age. Methods A cross-sectional survey was conducted among 636 respondents who received and completed an online questionnaire that was disseminated to the contacts of the researchers via WhatsApp, Email, LinkedIn, and Facebook. Respondents were presented with several statements to assess their handwashing knowledge, attitudes, and practices. Results Overall, 82.2% of respondents had good knowledge, 91% had a positive attitude, and 48.4% adhered to good handwashing practices. Having a high school level of education (OR = 0.193, p = 0.034.), (OR = 0.145, p = 0.000) and (OR = 0.448, p = 0.049) decreased the likelihood of having good knowledge, positive attitudes, and good practices than in persons with tertiary level education. Predictors of good handwashing practices were knowledge (OR = 1.059, p = 0.37) and attitude (OR = 1.095, p = 0.000). These results suggest that having a higher level of education could increase a person's knowledge and attitude, which in turn enhances the likelihood that the person would adhere to most handwashing and hand hygiene practices. Conclusions Enhancing people's handwashing practices requires positive attitudes and good knowledge about handwashing. These need to be complemented by enhanced access to handwashing facilities and innovative measures to enforce and encourage compliance.

Profitability of bioetanol production using cassava (Manihot esculentus crantz) and sweet potato (Ipomea batatas) as raw material

Komlaga, G.A., Oduro, I., Ellis, W.O., Dziedzoave, N.T., Awunyo Vitor D. and Djameh, C.

Ethanol, also called ethyl alcohol, is a volatile, colourless, flammable liquid which belongs to a class of organic compounds that are given the general name alcohols [1, 2]. Ethanol for industrial use as a solvent or chemical intermediate is largely obtained by acid-catalyzed (H3PO4) hydration of ethylene at a high temperature of 250°C [2]. Ethanol is also produced via biological processes by fermenting sugars with yeasts and bacteria, the method used for alcoholic beverages [3, 4, 5]. Ethanol is the most widely used biofuel today with production and consumption

of over 40 billion litres based primarily on corn [6, 1, 2]. Ethanol is also used as a solvent, extractant, antifreeze, fuel supplement and an intermediate feedstock in the synthesis of innumerable organic chemicals [4]. Bimolecular dehydration of ethanol gives diethyl ether, which is employed as a solvent, extractant and anaesthetic. These and other ethanol-derived chemicals are used in dyes, drugs, synthetic rubber, adhesives, explosives and pesticides [4]. Biochemical ethanol production has some advantages over thermochemical ethanol production as the ethanol is produced from a renewable resource, having economic relevance, and that starchy crops can readily grow in poorer hotter climates [7]. Relatively less amounts of energy is required during bioethanol production since the saccharification and fermentation temperatures are relatively low. Biochemical method of ethanol production could therefore be considered as the best to employ in developing countries where starchy crops such as cassava and sweet potato abound as raw material.

Effect of xanthan gum and carboxymethyl cellulose on structure, functional and sensorial properties of yam balls

Asiamah, E., Buckman, E. S., Peget, F., Akonor, P. T., Padi, A., Boateng, C., & Affrifah, N. S.

Yam and its products can be modified during processing to reduce losses and ensure food security in the developing world. Xanthan gum (XG) and carboxymethyl cellulose (CMC) were added at different concentrations to yam balls and their effect on the structural, functional, and sensory properties of frozen yam balls were investigated in this study. Freeze-thaw stability and oil absorption capacity of yam ball mix were determined. Sensory evaluation and instrumental texture profile analysis (TPA) were done on samples of deep-fried yam balls using TA-XT Texture Analyser. Yam balls mixture containing XG and CMC had significantly ($p < 0.05$) lower oil uptake and water migration rates of 0.19 g/g and 4.10% as compared to control products 0.25 g/g and 11.05% respectively. Deep-fried yam balls samples containing 1 g of both XG and CMC obtained higher scores for their sensory attributes, while samples containing 2 g of both hydrocolloids were the chewiest. The findings suggest that the addition of hydrocolloids; XG and CMC enhances the freeze-thaw stability and reduces the oil absorption potential of the yam balls mix, and improve the sensory and texture properties of deep-fried yam balls.

Household food security determinants and nutritional status of inhabitants of a peri-urban community: a case study in the Volta region of Ghana

Kortei, N. K., Koryo-Dabrah, A., Esua-Amoafo, P., Yarfi, C., Nyasordzi, J., Essuman, E. K., and Akonor, P. T

Food shortages and malnutrition widely persist and continue to be rural peculiarities across the sub-region. A cross-sectional study was conducted in a peri-urban community of Dzodze in the Volta region to ascertain the level of food security as well as the nutritional status of the inhabitants using a random sampling technique. This community-based comparative cross-sectional study conducted from May to July 2018 adopted a multistage random sampling and selected 105 households. Sociodemographic data were collected using a structured questionnaire. Chi-square, Cramer's-V, and Pearson's correlations models were used to assess the association of socio-demographic, anthropometric and food frequency data while the Logit model, FSI, HCR were used to measure food security. Over half of the sample (59.6%) were in the normal range of BMI which implied good nutritional status. Remarkably, a majority of those in this normal BMI range 81 (77%) were female. Women aged 41years and above constituted a large portion of study participants (54.3%) of which many 43 (41%) were married. Just 4.8% of this group said they were both separated and cohabited with their partners non-customarily. Data on the frequency of food intake by the community revealed that, a majority of 63.4% of the respondents ate three times a day. Most of the people (77.2%, 68.7%, and 86.9%) ate breakfast, lunch, and supper, respectively, daily over a week. The fallouts from the work showed majority (71.5%) of the respondents were food secure and the remaining (about 28.5%) were food insecure. Factors such as age, gender, educational level, household size, and age were found to be significant predictors that influenced food security of the peri-urban community according to the logit model used. The smallholder households according to the computed food security index of 1.13 and normal range of BMI were identified to be indices of food security.

Assessment of the volume seafood waste generation, utilization and management system from selected seafood processing companies in Ghana: a case study

Asiamah E, Oduro-Yeboah C, Mboom FP, Atter A, Idun-Acquah N.N and Nkansah, J

Seafood waste has gained attention globally due to its increasing demand and negative impact on the environment. Survey work was conducted because Ghana has a significant number of commercial seafood processing industries

but documentation on seafood waste is limited. The objective of this survey was to gain an insight into the volume of seafood waste generation, utilization and management system in seafood processing companies. Specifically, the study was to identify bottlenecks in the reuse of waste from seafood processing companies, quantify the seafood waste and determine the composition of the seafood waste generated. This study evaluated seafood waste from ten seafood processing companies situated in Tema, Effutu, Takoradi and Accra Metropolis in Ghana. Production and Quality Assurance managers from on-shore seafood processing companies were interviewed using a semi structured interview schedule (SSIS). These seafood processing companies have been in existence for between one to forty years. The highest proportion (40%) of the companies have been in existence for six to ten years. The companies which were in operation for a period of twenty to twenty-five years accounted for 20%. Most (80%) of these processing companies processed prawns, octopus, lobsters, grouper, catfish, whereas a minority (20%) processed tuna seafood. A majority (80%) of the surveyed processing companies did not process the waste generated. The remaining percentage occupied a production volume ranging from 10-50 tons of raw fish production. A large portion of the waste generated was from grouper (60%) with the least being tuna (11%). Survey results revealed that the companies did not process their seafood waste because of the unavailability of processing equipment and lack of knowledge on the seafood waste value-added products. Another challenge confronting seafood waste management was the absence of management policy to regulate it. It can be concluded that the 60% of the surveyed companies generated seafood waste and there is a need for steps to be taken to reduce it. The study revealed that there were no laws in Ghana that controlled the reuse of seafood waste. It is recommended that a holistic seafood waste reduction approach must be established between actors in the fishing and seafood processing sector. This study could be a driving tool to improve the seafood waste management system in Ghana.

CSIR – WORLD FOOD DAY CELEBRATIONS

In commemoration of the 2022 World Food Day, the CSIR – Food Research Institute in collaboration with the Food and Agriculture Organization of the United Nations organized a two (2)-day food fair and stakeholder's forum on the theme "Leave no one behind: Better production, better nutrition, a better environment, and a better life." The event scheduled for the 13th and 14th of October, 2022 happened at the Forecourt of the CSIR – Food Research Institute, Shiashie – Accra. The program was in three (3) parts consisting of a stakeholders' forum, an innovative challenge prize, and an exhibition.

The fair commenced with a stakeholder discussion on food safety commitments which was followed by a food fair with side events on innovations, safety, and health practices in the food industry. The objectives were 1. To understand the root causes of the present food safety issues 2. To provide evidence on the effects of food safety risks in raw and processed plant and animal products on nutrition, food security, health, and economic growth. and 3. To create sustainable partnerships that will provide a mechanism for continuous information and technology transfer among public and private stakeholders. The event hosted about 90 exhibitors including food vendors, banks and insurance companies who play a key role in the food industry. However, food vendors were required to provide an Accra Metropolitan Assembly (AMA) health registration card to be part of the exhibition. Other small and medium scale enterprises without Food and Drugs Authority certification were provided with the necessary assistance during the fair for registration.

The fair was supported by Ghana Gas Company Limited, Ghana Commercial Bank (GCB)Limited, Cocoa Touton Ghana Limited, Sir Cool – CSIR-Water Research Institute, World Food Program (WFP), Societe Generale, Cocoa Processing Limited and Niche Cocoa.

Sod-cutting ceremony to mark the opening of the Food Fair.

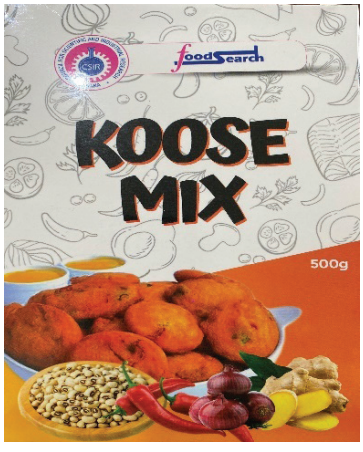
Dignitaries present for the opening.

Some exhibitors at the fair

CSIR-FRI food fair committee members

Launch of New FRI Food Products

The institute introduced five (5) new products into the market which were launched during the food fair under the brand name FoodSearch. These products – Koose mix, Pancake mix, Soy pancake mix, prekese pellets and Millet cereal mix – were outdoored by the Hon. Minister of Environment, Science Technology and Innovation, Hon. Kweku Afriyie, the Director General of CSIR, Prof. Paul Bosu and the Director of CSIR-FRI, Prof. Charles Tortoe.



COMMERCIAL SUMMARY

As part of its mandate, CSIR-FRI is to convert the outcomes of the scientific projects into snap short to solve peculiar problems. Over the years these outcomes have been converted to services or products. The Commercialization Division is responsible for commercializing technologies, services and products developed over the years in the Institute to benefit the individuals, SMEs, Companies and the industry as a whole. It actively collaborates with the Research Division to realize these goals.

The Institute provides physical, chemical and microbial analyses to food processing companies. Product development, product optimization and standardization, sensory analysis, contract productions, food processing equipment fabrication, feasibility studies for start-ups and trainings are among many commercial services rendered to clients.

Product development session for a client

Staff conducting microbial analysis on food samples.

Mushroom training session

Soymilk production session

FRI products are registered under the brand name *Foodsearch*.

Within the year 7,373 analytical services were rendered to industry/stakeholders on various number of samples. 53% of analysis were on microbial analysis while 35% and 12% were on chemical and mycotoxin analysis, respectively as shown in Figure 1.

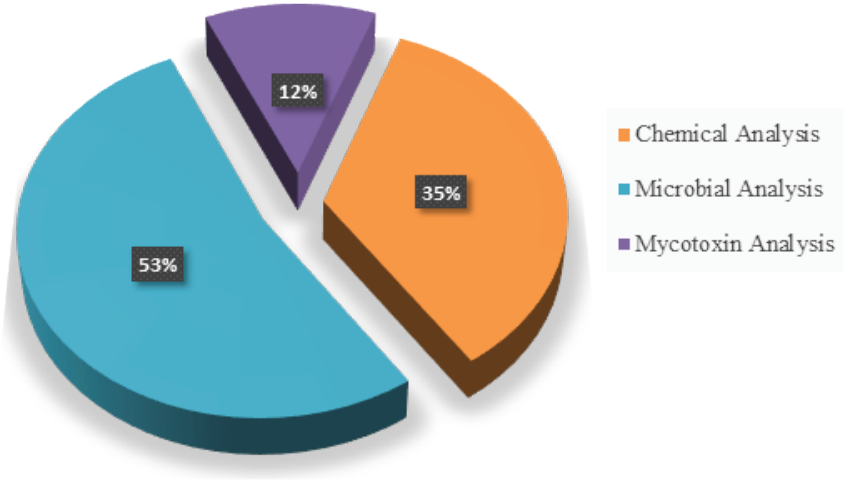


Figure 1: Proportions of analytical services rendered to clients.

FINANCIAL SUMMARY

CSIR-FRI's activities are financed through R&D with funding from donor agencies and by incomes generated from Commercialization. Internally, funds are generated from the sale of research products, rendering laboratory and technical services to clients, contract productions, fabrication of food processing equipment, consultancy services, etc.

The Institute generated a sum of $ 196,093.75 representing 58% of Funds as Internal Generated Funds (IGF) and $ 140,468.65 representing 42% was received as Donor funds for Research and Development. Donor agencies within the year included: EU (Healthy Food Africa), FAO (FAO Consultancy), Canadian Embassy (MAG Project), CABI International (Pesticide residues in fresh tomatoes) and Denmark (Cocoa Fermentation Consultancy)

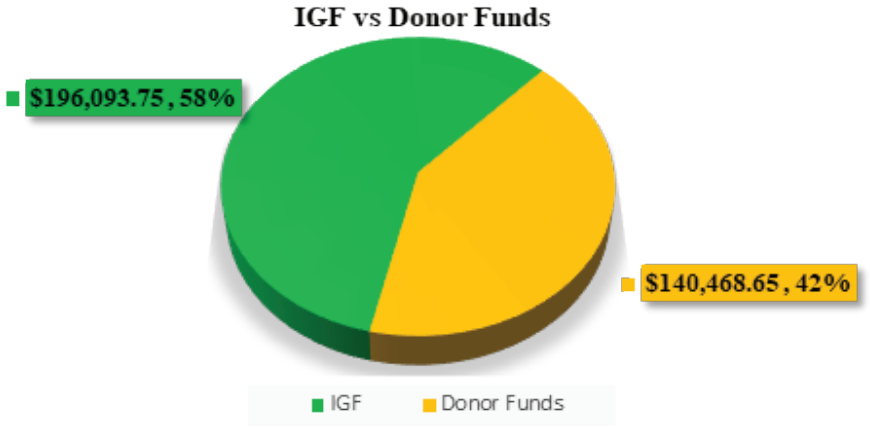


Figure 2: Comparing Donor funds and IGF

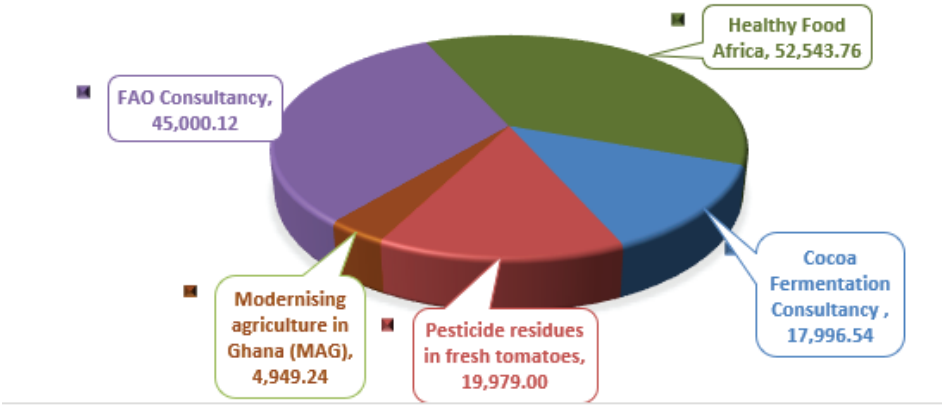


Figure 3: Representation of donor funds received within the year.

ADMINISTRATIVE ACCOUNT

CSIR-FRI has a staff strength of one hundred and sixty-four (164), comprising of 60% male and 40% female. Staff are grouped under Junior staff, Senior staff and Senior members (made of Research Staff, Principal Technologists and Administrators). The proportions of staff category are as shown in Figure 4.

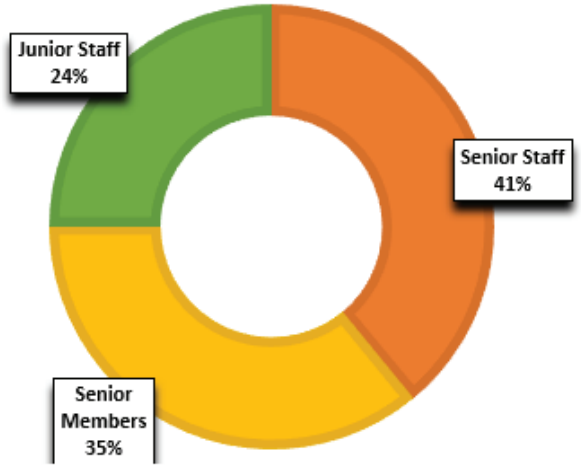


Figure 4: Percentage distribution of staff

Below are some activities carried out in the course of the year under review:

Promotions

The following staff were promoted effective January, 2022:

NO.	NAME	OLD GRADE	NEW GRADE
Senior staff			
	Mr. Ahmed Rufai Braimah	Senior Technical Officer	Principal Technical Officer
	Mr. Ofori Bempong	Principal Technical Officer	Chief Technical Officer
	Mrs. Naomi Agyapeng	Senior Accounting Assistant	Principal Accounting Assistant
Junior Staff			
	Mr. George Tetteh	Security Assistant Grade I	Senior Security Assistant
	Mr. Bob Atulibok	Security Assistant Grade I	Senior Security Assistant

Mr. Kojo Adamu	Security Assistant Grade II	Security Assistant Grade I
Mr. Edmund Gyampoh	Security Assistant Grade II	Security Assistant Grade I
Mr. Sunday Akantokdingin	Security Assistant Grade II	Security Assistant Grade I

Upgrading

The following underlisted staff were upgraded to Principal Technologist grade after completion of their Masters' degree programmes.

Name	Area of Study/training Institute	New Grade/Effective Date of Upgrading
Mr. Jeremiah Lartey-Brown	M.Phil., Agri-business, University of Ghana	December, 2021
Mrs. Edna M. Essel	M.Phil., Food Science Technology, CCST	March, 2022
Mrs. Ama Annan	M.Phil., Food Science Technology, CCST	September, 2022
Mrs. Dorothy Narh	M.Phil., Food Science Technology, CCST	September, 2022
Mrs. Mercy Ted Cofie	M.Sc.; Occupational Health and Safety Management	September, 2022

Transfers

The following staff were transferred to the Institute in the course of the year:

Mrs. Vivian Anane, Senior Administrative Officer was transferred from CSIR Head Office to the Institute to Head the Administration Division effective April, 2022.

Mr. Gladstone Saviour Cudjoe, Principal Accountant was transferred from CSIR-Institute of Industrial Research to CSIR-FRI to Head the Finance Division effective June, 2022.

Retirement

The underlisted staff proceeded on compulsory retirement after serving the Council for 15 years respectively:

1. Mr. Foster Bosempem, Security Officer
2. Mr. Paul Kportor Tetteh, Security Officer

Study Leave

The underlisted staff were granted study leave-with-pay to undertake various courses at the graduate level:

Name	Duration of Course	Grade	Course/Level
Ms. Wolase Efodzi	2 years	Principal Purchasing Assistant	MBA Purchasing and Supply
Ms Akua Arthur	4 years	Principal Technologist	PhD, Food Science
Mr. Solomon Dowuona	2 years	Senior Technologist	MPhil, Food Science

National Service/Internship Training

The Institute received 58 National Service Personnel in 2021-2022 session. The breakdown is as follows:

Year	Total	Female	Male
2021-2022	58	27	31
Percentage		46.6%	53.4%

The Institute also received 150 students from the various public and private for internship training.

Resignations

- Dr. Adwoa Padiki Nartey, Research Scientist resigned from the Council effective 1st February, 2022.
- Mrs. Gifty Naa Densua Aryee, Senior Administrative Officer resigned from the Council effective 16th February, 2022.
- Mrs. Belinda Quaye, Principal Technologist resigned from the Council effective 11th March, 2022.
- Mr. Mawuli Kwamla Azameti, Principal Technologist resigned from the Council effective 22nd March, 2022.
- Dr. James Ledo, Research Scientist resigned from the services of the Council effective 18th June, 2022.
- Ms. Mary Assimah, Chief Administrative Assistant resigned from the Council effective 20th June, 2022. The Council has since accepted their resignations.

OUR STAFF

DIRECTORATE

Prof. Charles Tortoe	-	Chief Res. Scientist / Director
Dr. (Mrs.) Charlotte Oduro-Yeboah	-	Prin. Research Scientist / Deputy Director
Mrs. Anthonia Andoh-Odoom	-	Snr. Res. Scientist / Quality Manager
Dr. (Mrs.) Esther Wahaga	-	Snr. Res. Scientist / M&E Officer
Ms. Mariam Yakubu	-	Scientific Secretary
Ms. Faustina Somuah	-	Administrative Officer
Mr. Ebenezer Tawiah	-	Marketing Officer (Deputy Quality Manager)
Ms. Barbara Asunka	-	Technical Officer (Asst. Scientific Secretary)

ADMINISTRATION DIVISION

Mrs. Vivian Anane	-	Senior Admin. Officer (Head,Administration)
Ms. Anita Adusah	-	Admin. Officer (Head, Registry Section)
Mrs. Victoria A. Asunka	-	Admin. Officer (Head, HR Section)
Ms. Gloria Ghansah	-	Senior Admin. Assistant
Ms. Esther Lamptey	-	Admin. Assistant
Ms. Rebecca Sefiah Drah	-	Admin. Assistant
Ms. Doris Menuye	-	Front Desk Officer
Mr. Emmanuel Kofi Bediako	-	Administrative Assistant

Transport Section

Mr. Eric K. Ofori	-	Administrative Officer (Head of Section)
Mr. Anthony Sevor	-	Snr. Asst. Transport Off.
Mr. Gariba Alimyao	-	Snr. Asst. Transp. Officer
Mr. Samuel Tettey Odjao	-	Snr. Asst. Transp. Officer
Mr. Seth Achuson	-	Assistant Transport Officer
Mr. Daniel Ayiku	-	Driver Gd. I
Mr. Moses Narh	-	Driver Gd. II

Mr. Philip Tetteh	-	Driver Gd. II
Mr. Carlos Babonye	-	Driver Gd. II
Estate Section		
Mr. Edmund Mensah-Yemoh	-	Chief Works Supt. (Head of section)
Mr. Abel Sogbe	-	Snr. Tech. Assist.
Mr. Samuel K. Adjei	-	Junior Foreman
Mr. Joseph Adivor	-	Supervisor Gd I
Mr. Daniel Obeng Oduro	-	Supervisor Gd I

Security Section

Mr. Philip Agyaye	-	Prin. Security Off. (Head, Security Section)
Mr. Samuel Quaye	-	Snr. Security Off.
Mr. Thomas Annor	-	Security Officer
Mr. Justice Blankson Dadzie	-	Snr. Security Asst.
Mr. George Tetteh	-	Snr. Security Asst
Mr. Francis Azure	-	Snr. Security Asst.
Mr. Abass Abdulai	-	Snr. Security Asst
Mr. George Ankwa	-	Snr. Security Asst
Mr. Bob Atulibok	-	Snr. Security Asst
Mr. Ebenezer Tieku	-	Security Asst. Gd I
Mr. Kojo Adamu	-	Security Asst. Gd I
Mr. Sunday Akantokdingin	-	Security Asst. Gd I
Mr. Edmund Gyampoh	-	Security Asst. Gd I
Mr. Gabriel K. Buluka	-	Security Asst. Gd II

FINANCE DIVISION

Mr. Gladstone S. Cudjoe	-	Prin. Accountant (Head of Division)
Mr. Derrick Victor Sallah	-	Accountant
Mr. Christian Amegah	-	Accountant
Ms. Judith Dogbegah	-	Chief Accounting Asst
Ms. Wolase Efodzi	-	Prin. Stores Supt.

Mrs. Angela Addy	-	Prin. Stores Supt.
Mrs. Naomi Agyebeng	-	Prin. Accounting Asst.
Ms. Judith Narkie Larweh	-	Prin. Marketing Asst.
Ms. Regina Tsotsoo	-	Snr. Accounting Asst.
Mr. Gasu Aikins	-	Snr. Accounting Asst.
Ms. Eclipseena N. O. Johnson	-	Accounting Assistant
Ms. Janet Abena Addo	-	Accounting Assistant
Ms. Rejoice Abla Fiazorli	-	Accounting Assistant
Mr. Prince K. Akuffo	-	Senior Accounts Clerk

COMMERCIAL DIVISION

Mr. Stephen Nketia	-	Scientific Secretary / Head of Division
Mr. Thomas Najah	-	Marketing Officer
Mr. Jeremiah Lartey – Brown	-	Principal Technologist
Mr. Solomon Dowuona	-	Snr. Technologist
Mr. Richard Takli	-	Snr. Technologist
Mr. Philip.O. Baidoo	-	Chief Marketing Asst.
Ms. Justina Thompson	-	Chief Marketing Assist.
Ms. Joana B. Dzikunu	-	Chief Admin. Officer
Mrs. Getty Appiagyei	-	Chief Technical Officer
Mr. Ofori Brempong	-	Prin. Technical Officer
Mr. Peter Dalabor	-	Prin. Works. Supt.
Mr. Emmanuel Agblo	-	Prin. Works. Supt.
Ms. Sindy M. Williams	-	Prin. Tech. Officer.
Ms. Benedicta Plahar	-	Snr. Admin. Assistant
Ms. Carris Dogbeda Ackuaku	-	Snr. Tech. Officer
Mrs. Rose Agorkor	-	Snr. Technical Officer
Mr. Deladem Ahiabor	-	Accounting Assistant
Mr. Godson Agbeley	-	Technical Officer
Mr. Paul Boadi	-	Technical Officer

Mr. Foster Akplaga	-	Technical Officer
Ms. Lydia Owusu Sekyere	-	Technical Officer
Ms. Jackline Boateng	-	Technical Officer
Ms. Stacy Ayitey	-	Technical Officer
Ms. Sophia Apenteng	-	Technical Officer
Ms. Naomi Taye	-	Technical Officer
Mr. Paul Godwin Fordjor	-	Marketing Assistant
Mr. Stephen Kofi Antwi Amoah	-	Senior Technical Assistant
Ms. Elizabeth Attah	-	Tech. Asst. Gd. II
Mrs. Ernestina Armah	-	Tech. Asst. Gd. II
Mr. Ababase Akanzinam	-	Supervisor Gd. I
Mr. Daniel Nuertey	-	Traffic Supervisor
Ms. Vicentia Mienuye	-	Supervisor Gd I
Ms. Rose Kornu	-	Supervisor Gd I
Mr. Emmanuel T. Kpabitey	-	Supervisor Gd I
Mr. Moses Mensah	-	Supervisor Gd I
Mr. Richard Ohemeng	-	Supervisor Gd I
Mr. Jeff Afenu	-	Supervisor Gd I
Mr. Nuru A. Abdulai	-	Tech. Assist Gd. II

FOOD TECHNOLOGY RESEARCH DIVISION

Mr. Paa Toah Akonor	-	Snr. Research Scientist/Head of Division
Dr. Gregory A. Komlaga	-	Snr. Research Scientist
Mr. Kwabena Asiedu Bugyei	-	Snr. Research Scientist
Mr. Raphael Kavi	-	Snr. Librarian
Mrs. Evelyn S. Buckman	-	Snr. Research Scientist
Mr. Jonathan Ampah	-	Research Scientist
Dr. John Edem Kongor	-	Research Scientist
Dr. Fransica Ansah	-	Research Scientist
Ms. Winifred Arthur	-	Prin. Technologist

Mrs. Leonora C. Baffour Gyasi	-	Prin. Technologist
Ms. Nancy Nelly Idun-Acquah	-	Prin. Technologist
Mr. Emmanuel Adokwei Saka	-	Prin. Technologist
Mrs. Jemima Dowuona	-	Prin. Technologist
Mr. Ebenezer Assimah	-	Prin. Technologist
Ms. Dorcas Naa Norley Thompson	-	Prin. Technologist
Mr. Enoch Aryeetey	-	Prin. Technologist
Mr. Felix Ebo Eyison	-	Chief Tech. Officer
Mrs. Edna Mireku Essel	-	Prin. Technologist
Mrs. Helen Ama Annan	-	Prin. Technologist
Mr. Frank Peget Mboom	-	Snr. Technologist
Mr. Solomon Dowuona	-	Snr. Technologist
Mr. Patrick Ofosu Mintah	-	Chief Tech. Officer
Mr. Desmond Mensah	-	Chief Tech. Officer
Mrs. Agartha Amuzu	-	Chief Tech. Officer
Ms. Constance Boateng	-	Chief Tech. Officer
Mrs. Alice Padi	-	Prin. Tech. Officer
Mr. Emmanuel Agblo Tettey	-	Prin. Works Supt.
Mr. Rufai Ahmed Braimah	-	Snr. Tech. Officer
Ms. Nana Akosua Adubea Mpere	-	Library Assistant
Mr. Eric Dogbey	-	Senior Tech. Asst.
Ms. Richel A. Boateng Oppong	-	Technical Assistant Gd. II

FOOD MICROBIOLOGY AND MUSHROOM DIVISION

Ms. Matilda Dzomeku	-	Snr. Research Scientist (Head of Division)
Dr. Margaret Owusu	-	Snr. Res. Scientist (Head, Accreditation Section)
Mrs. Amy Atter	-	Snr. Research Scientist

Mrs. Deborah L. N. Mensah	-	Snr. Research Scientist
Mr. Evans Agbemafle	-	Research Scientist
Mr. Theophilus Annan	-	Research Scientist
Dr. Ethel Juliet Serwaa Blessie	-	Research Scientist
Mrs. Akua Boatemaa Authur	-	Prin. Technologist
Mr. Michael Amoo-Gyasi	-	Prin. Technologist
Mr. Richard Y. Otwey	-	Prin. Technologist
Mr. Alexander Henry K. Appiah	-	Snr. Technologist
Ms. May A. Boham-Dako	-	Snr. Technologist
Mrs. Ruth Fosu	-	Prin. Technologist
Mr. Badaru Deen Yahaya	-	Technical Officer
Mr. Felix Afotey	-	Technical Officer
Mr. Emmanuel Bortey Mensah	-	Technical Officer
Mr. Philip Kwabena Mensah	-	Technical Officer
Mr. Eric Twum Sackor	-	Technical Officer
Mr. Emmanuel A. Tetteh	-	Work Supt.
Mr. Emmanuel Bassau Quansah	-	Senior Technical Assistant

FOOD CHEMISTRY AND NUTRITION DIVISION

Dr. Hayford Ofori	-	Snr. Research Scientist / Head of Division
Mr. George A. Anyebuno	-	Snr. Research Scientist
Dr. Jolene Mateko A. Nyako	-	Research Scientist
Dr. Emmanuel Kyereh	-	Research Scientist
Mrs. Hannah Oduro Obeng	-	Research Scientist
Dr. Benjamin K. Mintah	-	Research Scientist
Mr. Kofi Kwegyir Essel	-	Prin. Technologist

Mr. Hillary K. Ketemepi	-	Prin. Technologist
Mrs. Juliet Vickar	-	Prin. Technologist
Mr. Nelson Y. Amey	-	Prin. Technologist
Mr. Vincent Kyei-Baffour	-	Prin. Technologist
Ms. Vida Awidi	-	Prin. Technologist
Mrs. Mercy Ted Coffie	-	Prin. Technologist
Mrs. Dorothy Narh	-	Prin. Technologist
Ms. Emefa Gblende	-	Prin. Tech. Officer
Ms. Ruth Naa Gumah	-	Technical Officer
Mr. Benjamin Gyau Fosu	-	Technical Officer

PUBLICATIONS

JOURNAL PAPERS

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8. **Asiamah, E, Oduro-Yeboah, C., Mboom, F., Atter, A., Idun-Acquah, N. and Nkansah, J. (2022).** Assessment of the volume of seafood waste generation, utilization and management system from selected seafood processing companies in Ghana: A case study. African Journal of Food, Agriculture, Nutrition and Development, 22(112),20924–20941. doi:10.18697/ajfand.112.21745

9. **Asiamah, E.,** Aboagye, D., Zaky, A. A., Asakiya, C., & **Blessie, E. J. S.** (2022). Enzymatic modification of Fish Gelatin and Beet Pectin using Horseradish peroxidase. Food Hydrocolloids for Health, 2, 100080.

10. **Asiamah, E., Buckman, E. S., Peget, F., Akonor, P. T., Padi, A., Boateng, C., & Affrifah, N. S.** (2022). Effect of xanthan gum and carboxymethyl cellulose on structure, functional and sensorial properties of yam balls. Heliyon, 8(10), e11200.https://doi.org/10.1016/j.heliyon.2022.e11200

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16. **Komlaga, G.A.**, Oduro, I., Ellis, W.O., Dziedzoave, N.T., Awunyo Vitor D. and Djameh, C. (2022). Profitability of bioethanol production using cassava (Manihot esculantus crantz) and sweet potato (Impomea batatas) as raw material. African Journal of Food, Agriculture, Nutrition and Development.

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22. Kortei, N.K. and **Annan, T.** (2022). Aflatoxin M1 Contamination of Ghanaian Traditional Soft Cottage Cheese (Wagashie) and Health Risks Associated with Its Consumption. Journal of Food Quality, 2022, 1–12. doi:10.1155/2022/7595545.

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Research Reports

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2. **Oduro-Yeboah, C., Kongor, J. E., Asiamah, E., Padi, A., and Boateng, C.** (2022). Report on investors' forum on parboiled plantain chunks technology held at CSIR-FRI, Accra. CSIR-FRI/RE/O-YC/2022/004

3. **Tortoe, C., Ofori, H., Anyebuno, G., Gyau Fosu, B., Kyei-Baffour, V., & Ketemepi, K.H.** (2022). Pesticides residues in fresh tomatoes sampled across five regions in Ghana, CSIR-FRI/CABI INTERNATIONAL

4. **Dzomeku M, Obodai M** (2022): A checklist of Mushrooms of Ayum Forest Reserve, Bono Region,Ghana. v1.2. A Rocha Ghana. Dataset/Checklist. http://197.189.235.147:8080/iptghana/resource?r=ayum_mushrooms&v=1.2 CSIR-FRI/RE/DM/2022/009

5. **Komlaga, G.A., Nketia, S., Lartey-Brown, J. and Williams, S.** (2022). Feasibility studies on gari processing facility at Kwaman, Central region, Ghana. A consultancy report submitted to Mr. Vincent Koomson. CSIR-FRI/RE/KGA/2022/003

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