COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
CSIR
GHANA

2020 ANNUAL REPORT

CSIR - FOOD RESEARCH INSTITUTE

2020 ANNUAL REPORT

CSIR - FOOD RESEARCH INSTITUTE

Contact

Prof. Charles Tortoe, The Acting Director

CSIR-Food Research Institute

P. O. Box M20 Accra, Ghana

Location

Adjacent Ghana Standards Authority, Gulf Street,

Gulf House, Near Tetteh Quarshie Interchange, Accra, Ghana

E-mail: director@foodresearchgh.org

Website: www.foodresearchgh.org

Telephone: +233 30 296 2068

Compiled by

Mariam Yakubu

Edited by

Prof. Charles Tortoe

Dr. Charlotte Oduro-Yeboah

Mr. Stephen Nketia

Mr. Kwabena Bugyei

Ms. Mariam Yakubu

Table of Content

Figures

Acronyms

AEAs	Agricultural Extension Agents
AGRA	Green Revolution in Africa
ARDEC	Aquaculture Research and Development Centre
AU	African Union
BMGF	Bill and Melinda Gates Foundation
CCST	CSIR College of Science and Technology
DAEs	Directorate of Agricultural Extension Services
DANIDA	Danish International Development Agency
EU	European Union
FAO	Food and Agriculture Organization
FDA	Food and Drugs Authority
GAEC	Ghana Atomic Energy Commission
GHPs	Good Hygienic Practice
GMPs	Good Manufacturing Practices
GSA	Ghana Standards Authority
HQCF	High Quality Cassava Flour
MAG	Modernizing Agriculture in Ghana
MoFA	Ministry of Food and Agriculture
MESTI	Ministry of Environment, Science Technology and Innovation
MoTI	Ministry of Trade and Industry
NAES	National Agricultural Extension System
NARS	National Agricultural Research System
RELC	Research Extension Farmer Linkage Committees
RSA	Research Staff Association
SANAS	South African National Accreditation System
SDF	Skills Development Fund
SMEs	Small and Medium Enterprises
WIAD	Women in Agricultural Development
WRI	Water Research Institute

Management Board Members

1.	Nana Osei Bonsu	Chief Executive Officer, PEF	Chairman
2.	Prof. (Mrs.) Mary Obodai	Director, FRI	Member
3.	Dr. Francis Boateng Agyenim	Director, IIR (Cognate)	Member
4.	Mr. Emmanuel O. Brakoh	Director of Finance (CSIR)	Member
5.	Mr. Obeng Koranteng Manu	Private Chartered Accountant	Member
6.	Dr. Michael Osae	Director, BNARI, GAEC	Member
7.	Mr. Gabriel Ayiquaye Hulede	Head of Quality PFC	Member
8.	Mrs. Victoria A. Asunka	Ag. Head of Admin.	Secretary

Internal Management Members

1.	Prof. (Mrs.) Mary Obodai	Director	Chairperson
2.	Prof. Charles Tortoe	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

The year 2020 ushered us into COVID - 19 pandemic, a challenging situation for Ghana. However, we have progressed successfully and are thankful to the Almighty God for achieving our core mandate of conducting applied market-oriented research into problems of food processing and preservation, food safety, storage, marketing, distribution and utilization, and national food and nutrition security in support of the food industry and also to advise government on its food policy. Our strategic goal during the year was to create value in our research, technology and development as well as innovations for and with our stakeholders for national development.

The human resource base comprising of senior members, senior and junior staff continued to support the Institute to achieve its mandate and goals with excellent core values of professionalism, quality delivery, team-work, competitiveness and innovation during the year. The cooperation of all staff resulted in the peaceful and conducive environment in the Institute, as we adhered to good cooperate governance, complied with all statutory requirements, followed best practices on its accounting and internal controls in management to achieve growth.

We appreciate the support by the Management Board led by Nana Osei Bonsu, Chief Executive Officer of Private Enterprise Federation. We are highly grateful to our partners and donors for their collaboration and support, especially European Commission (Horizon 2020), AGRA , Bill and Melinda Gates Foundation, Institut de Recherche pour le Développement (IRD), African Union (AU), Canadian Embassy, DANIDA, Sheffield University UK, Food and Agriculture Organization (FAO), Natural Resources Institute (NRI), Food and Drugs Authority (FDA), Ghana Standards Authority (GSA), Association of Ghanaian Industries (AGI), Chamber of Agribusiness-Ghana, Ministry of Food and Agriculture (MoFA) and Ministry of Environment, Science Technology and Innovation (MESTI).

On behalf of the Management Board and on my own behalf, I wish to thank all our stakeholders, for their support and goodwill and to Management and staff of the Institute for their dedication to work during the year 2020 and look forward to a fruitful year, 2021.

God bless us all.

Thank you.

Prof. Charles Tortoe

Acting Director, CSIR-Food Research Institute

Executive Summary

Food Research Institute was established as an Institution of CSIR to provide scientific and technological support for the growth of the food and agricultural sectors of the Ghanaian economy. From its inception, the Institute has blossomed into the leading establishment in food research and post-harvest management technologies which are geared towards assisting the food industry. Capacity building, skills development as well as nutrition studies and interventions are also key areas targeted at curbing food insecurity related issues in the country.

Within the year, CSIR-FRI developed and transferred nineteen (19) post-harvest technologies, out of which six (6) products were newly developed for clients. Twenty-one (21) food preservation technologies and four thousand, one hundred and twenty-one (4,121) analytical services were rendered to stakeholders.

Under its R&D program, various projects executed activities that translated research work into community development by training 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 cassava for quality cassava products in order to introduce variety to product lines. Cassava processors were trained on quality production of High Quality Cassava Flour (HQCF) and ethanol.

Under the auspices of the MAG project, CSIR-FRI trained trainers 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 from the Eastern and Volta regions of Ghana. Fish pathogens were isolated, enumerated and identified for further work.

The Institute generated a total amount of GHS 1,890,297.48 as IGF; it also received GHS 1,159,317.80 in research grants under various projects.

Within the year, the Institute had a staff strength of one hundred and forty-six (146) comprising thirty-four (34) Senior members, seventy-seven (77) Senior staff and thirty-five (35) Junior staff. The Institute churned out forty-four (44) publications comprising of twenty-four (24) Journals papers, eighteen (18) Technical reports, one (1) Flyer and one (1) Conference abstract.

Introduction

Established in 1963 by the Government of Ghana, the Food Research Institute became one of the affiliate Institutes of the Council for Scientific and Industrial Research (CSIR) in 1965. It was mandated to conduct applied market-oriented research into resolving challenges of food processing and preservation; food safety; food storage, marketing, distribution and utilization. It is also mandated to advice government on national food and nutritional security in support of the food Industry. CSIR-FRI's mission is firstly, 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 has the vision to be recognized 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 focuses on Research and Development, Commercialization as well as 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 spices 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

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. 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. It 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 key Institutes involved in the Modernizing of Agriculture in Ghana (MAG) project. The aim of this project is to address the constraints identified through a Regional Extension Linkage Committee (RELCs) system at regional and districts levels; using existing food processing technologies developed over the years. Technologies are transferred through training of trainers programs organized in collaboration with district offices of Agriculture for Agricultural Extension Agents (AEAs), District Agriculture Officers (DAO), WIAD officers, processors and farmers. Technologies transferred by CSIR-FRI are those with focus on value addition to agricultural produce in order to reduce postharvest losses and improve the income of beneficiaries. Trainings are entrepreneurial in nature, affording beneficiaries the opportunities to venture into businesses to yield profits.

Key Activities and Achievements

Training of Trainers workshop on handling postharvest losses of fruits

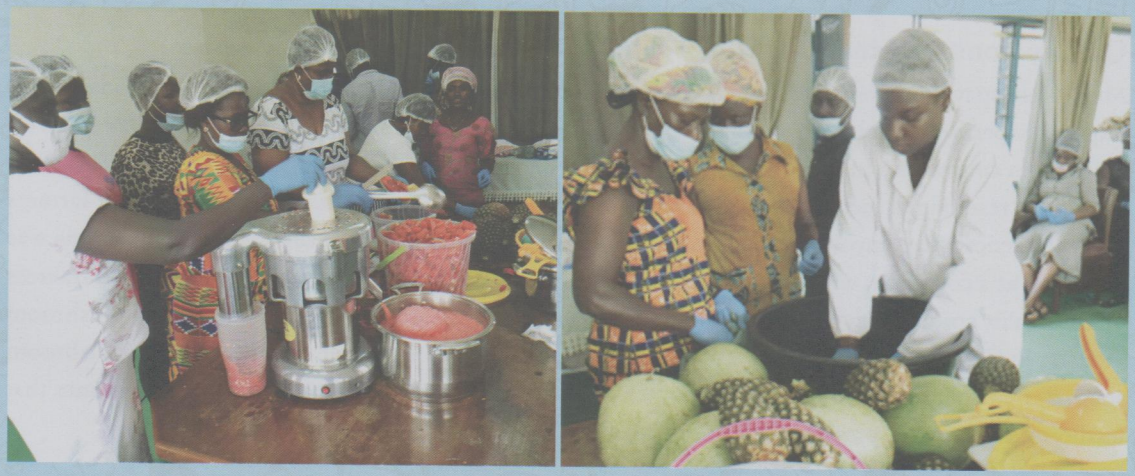
The project trained trainers in the Northern and Ashanti Regions on reducing postharvest losses of watermelons, pineapples, mangoes and oranges. A total of one hundred and thirty-two (132) beneficiaries were engaged, sixty-nine (69) males and sixty-three (63) females. Participants comprised of extension officers, DAO crops, DAO-WIAD, WIAD officers and processors.

Training included, key concepts of postharvest management of fruits and techniques involved in fruit juice processing. Topics included basics of food processing, importance of food preservation, processing of fruit juice, food safety and food packaging. Hands-on training and practical sessions were adapted to involve all participants of the workshop.

The overall objective of the workshop was to train field officers on how to properly handle post-harvest losses of the mentioned fruits. Beneficiaries were equipped to transfer acquired skills and knowledge to farmers and other processors.

Theoretical session in the Northern Region

Theoretical session in the Ashanti Region



Practical session on production of juice in the Ashanti Region

Example of product from training

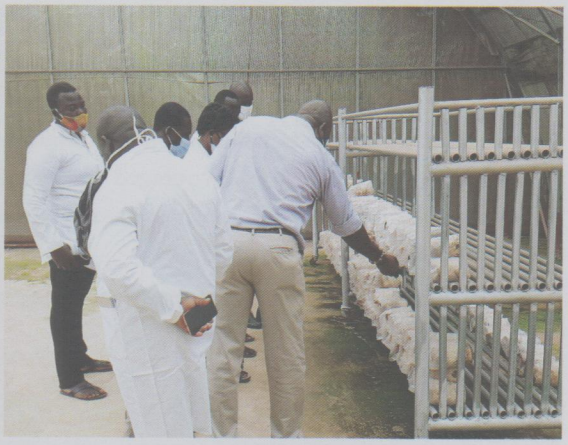
Participants of training in Tamale

Participants of training in Ashanti Region

Quality Control training on Mushrooms

Mushroom spawns are required to grow mushrooms. The process of spawn production is technical thus, requires expertise of trained personnel. CSIR-FRI over the years trained farmers and entrepreneurs on mushroom cultivation. In recent times, the numbers of trainees and mushroom farmers have increased drastically, resulting in increased demand for mushroom spawns. The Institute has trained some farmers on the practical steps involved in spawn multiplication. However, poor quality mushroom spawns was identified as a constraint within the Greater Accra Region. The MAG project trained twenty (20) trainees on the quality control activities required to ensure good quality spawns for sustainability of the mushroom industry in Ghana. The aim of the training was to outline the importance of quality control in mushroom spawns, find solutions to problems encountered in the handling of mushroom spawns and ensure that quality mushrooms are produced from good quality spawns.

Practical session



Trainees in mushroom growing house

Quality control and technical advisory on-farm training

The Eastern, Central and Western Regions of Ghana are known for humid weather conditions making them conducive environments for the cultivation of mushrooms. The quality control and technical advisory on-farm training exercise focused on identifying challenges faced by mushroom farmers in the regions and assisting to resolve those challenges. Objectives of this exercise was to provide consultancy services to the mushroom farmers, assist the mushroom farmers with any challenges they may be facing, provide expert advice on good agronomic practices to maximize yield and identify and locate the various mushroom farmers in the Eastern, Central and Western Regions of Ghana

The team visited thirty-nine (39) mushroom farmers in the target regions; 54% were in the Eastern Region, 28% in the Central Region and 18% in the Western Region as represented in Figure 1. Farmers comprised of 21 males and 18 females.

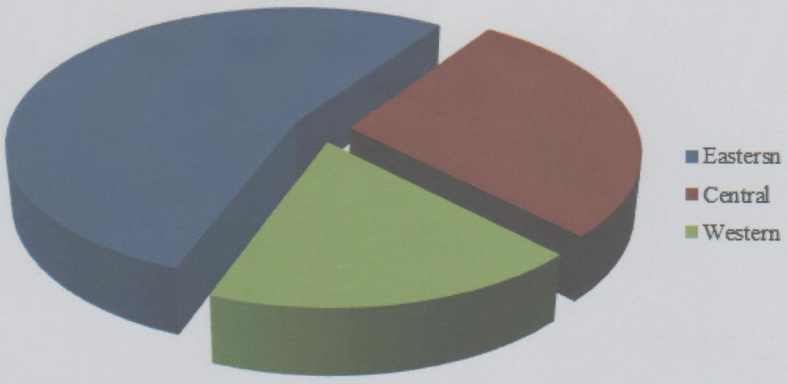


Figure 1: Representation of mushroom farmers engaged in target Regions

Challenges identified include the fact that, most farmers lacked the essential knowledge required to cultivate mushrooms. Those who had some form of training were trained by inexperienced farmers. The potency of spawns were compromised as a result of untrained personnel. It was therefore recommended that for effective and sustainable assistance to farmers, regular on-farm consultations should be made bi-annually. The team was also encouraged to organize annual refresher courses to help farmers better understand the processes of mushroom cultivation and spawn production and to also introduce new processes that will improve yields.

Compost bags to be sterilized and new space for incubation

Cropping house (Farm of Mr. Anim)

Cropping house and value addition to harvested mushrooms

Showing contamination by other fungi

Training beneficiaries on the use of composite flour

Forty-nine (49) beneficiaries in Greater Accra and Western Regions were trained on the use of composite flour for pastries, these involved more women than men as seen in Figure 2. Participants comprised of bakers, WIAD officers, Extension officers, processors and farmers. The primary objective was to foster and intensify the utilization of local root crops (sweet potato and cassava) and plantain flours in baking, in order to reduce quantities of wheat flour importation. The training focused on key concepts and principles in composite flour production, understand the processes involved in flour production and value addition of composite flour.

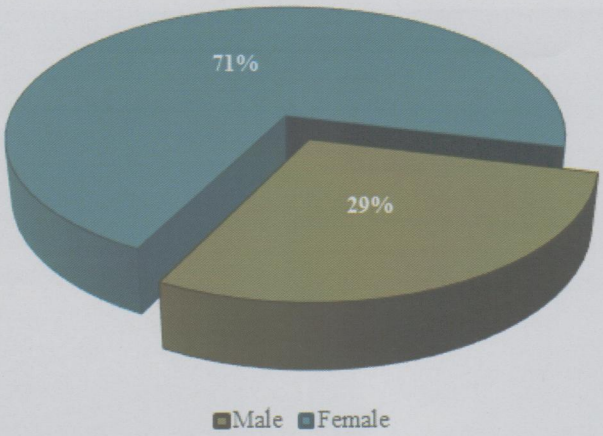


Figure 2: Percentage of men to women involved in composite flour trainings

Theory session on flour production by facilitators from CSIR-FRI

Practical sessions on value added products from composite flours


Products: Bread, Chips, Biscuits, Cassava cake and doughnuts from different formulation using HQCF, plantain/sweet potato flours

Through the MAG project, the Institute participated in the National Farmers' day celebrations in Techiman under the theme 'Ensuring Agribusiness Development under COVID-19: Opportunities and Challenges'. CSIR-FRI exhibited various research developed products including plantain fufu flour, *kokonte* flour, maize cereal mix, rice cereal mix, etc.


Marketing officer showcasing value added products at the 36th Farmers' day

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

In Ghana, the trading and drying of small fish is mostly by women. In the bumper season, fish is in abundance however, without sufficient incomes the women are unable to afford the small fish for processing and value addition. To ameliorate the situation, the project has provided improved raised drying platforms and racks, milling and sealing machines to small fish processors in Adina (Volta Region), Tema (Greater Accra) and Moree (Central Region) in order to reduce the cost of adding value to small fish.

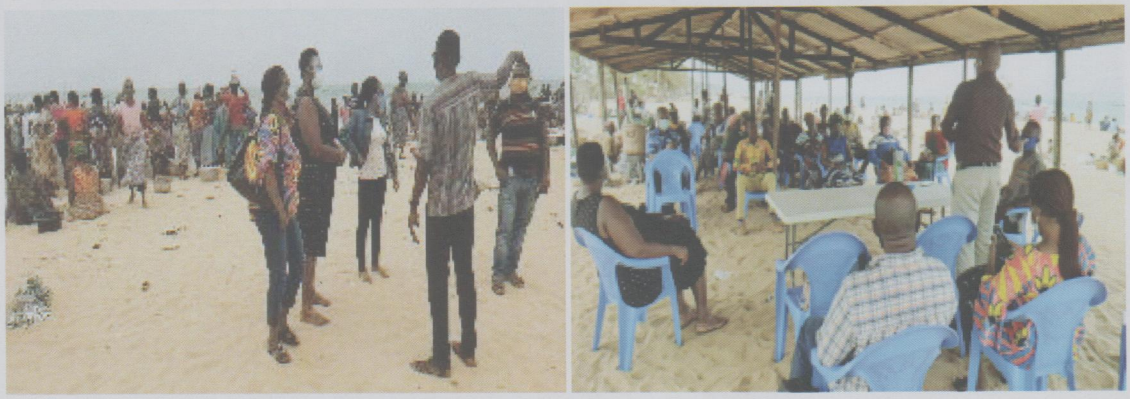
The traditional practice of sun drying of small fish involves drying them on bare ground, raising safety and quality concerns. Beneficiaries in the target communities were trained on good hygienic and manufacturing practices and on adding value to sun-dried fish by salting, milling and packaging as well as inclusion of the improved sun-dried fish or fish powder in existing foods and development of new food products. The objective of these activities was to enhance products' shelf life and its utilization as well as transfer of technology.

The process of drying and packaging small fish in whole or powdered form makes small fish available throughout the year. In its entirety, the project therefore offers to the target communities an alternative means of processing small fish by sun drying with improved, cost effective, user friendly technologies, and the development of value added products.

Key Activities and Achievements

Feasibility and Land Allocations

In the previous year, raised drying platforms were mounted for beneficiaries in Tema and Moree. Within the year, a feasibility study was conducted in Adina with the engagement of the fishing community. The team also visited several proposed locations within the township to select a suitable site for hammer mill and raised racks presented by the project.



Engaging community leaders and fish processors

Discussions with Chief fisherman of Adina

Selecting suitable location for construction of raised drying racks for small fish processors

Construction of drying platforms in Adina

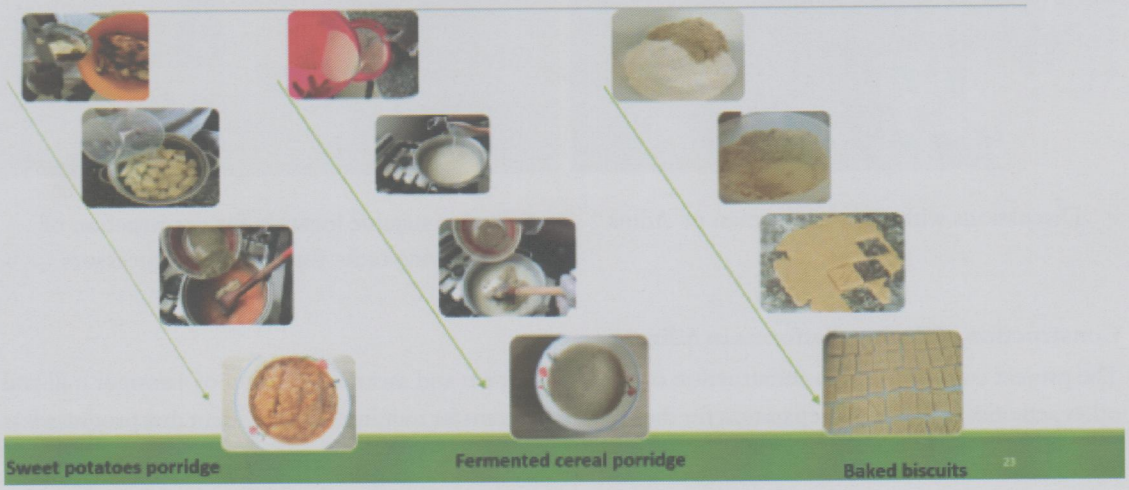
The project commenced the construction of drying platform and racks, installation of hammer mill and other activities at Adina in preparation for the technology transfer training. It was evident that progress was on-going and the community was highly expectant of the new technology.

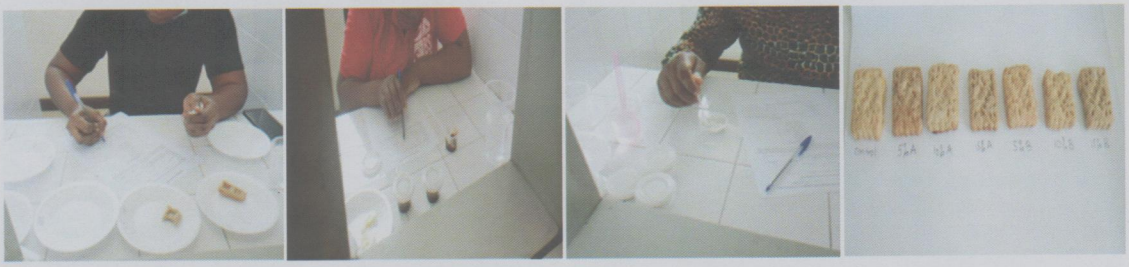
Construction of drying platforms

Optimization, sensory and consumer acceptability studies

Optimization, sensory and consumer acceptability studies was carried out on different products developed using sun dried anchovies and bumper fish powders. These included shito, waffles, biscuits, cereal mix, potato porridge and cereal porridge. Sensory evaluation was carried out on products.

Development of Products





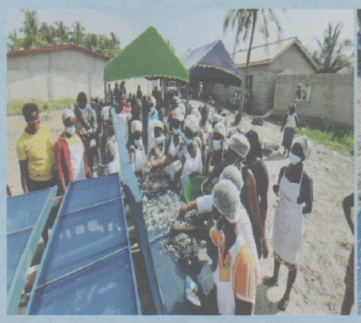
Sensory analysis on value added products (biscuits, waffles, shito and instant cereal mix)

Training at Adina

In order to improve the hygienic handling of fish, participants were made to wash the fish three times in different bowls of clean potable water (as opposed to their practice of washing only once with sea water) to which salt was added to a given concentration. Fish were spread on racks and flipped during drying to ensure thorough drying.


Participants observing COVID-19 protocols


Salting clean water and washing fish according to good hygienic practices

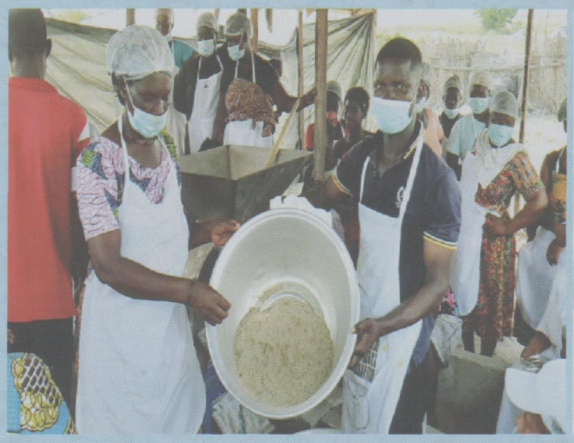


Spreading fish on racks for drying

Preparing fish for milling

De-headed fish was milled to obtain the fish powder used for product development. Small fish heads could be used as fish meal for their poultry.

Milling of prepared (de-headed) fish




Milled sun-dried small fish


Packaging de-headed sun-dried fish and fish powder

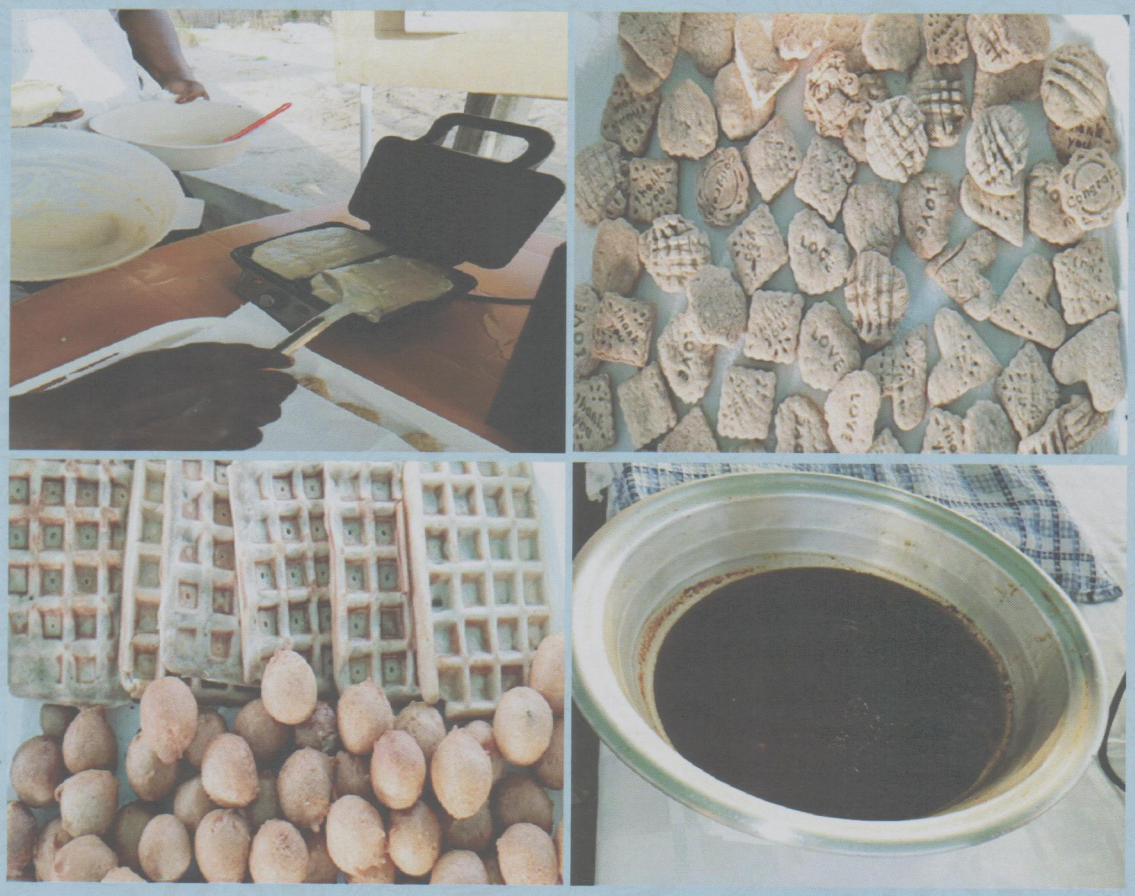


Simple hygienic packaging options

Product Development

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

Training on products developed from sun-dried fish



Products developed from sun-dried fish (Biscuits, Waffles, Shito)

Participants at training

Ghana Cassava Industrialization Partnership Project (GCIPP)

Komlaga, G., Dziedzoave, T. Nanam and Kongor, E. J.
Duration: 2years

Introduction

The demand for fresh cassava is projected to increase based on significant on-going private sector investment in the cassava value chain. Industrial cassava requirement is estimated at over $20 million worth of cassava being supplied annually benefiting over 50,000 smallholder farmers. Latent demand for industrial cassava processing is estimated to grow at 1.6 million MT per annum accounting for both domestic demand from Ghanaian industries and regional demand from other ECOWAS markets.

Smallholder farmers in Ghana are unable to access these huge markets to improve their livelihoods and incomes due to lack of structured markets through forward contracts agreements with off-takers, lack of adoption of good planting materials, which are required by markets, weak technical skills in good agronomic practices and postharvest technologies, low volume of supply of fresh cassava, and poor quality of produce.

The aim of the project is to catalyze and sustain an inclusive agricultural transformation in Ghana to increase incomes and improve household food security through consistent supply and processing of cassava for both industrial and food uses. Specific objectives of the project were;

- To enhance productivity of 110,000 smallholder farmers to cultivate 110,000ha of cassava farm, increase yield from 12tons/ha to 30tons/ha and produce at least 1.8million tons of fresh cassava (Technology Adoption).
- Increase and improve primary processing to reduce post-harvest losses by 50% and cost of supply.
- Increase capacity of smallholder farming households and agricultural system to be better prepared for and adapt to shocks and stresses.
- Facilitate affordable financing and non-financial incentives to smoothen value chain activities.

The implementing Partners include: Agri-Impact Consult, CSIR- Food Research Institute, CSIR- Crop Research Institute, Ohumpong Investment Limited, JOSMA Agro Industries Limited, Ghana Industrial Cassava Stakeholders Platform and Ministry of Trade and Industry. The role of CSIR- Food Research Institute is to build the technical capacities of cassava processing firms in standard processing techniques and their adaption and facilitate the establishment and monitoring of quality management systems of processing facilities.

Key Activities and Achievements

Within the year, the project trained two hundred and eighty-seven (287) beneficiaries on cassava processing technologies and production of quality products. The project focused on beneficiaries from both community and industry for a greater impact of technology transfer. Fifty-seven percent (57%) of beneficiaries trained were from industry while forty-three percent (43%) represented community (i.e. Aziedukope and Kintampo).

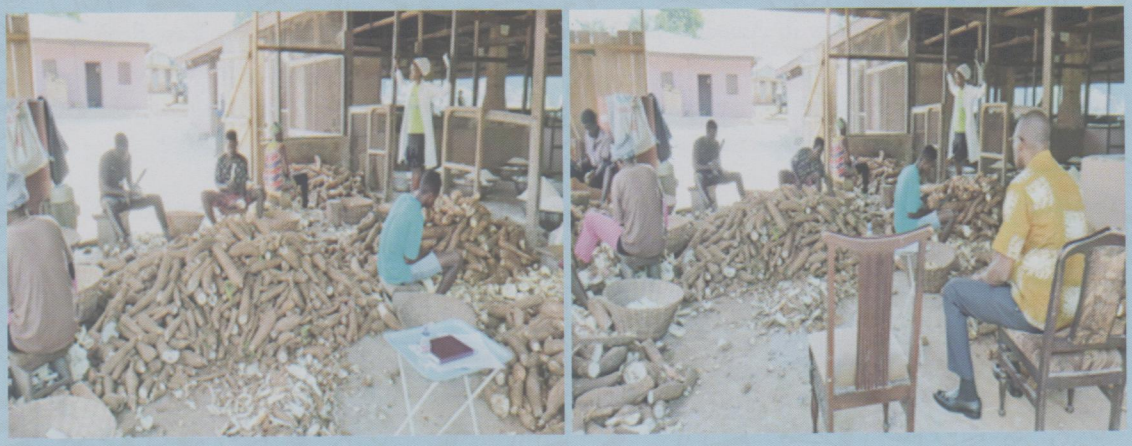
Forty-nine (49) beneficiaries in Aziedukope (Volta Region) and Kintampo (Bono East Region) were trained on High Quality Cassava Chips (HQCC). The number of male participants constituted 55% while 45% were female. Processors were empowered to supply on processing High Quality Cassava Chips (HQCC) to end users in their respective catchment areas.

Two companies, Josma Agro Industries Ltd. and Coastal Groves Company were trained on quality management systems and processing cassava products with standard quality, respectively. Thirty-seven (37) beneficiaries were trained, twenty-five (25) from Josma Processing factory and twelve (12) from Coastal Groves Company; 43% were male and 57% female. Participants included managers, supervisors and processors as represented in Figure 3. Trainings aimed at the three key pillars of quality management systems; Good Manufacturing Practices (GMP), Hazard Analysis Critical Control Points (HACCP) and Quality Assurance (QA). Emphasis were laid on the quality production of Gari, Kokonte and High Quality Cassava Flour (HQCF) for Josma Processing factory, and quality production of High Quality Cassava Flour (HQCF) and High Quality Cassava Chips (HQCC) for the Coastal Grove Company. Samples of products were taken for analysis; parameters analyzed included moisture, pH, particle size and colour.

Figure 3: Category of trainees involved in cassava quality processing training

A workshop was organized by MoTI in partnership with CSIR-FRI and other consortium members on the project in January 2020. The workshop was to train cassava processors on production of quality cassava products. Dr. Gregory Komlaga from CSIR-FRI was one of the key resource persons for the training workshop. Processors were trained on all aspects of cassava processing to ensure quality and safe products. A total of seventy-nine (79) participants from forty-five (45) processing facilities in Ghana were present at the training workshop.

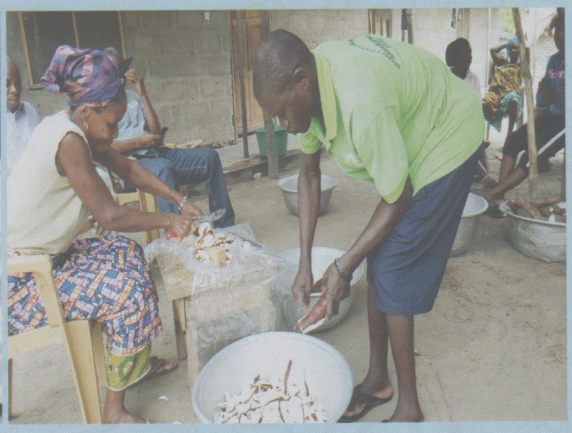
A two-day training workshop was organised by MoTI in partnership with CSIR-FRI and other consortium members on the project in December 2020 at CSIR-FRI. The workshop was to train cassava processors on quality processing of HQCF and ethanol. CSIR-FRI (Dr. Gregory Komlaga) was one of the key resource persons for the training workshops. Processors were trained on all aspects of HQCF and ethanol processing to ensure quality and safe products. A total of one hundred and twenty-two (122) participants were present at the training workshop.



Section of participants at Josma Agro Industries processing factory peeling cassava during the training

Dr. Komlaga explaining High Quality Cassava Chips processing steps to the participants at Kintampo

Trainees spreading the freshly sliced cassava for drying at Kintampo



Participants at Aziedukope practicing manual slicing of cassava into chips for drying

Development Of Bacteriophage Cocktails As Disease Biocontrol Agents For Improved Aquaculture Productivity, Food And Nutrition Safety In Ghana And Uganda

Agbemafle, E., Mensah, N.L.D., Blessie, J.E., Akonor, P., Annan, T., Gally, C., Etornyo, A., Tetteh-Doku, E., Anani, A.F., Kretsi, E, Damanka, S., Okyere, I., Mireku, M. 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 reasons 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

Public engagement or sensitization workshops (in-country)

The Safefish project's sensitization/buy-in awareness creation workshop at the national level was held with the theme: Safe fish: Improving culture tilapia health to optimize yield. Eighty (80) participants including stakeholders and target beneficiaries were present from sectors involved in cultured tilapia value chain in Ghana, comprising the Ministry of Fisheries and Aquaculture, tilapia fish farmers, extension officers, policy makers, students and research scientists.

The workshop was broadcasted on major local and national television stations as well as major print and electronic media in the country. There were online publications of this workshop (i.e. http://bridgenewsgh.com/2020/01/csir-food-research-institute-ghana-safefish-forum/, http://www.ghanaweb.com/GhanaHomePage/NewsArchive/CSIR-Food-Research-Institute-rolls-out-Safefish-project-to-save-aquaculture-sector-851527?channel=D2).

Participants at In-country awareness creation workshop

Community engagement

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 (16 farms in Eastern Region and 6 farms in the Volta Region). Data obtained from this activity is currently being analyzed.

Research team taken through ODK collection application

Sample and data collection at a cage farm by research team in the Eastern Region of Ghana

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 thirty-two (32) from Eastern, thirteen (13) from Volta, forty-three (43) from Ashanti, five (5) from Northern, four (4) from Upper East and seven (7) from the Upper West Region. Sample collection from the selected fish farms were done randomly with respect to each zonal district per study Region. Almost, all zonal districts in the six study regions in Ghana have some fish farming activities. A total of one hundred and four (104) fish farms (i.e. 20% of 520 active farms) were proposed for this research study.

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 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. Depending on the distance from the CSIR-WRI Aquaculture Research and Development Centre's laboratory, the fish samples were either delivered in the evening for processing or done on-site in a made-shift mobile lab under strict aseptic techniques and conditions.

Tilapia fish caught by farmers for laboratory analysis

Taking of cage dimensions by research team in the Volta Region

Sampled tilapia measurement and dissection for target parts for lab analysis

Sediment collection with Ekman Grab

Sample collection at a hatchery

Country stakeholders' meetings/ Focus Group discussions

Ghana stakeholders' meeting was jointly held for tilapia farmers in Eastern and Volta Regions. This program was held after project team had collected samples and administered questionnaires to fish farm owners/ workers in these two regions. It was a one-day workshop organized on the theme: Sensitization of tilapia fish farmers in the Eastern and Volta Regions of Ghana. Thirty-five (35) participants from across the fisheries sector in the Regions participated. Stakeholders were mainly from the Aquaculture Research and Development Centre (ARDEC), Fisheries Commission Volta Region (Director), Fisheries Commission Asuogyaman (Zonal Director), Fisheries Commission (Koforidua), Agric-businesses, Non-Governmental Organizations (NGOs), media and representatives of fish farmers from Volta and Eastern Regions of Ghana.

Major challenges facing the fish farmers were identified as poor quality fish, poor quality fish feed, poor storage of fish feed, leaching of chemicals from grass into lakes when there is overflow therefore contaminating the water which causes diseases in fish, lack of filtration systems at water canals before the water enters main water bodies by pond system farmers, conditioning of fingerlings before transportation to reduce mortality, among others.

Presentations during workshop (including current status of aquaculture in Ghana- focus on farmed tilapia diseases)

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

Introduction

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

During the year, the project undertook four major activities;

i. To identify and map out of the prevalence and potential health concern of micronutrient deficiencies (MNDS) in Ghana through literature review.

ii. To identify and assess existing and potential strategies available for reducing MNDS considering target groups, coverage, efficacy, effectiveness, potential adverse effects, costs, constraints to implement, potential integration with other interventions, sustainability and monitoring.

iii. Key informants' cross-sectional survey involving at least one person from identified major stakeholders.

iv. Identified key nutritional interventions with a greater focus on promoting national food sovereignty.

An extensive review of literature on computer based bibliographic databases (PubMed, Google Scholar, Scopus, Medline and Sciencedirect.com) covering pre-identified key search terms related malnutrition and its determinants, health and pragmatic preventive strategies was performed to retrieve published abstracts and full texts for nutrition surveillance data on MNDs in Ghana between 2000 and 2019. This was an initial coping exercise to define the limits of the study and provide a background to rationale of the study.

A systematic review of fortification and supplementation interventions in Ghana was conducted using the PICO model. The aim of systematic review was to assess the results of fortification and supplementation interventions published in the past 5 years in order to gather best practices, sustainable strategies in the field of nutrition intervention in Ghana. Interventions was drawn from four areas of nutrition (agriculture,

food and nutrient, disease control, behaviour change control) using the priori inclusion criteria outlined below:

- Studies published between 2014 and 2019 pertaining to effectiveness or efficacy of nutrition-related interventions, (including both trials and observational studies).
- Overviews of systematic reviews if they are found to be relevant.
- Grey data on interventions considered eligible for inclusion.
- Inclusion was not restricted to any particular reported outcome.

The 2FAS-INSIDER project evaluated how different strategies to combat MND can be combined (alongside diversification of diets) to achieve maximal impact in Ghana, without increasing risks for overconsumption.

The purpose of the key informants' survey was to collate and outline case studies on successes and failures of former and/or existing programmes. The key informants' survey was largely on key institutional and individual informants at the national level. These included representatives of relevant Ministries, Departments and Agencies (MDAs), as well as donors and NGOs. This assessment was to help provide insights on the key factors for success and/ or missed opportunities on former and/or existing programmes. Data was analyzed to identify how different strategies needed to combat MND can be combined (alongside diversification of diets) to achieve maximal impact in Ghana, without increasing risks for overconsumption.

The following MND interventions identified were:

- Through the Ghana Government's programmes "One District One Factory Initiative", "Planting for Food and Jobs" and "Aquaculture for Foods and Jobs, there is a need to increase local agricultural sector's capacity to grow indigenous healthy foods using climate-smart technologies that ensure food in the future. Prioritizing nutritious local food varieties will drastically decrease demand for imported fortified foods.

- Promote the utilization and consumption of indigenous recipes as food vehicles for diet diversification and in tackling micronutrient deficiencies. Local agriculture products should be at the centre of health promotion in lieu.

- Incentivize local food SMEs that utilize locally available foods in the development of food products through tax cuts, creating links with farmer groups for raw material and free skills/technology transfers.

- Revise mandatory fortification legislature to reflect current standards and dietary patterns and enforce sanctions to prevent abuse by processors, distributors and end users.

- Consolidate a national product testing protocols for the thorough testing of impact of fortified foods to ensure health claims are substantiated before accreditation so as to curtail the influx of fake products.

- Increase collaborations with the media (both visual and audio) in the planning and dissemination of nutrition education, dietary behavioural change campaigns and health promotion activities.
- There is a need to synchronize national nutrition-sensitive activities (education, disease control) with nutrition-specific strategies (supplementation and fortification) at all levels of implementation especially at district and community levels.
- Increase the capacity of the Ghana Statistical Services and other local actors to create a national database of nutrition surveillance data. This will help in the development of local meal guides and guidelines on food intake, portion size and recommended allowances to allow citizenry to make healthier choices. On the backdrop of COVID -19, there is a need to develop local dietary guidelines and reference database for the various regions of Ghana, that the general population can easily access to help them make healthier food choices as well as practice home food to food fortification.

Consultancies

Skills Building On Processing Of Quality Cassava Products

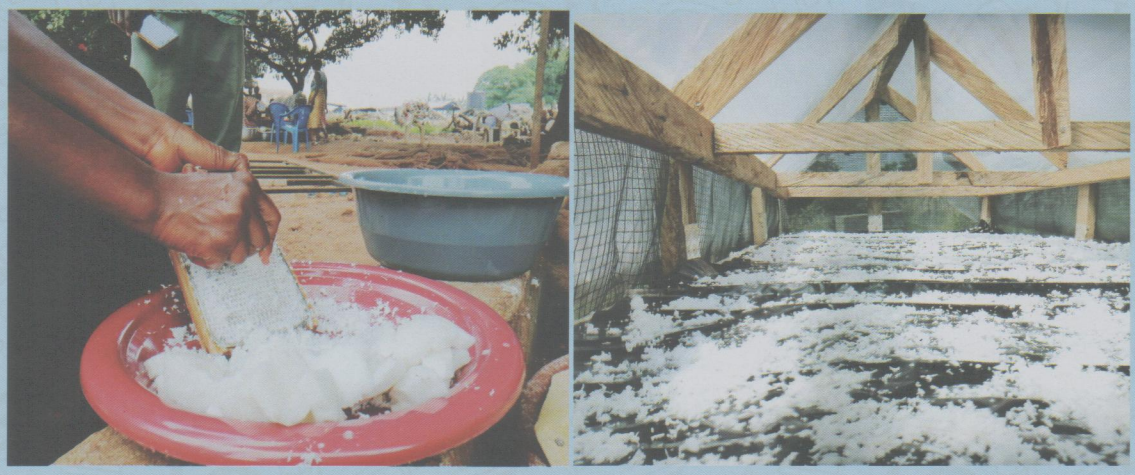
Tortoe, C., Nketia, S. and Yakubu, M.

Introduction

Cassava (*Manihot esculenta*) is one of the largely cultivated roots and tuber crops grown in Ghana. It is widely consumed as a major source of carbohydrate in various forms. In 2017, Ghana had produced 19,137.94, 000MT of cassava (Agricultural Sector Progress Report, 2017).Cassava harvested from demonstration farm for processing cassava products in training sessions

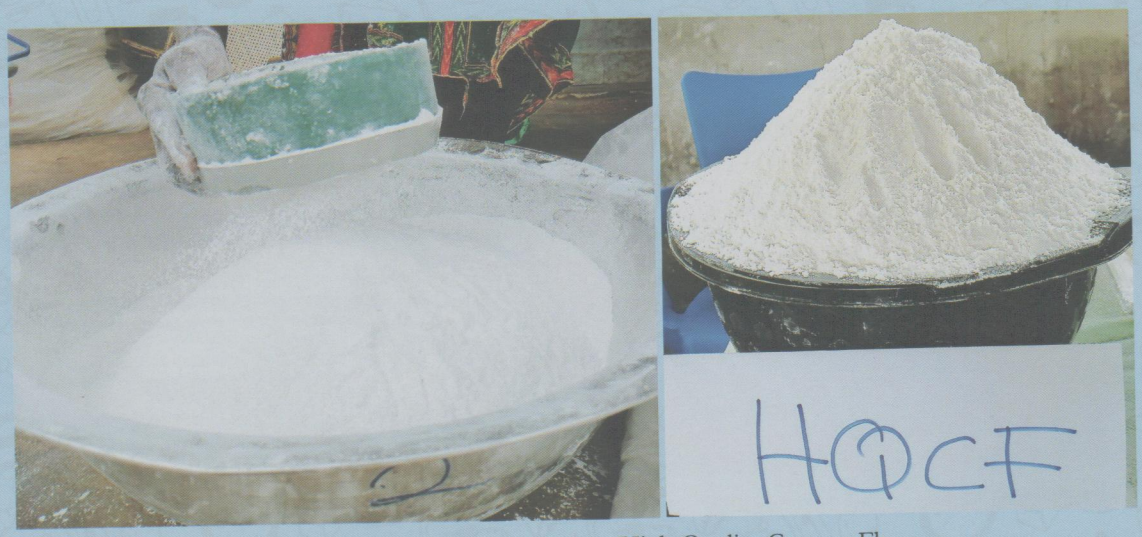
The use of cassava is varied. Industrially, it is used in the form of starch, dried chips, flour and syrup. For consumption, cassava is processed into convenient and shelf stable products such as gari. The market value of gari depends on its particle size, colour and taste. Under the sponsorship of Skills Development Fund (SDF) the CSIR-FRI trained members of the Asuogya processing Cooperative Agro-processing in Asueyi community, Techiman, on processing quality gari and diversifying products. The aim of the training included processing of quality gari, provide product diversification (HQCF, *gari* with soyabean flour, *gari* with coconut grits) and to position the group to increase profits.

Cassava harvested from demonstration farm for processing cassava products in training sessions

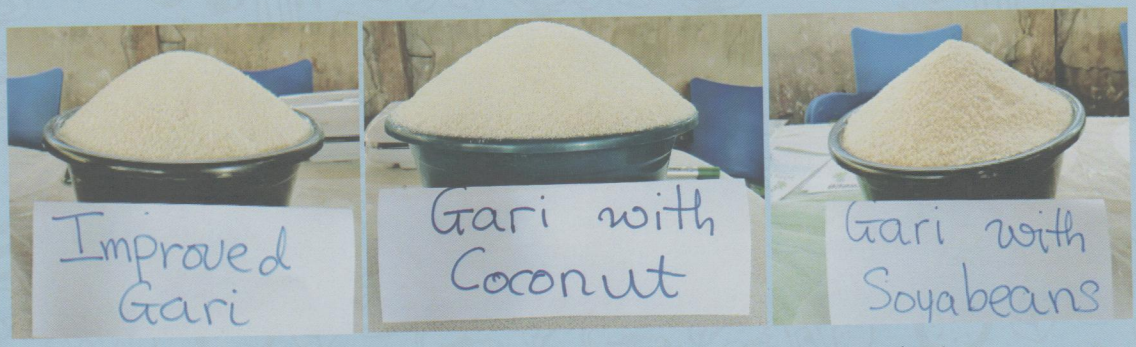


Grating and solar drying of coconut

Sifting and roasting of *gari*



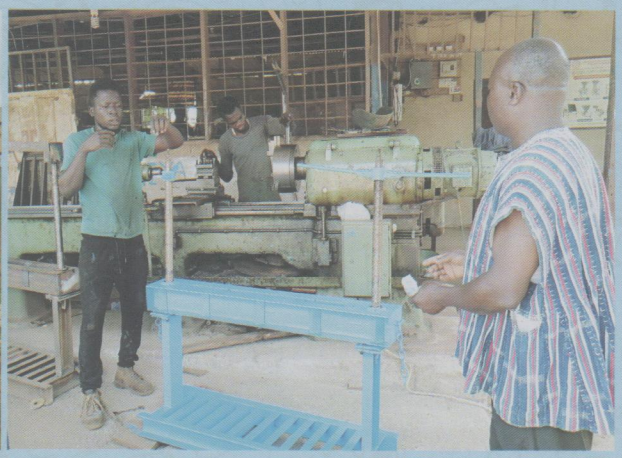
Beneficiaries trained on processing High Quality Cassava Flour



Beneficiaries were trained to produce improved *gari, gari* with coconut /soybeans

Packaging of value added products

A solar tent for drying was introduced and constructed for the group



Screw presses were fabricated for the group

Abstracts from Published Papers

Lactobacillus garii sp. nov., isolated from a fermented cassava product.

Diaz, M., Sayavedra, L, Atter, A., Mayer, J. M., Saha, S., Amoa-Awua, W. and Narbad, A.

A novel Gram-positive, catalase negative, rod-shaped strain, FI11369T, was isolated from gari, a traditional West African fermented food derived from cassava. Based on 16S rRNA gene sequence similarity, the closest type strains were Lactobacillus xiangfangensis LMG 26013T (99.4 % similarity), Lactobacillus plajomi NBRC 107333T (99.1 %), Lactobacillus paraplantarum DSM 10667T (99.1 %), Lactobacillus pentosus DSM 20314T (99.0 %), Lactobacillus plantarum subsp. plantarum ATCC 14917T (99.0 %), Lactobacillus odestisalitolerans NBRC 107235T (98.9 %), Lactobacillus plantarum subsp. argentoratensis DSM 16365T (98.9 %) and Lactobacillus daowaiensis NCIMB 15183T (98.8 %). The genome of strain FI11369T was sequenced and the average nucleotide identity (ANI) was compared with its closest relatives. ANI analysis showed that the closest relative, L. xiangfangensis DSM 27103T, had only a 82.4 % similarity. The main fatty acids of FI11369T were saturated C16 : 0 (18.2 %), unsaturated C18 : 1 ω9c (43.8 %) and cyclopropane C19 : 0 cyclo (ω10c and/or ω6; 22.5 %). Based on the genotypic and phenotypic data obtained in this study, a novel Lactobacillus species, Lactobacillus garii sp. nov., with the type strain FI11369T (=NCIMB 15148=DSM 108249), is proposed.

Fish for Food and Nutrition Security in Ghana: Challenges and Opportunities.

Hasselberg, A.E., Aakre, I., Scholtens, J., Overå, R., Kolding, J., Bank, M., Atter, A. and Kjellevold, M.

Fish is an important dietary source of micronutrients, particularly in low-and middle-income countries. In Ghana, effective management of fish and the fisheries is essential for food, economic and nutrition security and is critical towards achieving many of the UN Sustainable Development Goals especially those pertaining to hunger, poverty, gender equality and life under water. Ghana has experienced significant economic growth in the last few decades, but increasing inequality, uncertainties in fish availability and unsustainable management of the fisheries are challenging local food and nutrition security. This literature review examines and evaluates the role of fish and fisheries in supporting FNS in Ghana, and highlights the lack of focus on fish in the literature with regard to regional food security and fisheries governance. Our review highlights the importance of ensuring the viability of small fish populations to enhance micronutrient availability and counteract micronutrient deficiencies in Ghana. Additionally, strengthening women's role in decision making and promoting female education and empowerment in the fisheries sector is an important strategy towards enhancing FNS in the region.

Behavior of Malondialdehyde and Its Whey Protein Adducts during In Vitro Simulated Gastrointestinal Digestion

Vandemoortele, A., Babat, P., Yakubu, M. and De Meulenaer B.

The behavior of malondialdehyde and its whey protein adducts in aqueous buffer and fully hydrogenated coconut oil-in-water emulsions stabilized by Tween 20 or by whey protein was studied during *in vitro* gastrointestinal digestion. The malondialdehyde levels during in vitro digestion depended upon the kind of sample, the location of the whey protein, and the extent of adduct formation before digestion. During gastric digestion, degradation of acid-labile malondialdehyde-whey protein adducts as well as formation of new malondialdehyde adducts with hydrolyzed whey protein was suggested to occur, in addition to the earlier described equilibria with respect to the aldol self-condensation of malondialdehyde and its hydrolytic cleavage. After *in vitro* digestion, both malondialdehyde and its adducts were present in the digest with malondialdehyde recoveries varying between 55 and 86% depending upon the model system studied. To conclude, the reactivity of malondialdehyde toward (hydrolyzed) proteins does not stop at the point of ingestion.

Potential health risk assessment of toxic metals contamination in clay eaten as pica (geophagia) among pregnant women of Ho in the Volta Region of Ghana.

Kortei, N. K. Koryo-Dabrah, A., Akonor, P. T., Manaphraim, N. Y. B., Ayim-Akonor, M., Boadi, N. O., Essuman, E. K. and Tettey, C.

Geophagia although pleasurable and somewhat a necessity among pregnant women, also comes along with its own attendant problems such as exposure to potentially hazardous substances like bacteria, fungi, helminthes and ova, radioactive materials, and toxic elemental minerals in the soil depending on the geographical location. This study evaluated the potential health risk involved during the exposure of pregnant women to toxic elemental minerals via the consumption of clay as pica (geophagia). Elemental mineral analysis was carried out using Buck Scientific 210VGP Flame Atomic Absorption Spectrophotometer (Buck Scientific, Inc. East Norwalk, USA). Risk assessment methods were also used to ascertain the various risks factors and the overall risk level. Concentrations of the macro elements investigated were 1.38 ± 1.5, 2.40 ± 1.5, 7.74 ± 1.5, 4.01 ± 1.0, 13.24 ± 2.2 and 13.76 ± 2.1mg/Kg for iron (Fe), copper (Cu), zinc (Zn), potassium (K), magnesium (Mg) and sodium (Na) respectively. While that for the micro elements were 1.63 ± 0.03 µg/Kg, 4.72 ± 0.8, 0.53 ± 0.02 and 1.85 ± 0.3 mg/kg respectively for arsenic (As), manganese (Mn), lead (Pb) and nickel (Ni). Estimated Daily Intake (EDI), Hazard Quotient (HQ), Target Hazard Quotient (THQ) and Total Target Hazard Quotient (TTHQ) values ranged 0.611–5.44 (mg/kg Bw/day), $6.26 \times 10-4 - 106.5$, 0.067–10.34 and 15 respectively. There is the likelihood of posing adverse health problems when clay samples obtained from Anfoega which is sited in the Volta region of Ghana is consumed due to the fact that the HQ's of these elemental minerals were >1 which points to high content of Manganese (Mn) and Nickel (Ni). It is also likely to cause adverse health problems in an individual's life time since THQ for Arsenic, Lead and Nickel were above 1. Ultimately, the

cumulative effect of these toxicants were exceedingly great (≤ 15) which implied a high level of unsafety associated with this clay. Per the results from this study, it is not safe for pregnant women to consume clay as pica since these toxic elements may cause detrimental effects on the foetus of the unborn child.

Food safety knowledge and practices among fresh coconut vendors.

Oduro-Yeboah, C., Ackah, B. N., Akonor, T.P., Amponsah, K. S. and Mboom, P. F.

The study examines the distribution and sale practices of coconut vendors, identifies and analyzes food safety bottlenecks associated with street vending of fresh coconuts in Accra, Ghana. A cluster random sampling technique was used in which the study area was classified into three zones. One hundred fresh coconut vendors responded to a structured questionnaire. The results showed that vendors were predominantly male, most of who were educated up to secondary school level. Many (70.8%) of them learnt the trade through apprenticeship. The vendors were either stationed at a particular location (46.1%), or moved around as itinerant traders (53.8%), with their product displayed on pushcarts or head pans. The respondents revealed that more than 30% of consumers patronize fresh coconut because of its water. Food safety challenges identified in the coconut business include potential cross contamination of packaging materials by fresh coconuts, dipping pared coconut into alum solution to preserve freshness, and improper waste handling during and after sales. Education had a positive influence on food safety knowledge among the fresh coconut vendors ($\chi 2 = 12.8, p < 0.05$). Generally, vendors' knowledge in food safety was encouraging but there ought to be an improvement in these areas of their operations to safeguard the health of consumers.

Development of a HPTLC Method to Profile the Phytochemicals in Allanblackia Parviflora (Tallow Tree) Kernel and Seed Cakes.

Sefah,W., Sefah, L. and Ofori, H.

HPTLC is a useful and practical analytical tool to characterize plant compositions. This study was focused on exploring the results of high-performance thin-layer chromatography (HPTLC) analysis, particularly as a useful tool for the authentication of Allanblackia parviflora seed and kernel cakes. Bulked samples from sixteen different Ghanaian communities were analysed by HPTLC and their fingerprints were compared. The optimum experimental conditions were established: sample weight of 2.0 g, methanol:water (80:20 v/v) as extraction solvent, 30 min extraction time and twice extraction, ethyl acetate:methanol:water (100:16.5:13.5 v/v) as mobile phase, vanillic acid as derivatisation agent and 7 min of plate heating time after derivatisation. The HPTLC profile generated from extracts across 16 communities and 157 trees was very reproducible and demonstrates the robustness of the technique in characterising the profile.

Effect of the use of starches of three new Ghanaian cassava varieties as a thickener on the physicochemical, rheological and sensory properties of yoghurt

Agyeman, P.N., Akonor, P.T., Tortoe, C., Johnson, P-N.T and Manu-Aduening, J.

Yoghurt is a popular probiotic food rich in micronutrients but suffers from a thickness loss referred to as syneresis, which is caused by liquid expulsion from the gel during storage. To reduce this adverse sensory

effect, the starches of three new cassava varieties, *Abrabopa, AGRA* and *Bankye hemaa,* were used as thickening agents in the production of yoghurt and its physicochemical, functional and sensory properties evaluated. The starches were extracted by wet gravimetric method and initially characterised by assessing their pH, colour, water binding capacity, swelling power, Solubility index and pasting characteristics. Each of these three starch samples were incorporated at a rate of 2.5, 5.0 and 7.5%, to prepare yoghurt, from fully-skimmed, partially-skimmed and whole milk. The pH, viscosity, syneresis, textural and sensory properties of the yoghurt samples stored at 6 ±1 °C were monitored over 14 days. Whilst there were significant differences ($p < 0.05$) in the swelling power and indices, the water binding capacity of the starch samples were comparable. Their cooked paste viscosity were 512.5 BU (*Bankye hemaa*), 550 BU (*Abrabopa*) and 620 BU (*AGRA*) . When used in preparing the yoghurt, the whole milk yoghurt, with *Abrabopa* starch at 5.0% inclusion, gave the highest consistency (28.7 N.s) and cohesiveness (-2.1 N), whilst fully-skimmed milk yoghurt with *AGRA* starch, at 7.5%, gave the lowest consistency (7.5 N.s) and cohesiveness (-0.4 N). These results correlated well with those of the sensory scores, which gave the best taste, mouthfeel and sourness scores to yoghurt made from whole milk in which *Abrabopa* cassava starch at 7.5% had been incorporated and stored for 14 days. The starch of *Abrabopa* cassava variety therefore adequately prevented syneresis in yoghurt.

Optimization of a fruit juice cocktail containing soursop, pineapple, orange and mango using mixture design

Akonor, P. A., Tortoe, C. and Barwuah, J. P.

Plantain biomass value chain analysis was conducted to generate benchmark information that supports reduction of post-harvest 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.

Health risk assessment and levels of toxic metals in fishes (Oreochromis Noliticus and Clarias anguillaris) from Ankobrah and Pra basins: impact of illegal mining activities on food safety

Kortei, N. K., Heymann, M. E., Essuman, E. K., Kpodo, F. M., Akonor, P. T., Lokpo, S. Y., Boadi, N. O., Ayim-Akonor, M. and Tettey, C.

Arsenic (As), mercury (Hg), Cadmium (Cd) and lead (Pb) are toxic heavy metals that naturally occur in the ecosystem. Their levels are on the rise due to anthropogenic activities posing threat to aquatic wildlife and humans. In Ghana, pollution of some water bodies has led to unsafe consumption of riverine fishes as well as a shortage of treated potable water principally because the cost of treating polluted water has become expensive across the country. This study aimed to assess the As, Hg, Pb and Cd concentrations in water and fishes from rivers Pra and Ankobrah where activities of artisanal gold mining were carried out resulting in gross pollution of the water bodies. An experimental study was performed to ascertain the levels of As, Hg, Pb and Cd in fish species of Nile tilapia (Oreochromis noliticus) and mudfish (Clarias anguillaris) and aquatic media (water) from the Pra and River Ankobrah basins using the Atomic Absorption Spectrophotometer (AAS) (Varian AA240FS). Both river water samples recorded ranges of 0- 0.0040, 0.0060- 0.0387, 0 - 0.0020, 0.006-0.0093 mg/l for Cadmium, Lead, Arsenic and Mercury respectively. For Cadmium and Arsenic, their levels were comparable ($p > 0.05$). However, detected values for Lead and Mercury were not comparable ($p < 0.05$). Toxic metals concentrations in the rivers decreased in the order of Hg > Pb > Cd > As. For the fish samples, values ranged 0-0.08, 0.04-0.42, 0-0.04, and 0.40- 0.60 mg/kg for Cadmium, Lead, Arsenic and Mercury respectively. Generally, appreciably high values were obtained for Mercury. Toxic metals concentrations in the rivers decreased in the order of Hg > Pb > Cd > As. Human health risk assessment from heavy metal exposure through fish consumption from the Rivers for both children and adults showed no significant non-carcinogenic adverse health risk to humans since all calculated values for Hazard Quotient (HQ) were<1. Nonetheless, Target Hazard Quotient (THQ) values calculated for children and adult exposure to Cadmium and Mercury were>1 which implied a likely cause of adverse effects during a person's lifetime.

Effect of processing and storage on physical and texture qualities of oyster mushrooms canned in different media.

Nketia, S., Buckman, E.S., Dzomeku, M., and Akonor. P.T.

This study evaluated the influence of packing medium on some physicochemical, textural, and microbial properties of canned oyster mushrooms during storage. Mushrooms canned in brine or oil was stored at room temperature for six months. During this period pH, leached solids, drained weight, instrumental color, and texture were evaluated by standard methods. The results showed a 21% and 64% reduction in mushroom hardness after blanching and canning respectively. The pH of canning media ranged from 6.4 to 6.5 for brine and 5.6 to 5.8 for oil, during storage. Drained weight was higher in oil (124 – 127 g) compared to brine (104 – 120 g) whereas the extent of leaching was higher for mushrooms canned in brine. Mushrooms in brine were firmer (8.8 N) and chewier (3.6 N), compared to those canned in oil (7.6 N and 4.1 N). A significant reduction in firmness was recorded after the sixth month in both media. Color,

chewiness, and springiness of the canned mushrooms were stable during the six-month storage period. The study showed that whereas brine provided good stability in pH and color, oil was a better medium for reducing leaching and maintaining the drained weight of canned mushrooms during storage.

Unearthing the potential of Frafra potatoes (Solenostemon rotundifolius) flour in culinary application: Sensory and nutritional analysis of its pastry products.

Tortoe, C., Akonor, P.T., Kusi, F., Asungre, P.A., Owusu R.K. and Boateng C.

Frafra potato is an underutilized crop with enormous potential as a food security crop. Sensory attributes of bread and koose (a traditional Ghanaian pastry) produced from 10 varieties of Frafra potato flour as composite flour and nutritional values were analyzed. Bread and koose produced from partial substitution of Frafra potato flour were comparable to wholly wheat flour, especially 20% substitution with variety UW022 for bread and 30% substitution with variety UE021 for koose. Using a 9-point Hedonic scale, overall acceptability level was 7.8 for variety UW022 for bread compared to 7.9 for wheat flour, similar to koose. Variety UW022 bread was carbohydrate dense (72.58 g/100 g) whereas variety UE023 bread was richer in ash, fat, protein, crude fiber and energy. Variety UE023 koose at 20% was highest in protein content (20.75 g/100 g) but lower carbohydrates (47.3 g/100 g).

Sensory evaluation, descriptive textural analysis, and consumer acceptance profile of steamed gamma-irradiated Pleurotus ostreatus (Ex. Fr.) Kummer kept in two different storage packs.

Kortei, K.N., Odamtten, T.G., Obodai, M., Akonor, T.P, Wiafe-Kwagyan, M., Buckman, S. and Mills, O.N.W.S.

The influence of gamma irradiation on the sensory, acceptability and some descriptive textural attributes of dried P.ostreatus were evaluated. Sensory evaluation was carried out using steamed mushroom samples irradiated at doses 0 (control), 1, 2, 3, 4 and 5 kGy at a dose rate of 1.7 kGy/h from a Cobalt 60 source (SLL 515, Hungary) batch irradiator and stored in either polythene or polypropylene packs for 12 months at 28–30 °C. Using a structured questionnaire, 44 male and female panelists independently assessed the samples for sensory attributes. Organoleptic scores were made according to a nine (9) point hedonic scale. The evaluation showed mean scores of general likeness. There were no significant differences ($p > 0.05$) recorded for attributes such as appearance, aroma, taste, and mouthfeel. color and overall acceptability recorded some significant differences ($p < 0.05$). Also, descriptive textural attributes of hardness, adhesiveness, chewiness, and smoothness recorded no significant difference ($p > 0.05$). Cohesiveness however differed significantly ($p < 0.05$). Gamma irradiation of samples recorded no adverse effect on its organoleptic attributes. In the consumer acceptability test, the two differently treated samples; mushrooms irradiated with 1kGy and kept in polypropylene packs and non-irradiated mush- room (control) were rated similarly ($p > 0.05$), although more respondents preferred the control. Mostly, consumers wrongly perceive gamma irradiation to influence organoleptic properties of foods and also destructive to the food matrix hence the need to assess the quality difference organoleptically by human sensory analysis.

Potential health risk assessment of toxic metals contamination in clay eaten as pica (geophagia) among pregnant women of Ho in the Volta Region of Ghana

Kortei, N. K. Koryo-Dabrah, A., Akonor, P. T., Manaphraim, N. Y. B., Ayim-Akonor, M., Boadi, N. O., Essuman, E. K. and Tettey, C.

Geophagia although pleasurable and somewhat a necessity among pregnant women, also comes along with its own attendant problems such as exposure to potentially hazardous substances like bacteria, fungi, helminthes and ova, radioactive materials, and toxic elemental minerals in the soil depending on the geographical location. This study evaluated the potential health risk involved during the exposure of pregnant women to toxic elemental minerals via the consumption of clay as pica (geophagia). Elemental mineral analysis was carried out using Buck Scientific 210VGP Flame Atomic Absorption Spectrophotometer (Buck Scientific, Inc. East Norwalk, USA). Risk assessment methods were also used to ascertain the various risks factors and the overall risk level. Concentrations of the macro elements investigated were 1.38 ± 1.5, 2.40 ± 1.5, 7.74 ± 1.5, 4.01 ± 1.0, 13.24 ± 2.2 and 13.76 ± 2.1 mg/Kg for iron (Fe), copper (Cu), zinc (Zn), potassium (K), magnesium (Mg) and sodium (Na) respectively. While that for the micro elements were 1.63 ± 0.03 µg/Kg, 4.72 ± 0.8, 0.53 ± 0.02 and 1.85 ± 0.3 mg/kg respectively for arsenic (As), manganese (Mn), lead (Pb) and Nickel (Ni). Estimated Daily Intake (EDI), Hazard Quotient (HQ), Target Hazard Quotient (THQ) and Total Target Hazard Quotient (TTHQ) values ranged 0.611–5.44 (mg/kg Bw/day), $6.26 \times 10 - 4 - 106.5$, 0.067–10.34 and 15 respectively. There is the likelihood of posing adverse health problems when clay samples obtained from Anfoega which is sited in the Volta region of Ghana is consumed due to the fact that the HQ's of these elemental minerals were >1 which points to high content of Manganese (Mn) and Nickel (Ni). It is also likely to cause adverse health problems in an individual's life time since THQ for Arsenic, Lead and Nickel were above 1. Ultimately, the cumulative effect of these toxicants were exceedingly great (≤ 15) which implied a high level of unsafety associated with this clay. Per the results from this study, it is not safe for pregnant women to consume clay as pica since these toxic elements may cause detrimental effects on the foetus of the unborn child.

Composition of nutrients, heavy metals, polycyclic aromatic hydrocarbons and microbiological quality in processed small indigenous fish species from Ghana: Implications for food security

Hasselberg, A.E., Wessels, L., Aakre, I., Reich, F., Atter, A., Steiner-Asiedu, M., Amponsah, S., Pucher, J. and Kjellevold, M.

The triple burden of malnutrition is an incessant issue in low- and middle-income countries, and fish has the potential to mitigate this burden. In Ghana fish is a central part of the diet, but data on nutrients and contaminants in processed indigenous fish species, that are often eaten whole, are missing. Samples of smoked, dried or salted Engraulis encrasicolus (European anchovy), Brachydeuterus auritus (bigeye grunt), Sardinella aurita (round sardinella), Selene dorsalis (African moonfish), Sierrathrissa leonensis (West African (WA) pygmy herring) and Tilapia spp. (tilapia) were collected from five different regions in Ghana. Samples were analyzed for nutrients (crude protein, fat, fatty acids, several vitamins, minerals, and trace elements), microbiological quality (microbial loads of total colony counts, E. coli, coliforms, and

Salmonella), and contaminants (PAH4 and heavy metals). Except for tilapia, the processed small fish species had the potential to significantly contribute to the nutrient intakes of vitamins, minerals, and essential fatty acids. High levels of iron, mercury and lead were detected in certain fish samples, which calls for further research and identification of anthropogenic sources along the value chains. The total cell counts in all samples were acceptable; Salmonella was not detected in any sample and E. coli only in one sample. However, high numbers of coliform bacteria were found. PAH4 in smoked samples reached high concentrations up to 1,300 µg/kg, but in contrast salted tilapia samples had a range of PAH4 concentration of 1 µg/kg to 24 µg/kg. This endpoint oriented study provides data for the nutritional value of small processed fish as food in Ghana and also provides information about potential food safety hazards. Future research is needed to determine potential sources of contamination along the value chains in different regions, identify critical points, and develop applicable mitigation strategies to improve the quality and safety of processed small fish in Ghana.

Chemical, microbial quality and risk assessment due to toxic metal contamination of egusi (Citrullus colocynthis L.) powder sold in selected Ghanaian markets

Arthur, W., Ofori, J., Addo, P., Amey, N., Kortei, N.K. and Akonor, P.T.

The present study was undertaken to investigate the physicochemical and microbiological qualities of melon seed powder sold in some open Ghanaian markets. Twenty-five samples of powder were collected randomly from each of four major markets and analyzed for moisture, pH, total ash, acid insoluble ash, and free fatty acids (FFA) using standard methods. The microbial population was determined using the pour plate method. Melon seed powder samples had a neutral pH (6.9-7.3) and contained significant amounts of ash (0.1-0.6%). Acid insoluble ash of powder from one market was high (0.6%) and possibly indicate contamination with siliceous earth material. FFA ranged between 4.1 and 11.6% for powder from the four markets. Levels of lead were higher (0.4-0.8 ppm) than other metals such as cadmium (0.02 ppm) and copper (0.3-0.6 ppm). HQ values >1 were recorded for Pb, implying a greater risk of toxicity to consumers. Counts for aerobic bacteria, fecal coliforms, and yeast and molds were in the range of 3.2-4.4, 1.6-4.0, 1.4-2.8, and 1.1-3.2 log CFU/g correspondingly for these organisms. E. coli was not detected in any of the melon seed powder samples analyzed. This study highlights the need for proper handling of melon seed during processing, storage, and distribution, to safeguard its quality for consumers.

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

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

A simplex lattice mixture design was used to optimize the formulation of a juice cocktail containing soursop, pineapple, mango and orange, based on physicochemical and sensory attributes of the cocktail. In this study, juice from soursop, pineapple, mango and orange were the components. Physicochemical and sensory parameters were determined using standard methods. Mixture regression models explained up to 99 % of the variability in the experimental data. Cox response trace plots generated from the fitted models indicated that pH of the cocktail (ranging from 4.0 to 4.2) was greatly influenced by orange, pineapple and soursop. Increasing amounts of soursop juice resulted in a reduction in °Brix and b* value, which indicates

yellowness. Whereas taste of the cocktail was positively influenced by all the components, only extreme amounts of soursop or high amounts of either pineapple or mango enhanced product likeness. Results of the optimization indicated that high amounts of pineapple juice is required to achieve the best cocktail containing these four fruit components. The study demonstrates the potential of utilizing soursop in a juice cocktail together with popular tropical fruits.

Characterisation of Sandalwood Essential Oils: The Application of High Performance Thin-Layer Chromatography

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

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.

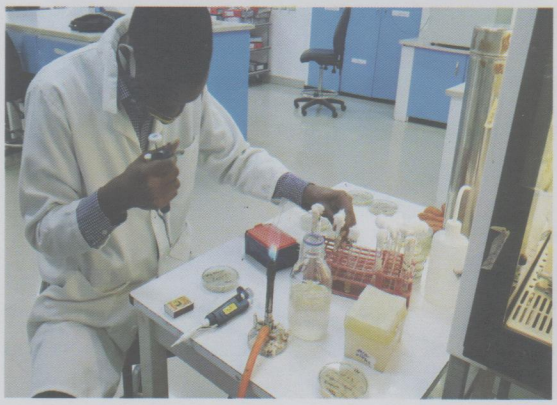
Utilization of grape pomace extract as a source of natural antioxidant in biscuits

Zaky, A. A., Asiamah, E., El-Faham S. Y, Ashour, S. M, M. and Sharaf, M.A.

In the present study, grape pomace extract (GPE) was employed as a source of natural antioxidants to *reduce lipid oxidation in the food matrix. The total phenolic of GPE was investigated by three various* solvents (methanol, ethanol, and acetone). Individual phenolic compounds by HPLC and antioxidant capability, including 1,1- diphenyl-2-picryhydrazyl (DPPH) and ferric reducing antioxidant power (FRAP) tests, were also evaluated. The obtained results showed that GPE owned good antioxidant activity, which gives DPPH of 86.89% and FRAP of 73.93%. Peroxide values (PV), free fatty acids (FFA), and thiobarbituric acid (TBA) were applied as measures to assess the antioxidant efficacy of GPE (0.5%, 1%, 2% and 3%) in biscuits. At the end of 6 months storage period of biscuits, it was observed that increasing the GPE concentration enhanced the capability of inhibiting lipid oxidation. The findings from this demonstrate that GPE at various levels exhibited very powerful antioxidant ability. Therefore, grape pomace extract in fatty food products could be utilized as a natural antioxidant to reduce lipid oxidation, which can be useful for future food applications.

Commercial Summary

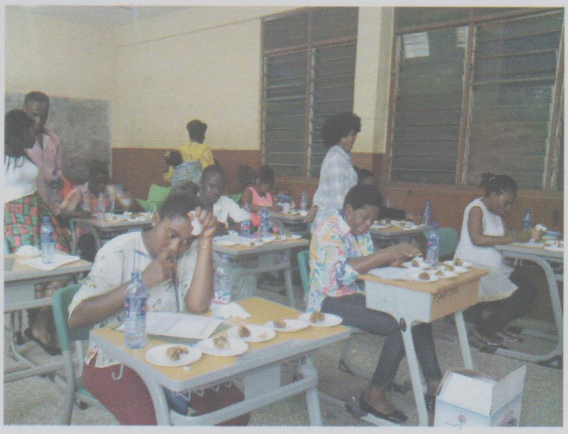
The Commercial Division is responsible for commercializing research outputs, technologies, services and products of the Institute. The Institute provides physical, chemical and microbial analyses to food processing companies. Product development, product optimization and standardization, sensory analysis, contract productions, food processing equipment fabrication, feasibility studies for start-ups and trainings are among many commercial services rendered to clients.



Staff conducting microbial analysis on food sample

Capacity development training on rice parboiling

Product development session for a client



Sensory evaluation session of local and foreign chicken by trained panelist

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

Within the year, nineteen (19) different post-harvest technologies were developed and transferred to clients, through product development sessions. Twenty-one (21) food preservation technologies and 4,121 analytical services were rendered to industry/stakeholders on various number of samples. 55% of analysis were on microbial analysis while 34% and 11% were on chemical and mycotoxin analysis, respectively as shown in Figure 4.

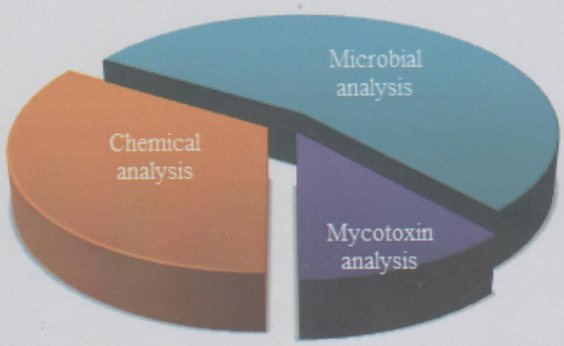


Figure 4: Proportions of analytical services rendered to clients

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.

Financial Summary

CSIR-FRI's activities are financially resourced through R&D and by incomes generated from Commercialization. Money generating activities include sale of research products, rendering laboratory and technical services to clients, contract productions, fabrication of food processing equipment, consultancy services, etc.

A sum of GHS 1,890,297.48 representing 62% of Funds was generated as Internal Generated Funds (IGF) and GHS 1,159,317.80 representing 38% was received as Donor funds for Research and Development. Donor agencies within the year included: EU (Healthy Food Africa and Small Fish Food Projects), FAO (CREAM Project), DANIDA (GreenGrowth Project), Canadian Embassy (MAG Project), SDF (Roots and tuber value addition Consultancy) and Denmark (Cocoa Fermentation Consultancy)

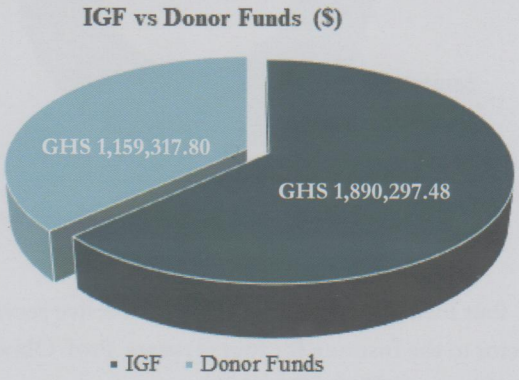


Figure 5: Comparing Donor funds and IGF

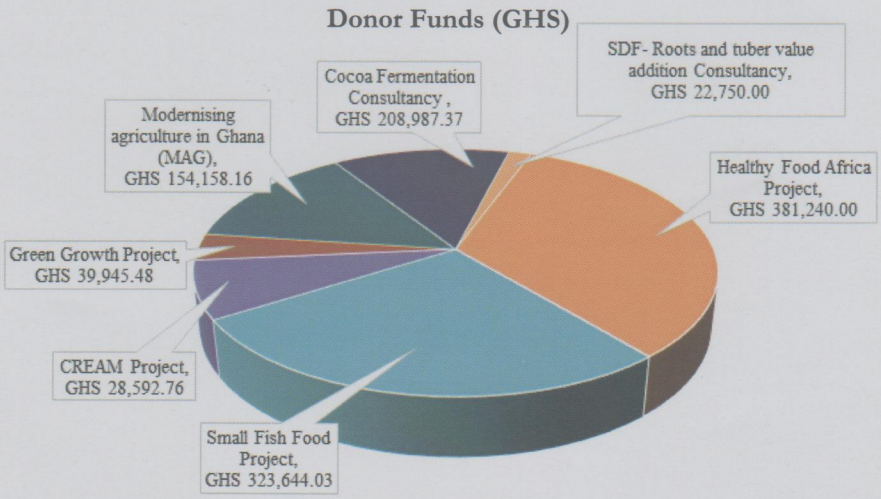


Figure 6: Representation of donor funds received within the year

Administrative Account

CSIR-FRI has a staff strength of one hundred and forty-six (146), comprising of 59% male and 41% female. Its staff are grouped under Junior staff, Senior staff and Senior members (made of Research Staff and non-Core Senior members). The proportions of staff category are as represented in Figure 7.

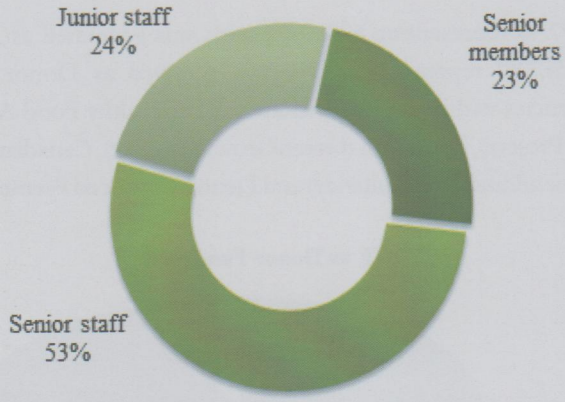


Figure 7: Percentage distribution of staff

At the end of the year, four members of staff retired from active service, among these was Prof. (Mrs.) Mary Obodai, the Director to the Institute for four (4) years. Prof. Obodai was a Chief Research Scientist specialized in mycology; she served CSIR-FRI for 28years.

Our Staff

Directorate

1.	Prof. (Mrs.) Mary Obodai	-	Chief Res. Scientist / Director
2.	Prof. Charles Tortoe	-	Chief Res. Scientist / Deputy Director
3.	Mrs. Anthonia Andoh-Odoom	-	Snr. Res. Scientist / Quality Manager
4.	Dr. (Mrs.) Esther Wahaga	-	Res. Scientist / M&E Officer
5.	Ms. Mariam Yakubu	-	Scientific Secretary
6.	Ms. Faustina Somuah	-	Chief Admin. Assistant

Administration Division

1.	Mrs. Gifty N.D. Aryee	-	Snr. Admin. Officer/(On Leave of Absence)
2.	Ms. Anita Adusah	-	Admin. Officer
3.	Mrs. Victoria A. Asunka	-	Admin. Officer (Ag. Head of Division)
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

Transport Section

8.	Mr. Eric K. Ofori	-	Chief Admin. Assist (Head of Section)
9.	Mr. Anthony Sevor	-	Snr. Asst. Transport Off.
10.	Mr. Gariba Alimyao	-	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

Estate Section

14.	Mr. Edmund Mensah-Yemoh	-	Chief Works Supt. (Head of Section)
15.	Mr. Abel Sogbe	-	Snr. Tech. Assist.
16.	Mr. Samuel K. Adjei	-	Foreman
17.	Mr. Daniel Nuertey	-	Traffic Supervisor
18.	Mr. Nuru A. Abdulai	-	Tech. Assist Gd. II
19.	Mr. Sunday Akantokdingin	-	Supervisor Gd I
20.	Ms. Vicentia Mienuye	-	Supervisor Gd I
21.	Ms. Rose Kornu	-	Supervisor Gd I
22.	Mr. Emmanuel T. Kpabitey	-	Supervisor Gd I
23.	Mr. Joseph Adivor	-	Supervisor Gd I
24.	Mr. Daniel Obeng Oduro	-	Supervisor Gd I
25.	Mr. Moses Mensah	-	Supervisor Gd I

26.	Mr. Richard Ohemeng	-	Supervisor Gd I
27.	Mr. Jeff Afenu	-	Supervisor Gd I
28.	Mr. Edmund Gyampoh	-	Supervisor Gd I

Security Section

29.	Mr. Philip Agyaye	-	Snr. Security Off. (Head of Section)
30.	Mr. Samuel Quaye	-	Snr. Security Off.
31.	Mr. Foster Bosompem	-	Security. officer
32.	Mr. Paul Kpotor Tetteh	-	Security. Officer
33.	Mr. Daniel Mustapha	-	Security Officer
34.	Mr. Justice Blankson Dadzie	-	Snr. Security. Assist
35.	Mr. Francis Azure	-	Snr. Security Asst.
36.	Mr. Abass Abdulai	-	Security Asst. Gd I
37.	Mr. George Ankwa	-	Security Asst. Gd I
38.	Mr. Bob Atulibok	-	Security. Asst. Gd I
39.	Mr. George Tetteh	-	Supervisor Gd I
40.	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.	Ms. Judith Dogbegah	-	Chief Accounting Asst
4.	Mr. Christian Amegah	-	Chief Accounting Asst.
5.	Ms. Joana B. Dzikunu	-	Chief Admin. Assistant
6.	Ms. Regina Tsotsoo	-	Snr. Accounting Asst.
7.	Ms. Wolase Efodzi	-	Prin. Stores Supt.
8.	Mrs. Angela Addy	-	Prin. Stores Supt.
9.	Ms. Judith Larweh	-	Prin. Tech. Officer

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. Accounting Asst.
7.	Ms. Mary Assimah	-	Chief. Admin. Assist.
8.	Mrs. Getty Afuukar	-	Prin. Technical Officer
9.	Mr. Ofori Brempong	-	Prin. Technical Officer
10.	Ms. Justina Thompson	-	Prin. Admin. Assist.
11.	Mr. Peter Dalabor	-	Prin. Works. Supt.

12.	Mr. Emmanuel Agblo	-	Prin. Works. Supt.
13.	Ms. Sindy M. Williams	-	Prin. Tech. Officer.
14.	Ms. Benedicta Plahar	-	Snr. Admin. Assistant
15.	Mrs. Rose Agorkor	-	Snr. Technical Officer
16.	Mr. Godson Agbeley	-	Technical Officer
17.	Mr. Paul Boadi	-	Technical Officer
18.	Mr. Foster Akplaga	-	Technical Officer
19.	Ms. Elizabeth Attah	-	Tech. Asst. Gd. II
20.	Mrs. Ernestina Armah	-	Tech. Asst. Gd. II
21.	Mr. Luke Anak	-	Tech. Asst. Gd. II
22.	Mr. Ababase Akanzinam	-	Supervisor Gd. I

Food Technology Research Division

1.	Dr. Gregory A. Komlaga	-	Snr. Research Scientist/Head of Division
2.	Dr. (Mrs.) Charlotte Oduro-Yeboah	-	Snr. Research Scientist
3.	Mr. Elvis A. Baidoo	-	Snr. Research Scientist
4.	Mr. Paa Toah Akonor	-	Snr. Research Scientist
5.	Mr. Kwabena Asiedu Bugyei	-	Snr. Research Scientist
6.	Mr. Raphael Kavi	-	Snr. Librarian
7.	Mrs. Evelyn S. Buckman	-	Snr. Research Scientist
8.	Mr. Jonathan Ampah	-	Research Scientist
9.	Dr. Godfred Ameyaw Asiedu	-	Research Scientist
10.	Dr. John Edem Kongor	-	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.	Mrs. Edna Mireku Essel	-	Snr. Technologist
18.	Mrs. Helen Ama Annan	-	Snr. Technologist
19.	Mr. Frank Peget Mboom	-	Snr. Technologist
20.	Mr. Patrick Ofosu Mintah	-	Chief Tech. Officer
21.	Mr. Desmond Mensah	-	Chief Tech. Officer
22.	Mrs. Agartha Amuzu	-	Chief Tech. Officer
23.	Ms. Constance Boateng	-	Chief Tech. Officer
24.	Mr. Ofori Brempong	-	Prin. Tech. Officer
25.	Mrs. Alice Padi	-	Prin. Tech. Officer
26.	Mr. Rufai Ahmed Braimah	-	Snr. Tech. Officer
27.	Ms. Carris Dogbeda Ackuaku	-	Snr. Tech. Officer

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. Alexander Henry K. Appiah	-	Snr. Technologist
11.	Ms. May A. Boham-Dako	-	Snr. Technologist
12.	Mrs. Ruth Fosu	-	Prin. Tech. Officer
13.	Mr. Badaru Deen Yahaya	-	Tech. Officer
14.	Mr. Emmanuel Bortey Mensah	-	Tech. Officer
15.	Mr. Philip Kwabena Mensah	-	Tech. Officer

Food Chemistry And Nutrition Division

1.	Mr. George A. Anyebuno	-	Snr. Research Scientist / Head of Division
2.	Dr. Hayford Ofori	-	Snr. Research Scientist
3.	Dr. Jolene Mateko A. Nyako	-	Research Scientist
4.	Dr. Emmanuel Kyereh	-	Research Scientist
5.	Mrs. Hannah Oduro Obeng	-	Research Scientist
6.	Mr. Kofi Kwegyir Essel	-	Prin. Technologist
7.	Mr. Hillary K. Ketemepi	-	Prin. Technologist
8.	Mrs. Juliet Vickar	-	Prin. Technologist
9.	Mr. Nelson Y. Amey	-	Prin. Technologist
10.	Mr. Ebenezer Tawiah	-	Prin. Technologist
11.	Mr. Vincent Kyei-Baffour	-	Snr. Technologist
12.	Mrs. Mercy Ted Coffie	-	Technologist
13.	Ms. Vida Awidi	-	Chief. Tech. Officer

Publications

Journal Papers

1. Aboagye, G., Gbolonyo-Cass, S., Kortei, N. K. and **Annan, T.** (2020). Microbial evaluation and some proposed good manufacturing practices of locally prepared malted corn drink ("asaana") and *Hibiscus sabdarifa* calyxes extract ("sobolo") beverages sold at a university cafeteria in Ghana. *Scientific African,* 8, 1-16.

2. Agyeman, P.N., **Akonor, P.T., Tortoe, C., Johnson, P-N.T** and Manu-Aduening, J. (2020). Effect of the use of starches of three new Ghanaian cassava varieties as a thickener on the physicochemical, rheological and sensory properties of yoghurt. *Scientific African* 9 (2020) e00521.

3. **Akonor, P. A., Tortoe, C.** and Barwuah, J. P. (2020). Optimization of a fruit juice cocktail containing soursop, pineapple, orange and mango using mixture design. *Scientific African*, 8, e00368. DOI: 10. 1016/j.sciaf.2020.e00368.

4. **Arthur, W., Ofori, J., Addo, P., Amey, N.,** Kortei, N.K. and **Akonor, P.T.** (2020). Chemical, microbial quality and risk assessment due to toxic metal contamination of egusi (*Citrullus colocynthis L.*) powder sold in selected Ghanaian markets. *International Journal of Food Science.* doi: 10.1155/2020/8862404.

5. **Blessie, E.J.**, Wruck, W., Abbey, B.A., Ncube, A., Graffmann, N., Amarh, V., Arthur, P.K. and Adjaye, J. (2020). Transcriptomic analysis of marine endophytic fungi extract identifies highly enriched anti-fungal fractions targeting cancer pathways in HepG2 cell lines. *BMC genomics*, 21, pp.1-17.

6. Diaz, M., Sayavedra, L, **Atter, A.**, Mayer, J. M., Saha, S., **Amoa-Awua, W.** and Narbad, A. (2020). "Lactobacillus garii sp. nov., isolated from a fermented cassava product." *International Journal of Systematic and Evolutionary Microbiology:* ijsem004121.

7. Hasselberg, A.E., Aakre, I., Scholtens, J., Overå, R., Kolding, J., Bank, M., **Atter, A**. and Kjellevold, M. (2020). Fish for Food and Nutrition Security in Ghana: Challenges and Opportunities. *Global Food Security.* 26, 100380. doi.org/10.1016/j.gfs.2020.100380.

8. Hasselberg, A.E., Wessels, L., Aakre, I., Reich, F., **Atter, A.**, Steiner-Asiedu, M., Amponsah, S., Pucher, J. and Kjellevold, M. (2020) Composition of nutrients, heavy metals, polycyclic aromatic hydrocarbons and microbiological quality in processed small indigenous fish species from Ghana: Implications for food security. *PLOS ONE* 15(11): e0242086. https://doi.org/10.1371/journal.pone.0242086.

9. Kortei, K.N., Odamtten, T.G., **Obodai, M., Akonor, T.P,** Wiafe-Kwagyan, M., **Buckman, S.** and Mills, O.N.W.S. (2020). Sensory evaluation, descriptive textural analysis, and consumer acceptance

profile of steamed gamma-irradiated *Pleurotus ostreatus* (Ex. Fr.) Kummer kept in two different storage packs. *Scientific African,* 8, 1-8.

10. Kortei, N. K. Koryo-Dabrah, A., **Akonor, P. T.**, Manaphraim, N. Y. B., Ayim-Akonor, M., Boadi, N. O., Essuman, E. K. and Tettey, C. (2020). Potential health risk assessment of toxic metals contamination in clay eaten as pica (geophagia) among pregnant women of Ho in the Volta Region of Ghana. *BMC Pregnancy and Childbirth*, 20, 1-7.

11. Kortei, N. K., Heymann, M. E., Essuman, E. K., Kpodo, F. M., **Akonor, P. T.**, Lokpo, S. Y., Boadi, N. O., Ayim-Akonor, M. and Tettey, C. (2020). Health risk assessment and levels of toxic metals in fishes *(Oreochromis noliticus and Clarias anguillaris)* from Ankobrah and Pra basins: impact of illegal mining activities on food safety. *Toxicology Reports*, 7, 360-369.

12. Kumi, F., **Ampah, J.,** Amoah, R. S., **Andoh-Odoom, A.** and Kodua, M. (2020). Performance evaluation of a chimney solar dryer for habanero pepper (Capsicum chinense). *African Journal of Food, Agriculture, Nutrition and Development* 20(4): 16029-16045. https://doi.org/10.18697/ajfand.92.18740.

13. Muhammad, D.R.A., **Kongor, J.E.** and Dewettink, K. (2020). Investigating the effect of different types of cocoa powder and stabilizers on suspension stability of cinnamon-cocoa drink. *Journal of Food Science and Technology.* https://doi.org/10.1007/s13197-020-04855-y.

14. **Nketia, S., Buckman, E.S., Dzomeku, M.,** and **Akonor. P.T.** (2020). Effect of processing and storage on physical and texture qualities of oyster mushrooms canned in different media. *Scientific African* 9, 1-7.

15. **Oduro-Yeboah, C.**, Ackah, B.N., **Akonor, T.P.,** Amponsah, K.S., **Mboom, P.F.** (2020). Food safety knowledge and practices among fresh coconut vendors. *Scientific African* 8 (2020), 1-6.

16. **Ofori, H.**, Hettiarachchi, D., Sostaric, T., Pandohee J., Chudasama, D.H. and Boyce, C.M. (2020) Characterisation of Sandalwood Essential Oils: The Application of High Performance Thin-Layer Chromatography. *Journal of Essential Oil Research,* 32, DOI: 10.1080/10412905.2020.1829721.

17. **Ofori, J., Tortoe, C.,** Agbenorhevi, J. K. (2020). Physicochemical and functional properties of dried okra (*Abelmoschus esculentus L.*) seed flour. *Food Science & Nutrition,* 8 (8), 4291-4296. DOI: 10.1002/fsn3.1725.

18. Omari R, and **Anyebuno G.** (2020). Risk Assessment of Aflatoxins in Maize-Groundnuts Complementary Foods Consumed by Ghanaian Infants. *Journal of Food Quality and Hazards Control.* 7: 128-135.

19. Precoppe, M., **Komlaga, G.A.,** Chapuis, A. and Muller, J. (2020). Comparative study between current practices on cassava drying by small-size enterprises in Africa. *Applied Sciences* 10, 1-17.

20. Sefah,W., Sefah, L., **Ofori, H**. (2020). Development of a HPTLC Method to Profile the Phytochemicals in *Allanblackia parviflora* (Tallow Tree) Kernel and Seed Cakes. *Journal of Planar Chromatography,* 33, 33-34.

21. **Tortoe, C.,** Quaye, W., **Akonor, P.T, Oduro-Yeboah, C., Buckman, S.B.** and Asafu-Adjaye, N.Y. (2020): Biomass-based value chain analysis of plantain in two regions in Ghana. *African Journal of Science, Technology, Innovation and Development.* DOI: 10.1080/20421338.2020.1766396.

22. **Tortoe, C., Akonor, P.T.,** Kusi, F., Asungre, P.A., Owusu R.K., **Boateng C.** (2020). Unearthing the potential of *Frafra* potatoes (*Solenostemon rotundifolius*) flour in culinary application: Sensory and nutritional analysis of its pastry products. *Journal of Culinary Science and Technology,* 18:1-12.

23. **Tortoe, C., Dowuona, S., Akonor, P. T.** and **Dziedzoave, N. T.** (2020). Enhancing the food security status of yam (Dioscorea spp.) for smallholder farmers through an improved farm-gate storage structure in Ghana. *African Journal of Science, Technology, Innovation and Development,* 12 (4), 499-504.

24. Vandemoortele, A., Babat, P., **Yakubu, M.** and De Meulenaer, B. (2020). Behavior of Malondialdehyde and Its Whey Protein Adducts during *In Vitro* Simulated Gastrointestinal Digestion. J Agric Food Chem. 68(42):11846-11854. doi: 10.1021/acs.jafc.0c03947. Epub 2020 Oct 7. PMID: 32985186.

25. Zaky, A. A., **Asiamah, E.,** El-Faham S. Y, Ashour, S. M, M. and Sharaf, M.A. (2020). Utilization of grape pomace extract as a source of natural antioxidant in biscuits. European academic research, Vol. VIII, Issue 1/ April 2020.

Technical Reports

Research Reports

1. **Ameyaw G.A., Oduro-Yeboah C., Akonor P.T., Saka E., Arthur W., Boateng C.** and **Padi A** (2020). Training for Small-Scale Fish Processors. 37pp.

2. **Ampah, J., Atter, A., Owusu, M., Andoh-Odoom, A., Akonor T.P.,** Overå, R., Kjellevold, M., Johannes, P. and Kolding, J. (2020). Technology transfer report on the smallfishfood project.

3. Arthur, P.K., Amarh, V., **Blessie, E.J.,** Yeboah, R., Kankpeyeng, B.W., Nkumbaan, S.N. and Tiburu, E.K., 2020. In vitro antibacterial activities of selected TB drugs in the presence of clay minerals against multidrug-resistant strain of *Myco bacterium smegmatis.*

4. **Atter, A., Andoh-Odoom, A., Owusu, M., Ampah, J.** and **Akonor, T. P.** (2020). Small Fish and Food Security: Towards innovative integration of fish in African food systems to improve nutrition. 2020 SmallFishFood Project Report.

5. **Atter, A., Nketia, S., Ameyaw, G., Blessie, J. E., Andoh-Odoom, A.,** Quartey, Q. Q. and Agyakwah, K.S. (2020). Report of the Stakeholder Workshop on Fish and Fishery Product, Processes, Innovations, Quality and Safety at Koforidua Guests' Hotel, 29th September – 2nd October 2020. European Union sponsored H2020. HealthyFoodAfrica (862740) project.

6. **Atter, A.,** Obiri, O. K., Asiedu-Coffie, S., Otu, O. B., Galley, C., **Agbemafle, E., Andoh-Odoom, A., Blessie, J.E., Amoa-Awua, W.** (2020). Technical report on molecular detection of some foodborne pathogens in ready-to-eat grilled beef sausages from selected street vendors in Accra using optimized reaction volume and single PCR condition.

7. **Atter, A.,** Obiri, O.K., Asiedu-Coffie, S., Otu, O. B., Galley, C., **Agbemafle, E., Andoh-Odoom, A., Blessie J. E.** and **Amoa-Awua, W.** (2020). Technical report on optimization of a reduced PCR reaction volume and a single PCR condition for five different foodborne pathogens.

8. **Atter, A., Owusu, M., Ampah, J., Andoh-Odoom, A., Padi, A.** and **Akonor, P.T.** (2020). Report on the training of fish processors on hygienic drying practices, use of drying platforms and value addition to dried small fish at Moree and Tema New Town.

9. **Komlaga G.A., Kongor, J.E** and **Dziedzoave, N.T.** (2020). Quality management training manual for JOSMA Agro Industries Limited. Ghana Cassava Industrialization Partnership Project (GCIPP) report. Pp 53.

10. **Najah, T., Takli, R.,** Thompson, J and **Oduro-Yeboah, C.** (November, 2020). Report on 36th farmers' day exhibition and the visit to mushroom farmers within Bono east and Ashanti regions of the republic of Ghana.

11. **Oduro-Yeboah, C., Akonor, T.P.,** Abubakari, M. and **Najah, T.** (2020). Report on training of trainers on handling postharvest losses of watermelons, mangoes and pineapples held on 27th & 28th January, 2020 at MOFA regional conference room- Tamale, Ghana.

12. Onumah, G., Plaisier, C., Villani, R., **Komlaga, G.** (2020). Sorghum Value Chain Analysis in Ghana. Report for the European Union, DG-DEVCO. Value Chain Analysis for Development Project (VCA4D CTR 2016/375-804), 168 p + annexes.

Consultancy Reports

1. **Oduro-Yeboah, C., Asiamah E.,** and **Pady, A.** (2020). Training of Trainers on the use of composite flour from 25th -26th of November, 2020 at Effia-Kwesimentim Municipal Assembly office, Takoradi, Western region.

2. **Oduro-Yeboah, C., Asiamah E., Pady, A.** and **Boateng, C.** (2020). Training of Trainers on the use of composite flour from 29th -30th of October, 2020 at Bakhita Hospitality Ltd, Dodowa. Greater Accra Region.

3. **Oduro-Yeboah, C., Komlaga, G., Asiamah, E., Najah, T., Idun-Acquah, N.N., Dowouna, J., Andoh-Odoom, A., Tawiah, E., Arthur, W., Desmond, M., Dowouna, S., Mireku-Essel, E., Amuzu, A.** and **Williams, S.** (2020). Training of MOFA-Agriculture College Tutors on food processing, packaging, and marketing technology at CSIR-Food Research Institute July,2020.

4. **Owusu, M., Blessie, E. J., Arthur, A. B., Anna, T.,** Obiri, K., Badaru **Deen**, Y., **Afotey**, F., **Andoh-Odoom, A., Ameh, N., Anyebuno, G., Tawiah, E.** (2020). Cocoa Fermentation Monitoring – Phase 2.

Manuals

1. **Atter,A., Owusu, M., Ampah, J., Andoh-Odoom, A., Akonor, P.T., Peget, F., Padi, A.,** Overå, R., Kjellevold, M., Johannes, P., and Kolding, J. (2020). Training manual for improved sun drying of small fish and development of small fish based food products.

2. **Bugyei, K.A.** and **Kavi, R.K.** (2020). User manual for FRI online analytical services. Pp28.

Flyers

1. **Atter, A., Owusu, M., Ampah, J., Andoh-Odoom, A., Akonor, P.T.,** Overå, R., Kjellevold, M., Johannes, P. and Kolding, J. (2020). Small Fish and Food Security: Towards innovative integration of fish in African food systems to improve nutrition.

Conference Abstract

1. Wessels, L., Hasselberg, E.A., Aakre, I., Reich, F., **Atter, A.,** Steiner-Asiedu, M., Amponsah, S., Kjellevold, M. and Pucher, J. (2020). Nutritional quality and food safety of processed small indigenous fish species from Ghana. Tropentag 2020 Virtual Conference on food and nutrition security and its resilience to global crises at ATSAF E. V. Germany 9th-11th September, 2020. (Link-https://www.tropentag.de/abstract.php?code=H87hcq3y)

Conference Presentation

1. **Atter, A., Owusu, M., Ampah, J., Andoh-Odoom, A., Akonor, T.P.** (2020). FAO. 2020. Empowering women in small-scale fisheries for sustainable food systems. Regional Inception Workshop. 3–5 March 2020. Alisa Hotel, Accra, Ghana. Fisheries and Aquaculture Proceedings No. 66. Rome) (Link: Empowering women in small-scale fisheries for sustainable food systems. FAO - Google Books: http://www.fao.org/documents/card/en/c/ca9742en/-

CSIR - FOOD RESEARCH INSTITUTE

Adjacent Ghana Standards Authority, Gulf Street,

Gulf House, Near Tetteh Quarshie Interchange, Accra - Ghana

P. O. Box M20 Accra, Ghana | E-mail: director@foodresearchgh.org

Website: www.foodresearchgh.org | Telephone: +233 30 296 2068

Designed and Printed by CSIR-INSTI, Tel.: 0302 780709