



CSIR-FRI
FOOD RESEARCH
INSTITUTE

2021
ANNUAL REPORT

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TABLE

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ACRONYMS

AEAs	Agricultural Extension Agents
ARDEC	Aquaculture Research and Development Centre
AU	African Union
BMGF	Bill and Melinda Gates Foundation
DAES	Directorate of Agricultural Extension Services
DAO	District Agricultural Officers
EU	European Union
FAO	Food and Agriculture Organization
FARA	Forum for Agricultural Research in Africa
HQCF	High Quality Cassava Flour
IFS	International Foundation for Science
MAG	Modernizing Agriculture in Ghana
NABCO	Nation Builders Corps
NAES	National Agricultural Extension System
NARS	National Agricultural Research System
OFSP	Orange Fleshed Sweet Potato
RAO	Regional Agricultural Officers
RELC	Research Extension Farmer Linkage Committees
SMEs	Small and Medium Enterprises
WIAD	Women in Agricultural Development
WP	Work Package

INTERNAL MANAGEMENT MEMBERS

1. Prof. Charles Tortoe	Ag. Director	Chairperson
2. Dr. Charlotte Oduro-Yeboah	Ag. Deputy Director	Member
3. Dr. Margaret Owusu	Head/FMMRD	“
4. Dr. Gregory A. Komlaga	Head/FTRD	“
5. Mr. George Anyebuno	Head/FCNRD	“
6. Mr. Stephen Nketia	Head/CD/Sci. Sec.	“
7. Mr. David Ahiabor	Head/Accounts	“
8. Mrs. Anthonia Andoh Odoom	Quality Manager	“
9. Mr. Kwabena Asiedu Bugyei	President/RSA	“
10. Mr. Michael Amoo-Gyasi	Chairman/TUC	“
11. Mr. Philip Baidoo	Ag. SSA Chairman	“
12. Mr. Theophilus Annan	Chairman, SWA	“
13. Mrs. Victoria A. Asunka	Ag. Head/Admin.	“/Secretary

FOREWORD



Prof. Charles Tortoe
Ag. Director, CSIR-Food Research Institute

In 2021, COVID-19 pandemic and its challenges persisted in Ghana. Interestingly, the Institute progressed successfully on its unique overall goal, which is to assist in poverty reduction by creation 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. Remarkably, our unique goal is in-line with the Sustainable Development Goals 1, 2, 3, 9 and 12.

The Institute witnessed the return of some staff from study leave after completion of their PhD and MPhil studies. The Institute continue to support other staff on study leave and short courses locally. Staff of the institute comprised of senior members-core, senior members non-core, senior members -technologist, senior staff, junior staff and contract staff. The excellent contribution of all staff to the peaceful and conducive environment in the Institute is strongly acknowledged. As this has contributed to the implementation of good management processes and procedures, good cooperate governance, adherence to all statutory requirements, ensured the implementation of best practices on its accounting and internal controls in management for successful growth in 2021.

We are grateful to our foreign partners for their tremendous sponsorship on research, technology and developmental programs especially Bill and Melinda Gates Foundation for sponsorship of the GC Fermented Foods Project, European Commission for sponsorship of Horizon 2020 and SmallFish Projects, Institut de Recherche pour le Développement (IRD) for sponsorship of 2FAS-INSIDER Project, African Union (AU) for sponsorship of SafeTilapia Project, Canadian Embassy, DANIDA, Forum for Agricultural Research in Africa (FARA), Food and Agriculture Organization (FAO), World Food Programme (WFP), Natural Resources Institute (NRI) United Kingdom, Alliance for a Green Revolution in Africa (AGRA), 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).

On behalf of the Internal Management Committee, I wish to thank all our stakeholders for their wonderful support, staff of the Institute for their dedication to work and the Almighty God for His goodness in 2021 and look forward to a productive year in 2022.

God Bless Us All.

Thank you.

EXECUTIVE SUMMARY

Since its inception, CSIR-Food Research Institute, an affiliate institute of the Council for Scientific and Industrial Research, provides scientific and technological support that are intended to meet the demands of the private sector and other stakeholders for the socio-economic development of Ghana. Mandated to conduct applied market-oriented research, the Institute has blossomed into the leading establishment in food research and post-harvest management technologies which are geared towards assisting the food industry. The activities of CSIR-FRI are purposely geared towards capacity building, skills development as well as nutrition studies and interventions. These are key areas targeted at curbing food insecurity related issues in the country.

Under its R&D program, various projects impacted society through programmes, workshops and other capacity building activities especially in rural communities on various processing technologies. These included improving small fish drying by trainings on quality and safety of small fish processing and providing drying platforms to community groups. Some communities were trained on the use of Orange fleshed sweet potato (OFSP) in order to introduce quality and variety to product lines such as the fortification of gari and baking bread and pastry products. Cassava processors were trained on quality production of HQCF and ethanol

Under the auspices of the MAG project, CSIR-FRI trained trainers in over ten (10) training sessions on handling post-harvest losses of watermelons, oranges, mangoes and pineapples. Bakers were trained on the use of composite flour from local roots and tuber crops for pastries and bread. Fish samples were collected for bacteriophage isolation in the Middle and Northern belts of the country of Ghana. Fish pathogens were isolated, enumerated and identified for further work under the SafeFish project.

Within the year, CSIR-FRI developed and transferred eleven (11) post-harvest technologies. Thirty (30) food preservation technologies and six thousand, three hundred and fifty-two (6,352) analytical services were rendered to stakeholders. The Institute generated a total

amount of \$ 290,294.13 as IGF; it also received \$ 380,777.04 in research grants under various projects. Within the year, the Institute had a staff strength of one hundred and sixty (160) comprising fifty-three (53) Senior members, seventy-seven (77) Senior staff and thirty (30) Junior staff. The Institute churned out sixty-eight (68) publications comprising of thirty-five (35) Journals papers, five (5) Technical reports, eighteen (18) Consultancy Reports, Eight (8) Manuals, one (1) Flyer and one (1) Conference abstract.

INTRODUCTION

Mandated to conduct applied market-oriented research into resolving challenges of food processing and preservation; food safety; food storage, marketing, distribution and utilization and also to advise the government on its food policy, Food Research Institute was established in 1963 by the Government of Ghana and in 1965, 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. To achieve its mission, CSIR-FRI conducts business in a conducive and transparent working environment with a cadre of highly qualified and motivated staff for timely delivery of quality services and products to clients.

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 CCST – MPhil in Food Science and Technology. The R&D component functions under four 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

CSIR-FRI contributes to food security and poverty reduction through various interventions including aiding in food storage, distribution, food quality and safety, improved nutrition, enhancing the use of underutilized food commodities, etc. Food insecurity remains one of the pertinent issues that correlate to poverty in sub-saharan Africa. The inability of all Ghanaians, at all times, to have access to sufficient, safe and nutritious food require different interventions along the food value chain. There still exist areas in Ghana where a high percentage of people are vulnerable to food insecurity. The institute also spearheads capacity building and development of skills and knowledge of various actors (in postharvest handling) and the food industry at large. Among interventions by the Institute are project activities on managing post-harvest losses.

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

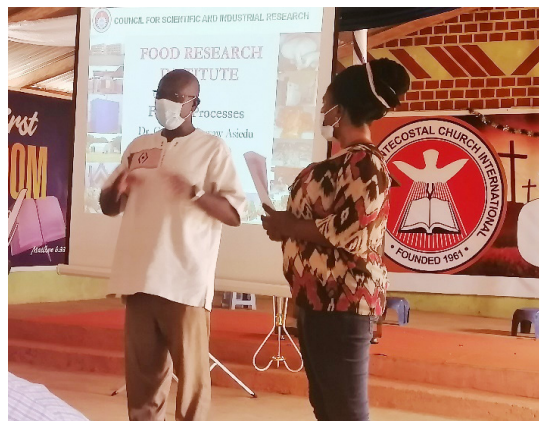
CSIR-FRI is one of the major institutes involved in the Modernizing of Agriculture in Ghana (MAG) Project. The aim of the MAG project is for the research institution like CSIR-FRI to address the constraint identified through the Regional Extension Farmer based linkage committee (RELCs) system at the 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. Technologies transferred by CSIR-FRI are mostly value addition to agricultural produce to reduce postharvest losses and improve the income of the beneficiaries because the trainings are entrepreneurial in nature and beneficiaries can venture into business to yield profits.

Key Activities and Achievements

Training of Trainers workshop on fish value addition using anchovies

Fish actors within the value chain at Denu in the Ketu South District of the Volta Region were trained on fish value addition using anchovies in a workshop spearheaded by the CSIR-Water Research Institute supported by Volta Regional RELC and facilitated by CSIR-Food Research Institute. Participants were made up of twenty-one (21) females and thirteen (13) males.

Training included, fishing processes, post-harvest utilization of fish, hygienic fishing practices, Fish selling, Fish processing methods, Food safety and hygiene, risk and hazards, equipment needs, value addition and value-added fish products.



Theoretical session



Practical session on value added anchovy products (anchovy balls and anchovy shito)

Training of Trainers on fish value addition using Tilapia and catfish

Fish processors and fish value chain actors within the Asuogyaman District of the Eastern Region were engaged in a two (2) day training of trainers’ workshop facilitated by Research Scientists from CSIR-Food Research Institute. A total number of thirty-six (36) people participated in this training workshop, sixteen (16) females and twenty (20) males.

The workshop centered on Fishing processes, post-harvest utilization of fish, Hygienic fishing practices, Fish selling, Fish processing methods, Food safety and hygiene, Risk and Hazards, Equipment needs, Value addition and Value-added fish products.

The overall objective of the workshop was to train fish processors and fish value chain actors on value addition to Tilapia and catfish besides the traditional processing methods they were used to. Beneficiaries were equipped to transfer acquired skills and knowledge to other fish processors.



Practical demonstration on fish product development (fish sausage)



Theoretical session



Practical session

Training workshops on business opportunities on one of CSIR technologies; Utilization of cassava and orange-fleshed sweet potato

Orange-fleshed sweet potato (OFSP) is a special type of bio-fortified sweet potato that contains high levels of beta-carotene. Beta-carotene is converted to vitamin A in the body after consumption to provide additional nutritional benefits. Dietary intervention with the use of locally grown crops such as OFSP that have been biofortified with vitamin A can serve as a cheap and sustainable approach to combating vitamin A deficiency (VAD) especially among vulnerable populations. A total of seventy-seven (77) participants, comprising of farmers, processors, caterers, MoFA Officials, Agriculture extension Agents and Research Scientists were trained in the Central and Volta Regions . This involved more women than men as seen in **Figure 1**. Total participants were made up of 58% females and 42% males. The training also involved practical hands-on demonstrations of OFSP utilization where both trainees and participants were taken through value addition of various food items with the OFSP and HQCF. The practical sessions included gari fortification with OFSP, production of yoghurt, bakery and pastry products with OFSP flour or mash and HQCF.

The objective of these training workshops was to develop the entrepreneurial and business capacity of farmers, processors and other cassava and OFSP value chain actors in the Central and Volta Regions on the production of OFSP flour and the utilization of HQCF and OFSP flour in fortification of gari, bakery and pastry products. Promoting the utilization of HQCF and OFSP will foster household food and nutrition diversification and contribute to generating additional household income. The training centered on the production and utilization of OFSP flour, business prospect and marketing of OFSP products.

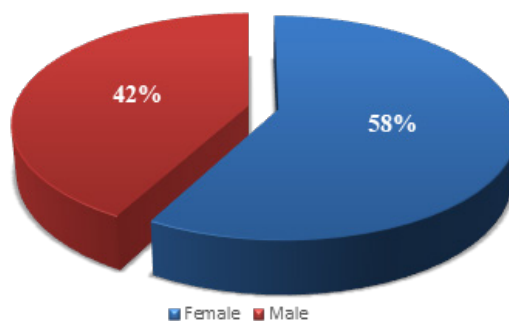


Figure 1: Percentage of men to women involved in utilization of cassava and orange-fleshed sweet potato workshop



Theoretical session in the Central Region



Theoretical session in the Volta Region



Frying of OFSP fortified gari by participants in the Central Region



Example of products from training in the Central Region



Examples of products from training in the Volta Region



Participants of training in Central Region



Participants of training in Volta Region

Training of Trainers workshop on handling postharvest losses of fruits

Workshops, in collaboration with the Council for Scientific and Industrial Research (CSIR)-Food Research Institute to train processors and Agricultural extension officers on reducing postharvest losses of some selected fruits (watermelons, mangoes and pineapples) and Soyabean were organized in the Shai Osu Doku district in the Greater Accra Region, North East Region and Ketu South Municipality. A total of sixty-seven (67) participants, thirty-three (33) from Shai Osu Doku, eighteen (18) from North East Region and sixteen (16) from Ketu South Municipality respectively as shown in **figure 2**. The workshops trained more males than females with a total of forty-three (43) male and twenty-four (24) females participating in the workshops.

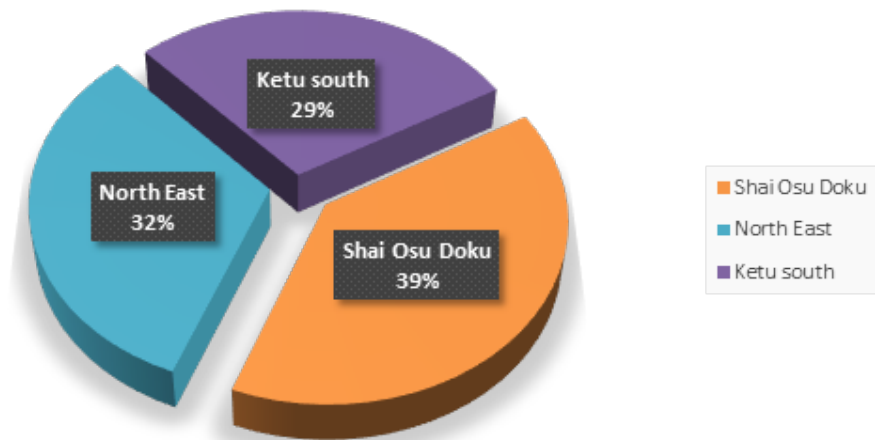


Figure. 2: Representation of participants trained in reducing postharvest losses of some selected fruits and Soyabean

The overall aim of the workshops was to train processors and Agricultural extension officers on how to properly handle post-harvest losses of the mentioned fruits. The topics covered included Basics of food processing, Importance of Food Preservation, Processing of fruits juice, Food safety and Food packaging. Hands-on training and practical sessions formed part of the workshop.



Practical session in Shai Osu Doku



Practical Session in North East Region



Participants in Ketu South Municipality

Training of Trainers’ workshops on Aflatoxin management in grains

To ensure that grains harvested and prepared for markets within, and outside Ghana are free of aflatoxins and can easily be exported, the project trained forty-seven (47) participants, comprising of Regional and District Agriculture Officers (RAO & DAO Engineering & Extension), WIAD officers, SMEs and Research Scientists in Aflatoxin management in grains in Damango, Ketu South and Hohoe.

The aim of these workshops was to train and build the capacity of regional and district Agriculture officers on Aflatoxin management in grains especially maize and groundnuts. Participants were taken through a theoretical and practical sessions, to broaden their understanding on the topic and to introduce them to current information in the field including the dangers of aflatoxins contamination of grains and the need to reduce

and eliminate aflatoxins from grains and also how to use the rapid test kit to analyse for aflatoxins in maize.



Participants in Damango



Participants in Ketu South



Participants in Hohoe

Training of Trainers' workshop on Good postharvest handling of cereals and vegetables

Fifteen (15) participants including Agriculture Extension Officers, NABCO-Agriculture Extension Officers and WIAD Officers in the Hohoe municipality of the Volta Region were trained on Good postharvest handling of cereals and vegetables. The main aim of the training workshop was to build the capacity of the participants on good postharvest handling of cereals and vegetables grown in and around Hohoe municipality of Volta region, Ghana.



Practical Session



Tomato ketchup products from training

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 SmallFishFod 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, having empowered women in Tema New Town (Greater Accra), Moree (Central Region) and Adina (Volta Region) in the previous years.

The project transferred technology on various value-added products to empower women fish processors to see the endless possibilities of utilizing their 'raw materials', the alternative processing value chains and income earning channels that are available to improve their livelihood and improve nutrition.

It also empowered women in Ningo-Ahwiam, Dangbe West in the Greater Accra Region to produce safe, cleaner, fish thereby improving the quality of their sun-dried fish. This made it more marketable in a bid to raise their income and reduced spoilage/waste especially in the rainy season when their dried fish are washed away by the rain.

Key Activities and Achievements

Construction of wooden raised platforms and drying racks

Wooden raised platforms and forty (40) drying racks were constructed for the women fish processors at Ningo-Ahwiam on land allocated by the Ningo-Ahwiam community and a hammer mill was also fabricated and installed. The platforms and racks provided

an alternative means of processing fish by sun drying with improved, cost-effective, user-friendly technologies. The design of the racks even though one-sided netting and wire mesh, allowed for easy flip-over to dry the bottom side of dried products when another rack is placed over it. This design was based on feedback given by the women processors and this was incorporated to encourage them to make full use of the racks. The affordable alternative drying platform has a wooden drying frame on which the racks are placed and supported on concrete stands to ensure stability and durability of the platforms.



Constructed racks and shed to house hammer mill

Training and technology transfer workshop in Ningo-Ahwiam

Following the successful fabrication and completion of the racks, platforms and hammer mill, a training and technology transfer workshop was held for the Women processors of the Ningo-Ahwiam community. The objective of this workshop was to train the women on proper handling of fish prior to drying and value addition to fish through product development. They were trained on hygienic ways to wash the fish, how to dry the fish on the racks instead of the floor, deheading and degutting of fish to prevent bitter aftertaste when used in cooking. They were also trained on how to use the hammer mill and properly package milled products.



Practical session on the proper ways to wash fish before drying



Drying of fish on racks



Deheading and degutting of fish in preparation for milling



Demonstration on the use of Hammer mill



Bagging and sealing of milled fish

Product Development

For product diversification using small fish, beneficiaries were trained on alternative uses of small fish. Products introduced included waffles, biscuits, doughnuts and shito.



Practical Session on Product Development



Training on biscuit production



Training on shito making



Training on Doughnut making



Participants with products developed from training

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 HealthyFoodAfrica initiative is a research and innovation project aiming at more sustainable, equitable and resilient food systems in 10 African cities. The project is a collaborative effort by 17 partners in Europe and Africa, funded by the European Union Horizon2020 programme.

Council for Scientific and Industrial Research (CSIR) entered into an agreement with the Natural Resources Institute of Finland to implement the EU Horizon 2020 project in Ghana. The CSIR-FSL is represented jointly by the Food Research Institute and the Water Research Institute. The project began in June 2020, and it is expected to be completed in December 2024.

The CSIR-Food Research Institute is actively participating in work packages 2, 4 and 6. The main goal of work package two (2) is to improve nutrition and health through transformation of consumption patterns towards sustainable healthy diets. The activities planned under this work package include collection and analysis of primary and secondary data on food consumption, food choices and dietary patterns, qualitative measurements of nutrient adequacy, and dietary diversity scores among others. Activities under work package four (4) are geared towards the development of innovative post-harvest technologies to improve food safety and reduce food waste. Against this backdrop, the following are some strategies earmarked to be accomplished under this work package, identification of current post-harvest and food safety issues, further development and piloting of relevant technologies and processes and more. Similarly, work package six (6) will focus on the development of novel food products, tools, and processes to support innovative agri-business models. Activities under this work package include participatory identification of innovative foods products, processes, and agri-business models, based on plant-based proteins and local agrobiodiversity. Also, there would be design and piloting of innovative foods products, processes, and agri-business models.

The general project design, therefore, seeks to take a multi-stakeholder network approach where scientists together with stakeholders' co-design the solutions through multi-actor teams. Also, the project will pilot the strategies, innovation, and tools from these studies to improve the supply of sustainable nutritious food products and the dietary habits of urban dwellers. This initiative will focus, identify, and promote the use of indigenous and local underutilized crops, fish, and animal species and encourage the consumption of minimally processed foods. Finally, lessons learned through these pilots will continuously be communicated to a larger range of stakeholders to enable the implementation of best practices.

Key Activities and Achievements

Renovation of Fish Processing Hall

The fish processing hall which was necessary to provide an ideal working space for smoking experiments to be carried out and for pilots on processes (fish processing) to be implemented under WP6 has been completed with expert inputs implemented to put the facility in a better. The fish processing unit will house the improved ovens and serve as a centre of excellence where groups and individuals especially women processors would be trained in hygienic fish handling and processing (smoking, drying, canning, packaging etc) as part of the piloting activities under WP6. Fish is mostly (about 80 %) processed by smoking in Ghana. Nevertheless, the improved oven (ahotor) currently used to smoke fish are fraught with many challenges limiting the attainment of zero Polycyclic aromatic hydrocarbons (PAH) in smoked fish in the country. Therefore, the goal of the fish processing unit is to review the smoking process, identify constraints and find ways to mitigate these challenges.



Processing Hall at the start of renovation works.



Tour of the renovated fish processing unit by the HFA project team members and stakeholders

Development of Novel Food Products

To accomplish the objectives of work package six (6) which is a critical aspect of the EU Horizon 2020 project, scientists from the CSIR-Food Research Institute together with stakeholders and other partners began trials towards development of novel food products from indigenous and local underutilised fish and crop species. These products included legume-based foods, cereal-based foods, seasoning and nutritive spices, soup base powders, fish products among others. A total of forty-five (45) food products were developed. The Accra Food Systems Laboratory (FLS-Ac) engaged stakeholders and potential product up-takers on the newly developed food products in Accra. CSIR-FRI has already added some of these products including pancake mix/soy pancake mix, Prɛkɛɛ pellets and koose mix to the range of products on sale at the shop.

Table 1: List of products developed

Product Name		Product Name	
1.	Fish nuggets	2.	Brown rice and tigernut pudding
3.	Fish floats	4.	Pickled tomatoes
5.	Fish chips	6.	Pickled onions
7.	Fish base cereal mix	8.	Picked tomatoes and onions
9.	Koobi in olive oil	10.	Pancake mix with desiccated coconut
11.	Tofu	12.	Pancake mix with mango
12.	Tofu sausage	14.	Soy pancake mix/Fruity soy pancake mix
15.	Soya bean sausage	16.	Instant fruity cereal
17.	Soya bean 5% noodles	18.	Vacuum packed ademe
19.	Soya bean 10% noodles	20.	Cut garden eggs
21.	Moringa noodles	22.	Vacuum packed okro and ademe
23.	Moringa base cereal mix	24.	Vacuum packed okro and garden eggs
25.	Mushroom noodles	26.	Vacuum packed bettor
27.	Mushroom in vinegar	28.	Prekese powder/cubes/pellets
29.	Mushroom in tomato sauce	30.	Watermelon juice
31.	Mushroom and dry herrings soup base	32.	Pineapple and watermelon juice
33.	Turkey berry soup base	34.	Pineapple and orange juice
35.	Tomato ketchup	36.	Koose mix
37.	Bambara in tomato ketchup	38.	Frozen fish drops
39.	Bambara in syrup	40.	Baobab yoghurt
41.	Bambara base cereal mix	42.	Soup tablet
43.	Bambara soup base thickener	44.	Tigernut, bambara and brown rice pudding
45.	Bambara and tigernut pudding		



Examples of products developed

Site Identification and Selection in the Eastern and Greater Accra Regions of Ghana

Under work package 4 of the project, the deliverables include investigating food safety indicators of tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*), as well as investigating and comparing the bacterial diversity of fish from earthen ponds, cages and from the wild. The project embarked on a site identification trip to educate farmers on the Healthy Foods Africa Project and to identify sites involved in tilapia and catfish farming within the Eastern and Greater Accra Regions of Ghana. The site identification activity was very successful with the assistance of Fisheries Commission officers. Sixteen (16) farms practicing the caged, earthen, and wild system of production within the Greater Accra and Eastern Regions were visited.



Interactions with local fishermen



Inspection of dug-out ponds on some farms



Inspection of fish smoking sheds on some farms



Interactions with Mr. Roger Aboujaoude (Managing Director) of Maleka Farms

Food safety and nutrition related surveys

Questionnaires were developed for surveys under WP4 and WP6. Following the site visits, fishes were sampled from the Greater Accra and Eastern regions of the country. The surveys were in three parts: - Assessment of food safety knowledge and practices of tilapia fish mongers, processors, and quantification of waste generated in tilapia processing, Assessment of food safety knowledge and practices of tilapia fish farmers and fishermen and Taste preferences and food safety knowledge and concerns among consumers. Similarly, fishes were sampled from sixteen (16) farms in both regions for Microbiological/Molecular and Chemical analyses. The 16S sequence data obtained for microbial diversity studies are ready and bioinformatics analyses are being performed on the data. Survey to assess consumer use, consumption patterns of tilapia, and interest/willingness to patronize filleted, spice-preserved and packaged tilapia is completed. Survey on the fish consumption/dietary patterns on fish intake and preferences among

Ghanaians in selected communities with Greater Accra and Eastern Regions is still ongoing.



Members of a community being interviewed on food consumption patterns



Sampling of fish from sites in the Greater Accra, Eastern and Western Region for Microbial analysis, Pesticide residues and Heavy Metal analysis



Studies on sampled tilapia fish to determine the Microbial analysis, Pesticide residues and Heavy Metal analysis

Survey on improved stove (Ahotor) performance evaluation

Data was collected from the Greater Accra, Central and Volta regions of Ghana on the existing fish smoking ovens with special focus on the Ahotor Oven. In general, all respondents who used the improved stove (Ahotor) frequently were satisfied with its use of less fuelwood. Thus, saves fuelwood. The improved stove produced less smoke, smoked fish tastes good and gives the fish a golden – brown colour. Furthermore, improved stove (Ahotor) users recorded less or no burns and accidents and less irritation of the eye during operation and were willing to purchase more and recommend to other fish processors. However, despite the advantages of the improved stove (Ahotor) respondents were not willing to discard the Chorkor smoker. 50% of respondents said they will use the Chorkor smoker to support or supplement the improved one. 95% of respondents were of the view that the Chorkor smoker can smoke large capacity than the improved stove (Ahotor) and other 5% said the Chorkor smoker is faster than the improved one in terms of speed. In the future, 85% of respondents asserted that they will be happy and interested to own an improved version of the current improved stoves (Ahotor) particularly when the problem of heat distribution, speed and capacity is solved.



Administering of questionnaires on improved smoking oven

Refurbishment of the sensory laboratory and digitalisation of the unit

During the year, the project refurbished the sensory laboratory unit. This refurbishment is to present a new and modern sensory laboratory in the Institute, which is more digitalised and environment- friendly. Also, it is expected to be more supportive for research and creative activities following the highest scientific and industry standard methods. The old sensory laboratory did not provide a welcoming and user-friendly environment

anymore because of its inability of supplying enough computing workstation and multimedia tools. It was for this reason the project provided the following equipment: computer, computer tablets (9), a printer and an Uninterruptible Power Supply (UPS) as computing workstation to the refurbished laboratory to help with the sensory activities to be carried out on the developed novel food products under work package (WP) 6.



The new digitalized sensory laboratory at the CSIR-Food Research Institute after the refurbishment

The procurement of equipment

During the year some equipment were procured for the smooth running of the project activities under WP 4 and 6. They include Bead Genie/homogenizer, BIORAD thermal cyclers T100 complete with accessories, BIORAD sub-cell tank system with electrophoresis power supply, Memmert water bath with gabled lid. These were obtained to enhance all the microbiological analysis aspect of the project. Other items also acquired were six (6) tablets for data collection and field activities, chest freezer, ice chests, printer, packaging/sealing machine and packaging materials to facilitate the improved product packaging drive of the developed products.

DEVELOPMENT OF BACTERIOPHAGE COCKTAILS AS DISEASE BIOCONTROL AGENTS FOR IMPROVED AQUACULTURE PRODUCTIVITY, FOOD AND NUTRITION SAFETY IN GHANA AND UGANDA

Agbemafle, E., Etornyo, A., Anani, A.F., Mensah, E.T.D., Okyere, I., Mireku, M., Damanka, S., Blessie, J.E., Narh Mensah, D. L., Akonor, P., Wahaga, E., Asamoah, F., Appiah, A. H.K., Galley, C., Kretsi, E., BadaruDeen, Y., Authur, A.B., Arthur, W., and Clokie, M.

Duration: 3 years

Introduction

Consumer preference for fish has increased in Ghana due to the health benefits associated with fish consumption. Fish, a major source of micronutrients has a pivotal role in the diet of many people living in low-and middle-income countries. Therefore, effective management of the fisheries sector is essential for food, economic and nutrition security.

Food security has continually been identified as a challenge in Ghana and worldwide. Aquaculture production in Ghana has drastically declined from 76,620 MT in 2018 to 52,000MT in 2019 which is a major source of concern. The main contributor to this decline is fish mortality caused by fish pathogens. Also, high cost of fish feed, inadequate quality fish seed/fingerlings, poor water quality, introduction of foreign tilapia strains, lack of transportation and cold storage for fish are all reason for this decline.

Many interventions have been introduced to mitigate the high fish mortality and the dwindling aquaculture production in the country. As part of these interventions, the fisheries commission introduced a vaccine known as Streptococcus, ISKNV. However, this vaccine was not very effective. Fish diseases are very difficult to control or treat. The use of drugs such as antibiotics have not been effective because the pathogens soon develop resistance against such drugs leading to more dangerous forms of the microbes which could cause harm to humans.

Drug use in animal production has been banned in EU, highly regulated in USA but in Africa not very much regulatory measures are in place. The main reason why these drugs are continuously used in agriculture in Africa is that they have no effect on the quality and sensory attributes of food products even in high doses. There is a need

to search for new and alternative ways to eradicate diseases that affect agriculture particularly Tilapia production. Bacteriophages are natural enemies of bacteria used to control bacteria populations in the ecosystem. They are not known to attack animals, human, plant, and fish cells hence making them very safe to use as bio-control agents. Bacteriophages are effective against antimicrobial resistant pathogens. They can effectively lyse antimicrobial resistant bacteria species.

Therefore, the main goal of the Safefish project is to develop bacteriophage products for integrated fish disease management to minimize antibiotic use in fish production in Ghana.

It is expected that at the end of the project, aquaculture production will be improved and largely impact food security in the country as farmers will be able to better control and treat fish diseases on their farms. This will improve food security in the country enabling inhabitants to gain access to safe and nutritious fish always. Also, capacity would be built in the phage technology in Africa.

Key Activities and Achievements

Community engagement - Farmers

The designed project questionnaire titled: Factors and Farmer's Practices Influencing Fish Health in Selected Farms in Uganda and Ghana was administered concurrently with sample collection in the Eastern and Volta regions of Ghana. A data collection app (ODK) was used for administering questionnaires to fish farmers/farm owners. Farm owners/managers/caretakers were interviewed to obtain the socio-demographic information, fish farm management practices, fish health and management, and source of feeds and fish seed (fingerlings). Questionnaires were administered to twenty-two (22) farms randomly selected from the two regions (sixteen (16) farms in Eastern Region and six (6) farms in the Volta Region). Data obtained from this activity is currently being analyzed.



Research team administering questionnaires



Research team administering questionnaires



Sample collection for fish pathogen studies

Sample collection was carried out in conjunction with questionnaire administration. Selection of fish farms and study areas within the fish zonal district were based on the five hundred and twenty (520) total active farmers in the six study regions (given by the Fisheries Commission of Ghana through the respective district/zonal officers). This comprises forty-three (43) from the Ashanti region, five (5) from the Northern region, four (4) from the Upper East region and seven (7) from the Upper West region. Sample collection from the selected fish farms were done randomly within each ecological belt. Almost, all zonal districts in the six study regions in Ghana have some fish farming activities. A total of of 59 fish farms were proposed by the team for these two ecological belts of the country (i.e., Southern and Northern Ghana).

Physico-chemical water quality parameters (i.e., Temperature, pH and Dissolved Oxygen) were determined to be within acceptable limits for aquaculture use for some fish farms. Further, other physico-chemical and biological parameters of the water samples collected was determined at the CSIR- WRI, ARDEC workstation’s laboratory in Akosombo. The Fisheries and Aquaculture research team from CSIR-WRI advised fish farmers and caretakers to seek technical knowledge and support from relevant authorities in the Aquaculture sector. The team also advised fish farmers on good management practices and biosecurity tips to enhance the sustainability and growth of fish and the aquaculture sector. Samples for bacterial pathogen isolation, (fishpond water, sediment, feed, and live fish/whole tilapia) were taken. For each farm, an average of ten (10) live fish were sampled; fish weight, length and width were measured. The sampled fishes were dissected on-site in a made-shift mobile lab under strict aseptic techniques conditions after swabbing with 70% ethanol.



Sampled tilapia measurement and dissection for target parts for lab. analysis



Lab. Technologists collecting fish feed samples from farmers

Sample collection by research team on a cage farm

Antimicrobial Susceptibility Testing (AST) of fish bacterial isolates

The antibiotic susceptibility profiling of isolated bacteria commenced after the bacterial identification by the MALDI-TOF MS instrument at the Bacteriology laboratory of the NMIMR. Purified isolates were firstly grouped into either Gram-negative (i.e., 80%) or Gram-positive (i.e., 20%) before the identification test and afterwards, the AST analysis was carried out on the identified isolates by the disc diffusion antimicrobial susceptibility test protocol. About fourteen types of antibiotics of different classes were used for the antibiotic susceptibility profiling.

Sample collection for bacteriophage (Phage) isolation was done concurrently with sample collection for fish bacterial pathogens isolation in the Middle and Northern belts of the country. The samples were collected from the cultured tilapia systems as well as fish landing sites, fish processing plants and sewage treatment plants if available. These were the various targeted samples ranging from sludge, effluent, sediment, and fish gut which were obtained from the eight study regions of both ecological zones of Ghana. However, other targeted sites with good ecological features for the presence of bacteriophages were sampled as well.



Collection of samples from a Lagoon in Tema for phage isolation



Collection of Sea water sample for phage isolation



Sea water collection for bacteriophage isolation



Pond sediment sample collection for Phage isolation

Country stakeholders' meetings/ Focus Group discussions

Ghana's phases 3 & 4 stakeholders' sensitization meetings were held for farmed tilapia farmers in the Middle and Northern belts of the country. This programme was held after the team had collected aquaculture samples and administered questionnaires to fish farm owners/ workers in these two ecological belts. It was a one-day workshop organized on the theme: Sensitization of tilapia fish farmers in the Ashanti region (middle belt) and Upper East region (Northern belt) of Ghana. Forty-five (45) participants from across the fisheries sector in the regions participated. Stakeholders at the workshop were mainly from the Fisheries Commission (Ashanti, Ahafo, Bono East, Upper East, Savanna and Northern regions), Aquaculture Research and Development Centre (ARDEC), fish farmers, Agric-businesses, Non-Governmental Organisation (NGO), and representatives of fish farmers from both ecological belts of Ghana

Major challenges facing most farmed tilapia farmers along the value chain included poor quality fish (i.e. fingerlings), wrongful in-breeding of fish by farmers, poor quality fish feed, inadequate fish feed supply to the hinterlands, poor storage of fish feed, wrongful use of antibiotics by farmers, introduction of foreign strains of tilapia into local farms, agro-chemicals pollution from farming areas into lakes when there is overflow therefore contaminating the water which causes fish death, lack of filtration systems at the water canals before it enters the main water body by pond system farmers, conditioning of fingerlings before transportation to reduce mortality, among others .



Participants during and after workshop in the Northern belt

FOOD FORTIFICATION RESEARCH PORTFOLIO DEVELOPMENT AND MANAGEMENT (2FAS): INTEGRATED STRATEGIES FOR MICRONUTRIENT DEFICIENCY REDUCTION

Tortoe, C., Nyako, J, Akonor, P. T. and Padi, A.

Duration: 1year 8months

Improving nutrition is of crucial importance to achieve the Sustainable Development Goals. Inadequate levels of micronutrients have severe and far-reaching adverse health consequences. These include impaired physical and cognitive development, poor neonatal and maternal outcomes, reduced work capacity of adults, and negative impacts on national economic development. The most vulnerable populations include young children and women of reproductive age. Despite substantial past and ongoing efforts, there remains a surprising lack of clarity about which interventions are most effective in addressing micronutrient deficiencies. This project therefore aims to evaluate how different strategies to combat micronutrient deficiencies (MNDs) can be combined, alongside diversification of diets, to maximize impact in West Africa, particularly amongst the most vulnerable populations, without increasing risks for overconsumption. The primary beneficiaries are the most vulnerable populations including young children and women of reproductive age in Ghana.

Key Activities and Achievements

The INSIDER project is divided into 3 specific phases. The first phase concerns translating data into evidence, whereas the second phase concerns translating this evidence into policy. The third phase focuses on the dissemination of the results of the project. The 2FAS-INSIDER project in the period under review is in the final policy drafting phase. The INSIDER Ghana study aimed at evaluating the impact associated implementation of national strategies and their primary outcomes and identify the main strategies employed to tackle malnutrition in the opinion of actors in the nutrition-related sectors of Ghana. The project's aim extends to drawing on the consensus between stakeholders from all levels of decision making and implementation to develop policy recommendations and catalogue best practices. To do this the team undertook interviews with representatives of stakeholders between November 2020 and April, 2021. In all, eighteen key informants representing mainly independent academic/research professionals or health experts (n=5) and governmental organisations (n=4), local non-governmental organisations (n=3), food industry (n=4) and international non-governmental organisations (n=2) participated. Data was analysed collected and analysed Multicriteria Mapping analysis.

Summary of Results

Participation was received from eighteen (18) of the twenty-six (26) invited respondents; giving a general response rate of 69.23%. This response rate was higher than that usually obtained for online/email-based surveys. Of the participants, nine (9) 52.94% were males and 8 (eight) females 47.06% and the participants were average aged 44.88 ± 10.41 with most being in the age category of above forty (40) years with a total of two hundred and fifty-two (252) years of experience between them.

Out of the criterion participants expressed, twenty (20) 25% were categorised as resource issues and eighteen (18) 22.5% were categorized under political commitment, with fifteen (15) 18.75% falling under acceptability issues. The remaining criteria were either categorized under sustainability issues with fourteen (14) respondents making 18%, twelve (12) respondents under stakeholders' commitment and impact issue having the least number of two (2).

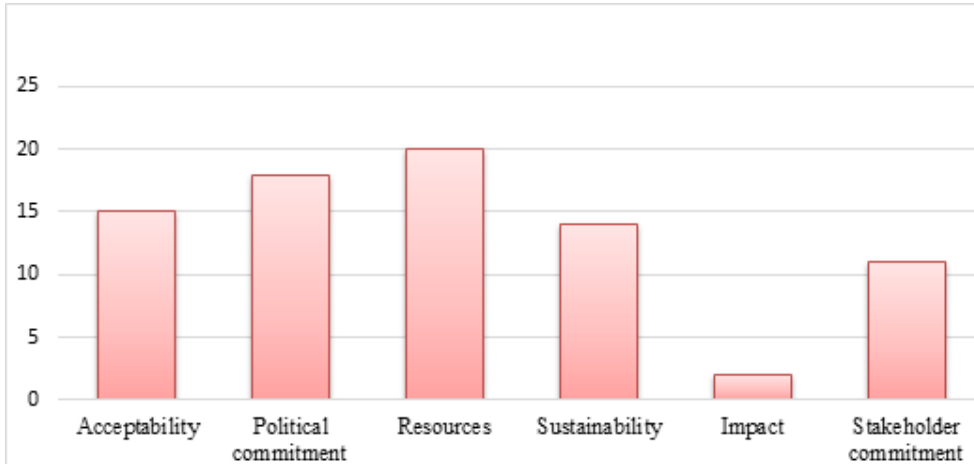


Figure 3: Distribution of criteria (number) across the 6 issue categories.

Considering the complexity of issues such as acceptability, categorization decisions under each issue was based on multiple consideration for both the name and definition of the criterion from the stakeholder’s perspective. The criteria were grouped into the respective issues based on the definition of criteria provided by the participants through the interview and not necessarily just the name of the criteria. No participant evaluated the options by using more than 5 criteria.

To determine relative degree of importance of each criterion, stakeholders were asked to weight the criteria. Resources obtained the most weight across perspectives. Stakeholders’ commitment being the least selected issue for evaluation of the predefine option. The wide of lengths of graph bars indicate wide variance in the degree relative importance in evaluating of the options. The bands illustrate the highest and lowest weighting of participant’s criteria with the Issue, illustrating the degree of agreement (narrow band) on the relative importance of criteria within each Issue.

Summary of recommendations

In the group interviewed, there is general belief that investing in nutrition is critical and cannot be over-emphasized. Nutrition potentially helps to achieve not only public health impact but results in the creation of social safety nets, growth of agribusiness, but also helps to reduce cost of health (present and future) and ultimately achieving the SDGs. To do this, the participants provided the following insights.

Nutrition and nutrition agenda must be made a priority at the national and political levels. It would be too idealistic, however, to expect policy and decision makers to automatically understand the importance of nutrition. This can be done by creating enabling environment within political and policy processes that build and sustain momentum for the effective implementation of actions that reduce malnutrition. Rather than wait for political will to emerge generic, political momentum can be developed and sustained through deliberate action such as the following. Streamlining financing and budgeting for nutrition activities towards a food-system approach which looks at financing for all nutrition-related activities (both nutrition-specific and nutrition-sensitive) across all sectors.

As the Ghana national nutrition policy is now in place, there is a need to consolidate this effort with creation of a Nutrition Commission or Council. This body will bear the mandate and power to facilitate, coordinate and monitor all nutrition activities across all sectors and actors. This is to ensure adequate coverage tracking, monitoring and evaluation across the various pockets of nutrition strategies being carried out nationwide. The current vertical style of nutrition programming model, where unilateral decisions are made in national office and trickled down to the district and local level does not adequately address the day-to-day dynamics of nutrition vulnerability.

Micronutrient survey was viewed a step in the right direction. Additional Research was seen as fundamental to evaluate the short falls of past nutrition strategies, adapt current strategies to the everchanging 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 for nutrition surveillance. Research is also required for national early warning systems and nutrition emergency.

At least two (2) out of every four (4) stakeholders interviewed reiterated the importance of nutrition education influence of 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: The establishment of national guidelines/legislature that create an enabling environment for nutrition education to able influence public policies and programming. Research-informed guidelines that promote access to a variety of nutritious local foods, address of the barriers to nutrition and move beyond from 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) taskforce that will develop national nutrition messages, vets at 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 national system of identifying, reporting misinformation and correcting wrong nutrition message especially in hindsight of the impact of nutritional misinformation during the Covid -19 pandemic.

Institutionalising knowledge of the nutritional value of foods and awareness on 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 level throughout secondary school academic environment. Teaching and learning methods employed should reinforcement 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 champaigns must adopt of innovative communication, interactive teaching and learning strategies and technologies that are creativity to guide the design, development and dissemination of innovative and useful messages; especially communication technology which includes both mass media, folk media and person-to-person.

Stakeholders also 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 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 current status of women and women's organizations in decision-making, (existing institutional policies demanding female involvement in decision-making and the progress made) and invest in targeted action to promote women's leadership that strengthening women's roles in decision-making. In order for women to garner some power and thrive, stakeholder organizations need to elevate an agenda that caters for women's agency and autonomy.

A central assumption realised among participants is the question of nutrition strategies should be focused on short term result of long-term rewards. Participants were mainly concerned with vulnerable population sub-groups at risk or already suffering from malnutrition, and whether strategies would be working more actively to prevent malnutrition and promote the knowledge, skills, and supports which will enhance and sustain good nutritional health. Participants believed that target supplementation despite its problems with targeting is a relative effective strategy in the treatment of acute malnutrition across vulnerable groups. In this way, supplementation is very important short-term measure in malnutrition alleviation as part longer-term health care programmes or whilst planning for long term nutrition specific programmes such as fortification. Despite the recognition of fortification's importance, fortification-related strategies efforts were ranked relatively low by participants. Participants were wary about cost effectiveness, poor education campaigns, lax monitoring and enforcement of legislation.

In Ghana, the integrated approach within the national stakeholders interviewed has not been without its short-falls, Stakeholders however seem optimistic that integrate strategies are the way forward for nutrition programming in Ghana and the need to look at it from a multisectoral food system approach that require a combination on preventive and curative strategies (package of nutrition-specific and nutrition-sensitive interventions).

Reversing these current short falls is not impossible, and can be achieved with an systematic analysis of the broader spectrum nutrition drivers(socio-economic,

biophysical, technological, political, demographical, cultural resources) and linking these drivers to more immediate factors (water supply , sanitation, and hygiene, and 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.

ABSTRACTS FROM PUBLISHED PAPERS

Characterisation of sandalwood essential oils: the application of high performance thin-layer chromatography

Ofori, H.; Hettiarachchi, D.; Sostaric, T.; Pandohee, J.; Chudasama, H. D.; Boyce, M. C.

The potential of HPTLC to characterise the essential oils of four sandalwood species was explored for *Santalum album*, *Santalum spicatum*, *Santalum austrocaledonicum*, and *Santalum paniculatum*. The variation in sandalwood oils for each species was documented and High-Performance Thin-Layer Chromatography (HPTLC) band and peak intensity profiles of mix of oils were used to generate a more representative profile. The individual oils of *S. album* and the pooled sample were quite similar, indicating that this pooled sample represents the oil. The pooled oil sample for *S. paniculatum* captured the variation observed for the individual oils. However, the band profiles from pooled samples of *S. spicatum* and *S. austrocaledonicum* did not always capture the complexity and unique aspects of the individual oils. For all oils analysed, the *S. spicatum* oils were correctly identified due to a unique pink band at RF 0.71 and distinctive peaks at RF 0.28, 0.45 and 0.47. The HPTLC band and peak profiles of *S. album* and *S. paniculatum* oils could easily be distinguished from each other with distinctive peaks at RF 0.51 and 0.17, respectively.

Cowpea; *Vigna unguiculata*; compositional; Physico-mechanical properties; Functional properties

Tawiah, E. R.; Akonor, P. T.; Johnson, P. N. T.; Oduro-Yeboah, C.; Idun-Acquah, N. N.; Mingle, C.; Tengey, T. K.

Cowpea (*Vigna unguiculata*) is an important legume cultivated in many parts of Africa and contributes a significant amount of plant-based protein to human diets. There are many varieties of cowpeas, and these have varying seed characteristics such as shape, size, colour and nutritional properties. The compositional, physico-mechanical and functional properties of two varieties of cowpea seeds were studied in order to

establish their full food-use potentials as well as key parameters for their postharvest machinery for processing, handling, and storage. The proximate composition of the two cowpea cultivars was determined using standard methods. Physico-mechanical analyses carried out were the hundred-seed weight and volume, bulk density, true density, size, aspect ratio, surface area, equivalent diameter, porosity and angle of repose. Functional properties determined were cooking time and water uptake of the grain, water and oil absorption, foam capacity and stability, and emulsion capacity and stability. Padi Tuya was longer, broader and thicker than Wang Kae. The results showed both varieties to be a useful source of macronutrients. The moisture, fat and fibre in Wang Kae were significantly higher ($p < 0.05$) than Padi Tuya. However, the cowpea varieties had comparable protein levels with a mean of 17.7 g/100 g. The cooking time, hydration capacities and indices of the two varieties were also significantly different ($p < 0.05$), but their swelling capacities, indices and water uptake indices were comparable. Cooking times were 40 and 62 min for Padi Tuya and Wang Kae, respectively. The flours of the two varieties had comparable water and oil absorption capacities as well as for the swelling indices, but their emulsion capacities and stabilities were significantly different ($p < 0.05$). Padi Tuya had a higher foam capacity with lower stability compared to Wang Kae. The physico-mechanical properties determined would aid in the design of cleaning, handling and other processing machinery as well as storage facilities for the new cowpeas. The functional and the compositional parameters would assist in the food formulations

Influence of cooking duration on carotenoids, physical properties and in vitro antioxidant capacity of pasta prepared from three Canadian durum wheat cultivars

Oduro-Obeng, H.; Fu, B. X.; Beta, T.

This study investigates the impact of different pasta cooking durations (al dente, fully cooked or overcooked) on the carotenoid content and physical properties of whole wheat and refined semolina pasta prepared from three Canadian durum wheat cultivars. Carotenoids were analyzed using HPLC and spectrophotometry. Generally increasing cooking duration non-significantly increased lutein, zeaxanthin, total carotenoids, significantly increased the cis carotenoids but decreased carotenoid retention and firmness regardless of flour type or wheat cultivar. Despite this decrease, whole wheat pasta was significantly firmer than semolina when overcooked regardless of wheat

cultivar. Antioxidant capacity was highly influenced by flour type but did not show a clear trend with cooking duration. Overall analysis indicates that increasing cooking duration of whole wheat or semolina pasta above 7 or 8 mins respectively allows for the maximum extraction of carotenoids with possible accessibility by digestive enzymes when consumed but this affects cooking quality including high cooking loss.

Gamma irradiation and drying method: the effects on kola nut powder

Darfour, R.; Ofori, H.; Asare, I. K.

Kola nut is a fruit produced by the kola tree which is mostly found in West Africa. Kola nut contains a high amount of caffeine and it is used as a flavoring agent in many drinks. At storage, kola nut may become mold-infested resulting in rotting and rendering it unusable. However, well-dried kola nut coupled with gamma (γ) irradiation treatment can prevent fungi infestation at storage. This study sought to determine the effects of γ -irradiation and drying method on proximate, phytochemical, and free scavenging properties of kola nuts. The kola nuts were dried in shade and solar tent. The milled samples packaged in polyethylene bags were irradiated with cobalt-60 source at 2 kGy/h dose rate, and the delivered dose determined with ethanolchlorobenzene dosimeter. The γ -irradiated and un-irradiated flours were quantitatively analyzed to determine proximate, phytochemical, and free radical scavenging activities. The fat, ash, protein, carbohydrate, and caffeine contents were slightly altered by the γ -irradiation, while moisture content remained stable. Total phenolic content in the aqueous extract of the irradiated kola nut increased at irradiation dose above 5 kGy. The changed in total flavonoid content was inconsistent with increasing irradiation dose while 2,2-diphenyl-1-picrylhydrazyl decreased at irradiation dose higher than 5 kGy. Importantly, the health and nutritional qualities of kola nut were not sufficiently affected by γ -irradiation. The kola nut type, irradiation dose, and drying method, and the respective interactions differed in effects with respect to proximate, phytochemical and free scavenging properties of kola nuts. Generally, the observed irradiation-induced impacts were not deleterious on the studied properties of kola nut.

Effect of flour types and flour concentrations on the physicochemical and sensory characteristics of an indigenous senescent plantain cake (ofam)

Adi, D. D.; Oduro, I. N.; Tortoe, C

Ofam is a Ghanaian indigenous cakelike product made mainly from senescent plantain and local flours from cereal, grain and/or tuber sources. The effect of three flour types (steeped corn flour (SCF), roasted corn flour (RCF) and kokonte flour (KF)) and flour concentrations (20, 17.5, 15, 12.5 and 10%) on the physicochemical characteristics and sensory acceptability of ofam was investigated. Parameters such as moisture, pH, total soluble solids (TSS), viscosity, colour and texture profile were measured using standard methods. A 50-member untrained panelist was used to conduct a sensory acceptability test using a 9-point hedonic scale. Ofam batter were characterised by high moisture content (ranging from 52.7 to 55.1%), pH (ranging from 5.4 to 5.5), TSS (ranging from 2.30 to 2.62) and a dark colouration (L-value ranging from 30.39 to 45.55). The flour type and concentration affected the viscosity of the batter which also influenced the hardness of ofam. RCF ofam was the hardest (1541.49 g Force) while KF ofam was the softest (966.79 g Force). Generally, RCF ofam was the most preferred (7.0) whilst KF ofam was the least preferred (6.68). Also, ofam with flour inclusion of 15% was also the most preferred (7.89) while products with 20% flour inclusion were the least preferred (6.47). This would form the basis for the standardisation of the product and formulation of a convenient powder mix suitable for ofam.

Aflatoxins in randomly selected groundnuts (*Arachis hypogaea*) and its products from some local markets across Ghana: human risk assessment and monitoring

Kortei, N. K.; Annan, T.; Akonor, P. T.; Richard, S. A.; Annan, H. A.; Wiafe-Kwagyan, M.;
Ayim-Akonor, M.; Akpaloo, P. G.

A random assessment and human risk analysis were conducted on 80 groundnut pastes and raw groundnuts from some local markets across the different agroecological zones of Ghana. Total aflatoxins (AF_{total}) and aflatoxins (AFB₁, AFB₂, AFG₁, and AFG₂) were analyzed using the High-Performance Liquid Chromatography (HPLC) method. Out of 80 samples investigated, 49 (61.25 %) tested positive for AFB₁ and ranged from 0.38 ± 0.04-230.21 ± 22.14 µg/kg. The same proportion was recorded for total aflatoxins (AF_{total}) and ranged between 0.38 ± 0.02-270.51 ± 23.14 µg/kg. Limits of AFB₁ and

total aflatoxins (AF_{total}) for the Ghana Standards Authority (GSA) (5 and 10 µg/kg) and the European Food Safety Authority (EFSA) (2 and 4 µg/kg), were used as checks. A total of 33 (41.25 %) samples were above the limits for both. Risk assessments recorded for Estimated Daily Intake (EDI), Margin of Exposure (MOE), potency, cancer risk, and population risks ranged 0.087-0.380 µg/Kg.bw/day, 1052.630-4597.700, 0-0.00396 ng Aflatoxins kg⁻¹bwday⁻¹ and, 1.5×10^{-3} - 7.9×10^{-4} respectively for total aflatoxins. While for aflatoxins B1 (AFB₁), ranges of values of 0.068-0.300 µg/Kg.bw/day, 1333.33-5882.35, 0-0.00396 ng aflatoxins kg/bw/day and, 1.19×10^{-3} - 6.34×10^{-4} corresponded for Estimated Daily Intake (EDI), Margin of Exposure (MOE), potency, cancer risk, and population risk respectively. There were risks of adverse health effects involved in the consumption of groundnuts for all age groups investigated since MOE values were all below 10,000

Investigating the effect of different types of cocoa powder and stabilizers on suspension stability of cinnamon-cocoa drink.

Muhammad, D. R. A.; Kongor, J. E.; Dewettinck, K.

Sedimentation of particles in cocoa drink is a technological challenge for the food industry. This study investigates the effect of different stabilizers (alginate, xanthan gum or carrageenan) on the suspension stability of cinnamon-cocoa drink made from 2 types of cocoa powder (natural or alkalized). Rheological and microstructural properties determination was used to examine the stabilization effect mechanism. The cocoa powder characteristic was investigated to study the correlation between cocoa powder properties and suspension stability. The results showed that xanthan gum is the most effective stabilizer to prevent particle sedimentation of the cinnamon-cocoa drink. Xanthan gum formed a network entrapping the particles. It increased the viscosity from 2.47 to 70.44 mPa s at a shear rate of 10/s. The drink formulated with alkalized cocoa powder has a better stability than that formulated with natural cocoa powder. However, at the concentration of 0.1% (w/v), xanthan gum could prevent sedimentation regardless the type of cocoa powder. The addition of xanthan gum up to 0.1% (w/v) had no significant effect on pH and antioxidant properties of the cinnamon-chocolate drink with a minor change in the lightness (L*) parameter. As such, the value of L*, pH, phenolic content and antioxidant activity of the cinnamon-cocoa drinks remained stable at around 22.5 ± 0.9 , 7.2 ± 0.1 , 0.31 ± 0.5 mg epicatechin equivalent /ml and 0.44 ± 0.3 mg

tannic acid equivalent /ml, respectively. This study can be useful for the food industry to define a novel strategy to produce “ready-to-drink” cocoa-based beverage with prolonged suspension stability.

Status, challenges and prospects of food processing equipment fabricators in Ghana

Ampah, J.; Ribeiro, J. X. F.; Bugyei, K. A.; Kumi, F.; Akowuah, J. O.; Ofori, H.; Otchere, C.

To facilitate effective provision of government support to local fabricators and improve their exposure to prospective clients in order to boost their productivity, it is necessary to understand the challenges currently impeding existing businesses as well as prospects at play with a view to identifying and promoting some recommendations and suggestions. The study explored the status, challenges and prospects of food processing equipment fabricators in three regions of Ghana: Greater Accra, Ashanti and Volta. The research generated an updated database of fabricators, identified relevant challenges and prospects, and established a relationship between the education level of respondents and the types of food processing equipment fabricated. A total of 101 fabricators answered the structured questionnaire. Majority of respondents (81%) were married. 41% had junior high school and 20% senior high school education. Farming (31%) and trading (23.8%) provided the highest secondary sources of income to fabricators. 953 dependents were found to be direct beneficiaries of income generated from fabrication works. 33 food processing equipment were recorded with the fufu extruder and cassava grater obtaining the highest frequencies. 33.9% of respondents had not registered their businesses with the Registrar General’s Department. Cross reference analysis depicted that education level of fabricators influenced the types of equipment fabricated; most especially in the fabrication of palm fruit boilers. The work recommends downward review of electricity and import tariffs of fabrication raw materials and machine spare parts, regular capacity building programs, and reduced requirements for company registration and association membership to boost productivity in the sector.

Challenges in the management of small-scale marine fisheries conflicts in Ghana

Ameyaw, G. A.; Tsamenyi, M.; Mcllgorm, A.; Aheto, D. W.

Marine fisheries play important socio-economic roles in Ghana including the provision of food, livelihoods, employment, income generation and poverty reduction. Small-scale fisheries in Ghana face many management challenges such as overfished stocks, and user conflicts which can threaten resource sustainability and social stability. Previous research on conflict management in Ghanaian fisheries in 2001, gave a view of conflicts at that time. Since then, the institutional arrangements for fisheries management have developed, but there have also been other pressures from overfishing, population growth and the development of a national oil industry. This paper identifies previous studies and conducts participatory research interviews with a range of stakeholders to determine current fishery conflicts, their causes, consequences and their management. Different types of conflicts were identified which include, spatial, fishing gear, resource competition, and a range of governance and inter-agency conflicts. Conflicts among fishers have negative impacts on economic and social development. Unfortunately, the decline in fish production due to overfishing precipitates some of the conflict issues. It is concluded that fisheries governance of the small-scale fisheries sector can be enhanced, if fish production declines are addressed, open access canoe fisheries are restricted, management of pre-mix fuel administration and distribution improved, with the subsidy on the commodity being gradually removed. Fishery regulations can be enhanced, fisheries arbitration systems strengthened and fishers made more aware of fisheries laws through education via co-management. However, given the extensive changes envisaged and the time required to reduce levels of fishing effort, it is essential that co-management governance structures and relations among small-scale fishers keep improving, so as to contain the level of conflict in Ghana's fisheries in the transition to more sustainable fishing and food security.

Biomass-based value chain analysis of plantain in two regions in Ghana

Tortoe, C.; Quaye, W.; Akonor, P. T.; Oduro-Yeboah, C.; Buckman, E. S.; Asafu-Adjaye, N. Y.

Plantain biomass value chain analysis was conducted to generate benchmark information that supports reduction of postharvest losses of plantain and to identify value-added opportunities and linkages to new markets in Ghana. Specifically, this study sought to identify the actors and their roles along the plantain value chain, understand the plantain value chain activities and identify biomass value addition opportunities that will help reduce post-harvest losses of plantain. Using the value chain analysis approach a total of 309 plantain value chain actors including producers, processors, traders, caterers and consumers in the Brong Ahafo and Western regions of Ghana were interviewed. Post-harvest losses of 20% at the production, 15% at the market levels and less than 5% at the consumption level were revealed. Plantains were traded mostly in the unprocessed form and 83% farmer respondents sold plantain unprocessed. The cross-cutting constraints among the actors were inadequate credit accessibility, high transportation cost, limited processing capacities, seasonality of plantains and fluctuation in prices, marketing challenges and post-harvest losses among others. The study provides useful baseline information for new products development from the biomass along the plantain value chain.

Associations of blood glucose levels with some diabetes risk factors (body mass index, blood pressure and total body fat) in inhabitants of Ho Municipality, Ghana: a cross sectional survey.

Kortei, N. K.; Koryo-Dabrah, A.; Angmorterh, S. K.; Adedia, D.; Yarfi, C.;
Essuman, E. K.; Tettey, C.; Akonor, P. T.

One complex metabolic disorder that can unenviably affect the normal human physiology is diabetes mellitus (DM). It is indeed one of the commonest noncommunicable diseases that has heightened to an epidemic level worldwide. For diseases like DM, hypertension, cardiovascular disease, type II DM, and other chronic diseases, body mass index (BMI) is identified as a positive and independent risk factor associated with morbidity and mortality. The objective of the study was to determine the relationships between BMI, blood pressure, and total body fat among inhabitants of periurban Ho, Ghana. A cross-sectional survey was carried out between May and June, 2018, among

132 inhabitants of Ho to determine the prevalence and associations among DM risk factors. The participants were selected by systematic random sampling. Standardized international protocols were used to measure BMI, blood pressure, blood glucose, and total body fat. Out of 132 respondents, majority 96 (72.7%) were female and the most common age group was 54-60 (31.1%). From the BMI classifications, 65 (49.2%) people were of normal weight while 6 (4.5%) were underweight. Total body fat (%) and blood pressure, likewise total body fat and BMI recorded significant associations of values (0.299, $p < 0.001$ -systolic; 0.298, $p = 0.001$ -diastolic), and 0.585 ($p < 0.001$), respectively. On the contrary, there were insignificant associations found between blood glucose and diastolic blood pressure and also blood glucose and systolic blood pressure (0.100, $p = 0.253$) and (0.057, $p = 0.514$), respectively using the Spearman's correlation analysis. Lastly, the test of association of socio-demographics and anthropometrics revealed there was a significant ($p < 0.001$) correlation between total body fat and BMI using Pearson's correlation analysis. BMI is closely related to total body fat and blood pressure; hence, education on lifestyle modification needs to be intensified to create awareness among the inhabitants of Ho municipality of Ghana. It is imperative to educate Ghanaians and beyond about the risk factor associations that predispose an individual to DM.

Viability of *Lactobacillus plantarum* NCIMB 8826 immobilized in a cereal-legume complementary food “weanimix” with simulated gastrointestinal conditions

Kyereh, E.; Sathivel, S.

Three cereal-legume complementary foods (weanimix) were formulated and evaluated for their ability to enhance the survival of probiotic bacteria *Lactobacillus plantarum* NCIMB 8826 in simulated gastrointestinal tract conditions. The three different blends of weanimix: MCPPM (maize:cowpea:peanut:powdered milk), MCP (maize:cowpea:peanut) and MC (maize:cowpea) were used. *L. plantarum* was inoculated and cultured in the weanimix slurry media to immobilize the cells. *L. plantarum* free cells in MRS broth were used as a control. Simulated gastric fluid (SGF) of pH 2.5, 3.0 and 3.5, and bile salt (0.3 and 1 g/100 ml of ox gall) were used to simulate the gastrointestinal conditions. The three complementary blends offered a protective shield, which improved cell viability in SGF at all pH levels. *L. plantarum* survived well in MCPPM, MCP and MC with < 2 log cell reduction compared with the free cells reduction of ~ 5 log after 180 min of incubation for each pH. For bile tolerance, viable cell counts in the weanimix were

higher than the free cells after 24 h suspension. The results of the study showed that weanimix improved the survival and viability of *L. plantarum*.

Effect of home processing methods on the levels of heavy metal contaminants in four food crops grown in and around two mining towns in Ghana

Adjei-Mensah, R.; Ofori, H.; Tortoe, C.; Johnson, P. N. T.; Aryee, D.; Frimpong, S. K.

Unregulated small-scale mining activities, by young untrained men using some poisonous chemicals, occur in several agricultural forest belts in Ghana. These activities contaminate water bodies in these areas, which happen to be the main farming sites where food crops are intensively cultivated. The presence of these heavy metal contaminants in popular food staples is therefore worrying because of its adverse health implications. Previous studies have shown that processing is able to decrease the concentrations of heavy metals in foods. This study investigated the effectiveness of home processing methods (boiling, frying and roasting) in significantly reducing the levels of heavy metal contaminants in food crops grown in and around two main mining centers in Ghana. The heavy metals contaminants analyzed for, were Arsenic (As), Cadmium, (Cd), lead (Pb), Manganese (Mn), and Mercury (Hg), determined using atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry (ICP-MS). From the data, the average daily intakes of the heavy metals and the associated long-term health risks to consumers were assessed. Unprocessed samples from Akwatia had higher levels of contaminants than those from Obuasi. Levels of Mn, Pb and As recorded in all unprocessed samples were higher compared to WHO permissible limits in foods. The levels showed a decreasing trend in the processed samples; with the lowest As and Pb content recorded after frying and boiling. The study showed that roasting allowed for the least reduction in the heavy metal contaminations in the four food crops. The levels of Cd in both processed and unprocessed samples were within safe WHO specifications. Except for Pb in unprocessed cassava, boiled cassava and unprocessed plantain and Hg (unprocessed yam and roasted yam), the hazard indices of all metals in all food crops were less than one and posed no risk to consumers. The study therefore reveals that the normal home processing methods are able to reduce the levels of heavy metal contaminants found in cassava, cocoyam, plantain and yam considerably.

The occurrence of aflatoxins and human health risk estimations in randomly obtained maize from some markets in Ghana

Kortei, N. K.; Annan, T.; Akonor, P. T.; Richard, S. A.; Annan, H. A.; Kyei-Baffour, V.;
Akuamoah, F.; Akpaloo, P. G.; Esua-Amofo, P.

Maize and its products are most often prone to fungal contamination especially during cultivation and storage by toxigenic fungi. Aflatoxicosis still persists in Ghana despite the numerous education on several ways of its prevention at the farm as well as its adverse health implications which are food safety concerns. A random assessment and human risk analysis was conducted on 90 maize (72 white and 18 colored) samples from markets across all the regions of Ghana. Total aflatoxins (AFTotal) and the constitutive aflatoxins (AFB1, AFB2, AFG1, and AFG2) were analyzed by High-Performance Liquid Chromatography (HPLC). Out of a total of ninety (90) samples investigated, 72 (80%) tested positive for AFB1 and the contamination levels ranged from 0.78 ± 0.04 to $339.3 \pm 8.6 \mu\text{g kg}^{-1}$. Similarly, AFG2 was detected in only 14 (15.5%) samples, and their values ranged between 1.09 ± 0.03 and $5.51 \pm 0.26 \mu\text{g kg}^{-1}$ while AF total ranged between 0.78 ± 0.04 and $445.01 \pm 8.9 \mu\text{g kg}^{-1}$ constituting approximately 72 (80%). Limits of AFB1 and total aflatoxins (AFTotal) for the Ghana Standards Authority (GSA) (5 and $10 \mu\text{g kg}^{-1}$) and the European Food Safety Authority (EFSA) (2 and $4 \mu\text{g kg}^{-1}$), were used as checks. A total of 33 (41.25%) samples were above the limits for both. Risk assessments recorded for Estimated Daily Intake (EDI), Hazard Quotient (H.Q), Hazard Index (H.I), Margin of Exposure (MOE), av. Potency, and population risks ranged $0.087\text{--}0.38 \mu\text{g kg}^{-1} \text{ bw day}^{-1}$, 1.5–6.9, 0.0087–0.38, 3.64–12.09, 0–0.0396 ng Aflatoxins $\text{kg}^{-1} \text{ bw day}^{-1}$ and, $3.5 \times 10^{-1}\text{--}0.015$ respectively for total aflatoxins. While ranges for aflatoxins B1 (AFB1) recorded were 0.068–0.3 $\mu\text{g Kg bw}^{-1} \text{ day}^{-1}$, 2.43–10.64, 0.0068–0.030, 4.73–20.51, 0–0.0396 ng Aflatoxins $\text{kg}^{-1} \text{ bw day}^{-1}$ and, $2.69 \times 10^{-3}\text{--}0.012$ for Estimated Daily Intake (EDI), Hazard Quotient (H.Q), Hazard Index (H.I), Margin of Exposure (MOE), Av. potency, and population risks respectively. It was deduced that although there was some observed contamination of maize across the different ecological zones, the consumption of maize (white and colored) posed no adverse health effects on the population of Ghana since computed H.I was less than 1 (<1).

Anchovy powder enrichment in brown rice-based instant cereal: a process optimization study using Response Surface Methodology (RSM)

Akonor, P. T.; Atter, A.; Owusu, M.; Ampah, J.; Andoh-Odoom, A.; Overa, R.; Kjellevoid, M.; Pucher, J.; Kolding, J.

There is a need for expanding the utilization of small fish as they constitute an undervalued and important source of protein and micronutrients in many developing countries suffering from micronutrient deficiencies. One way to increase consumption and health benefits is to add nutrient-rich fish meal into staple food ingredients. In this study, Response Surface Methodology (RSM) was applied to optimize the processing of an instant rice-based cereal enriched with anchovy powder. The Box-Behnken design was used to study the effect of principal processing variables (drying temperature, drum rotation speed, and slurry solids concentration) on product water activity, color, bulk density, and water solubility index. Viscosity, consistency, and cohesiveness of the reconstitute cereal were also evaluated. Empirical models were developed to describe the relationship between independent and dependent variables and showed regression coefficients (R^2) ranging between 71% and 98%. Higher drying temperatures resulted in reduced water activity, darker product color, and lower consistency. While drum speed influenced ($p < .05$) product color and water-binding capacity, bulk density, and consistency of the reconstituted product was associated with slurry solids concentration. Optimal processing conditions obtained from the study were temperature of 130°C, drum speed of 9.3 rpm, and solids concentration of 20.5%. These conditions would be useful in the production of brown rice-based instant cereal enriched with anchovy powder with desired quality properties.

Microbial diversity and metabolite profile of fermenting millet in the production of Hausa koko, a Ghanaian fermented cereal porridge

Atter, A.; Diaz, M.; Tano-Debrah, K.; Kunadu, A. P. H.; Mayer, M. J.; Colquhoun, I. J.; Nielsen, D. S.; Baker, D.; Narbad, A.; AmoaAwua, W.

Hausa koko is an indigenous porridge processed from millet in Ghana. The process involves fermentation stages, giving the characteristic organoleptic properties of the product that is produced largely at a small-scale household level and sold as a street food. Like many other indigenous foods, quality control is problematic and depends on

the skills of the processor. In order to improve the quality of the product and standardize the process for large-scale production, we need a deeper understanding of the microbial processes. The aim of this study is to investigate the microbial community involved in the production of this traditional millet porridge and the metabolites produced during processing. High-throughput amplicon sequencing was used to identify the bacterial (16S rRNA V4 hypervariable region) and fungal [Intergenic Transcribed Spacer (ITS)] communities associated with the fermentation, while nuclear magnetic resonance (NMR) was used for metabolite profiling. The bacterial community diversity was reduced during the fermentation processes with an increase and predominance of lactobacilli. Other dominant bacteria in the fermentation included *Pediococcus*, *Weissella*, *Lactococcus*, *Streptococcus*, *Leuconostoc*, and *Acetobacter*. The species *Limosilactobacillus fermentum* and *Ligilactobacillus salivarius* accounted for some of the diversities within and between fermentation time points and processors. The fungal community was dominated by the genus *Saccharomyces*. Other genera such as *Pichia*, *Candida*, *Kluyveromyces*, *Nakaseomyces*, *Torulaspora*, and *Cyberlindnera* were also classified. The species *Saccharomyces cerevisiae*, *Stachybotrys sansevieriae*, *Malassezia restricta*, *Cyberlindnera fabianii*, and *Kluyveromyces marxianus* accounted for some of the diversities within some fermentation time points. The species *S. sansevieria* and *M. restricta* may have been reported for the first time in cereal fermentation. This is the most diverse microbial community reported in Hausa koko. In this study, we could identify and quantify 33 key different metabolites produced by the interactions of the microbial communities with the millet, composed of organic compounds, sugars, amino acids and intermediary compounds, and other key fermentation compounds. An increase in the concentration of organic acids in parallel with the reduction of sugars occurred during the fermentation process while an initial increase of amino acids followed by a decrease in later fermentation steps was observed

COMMERCIAL SUMMARY

As part of its objectives, CSIR-FRI is to appropriate technology packages for processing, provide technical trainings and services to public and private sectors. The Commercialization Division is responsible for commercializing research outputs, technologies, services and products of the Institute. 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 sample



Mushroom training session



Chocolate making training session



Product development- development of shelf-stable products using local food commodities for clients

Within the year, eleven (11) different post-harvest technologies were developed and transferred to clients, through product development sessions. Thirty (30) food preservation technologies and 6,352 analytical services were rendered to industry/ stakeholders on various number of samples. 59% of analysis were on microbial analysis while 33% and 9% were on chemical and mycotoxin analysis, respectively as shown in **Figure 4.**

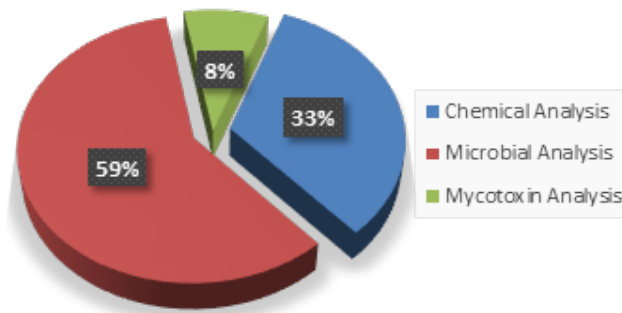


Figure 4: Proportions of analytical services rendered to clients

The Institute houses three start-up companies under the auspices of its incubation program. This initiative is to foster technology transfer and industry adoption of processing technologies.



Samples of products developed for start-up companies

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 \$ 290,294.13 representing 43% of Funds as Internal Generated Funds (IGF) and \$ 380,777.04 representing 57% was received as Donor funds for Research and Development. Donor agencies within the year included: EU (2FAS, Healthy Food Africa and Small Fish Food Projects), FAO (CREAM Project), Canadian Embassy (MAG Project), Bill & Melinda Gates Foundation (GC Fermented Food), IFS (Beetroot dark chocolate and Performance of yellow cassava in food application projects), FARA (Small scale dryers for post-harvest management enterprises in Africa project) and Denmark (Cocoa Fermentation Consultancy)

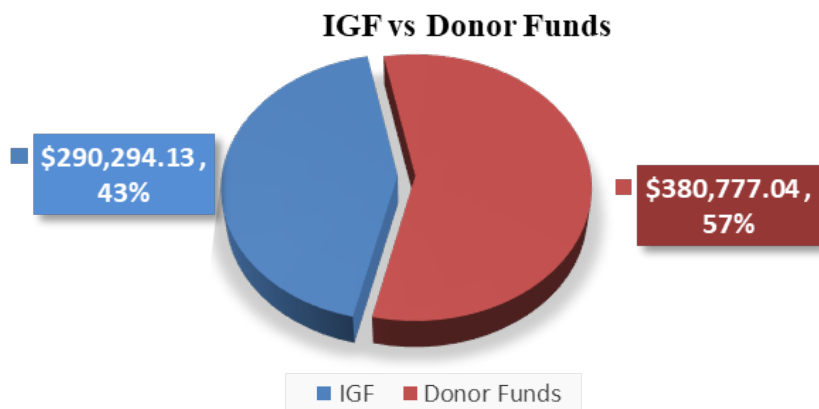


Figure 5: Comparing Donor funds and IGF

Donor Funds (GHC)

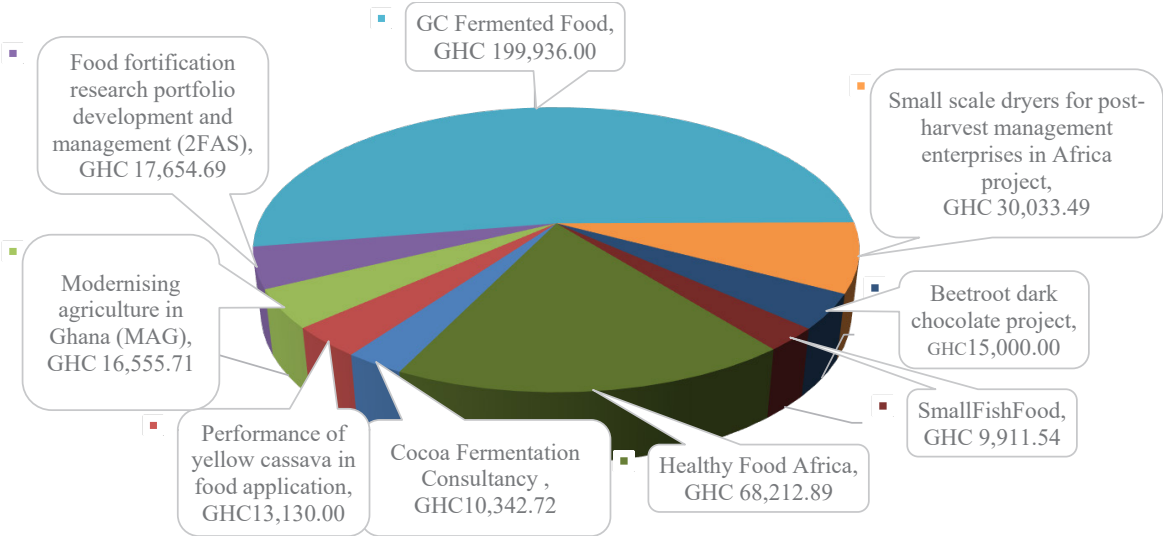


Figure 6: Representation of donor funds received within the year

ADMINISTRATIVE ACCOUNT

CSIR-FRI has a staff strength of one hundred and forty-six (160), comprising of 58% male and 42% female. Staff are grouped under Junior staff, Senior staff and Senior members (made of Research Staff, Principal technologists and non-Core Senior members). The proportions of staff category are as shown in **Figure 7**.

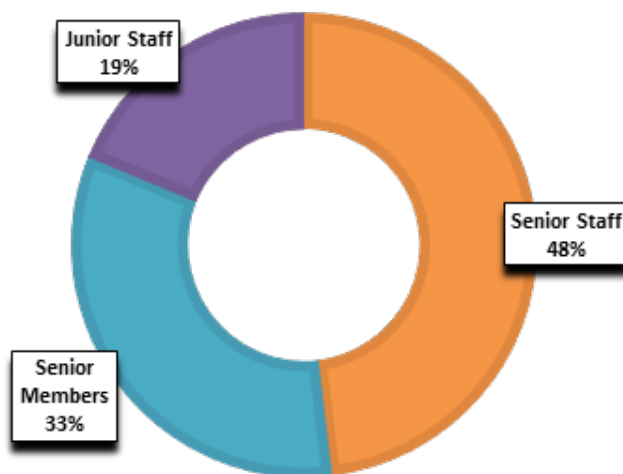


Figure 7: Percentage distribution of staff

At the end of the year, three (3) members of staff retired from active service, among these was Mr. David-Hayford Ahiabor, a Principal Accountant and the head of the Finance Division for five (5) years. He served CSIR-FRI for eight (8) years and worked in CSIR for a total of twenty-eight (28) years.

OUR STAFF

DIRECTORATE

- | | | |
|--------------------------------------|---|--|
| 1. Prof. Charles Tortoe | - | Chief Res. Scientist / Ag. Director |
| 2. Dr. (Mrs.) Charlotte Oduro-Yeboah | - | Prin. Research Scientist / Ag. Dep. Director |
| 3. Mrs. Anthonia Andoh-Odoom | - | Snr. Res. Scientist / Quality Manager |
| 4. Dr. (Mrs.) Esther Wahaga | - | Snr. Res. Scientist / M&E Officer |
| 5. Ms. Mariam Yakubu | - | Scientific Secretary |
| 6. Ms. Faustina Somuah | - | Chief Admin. Assistant |
| 7. Mr. Ebenezer Tawiah | - | Marketing Officer (Deputy Quality Manager) |
| 8. Ms. Barbara Asunka | - | Technical Officer (Asst. Scientific Secretary) |

ADMINISTRATION DIVISION

- | | | |
|------------------------------|---|---------------------------------------|
| 1. Mrs. Victoria A. Asunka | - | Admin. Officer (Ag. Head of Division) |
| 2. Ms. Anita Adusah | - | Admin. Officer |
| 3. Mr. Eric K. Ofori | - | Chief Admin. Assist (Head of Section) |
| 4. Ms. Esther Lamptey | - | Admin. Assistant |
| 5. Ms. Gloria Ghansah | - | Admin. Assistant |
| 6. Ms. Rebecca Sefiah Drah | - | Admin. Assistant |
| 7. Ms. Doris Menuye | - | Front Desk Officer |
| 8. Mr Emmanuel Kofi Bediako | - | Senior Clerk |
| 9. Mr. Anthony Sevor | - | Snr. Asst. Transport Off. |
| 10. Mr. Gariba Alimyo | - | Snr. Asst. Transp. Officer |
| 11. Mr. Samuel Tettey Odjao | - | Snr. Asst. Transp. Officer |
| 12. Mr. Seth Achuson | - | Traffic Supervisor |
| 13. Mr. Daniel Ayiku | - | Driver Gd. I |
| 14. Mr. Moses Narh | - | Driver Gd. II |
| 15. Mr. Edmund Mensah-Yemoh | - | Chief Works Supt. (Head of Section) |
| 16. Mr. Abel Sogbe | - | Snr. Tech. Assist. |
| 17. Mr. Samuel K. Adjei | - | Foreman |
| 18. Mr. Sunday Akantokdingin | - | Supervisor Gd I |
| 19. Mr. Joseph Adivor | - | Supervisor Gd I |
| 20. Mr. Daniel Obeng Oduro | - | Supervisor Gd I |
| 21. Mr. Jeff Afenu | - | Supervisor Gd I |
| 22. Mr. Edmund Gyampoh | - | Supervisor Gd I |

23. Mr. Philip Agyaye	-	Snr. Security Off. (Head of Section)
24. Mr. Samuel Quaye	-	Snr. Security Off.
25. Mr. Foster Bosompem	-	Security. officer
26. Mr. Paul Kpotor Tetteh	-	Security. Officer
27. Mr. Daniel Mustapha	-	Security Officer
28. Mr. Thomas Annor	-	Security Officer
29. Mr. Justice Blankson Dadzie	-	Snr. Security. Assist
30. Mr. Francis Azure	-	Snr. Security Asst.
31. Mr. Abass Abdulai	-	Security Asst. Gd I
32. Mr. George Ankwa	-	Security Asst. Gd I
33. Mr. Bob Atulibok	-	Security Asst. Gd I
34. Mr. Ebenezer Tiekue	-	Security Asst. Gd I
35. Mr. George Tetteh	-	Supervisor Gd I
36. Mr. Kojo Adamu	-	Supervisor Gd I

FINANCE DIVISION

1. Mr. David – Hayford Ahiabor	-	Prin. Accountant / Head of Division
2. Mr. Derrick Victor Sallah	-	Accountant
3. Mr. Christian Amegah	-	Accountant
4. Ms. Judith Dogbegah	-	Chief Accounting Asst
5. Ms. Wolase Efodzi	-	Prin. Stores Supt.
6. Mrs. Angela Addy	-	Prin. Stores Supt.
7. Ms. Mabel Nunoo	-	Prin. Auditing Assistant
8. Ms. Regina Tsotsoo	-	Snr. Accounting Asst.
9. Mrs. Naomi Agyebeng	-	Snr. Accounting Asst.
10. Mr. Gasu Aikins	-	Snr. Accounting Asst.
11. Ms. Eclipseena N. O. Johnson	-	Accounting Assistant
12. Ms. Janet Abena Addo	-	Accounting Assistant

COMMERCIAL DIVISION

1. Mr. Stephen Nketia	-	Scientific Secretary / Head of Division
2. Mr. Thomas Najah	-	Marketing Officer
3. Mr. Solomon Dowuona	-	Snr. Technologist
4. Mr. Richard Takli	-	Snr. Technologist

5. Mr. Jeremiah Lartey- Brown	-	Chief Tech. Officer
6. Mr. Philip.O. Baidoo	-	Chief. Marketing Asst.
7. Ms. Mary Assimah	-	Chief. Admin. Assist.
8. Ms. Joana B. Dzikunu	-	Chief Admin. Officer
9. Mrs. Getty Afuukar	-	Prin. Technical Officer
10. Mr. Ofori Brempong	-	Prin. Technical Officer
11. Ms. Justina Thompson	-	Prin. Admin. Assist.
12. Mr. Peter Dalabor	-	Prin. Works. Supt.
13. Mr. Emmanuel Agblo	-	Prin. Works. Supt.
14. Ms. Sindy M. Williams	-	Prin. Tech. Officer.
15. Ms. Judith Narkie Larweh	-	Prin. Marketing Asst.
16. Ms. Benedicta Plahar	-	Snr. Admin. Assistant
17. Ms. Carris Dogbeda Ackuaku	-	Snr. Tech. Officer
18. Mrs. Rose Agorkor	-	Snr. Technical Officer
19. Mr. Deladem Ahiabor	-	Accounting Assistant
20. Mr. Godson Agbeley	-	Technical Officer
21. Mr. Paul Boadi	-	Technical Officer
22. Mr. Foster Akplaga	-	Technical Officer
23. Ms. Lydia Owusu Sekyere	-	Technical Officer
24. Ms. Jackline Boateng	-	Technical Officer
25. Ms. Elizabeth Attah	-	Tech. Asst. Gd. II
26. Mrs. Ernestina Armah	-	Tech. Asst. Gd. II
27. Mr. Ababase Akanzinam	-	Supervisor Gd. I
37. Mr. Daniel Nuertey	-	Traffic Supervisor
38. Ms. Vicentia Mienuye	-	Supervisor Gd I
39. Ms. Rose Kornu	-	Supervisor Gd I
40. Mr. Emmanuel T. Kpabitey	-	Supervisor Gd I
41. Mr. Moses Mensah	-	Supervisor Gd I
42. Mr. Richard Ohemeng	-	Supervisor Gd I
43. Mr. Nuru A. Abdulai	-	Tech. Assist Gd. II

FOOD TECHNOLOGY RESEARCH DIVISION

1.	Dr. Gregory A. Komlaga	-	Snr. Research Scientist/Head of Division
2.	Mr. Elvis A. Baidoo	-	Snr. Research Scientist
3.	Mr. Paa Toah Akonor	-	Snr. Research Scientist
4.	Mr. Kwabena Asiedu Bugyei	-	Snr. Research Scientist
5.	Mr. Raphael Kavi	-	Snr. Librarian
6.	Mrs. Evelyn S. Buckman	-	Snr. Research Scientist
7.	Mr. Jonathan Ampah	-	Research Scientist
8.	Dr. John Edem Kongor	-	Research Scientist
9.	Dr. James Ledo	-	Research Scientist
10.	Dr. Francisa Ansah	-	Research Scientist
11.	Ms. Winifred Arthur	-	Prin. Technologist
12.	Mrs. Leonora C. Baffour Gyasi	-	Prin. Technologist
13.	Ms. Nancy Nelly Idun-Acquah	-	Prin. Technologist
14.	Mr. Emmanuel Adokwei Saka	-	Prin. Technologist
15.	Mrs. Jemima Dowuona	-	Prin. Technologist
16.	Mr. Ebenezer Assimah	-	Prin. Technologist
17.	Ms. Dorcas Naa Norley Thompson	-	Prin. Technologist
18.	Mr. Felix Ebo Eyison	-	Chief Tech. Officer
19.	Mrs. Edna Mireku Essel	-	Snr. Technologist
20.	Mrs. Helen Ama Annan	-	Snr. Technologist
21.	Mr. Frank Peget Mboom	-	Snr. Technologist
22.	Mr. Solomon Dowuona	-	Snr. Technologist
23.	Mr. Patrick Ofosu Mintah	-	Chief Tech. Officer
24.	Mr. Desmond Mensah	-	Chief Tech. Officer
25.	Mrs. Agartha Amuzu	-	Chief Tech. Officer
26.	Ms. Constance Boateng	-	Chief Tech. Officer
27.	Mrs. Alice Padi	-	Prin. Tech. Officer
28.	Mr. Emmanuel Agblo Tettey	-	Prin. Works Supt.
29.	Mr. Rufai Ahmed Braimah	-	Snr. Tech. Officer
30.	Ms. Nana Akosua Adubea Mpere	-	Library Assistant
31.	Mr. Eric Dogbey	-	Senior Tech. Asst.

FOOD MICROBIOLOGY AND MUSHROOM DIVISION

1.	Dr. Margaret Owusu	-	Snr. Research Scientist/Head of Division
2.	Ms. Matilda Dzomeku	-	Snr. Research Scientist
3.	Mrs. Amy Atter	-	Snr. Research Scientist
4.	Mrs. Deborah L. N. Mensah	-	Snr. Research Scientist
5.	Mr. Evans Agbemafle	-	Research Scientist
6.	Mr. Theophilus Annan	-	Research Scientist
7.	Dr. Ethel Juliet Serwaa Blessie	-	Research Scientist
8.	Mrs. Akua Boatemaa Authur	-	Prin. Technologist
9.	Mr. Michael Amoo-Gyasi	-	Prin. Technologist
10.	Mr. Mawuli Kwamla Azameti	-	Prin. Technologist
11.	Mr. Alexander Henry K. Appiah	-	Snr. Technologist
12.	Ms. May A. Boham-Dako	-	Snr. Technologist
13.	Mrs. Ruth Fosu	-	Prin. Tech. Officer
14.	Mr. Badaru Deen Yahaya	-	Technical Officer
15.	Mr. Felix Afotey	-	Technical Officer
16.	Mr. Emmanuel Bortey Mensah	-	Technical Officer
17.	Mr. Philip Kwabena Mensah	-	Technical Officer
18.	Mr. Eric Twum Sackor	-	Technical Officer
19.	Mr. Emmanuel A. Tetteh	-	Work Supt.

FOOD CHEMISTRY AND NUTRITION DIVISION

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5.	Mrs. Hannah Oduro Obeng	-	Research Scientist
6.	Dr. Benjamin K. Mintah	-	Research Scientist
7.	Dr. Adowa Padiki Nartey	-	Research Scientist
8.	Mr. Kofi Kwegyir Essel	-	Prin. Technologist
9.	Mr. Hillary K. Ketemepi	-	Prin. Technologist
10.	Mrs. Juliet Vickar	-	Prin. Technologist
11.	Mr. Nelson Y. Amey	-	Prin. Technologist
12.	Mrs. Belinda Quaye	-	Prin. Technologist

13. Mr. Vincent Kyei-Baffour	-	Prin. Technologist
14. Ms. Vida Awidi	-	Prin. Technologist
15. Mrs. Mercy Ted Coffie	-	Technologist
16. Mrs. Dorothy Narh	-	Chief. Tech. Officer
17. Ms. Emefa Gblende	-	Prin. Tech. Officer
18. Ms. Ruth Naa Gumah	-	Technical Officer
19. Ms. Stacy Ayitey	-	Technical Officer
20. Mr. Benjamin Gyau Fosu	-	Technical Officer

PUBLICATIONS

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2. **Idun-Acquah, N. N.; Baffour Gyasi, L. C.; Mensah, D.; Najah, T.;** Dogbey, E. (2021). Training manual on extruded cereal (maize and millet) snacks
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4. **Idun-Acquah, N. N.; Baffour Gyasi, L. K.; Mensah, D.; Najah, T.; Dowuona, S.** (2021). Training manual for fruit drying.
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FLYERS

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