CSIR- FOOD RESEARCH INSTITUTE
(CSIR-FRI)

2023 ANNUAL REPORT

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TABLE OF CONTENT

ACRONYMS

CRP	C-Reactive Protein
FTRD	Food Technology Research Division
FAO	Food and Agriculture Organization
FDA	Food and Drugs Authority
MESTI	Ministry of Environment, Science, Technology and Innovation
IGF	Internally Generated Funds
RSA	Research Scientist Association
FDA	Food and Drugs Authority
MoFA	Ministry of Food and Agriculture
S & T	Science and Technology
FSL	Food System Laboratory
RBC	Red Blood Cells
PAH	Polycyclic Aromatic Hydrocarbons
CAG	Chamber of Agribusiness Ghana
RE	Routine Expansion
CD	Commercial Division
SSA	Senior Staff Association
SDG	Sustainable Development Goal
WP	Work Package

MANAGEMENT BOARD MEMBERS

1.	Nana Osei Bonsu	CEO, PEF	Chairman
2.	Mr. Obeng Manu Koranteng	Private Chartered Accountant	Member
3.	Dr. Michael Yao Osae	Director, BNARI-GAEC	Member
4.	Mr. William Kwabena Boateng	Quality Manager, Cocoa Processing Co. Ltd.	Member
5.	Dr. Francis Boateng Agyenim	Director of CSIR-IIR (Cognate)	Member
6.	Mr. Emmanuel Ofosu Brakoh	Director of Finance - CSIR	Member
7.	Prof. Charles Tortoe	Director - CSIR-FRI	Member
8.	Mrs. Vivian Anane	Head of Admin. - CSIR-FRI	Secretary
9.	Dr. Charlotte Oduro-Yeboah	Deputy Director - CSIR-FRI	In attendance
10.	Mr. Saviour Gladstone Cudjoe	Head of Finance - CSIR-FRI	In attendance

INTERNAL MANAGEMENT MEMBERS

1.	Prof. Charles Tortoe	Director	Chairperson
2.	Dr. Charlotte Oduro-Yeboah	Deputy Director	Member
3.	Ms. Matilda Dzomeku	Head/FMMRD	“
4.	Mr. Papa Toah Akonor	Head/FTRD	“
5.	Mr. Hayford Ofori.	Head/FCNRD	“
6.	Mr. Stephen Nketia	Head/CD/Sci. Sec.	“
7.	Mr. Saviour Gladstone Cudjoe	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. Vivian Anane	Head/Admin.	Secretary
14.	Mrs. Victoria Asunka	Admin	Recorder

FOREWORD

The mandate and goals of CSIR-Food Research Institute were pursued during the year under review. The Institute's mandate is to conduct applied market-oriented research into problems of food processing and preservation, food safety, storage, marketing, distribution and utilization, and national food and nutritional security in support of the food industry and to advise government on its food policy. Its goal, which is uniquely linked with its mandate is to assist in poverty reduction by creating opportunities that can generate and increase revenues within the micro-small-medium and large scale agro-food processing industries as well as contribute to food security, foreign exchange earnings and the application of cost-effective food processing and preservation technologies that are environmentally sustainable. Our mandate and goal is clearly in-line with the Sustainable Development Goals 1, 2, 3, 9 and 12.

For its progress, the Institute continued to support staff on their various job, training and study leave activities. The Institute has senior members-core, senior members non-core, senior members - technologist, senior staff, junior staff and contract staff. Contributions from all staff resulted in the successful implementation of good management processes and procedures, good cooperate governance, adherence to all statutory requirements, ensured the implementation of best practices on its accounting and internal controls in management during 2023. These laudable achievements were witness by the peaceful and conducive environment in the Institute in 2023. Further, some staff on study leave returned to the Institute upon completion of their PhD, MPhil and MSc studies.

The Institute applause its foreign partners for their supportive sponsorship on research, technology and developmental programs especially European Commission for sponsorship of Horizon 2020 and SmallFish Project and HealthFoodsAfrica Project, Bill and Melinda Gates Foundation for sponsorship of the GC Fermented Foods Project, Forum for Agricultural Research in Africa (FARA), Food and Agriculture Organization (FAO), World Food Programme (WFP), Natural Resources Institute (NRI) United Kingdom, Alliance for a Green Revolution in Africa (AGRA), Ministry of Environment, Science Technology and Innovation (MESTI), Ministry of Food and Agriculture (MoFA), Association of Ghanaian Industries (AGI), Ghana Standards Authority (GSA), Food and Drugs Authority (FDA) and Chamber of Agribusiness-Ghana (CAG).

On behalf of the Internal Management Committee, I wish to thank all our stakeholders for their unrelenting support of our mandate and goals, staff of the Institute for their contribution to the progress of the Institute and the Almighty God for His goodness in 2023 and look forward to a successful year in 2024. God Bless Us All.

Thank you.

EXECUTIVE SUMMARY

As an affiliate institute of the Council for Scientific and Industrial Research, CSIR-Food Research Institute has since its inception provided technical and scientific assistance to satisfy the needs of the private sector and other stakeholders for the socioeconomic development of Ghana. Over the years, the Institute has developed into the premier organization for food research and post-harvest management technologies that are targeted at supporting the food sector by carrying out its mandate of conducting applied market-oriented research. The CSIR-FRI's operations are deliberately focused on developing skills, building capacity, and conducting studies and interventions related to nutrition. These are key areas targeted at curbing food insecurity related issues in the country. Through programs, workshops, and other activities aimed at increasing capacity, particularly in rural communities, on various processing technologies, numerous initiatives under FRI's R&D program had an impact on society. The HealthyFoodAfrica Project conducted training programs for some Small Medium Enterprises (SMEs) on food product development. The participants included various agro processing SMEs such as LynMay Farm to Fork, Success Axis Foods, Yokheved Enterprise, Delle's Coast Enterprise, Selasie Foods, Okyeade Foods, Afra Koya Enterprise, Ndudu Foods & Beverages, Kafel Farms and Daa Fisheries Training Centre. Participants were trained in appropriate food processing techniques, packaging, storage and marketing. Some of the products that were developed under the training included fish sausage, okro and ademe, cereal mix, fish chips, koobi in oil among others. The ACP coffee project in partnership with CSIR-FRI organized a workshop with key partners and stakeholders in the coffee value chain, validated and operationalized the drafted coffee handbook resulting from the enterprise assessment. The workshop included stakeholders such as Ministry of Food and Agriculture (MoFA), International Trade Centre (ITC), Ghana Cocoa Board (COCOBOD), Food and Drugs Authority (FDA), Ghana Standards Authority (GSA), Ghana Export Promotion Authority, Robusta Coffee Agency of Africa and Madagascar (ACRAM) Focal Person, and some scientists from the Cocoa Research Institute of Ghana (CRIG). The Institute generated a total amount of $ 289,916.84 as IGF; it also received $ 81,466.00 in research grants under various projects. Within the year, the Institute had a staff strength of thirty-five percent (35%) Senior members, forty-one percent (41%) Senior staff and twenty-four percent (24%) Junior staff.

The Institute churned out sixty-eight (68) publications comprising of forty (40) Journals papers, eleven (11) Technical reports, two (2) Consultancy Reports, five (5) Manuals, one (1) Flyer, two (2) Conference papers, three (3) book chapters, one (1) handbook and three (3) blog posts.

INTRODUCTION

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

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

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

Products and Services

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

- **Fabrication of Food Processing Equipment** (Fabricating strong & reliable food processing equipment and industrial dryers).
- **Food Processing** (Processing of high-quality natural food products and Contract productions).
- **Extension Services** (Technology transfer, Business incubation, Hiring of conference facilities etc.)
- **Incubation Services** (Support individuals and companies to produce their food recopies in our premises or in their premises)

RESEARCH AND DEVELOPMENT

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

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

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

Duration: 4 years, 6months

Introduction

The HealthyFoodAfrica initiative is a research project aimed at developing sustainable, equitable, and resilient food systems in ten African cities. The project is a collaborative effort between 17 partners from Europe and Africa, with funding from the European Union Horizon2020 programme. The Council for Scientific and Industrial Research (CSIR) in Ghana has partnered with the Natural Resources Institute of Finland to implement the project. The CSIR-Food Research Institute and the Water Research Institute are jointly representing CSIR-FSL in the project. The project began in June 2020 and is expected to be completed in December 2024. The CSIR-Food Research Institute is actively involved in work packages 2, 4, and 6. Work package 2 aims to improve nutrition and health by transforming consumption patterns towards sustainable healthy diets. The activities planned under this work package include the collection and analysis of primary and secondary data on food consumption, food choices, and dietary patterns, as well as qualitative measurements of nutrient adequacy, dietary diversity scores, and more. Work package 4 focuses on the development of innovative post-harvest technologies to improve food safety and reduce food waste. The activities under this work package include identifying current post-harvest and food safety issues, developing and piloting relevant technologies and processes. Similarly, work package 6 focuses on the development of novel food products, tools, and processes to support innovative agri-business models. The activities under this work package include the participatory identification of innovative food products, processes, and agri-business models, based on plant-based proteins and local agro-biodiversity. The project seeks to take a multi-stakeholder network approach where scientists and stakeholders co-design solutions through multi-actor teams. The project aims to pilot the strategies, innovation, and tools from these studies to improve the supply of sustainable nutritious food products and the dietary habits of urban dwellers. This report presents the activities undertaken during the period at CSIR-FRI.

Key Activities and Achievements

WP4 ACTIVITIES

Chemical and fatty acid profile of oil extracted from Nile tilapia gut

Fatty acids are important components of our diet and can be classified based on the number of unsaturated double bonds present in the fatty acid chain. Fish oils, which are a principal constituent of fish, are made up of polyunsaturated fatty acids with five (5) and six (6) double bonds and usually contain the ω-3 series of fatty acids. These polyunsaturated fatty acids are derivatives with over 18 carbon atoms in their chains and are classified as essential fatty acids because the human body is unable to synthesize them and must be included in any diet. Eicosapentaenoic acid and docosahexaenoic acid are the most important ω-3 fatty acids in fish and play a key role in cardiovascular, central nervous, immune and visual systems.

Minerals, including copper (Cu), iron (Fe), zinc (Zn), and phosphorus, are essential inorganic nutrients required in small amounts between less than 1 and 2500 mg per day, depending on the mineral. Zinc is the second most abundant trace metal in higher animals, and the Zn2+ cation is a critical component of many proteins, playing an important function in most biological processes. Lower levels of Cu are essential for human health, while excess Cu can produce free radicals and cause toxicity or inflammation. Cu also influences the activities of enzymes, such as tyrosinase, cytochrome oxidase, and many more. Phosphorus is an important component of adenosine triphosphate (ATP) and nucleic acid and is essential for acid-base balance, bone, and tooth formation. In this experiment, the chemicals and fatty acids extracted from Nile Tilapia were analyzed to understand their composition and nutritional value.

The highest acid value of 10.98 mgKOH/gFat was obtained by oil extracted from wild tilapia fish caught from Weija in Accra. Variation was observed in the moisture, free fatty acid, acid value, Cu, Fe, P and Zn recorded for Tilapia fish oil extract analyzed. Moisture content recorded for Tilapia fish oil extracts analyzed ranged from 0.10-0.79% with oil extracted from wild Tilapia fish caught from Weija obtaining the highest moisture content of 0.79%. Free fatty acid obtained by fish oil extracts analyzed ranged from 0.25 to 5.25%.

A draft manuscript on the chemical analysis of the oils extracted from the guts of Nile Tilapia samples from 10 selected fish farms (cages, ponds, and wild) in the Greater Accra and Eastern regions of Ghana is being worked on in collaboration with the University of Helsinki team that worked on the fatty acid profile and tocopherols.

The safety practices of fishermen, fish farmers, fish mongers and processors and nutritional profile of wild and cultured tilapia in the Greater Accra and Eastern Regions of Ghana.

The main objective of the study was to evaluate the level of food safety knowledge and handling practices among key stakeholders in the tilapia value chain in Ghana. In addition, the study aimed to examine the nutrient profile of wild, cage, and pond-cultured tilapia (Oreochromis niloticus) that are commonly available to Ghanaian consumers. To achieve this, the researchers administered well-structured, pretested questionnaires to 206 fishermen and fish farmers, as well as 201 fishmongers and processors in the Greater Accra and Eastern Regions of Ghana. The questionnaire aimed to investigate the stakeholders' knowledge and practices of food safety. Furthermore, the researchers collected tilapia samples from the wild, ponds, and cages in the Greater Accra and Eastern regions of Ghana, which were then analyzed for a range of nutrients such as proximate, amino acids, vitamins, and minerals. The results of the study showed that in general, stakeholders' food safety knowledge and practices were commendable but there were still some areas that required improvement to ensure the safety of consumers. Moreover, the wild and cultured tilapia samples collected were mostly composed of moisture (68.50%–80.64%), protein (14.88%–25.96%), and fat (2.21%–3.72%). In most cases, macro and microelements were detected. The main essential amino acids in tilapia were leucine and lysine, while the main non-essential amino acids were aspartic acid and glutamic acid. The vitamin A content varied from 0.03mg/100g to 0.63mg/100g. On the other hand, there was no significant difference in vitamin E concentrations in all tilapia samples analyzed. Overall, the nutritional makeup of the sampled tilapia suggests that it is a suitable source of nutrition for human consumption. However, it is worth noting that consuming gutted whole tilapia is highly beneficial due to its high nutritional value.

Thesis submission

A thesis titled "The safety practices of fishermen, fish farmers, fish mongers, and processors and the nutritional profile of wild and cultured tilapia in the Greater Accra and Eastern regions of Ghana" was submitted by Gloria Asare. The thesis was supervised by Prof Amoa-Awua and Dr. Ethel Juliet Blessie.

Manuscript development

An upcoming manuscript is in the works which focuses on the safety practices being followed by the actors of the tilapia value chain in the Greater Accra and Eastern regions of Ghana.

Manuscript titled: Safety practices of tilapia value chain actors in the Greater Accra and Eastern Regions of Ghana is currently being developed.

Tilapia waste quantification and consumption patterns study.

Aquaculture plays a crucial role in Ghana's food system, addressing the growing demand for sustainable animal protein alongside traditional marine fisheries. Despite its significance, global reports indicate that over 65% of cultivated fish go to waste annually. This study focused on Nile tilapia, a prominent cultured species, aiming to assess consumer wastage. A web-based survey gathered responses from 246 participants, exploring perceptions of edibility in various tilapia parts and preparation methods. Also, the various parts of the fish including flesh, fins, offal, head, scales, bones, and gill flap/operculum were carefully quantified. Results showed widespread tilapia consumption, with females exhibiting a stronger preference. Fried preparations were deemed more edible than boiled or grilled. Analysis of consumed and wasted parts revealed that approximately 30 to 45% of Nile tilapia in Ghana's supply chain is wasted, emphasizing the need for improved processing methods, potentially selling edible and inedible parts separately to mitigate aquaculture waste.

Manuscript submission

Out of this study, a manuscript titled “Assessment of Waste Generated from Fresh Nile Tilapia Oreochromis Niloticus in Accra-Ghana” has been submitted to Aquaculture, Fish and Fisheries journal.

Gelatin extracted from Nile tilapia scales

Fish gelatin serves as an important raw material in the production of drugs and other important products. As part of the effort to explore the possibility of transferring and upscaling the fish gelatin technology, a delegation from CSIR-FRI namely: Mr. Ebenezer Asiamah, Dr. Ethel Serwa Blessie and Mrs Rita Gyansah Tsiquaye visited the Entrance Pharmaceuticals & Research Centre owned by Mr. Samuel Amo Tobbinon on 9th June 2023. This Centre is a leading producer of pharmaceutical products in West Africa with dedicated facilities for both production and in The Managing Director, Personal Assistant, and Secretary of the company were welcomed by the team. In the course of the discussions, CSIR-FRI highlighted the success and benefits of fish gelatin extraction, knowledge transfer to industry, and potential economic gains for pharmaceutical companies. Nonetheless, the MD emphasized that while gelatin was once their primary raw material for production, the company had to switch to maize starch because of the capsules' poor dissolution and binding problems. He also pointed out that other industries, such as food production, cosmetics, photography, etc., will benefit as well because they still use gelatin in their processes. The potential of gelatin production according to him could be a big boost and good leverage for the local industry which relies heavily upon production and product development if its technology is accepted and implemented. They offered to test the gelatin sample for the project for free but they are yet to provide feedback as at the time of reporting.

CSIR-FRI delegation at Entrance Pharmaceuticals & Research Centre with owner Mr. Samuel Amo Tobbinon

Manuscript submission

Out of the gelatin study, a manuscript titled “Effect of Seasonal Variation and Farming Systems on the Properties of Nile Tilapia Gelatin Extracted from Scales” was submitted to Heliyon for publication (HELIYON-D-23-45369R2).

Blog post

A blog post titled "Enhancing a Sustainable Circular Economy in the Aquaculture Sector in Ghana: Using Tilapia Waste" was also published on these studies.
https://healthyfoodafrica.eu/blog/enhancing-a-sustainable-circular-economy-in-the-aquaculture-sector-in-ghana-using-tilapia-waste/

Doctoral thesis and manuscript submission

A doctoral thesis was also submitted to the University of Ghana for examination on 'the study of the bacterial diversity of African Nile Tilapia (Oreochromis nilocitus) and shelf-life extension of tilapia fillets.

A manuscript has been submitted for review with manuscript reference number: HELIYON-D-23-44206 and titled "Tilapia consumption patterns and consumer preferences: Predictors and perspectives of consumers in Ghana.
There is a second manuscript under development titled 'Bacterial diversity of degutted African Nile Tilapia (Oreochromis niloticus) and the antimicrobial potential of two essential oils against tilapia-associated bacteria.

WP6 ACTIVITIES

Up-takers practical training programme

As part of the HealthyFoodAfrica project, the various technologies developed had to be adopted by local up-takers/companies. A training programme was thus implemented to transfer these technologies to the interested parties. The participants comprised various agro-processing industries namely LynMay Farm to Fork, Success Axis Foods, Yokheved Enterprise, Delle's Coast Enterprise, Selasie Foods, Okyeade Foods, Afra Koya Enterprise, Ndudu Foods & Beverages, Kafel Farms and Daa Fisheries Training Centre. The value-added products adopted by the HFA up takers comprised fish chips, fish sausage, frozen okra and ademe, koobi in oil, koose mix, pancake mix and instant cereal mix. The goal of the training programme was to pass on knowledge on the developed products using the appropriate food processing techniques, packaging, storage, and marketing of their preferred products. The training programme began on the 3rd of April 2023 and ended on the 6th of April 2023 with an overall attendance of 42 participants in total, 22 males and 22 females. All sessions were conducted in person and facilitated by project team members and staff of the Product Development Laboratory of the CSIR – Food Research Institute. Participants were taken through the theoretical and practical aspects of the training. At the end of the training period, participants were enlightened, and this spurred them to select some of the novel food products they could incorporate into their businesses. Dr. Amy Atter announced at the end of the training that the Food and Drugs Authority (FDA) and Ghana Standard Authority (GSA) have granted Safe Fish Compliance Certification for the CSIR-FRI fish processing facility, allowing fish smoked from the facility to be considered safe for consumption and gain access to African markets under the AfCFTA agreement. She promised to apply for the European Union certification from the Ghana Standard Authority for fish and fisheries product exportation and presented the certificate to the Director, Prof. Charles Tortoe. Details of the training are presented in a report (CSIR-FRI/RE/AA/2023/003).

Online media reportage on the training

https://ghstandard.com/eu-funded-healthyfoodafrica-project-develops-seven-new-healthy-convenience-food-products/77505/

https://www.ghanabusinessnews.com/2023/04/12/seven-new-convenience-food-products-developed/

Scenes from the training

Participants with CSIR-FRI Director Prof. Charles Tortoe

Food and Drugs Authority product registration for up takers

After completing the training, each company chose one or two novel products that they planned to expand. Subsequently, food product samples for registration were produced by the Sensory Evaluation/Food Test Laboratory of the CSIR-Food Research Institute for the 10 up takers and studies on the nutritional profile, microbial safety, and shelf-life of the products were carried out before submission to Food and Drugs Authority (FDA). The registration process involved submitting well-labelled packaged products, company registration certificates, and other documents. The companies and their selected product are listed in Table 1.

Up-takers and their selected product(s)

COMPANY NAME	**PRODUCT**
Afra Koya Enterprise	Instant Cereal
Delle's Coast	*Koobi* in Oil and Fruity Soy Pancake
Lyn May from Farm to Fork	Instant Cereal and Fish Chips
Selasie Foods	Mix and Instant Cereal
Daa Fisheries Training Center	Fish Chips and Okro and *Ademe*
Success Axis Foods	Fish Sausage and Fish Chips
Yokheved Enterprise	Fruity Soy Pancake Mix and Koose Mix

Ndudu Foods & Beverages	*Koobi* in Oil and Okro and
Kafel Farms	Fish Sausage
Okyeadie Foods	Instant Cereal and *Koose* mix
CSIR-Food Research Institute	Pancake Mix, Soy Pancake Mix, *Koose* Mix, Cereal Mix, *Okro* and *Ademe*

Some challenges that were experienced included delays in the submission of labels and packaging materials of their own choice for the food samples, mistakes in some information provided on labels and delays in communication/feedback from up takers. Training manuals for the seven innovative food products are still being developed.

Some products produced for up takers and submitted to the FDA for registration

The FDA previously approved the CSIR-Food Research Institute's product registration, and the institute is currently producing and selling these products commercially. The selected products currently being produced include soy pancake mix, pancake mix, cereal mix, and koose mix. Packaged okro and Ademe is yet to be registered. According to the sales officer in charge at the shop, the developed products are well patronized and are available in a few other shops in Accra.

Displayed products on the sales outlet shelf

Catfish value addition

Catfish (Clarias gariepinus) is a popular fish species in Ghana and is commonly consumed as a source of protein. The catfish industry according to processors has witnessed significant growth in recent years due to the rising demand for fish in the subregion. A lot more intensive aquaculture is being practiced which has seen a lot more people set up tanks for culturing the fishes. Aside from the traditional consumption of catfish, not a lot of work has been done on catfish in terms of value addition. The study aims to comprehensively compare the quality of catfishes from different farming systems [i.e., pond, tarpaulin, and concrete tanks] in terms of their microbial diversity, product development and safety, thus, assessing the impact of the farming system on the quality of the catfish. Other value addition options will be explored.

Sampling

Sampling took place between July and November 2023 with some supplementary currently taking place. A total of 12 farms were randomly selected to be sampled from within the Greater Accra Region and Eastern Region. Sample locations included Haatso, Atomic, Mampong, Aburi, Ashaiman, Nsawam, and Kwabenya. The 12 sample locations were made up of 4 each of the three different farming systems [i.e., pond, tarpaulin, and concrete tanks]. Catfish samples that have been purchased so far have been frozen awaiting analysis.

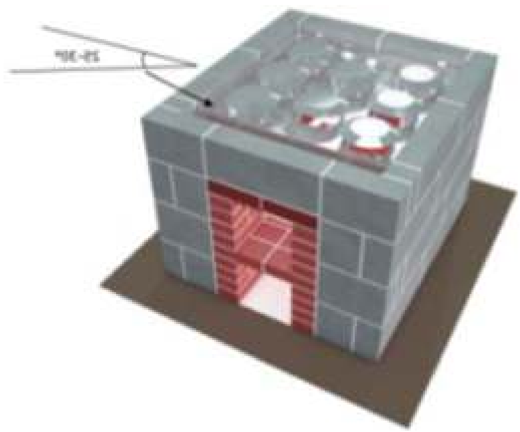
Next steps

- Food Safety Analysis
- Microbial/molecular analysis
- Histamine
- Baseline chemical (proximate) study
- Product Development [Canning experiments]. Other value addition options such as vacuum packaged catfish chips, vacuum packaged grilled fish, dried catfish, smoked catfish, catfish sausage, catfish powder and so on will be explored.
- Texture profiling.
- Survey on consumption patterns.

Cat fish cages and sampling

Improvement of the fish smoking oven experiment

A survey was conducted in September 2021 to evaluate stove technology innovations available in the country. The Ahotor oven was identified as the dominantly improved technology in Ghana. The technology comprises a combustion chamber fitted centrally to a Chorkor-like outer shell, with fish processing trays above as in a normal traditional oven. Above the combustion chamber, a fat-collecting tray is fitted that allows the hot gases to flow up through the fish while preventing any fat from dropping down onto the fire. A primary air inlet supplies oxygen into the combustion chamber to enhance the efficient combustion of fuelwood. The secondary air inlet located on top of the fuelwood entrance introduces cool air into the smoking chamber to meet with hot gases from the combustion chamber to enable an evenly distributed circulation of air and heat in the smoking chamber. The grate located in the combustion chamber improves combustion by reducing smoke emissions.



The improved *Ahotor* oven

The *Ahotor* oven survey report reviewed found that the technology had numerous benefits for end users. The oven produces less smoke, produces fish with better taste, and gives the fish an attractive colour and texture. Furthermore, the users of the technology recorded no burns and less irritation of the eye during the operation.

However, there was an urgent need for *Ahotor* technology assessment and improvement. These technological advancements prioritize end-user preferences and expectations without compromising product output quality or consumer safety. A technical committee of experts was formed to evaluate the improved technologies and make recommendations for improvement actions.

Four different versions of the *Ahotor* oven were developed. These versions made room for the use of alternative fuels, including charcoal briquettes and liquified petroleum gas (LPG). This was intended to allow fish processors to use a variety of fuel alternatives. In addition to these, technological improvements were made to the dominant chorkor oven as well as the FTT oven. The improvement works sought to address energy and time efficiencies, user-friendliness, poly aromatic hydrocarbon (PAH) level improvement, safety, and affordability.

Following the stove improvement experiment, different fish species smoked on these ovens were sampled for PAH, chemical/nutritional, microbiological, energy, and other performance tests to determine the impact of the improvements on the technology. Mr Emmanual Kwarteng, the PhD student on this aspect of the work led this experiment. A member of the National Fish Processors and Traders Association (NAFPTA), Mrs. B. Borley Wradi and representatives from the Fisheries Commission were invited to partake in the experiment. Data analysis is now underway.

Fish smoking experiment

Thesis submission

A master's thesis titled "Physicochemical and microbiological characterization of hygienically developed salted dried Nile tilapia (koobi) in vegetable oil" was submitted to CSIR College of Science and Technology (CCST) for examination. The student (Ms Emefa Gblende) passed and successfully defended the thesis.

Visitors to the fish processing facility

The project team also received some guests visiting the fish processing facility. A three-member delegation led by Ms Sonia Sharan from Oceana, USA, visited the facility. Oceana is the largest non-governmental organization in the world that is solely focused on ocean conservation. They utilize science-based campaigns to influence policy on a variety of ocean-related topics. They are members of the Small-Scale Fisheries Hub, a forum for fishermen, fish workers, their communities, and allies. Additionally, they are a part of the global network known as the Aquatic/Blue Food Coalition, which promotes the importance of fish in food systems. Selected fish processors from the West African Sub-region were also brought in by the Food and Agricultural Organization. Members of the Ghana Aquaculture Association led by Mr Francis De Heer also paid a visit to the facility. Others were the officials from the Kpone Katamanso Municipal Assembly, who came with fish processors operating within the Assembly to observe and learn the hygienic fish smoking process at CSIR-FRI.

Various visitors in the fish processing lab

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

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

Introduction

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

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

The GC fermented project aimed at investigating the impact of the intake of soymilk-brukina, a novel Ghanaian indigenous fermented milk and millet beverage (smoothie), on the gut microbiome and nutritional status of women of reproductive age (15-49 years) living in the Hohoe Municipality in the Volta region. This project replaced cowmilk, which is one of the main ingredients in “brukina smoothie” with a plant protein. Soymilk offers a healthful nutritional profile, including flavonoids that exert antioxidant, anti-inflammatory, and cardioprotective properties. Soymilk substitution will therefore enhance the nutritional and health benefits of brukina. Besides its lower environmental impact compared to livestock rearing for milk, the used of soymilk in brukina production will ultimately boost the soybean market, which is being currently vigorously promoted, to enhance livelihood of local farmers in Ghana.

Key Activities and Achievements

The GC-Fermented food project was divided into four (4) phases.

The first phase of the project tackled soymilk brukina fermentation and standardization, which encompassed activities such as product fermentation and standardization included activities such as: soymilk production, soy yoghurt production, production of steamed ground millet, sensory evaluation of soymilk brukina, laboratory examination and consumer acceptability of soymilk brukina.

Soymilk-Brukina Fermentation and Standardization

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

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

Equipment

Fish sausage production equipment was purchased and installed at the Fish Processing Hall for training.

CONCLUSION

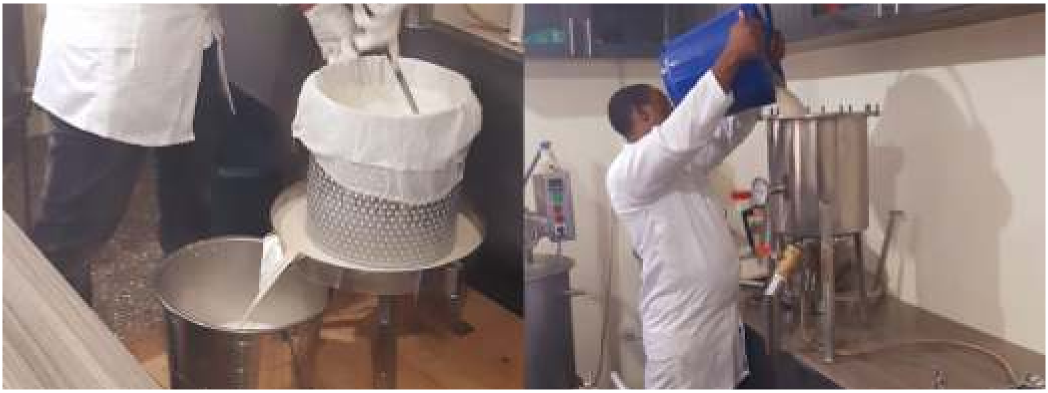
The HealthyFoodAfrica (HFA) Project is a beacon of collaboration and innovation in the quest to achieve sustainable, equitable, and resilient food systems across ten African cities. With funding from the European Union Horizon2020 programme and the dedicated efforts of 17 partners from Europe and Africa, including the Council for Scientific and Industrial Research (CSIR) in Ghana and the Natural Resources Institute of Finland, this project represents a pivotal endeavour to transform consumption patterns, enhance food safety, and promote innovative agri-business models.

The activities undertaken by CSIR-FRI, as outlined in this report, underscore the project's commitment to stakeholder engagement and the co-creation of solutions. Beyond nutritional education, the project also encompasses practical interventions and technological advancements to achieve positive nutritional outcomes and food security.

The HFA project also recognizes the importance of technology adoption and capacity building among local up-takers and companies. Through training programs and product registration initiatives, the project has empowered stakeholders to leverage innovative food processing techniques and improve market access for nutritious food products.

Going forward, the project is poised to deliver tangible outcomes that will not only benefit urban dwellers in African cities but also contribute to the broader discourse on sustainable food systems. This would be achieved by fostering interdisciplinary collaboration, leveraging indigenous knowledge, and embracing technological innovation. As the project progresses towards its completion in 2025, the insights gained, and solutions developed will serve as valuable resources for shaping the future of food systems across the continent and beyond.

Steeping and mashing of soymilk for soymilk-*brukina* drink



Preparation of soy yogurt for Soymilk-*brukina*.

Bottling soymilk-*brukina* drink with millet flakes.

Table 1. Proximate and Micronutrient Composition of Soymilk-*Brukina*

Parameter	Unit	Result	Per 330ml	DRI (Female: 19-50yrs)
Moisture	g/100	85.20	280.5	-
Total fat	g/100	1.78	5.87	20 – 35% of total calories
Protein	g/100	4.26	14.06	38
Crude fibre	g/100	0.55	1.82	-
Total Carbohydrate	g/100	7.75	25.58	100
Energy	Kcal/100g	64.06	211.40	-
Iron	mg/100g	1.24	4.09	18
Calcium	mg/100g	28.94	95.50	1000
Phosphurus	mg/100g	74.85	247.00	700
Manganese	mg/100g	0.10	0.33	1.8
Zinc	mg/100g	0.97	3.20	8
Copper	mg/100g	0.14	0.46	2.5

Table 2. Microbiological Quality of Soymilk-*Brukina*

Product	APC	Yeast	Moulds	Enterobacteriaceae	Coliforms	*Escherichia coli*	*Staphylococcus aureus*	*Bacillus cereus*
Soymilk-*burkina*	3×10^2	nd	nd	nd	nd	nd	nd	nd

Table 3. Consumer Acceptability Results for Soymilk-*brukina*

Food Product	Appearance	Aroma	Consistency	Taste	Mouthfeel	Overall acceptability
Soymilk-*brukina*	8.30 ± 0.90^a	8.73 ± 0.86^a	8.58 ± 0.91^a	8.62 ± 1.00^a	8.47 ± 0.97^a	8.75 ± 0.86^a
Cowmilk *brukina*	5.22 ± 2.25^b	6.14 ± 2.26^b	4.56 ± 2.27^b	6.19 ± 2.35^b	5.39 ± 2.28^b	6.20 ± 2.26^b

Data is presented as means ± standard deviation of 150 consumer responses. Participants' responses were ranked on a 9-point hedonic scale of 1=dislike extremely; 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=neither like nor dislike; 6=like slightly; 7=like moderately; 8=like very much; and 9= like extremely. Mean values in the same column with different superscripts are significantly different at $p \leq 0.05$.

Work Package 2 tackled Metagenomics analysis of bacterial [16S] and fungal [ITS] constituents which included activities such as microbiological analyses (Enumeration of Microbial Constituent of soymilk-brukina, Isolation of Microbes and Physical Characterization), molecular analyses (DNA Extraction, PCR Amplification and Sequencing of Bacterial Constituents, DNA Extraction, PCR Amplification and Sequencing of Fungal Constituents.)

MALDI-TOF Mass Spectrometry Analysis of Bacteria

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

Result Overview

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

Result overview table—continued on next page

Report created at 2022-10-25T14:49:25. Research Use Only Page 1 of 90

Figure 1. Overview of some identified bacteria strains in the soymilk-brukina drink

Table 4. Microbial population in soymilk-brukina and soymilk-millet blend (control diet) produced in Week 1 of the intervention study period (Log CFU/ml)

Sample	APC	Yeast	Mold	*Entero-bacteriaceae*	coliform	*E. coli*	LAB
SYB a	(6.5 ± 0.01)^{a}	nd	nd	nd	nd	nd	(4.1 ± 0.0
SYBb	(6.1 ± 0.01)^{b}	nd	nd	nd	nd	nd	(5.8 ± 0.1
USYBa	(5.1 ± 0.05)^{d}	nd	nd	nd	nd	nd	nd
USYBb	(5.1 ± 0.1)^{c}	nd	nd	nd	nd	nd	nd

Means that do not share the same superscript are significantly different at p≤0.05. where; SYBa and USYBa- first production of soymilk-burkina and soymilk-millet blend in Week 2. SYBb and USYBb- second production of soymilk-burkina and soymilk-millet blend in Week 2

Table 5. Microbial population in fermented and non-fermented soymilk- burkina produced in Week 2 during the intervention period in Log CFU/ml

Sample	APC	Yeast	Mold	*Entero-bacteriaceae*	*Coliform*	*E. coli*	LAB
USYBa	(2 ± 0.1)^{c}	nd	nd	nd	nd	nd	nd
USYBb	nd	nd	nd	nd	nd	nd	nd
SYBa	(3.6 ± 0.1)^{b}	nd	nd	nd	nd	nd	(3.7 ± 0.1)^{a}
SYBb	(4.7 ± 0.1)^{a}	nd	nd	nd	nd	nd	(3.8 ± 0.1)^{a}

Means that do not share the same superscript are significantly different at p≤0.05. Where; SYBa and USYBa- first production of soymilk-*burkina* and soymilk-millet blend in Week 2. SYBb and USYBb- second production of soymilk-*burkina* and soymilk-millet blend in Week 2

Table 6. Beneficial Lactic Acid Bacteria isolated and identified from soymilk-*burkina* produced for intervention study over 8 weeks

Week	Beneficial LAB Isolated and identified
1	*Limosilactobacillus fermentum, Lactobacillus delbrueckii, Limosilactobacillus reuteri*
2	*Lactobacillus delbrueckii, Limosilactobacillus reuteri*
3	*Lactobacillus delbrueckii, Limosilactobacillus reuteri*
4	*Lactobacillus delbrueckii, Limosilactobacillus fermentum*
5	*Limosilactobacillus reuteri, Lactobacillus delbrueckii, Limosilactobacillus fermentum,*
6	*Limosilactobacillus reuteri, Lactobacillus delbrueckii, Limosilactobacillus fermentum,*
7	*Lactobacillus delbrueckii*
8	*Lactobacillus delbrueckii, Limosilactobacillus reuteri*

Work Package 3 looked at human intervention studies. These included activities such as Research Design and Study Area, Study participants, Sampling and Sample size, Randomization and the Intervention, Data Collection.

Human Intervention Studies

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

Participant assisting volunteers with bio-data.

Field volunteers distributing soymilk-brukina to study participants.

Some field volunteers distributing soymilk-brukina to study participants.

Table 7. Changes in RBC, HB & haematocrit with time (n =176)

Haematological indices	Soymilk-*burkina* (n=70)			Soymilk-millet blend (n=106)		
	Baseline	8W	Change	Baseline	8W	Change
RBC (M/µL)	4.08 ± 0.50	3.85 ± 0.44	-0.23 ± 0.67	4.21 ± 0.49	4.00 ± 0.51	-0.20 ± 0.69
HB (g/dL)	11.41 ± 1.20	11.31 ± 1.44	-0.10 ± 2.04	11.78 ± 1.75	11.60 ± 1.19	-0.18 ± 2.17
HCT (%)	33.05 ± 3.25	32.72 ± 3.75	-0.33 ± 5.31	34.05 ± 3.33	33.65 ± 3.86	-0.40 ± 5.33

8W= 8 weeks; RBC= Red Blood Cells; HB= Haemoglobin; HCT= Haematocrit

Table 8. Changes in Ferritin indices with time (n=176)

Biochemical indices	Soymilk-*burkina* (n=70)			Soymilk-millet blend (n=106)		
	Baseline	8W	Change	Baseline	8W	Change
Ferritin (µg/L)	6.19 ± 2.33	5.40 ± 2.22	-0.22 ± 3.21	5.97 ± 2.99	5.21 ± 1.92	-0.27 ± 3.77

Work Package 4 addressed gut microbiome studies. The main activities conducted were faecal Samples collection, Microbiota Analysis by Next-Generation Sequencing.

Omics Laboratory Space

The Omics Laboratory was needed as an ideal space to help execute phase four (work package 4) of the GC fermented food project. The Omics laboratory housed all the gut microbiome activities under this project and future studies. This space ensured that all biological samples were sorted, stored and analyze without contamination. This facility was equipped with Qubit 4.0 fluorometer, beadbeater, thermos scientific Megafuge 16 centrifuge, -20 freezer and a host of other equipment's required for molecular analysis. A sequencer, microarray, RT-PCR among others were purchased under the project to strengthen FRI capabilities and competitive in research areas such as genomics, transcriptomics, proteomics and metabolomics.

Renovated Omics Laboratory Space

Gut Microbiome Studies

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

OM-200 stool sample collection kids.

Project research assistants assisting in stool DNA isolation.

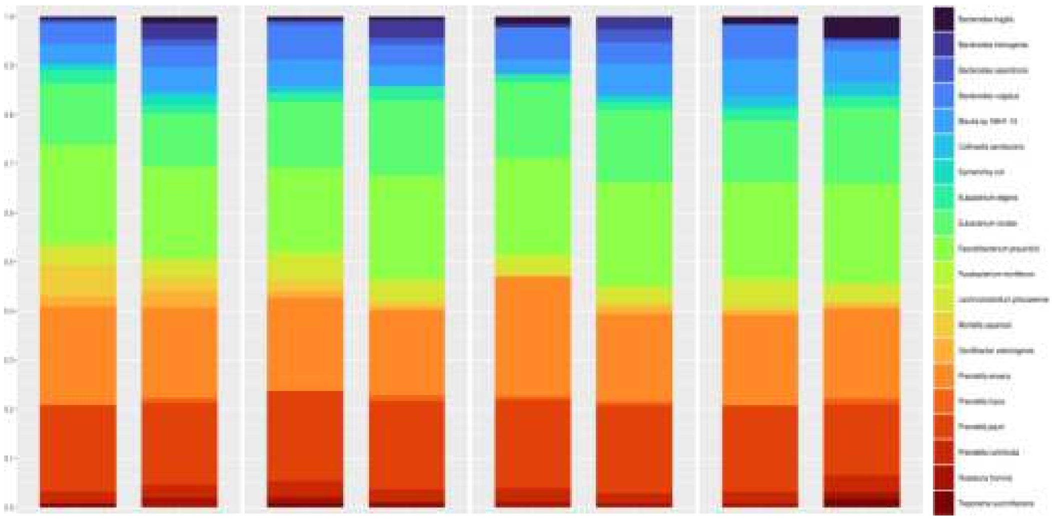


Figure 2. The most abundant bacteria making up 60% of reads from each cohort.
SMB = group of women in their reproductive age fed Soymilk-burkina (1st cohort); SMMB = group of women in their reproductive age fed with Soymilk-millet-blend (2nd cohort); WK0 = Before feeding intervention; WK4 = four weeks during feeding intervention; WK8 = eight weeks into feeding intervention; WK12 = four weeks after termination of feeding intervention.

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

Kongor, J.E., Owusu, M., Oduro-Yeboah, C., Kyei-Baffour, V., Tawiah, E., Amey, N.K.
Duration: 30 Months

Introduction

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

Conventional chocolate manufacture consists of the following processing steps: mixing, refining, conching and tempering. These steps are carried out separately, requiring equipment with huge investment costs, operational space and the use of skilled personnel. The use of the alternative technique for chocolate production is thus, gaining attention mainly due to the lower investment cost, maintenance and multi-functionality of the equipment. The melanger is one of such piece of equipment found to have great potential in alternative small-scale chocolate manufacture. Studies on the use of the melanger for chocolate production have however, focused mainly on particle size reduction during refining and conching. The extent to which mixing, refining and conching could be carried out simultaneously in the melanger and how this influences the quality characteristics of dark chocolates remains unknown. With a national unemployment rate of 4.51% in 2020, a more cost-effective technique for chocolate production will provide decent employment and economic growth, especially for women and youth chocolate processors and retailers, who dominant small-scale chocolate value chain in Ghana, and contribute to eradicating poverty. The main goal of this project is to develop beetroot dark chocolate using the melanger as an alternative chocolate production technique and study the effect of beetroot powder concentration and processing time on the physicochemical, nutritional, bioactive compounds compositions, antioxidant capacity, particle size distribution, hardness, microbial safety, sensory profile (mouthfeel, aroma, taste), consumer acceptability and shelf life of the product.

Key Activities and Achievements

Production of beetroot powder

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

Washing of the freshly harvested beetroots

Peeling of the washed beetroots

Slicing of the peeled beetroots

Arranging the sliced beetroot on trays

Beetroots arranged on trolleys and placed in the mechanical dryer.

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

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

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

Beetroot powder

Production of Beetroot dark chocolate

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

After de-moulding, the chocolate bars were stored in a refrigerator at 20 °C prior to analyses.

Table 9: Recipe for the formulation of beetroot dark chocolate

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

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

Processing of the chocolate mix in the melanger.

Tempering of molten beetroot dark chocolate

Tempered beetroot dark chocolate molded into bars and heart shapes.

Based on the results from the quantitative descriptive analysis (QDA) and consumer acceptability test, two chocolate samples, one without beetroot powder and the other with 15% beetroot powder, were selected for shelf-life studies. The shelf-life studies were conducted in the climate chamber to determine the best storage temperature and duration for the chocolate. Works on the bioactive compound composition and antioxidant capacity of beetroot dark chocolate have been published in the Journal of the Science of Food and Agriculture (Kongoretal, 2024).

https://onlinelibrary.wiley.com/doi/10.1002/jsfa.12902).

Another manuscript on the physicochemical properties, sensory profile, and consumer acceptability of beetroot dark chocolate has been submitted to the Journal of the Science of Food and Agriculture and is currently under review.

Memmert ICH260 climate chamber used for the shelf life studies

Chocolate samples in the climate chamber

ACP COFFEE

Kongor, J.E., Owusu, M., Tortoe, C., Ampah, J., Ayeh, E.S.
Duration: 12 Months

Introduction

The International Trade Centre invited the CSIR-Food Research Institute to participate in an enterprise assessment of the coffee value chain actors in the Volta, Ashanti, Eastern, and Greater Accra regions as part of the European Union's "Support to Business-Friendly and Inclusive National and Regional Policies and Strengthening Productive Capabilities and Value Chains" (ACP Coffee Project) Project. This was done to obtain first-hand information on the coffee value chain in Ghana. This assessment identified several challenges, including poor harvesting techniques, the use of inappropriate equipment, poor manufacturing practices, a low-hygienic processing environment, poor storage facilities, few innovations (in terms of value addition), and so on. Based on the findings of the enterprise assessment, a coffee handbook was drafted to aid in capacity building for coffee value-chain actors to address the challenges identified and improve both the quantity and quality of coffee produced in the country. The ITC and CSIR-FRI then signed a Memorandum of Understanding (MoU) to build the capacity of coffee MSMEs and agro-processors to increase productivity and incomes through good post-harvest management and value addition practices, participation in formal markets, and improve the value chain competitiveness of Ghana's coffee sector through the implementation of the Alliances for Action (A4A) approach.

Under the signed MoU, CSIR-FRI was tasked with three (3) main activities: Validation of the drafted ITC coffee handbook; capacity building for coffee smallholder farmers and agro-processors in Ghana (in the areas of food safety, product quality and processing technology, value addition, labelling and packaging, good manufacturing practises, branding and marketing, and other priority selected topics by agro-processors for selected products); and finally, coffee value-added product development. The purpose of this report is to provide information on activities that have been completed and their respective outcomes.

Key activities and achievements

Validation Workshop with Stakeholders and Coffee Value Chain Actors

The ITC and CSIR-FRI organized a one-day workshop with key partners and stakeholders in the coffee value chain to validate and operationalize the drafted coffee handbook resulting from the enterprise assessment. The validation workshop took place in the Director's Conference Room of CSIR-FRI, Accra. The workshop attracted 66 participants, including coffee farmers, hullers, roasters, agro-processors, consultants, officials from the Ministry of Food and Agriculture (MoFA), International Trade Centre (ITC), Ghana Cocoa Board (COCOBOD), Food and Drugs Authority (FDA), Ghana Standards Authority (GSA), Ghana Export Promotion Authority, Robusta Coffee Agency of Africa and Madagascar (ACRAM) Focal Person, and some scientists from the Cocoa Research Institute of Ghana (CRIG) and CSIR-FRI. The participants comprised 62% males and 38% females.

Prof. Charles Tortoe delivering the welcome address

Mr. Lawrence Attipoe delivering a statement on behalf of the ITC

Group photograph of stakeholders

The validation of the coffee manual was preceded by a presentation on the harvesting, postharvest management, and processing of coffee by Dr. John Edem Kongor and Mr. Richard Nyumuah. The presentation gave a snippet of the developed coffee manual to be validated. To facilitate a smooth discussion by all stakeholders during the validation exercise, the participants were grouped into two (2). Group 1 focused on Chapter 1 of the manual, while Group 2 focused on Chapters 2–4. The groups comprised the following stakeholders:

Table 10: Groups of participants for the validation exercise

Group 1	Group 2
Coffee farmers	Coffee processors
Coffee hullers	Coffee consultant
Coffee roasters	Ghana Barista Association
Coffee consultant	Ghana Export Promotion Authority
Ghana Cocoa Board	Ghana Cocoa Board
Ghana Standards Authority	Ghana Standards Authority
Food and Drugs Authority	Food and Drugs Authority
Cocoa Research Institute of Ghana	Cocoa Research Institute of Ghana
CSIR-Food Research Institute	CSIR-Food Research Institute

A presentation on the developed ITC coffee handbook by Dr. John Edem Kongor

Mr. Richard Nyumuah, an ITC consultant gaving a presentation on the developed coffee manual

Dr Samuel Lowor, Deputy Chief Executive, CRIG contributing to the workshop

Samuel Adimado, Manager, Golden Coffee, Accra contributing to the workshop

Meeting with Experts in the Coffee Value Chain

Following the successful stakeholders' workshop to validate the ITC coffee handbook on March 1, 2023, some key experts in the coffee value chain gathered on March 24, 2023, to review the stakeholders' inputs, suggestions, and comments. The meeting was attended by 16 coffee value-chain experts. Among the experts were scientists from the Cocoa Research Institute of Ghana (CRIG), Ghana Cocoa Board (COCOBOD), Food Research Institute (CSIR-FRI), and officials from the Food and Drugs Authority (FDA), Ghana Export Promotion Authority, Ministry of Food and Agriculture (MoFA), International Trade Centre (ITC), coffee processors, and ACRAM.

The main goal of the experts' meeting was to revise the developed ITC coffee handbook, taking into account all of the comments, suggestions, and revisions made by coffee stakeholders during the validation workshop. The meeting was held in Accra at the Director's Conference Room of the Council for Scientific and Industrial Research-Food Research Institute.

The manual was revised to incorporate all the comments and suggestions made by stakeholders during the validation workshop. During the meeting, the experts reviewed the manual again to ensure that all the corrections had been implemented to improve the manual. The experts provided a wide range of perspectives, comments, and suggestions to help improve the manual.

Experts who attended the meeting

A section of the experts during the meeting

Media Launch of ITC Coffee Handbook

The ITC handbook on coffee processing for MSMEs in West Africa was launched in a colourful ceremony at the CSIR-Food Research Institute in Accra following its successful validation and revision by stakeholders and coffee value-chain experts. The launch was attended by key stakeholders in Ghana's coffee value chain. In attendance were representatives from the Ministry of Food and Agriculture, Ghana Export Promotion Authority (GEPA), Ghana Standards Authority (GSA), Food and Drugs Authority (FDA), Department of Nutrition and Food Science (University of Ghana), Coffee Federation of Ghana, ACRAM, Cocoa Research Institute of Ghana, CSIR-FRI, and some coffee processors. The handbook, dubbed 'Harvesting, Post-harvest Management, and Processing of Coffee' was officially launched by Prof. Charles Tortoe, Director of CSIR-FRI; Lawrence Attipoe, National Programme Coordinator, ITC Alliances for Action; and Miss Ivy Cynthia Osei Sampah, ACRAM's Focal Person.

The handbook, which will serve as a comprehensive reference for farmers, processors, SMEs, and other players in the coffee value chain, covers a wide range of topics. It covers crucial topics such as harvesting, post-harvest management, good manufacturing practices, food safety and quality management systems, and product development in coffee processing. The goal is to ensure that overall industry-wide quality standards are met and maintained. The launch was covered by some Ghanaian media outlets, including print, television, and online. Some stakeholders present at the launch also delivered goodwill messages in support of the handbook.

Prof. Charles Tortoe delivering the welcome address

Mr. Lawrence Attipoe addressing stakeholders

Official unveiling and launch of the ITC coffee handbook

ACRAM focal person , Miss Ivy Cynthia Osei Sampah

Mr. Michael Owusu-Manu, Cocoa Research Institute of Ghana

Mr. Samuel Adimado, Coffee Federation of Ghana

Benedicta Tamakloe, CEO of Bean Masters with the launched coffee handbook


Norfund invests $10.5m in Miniplast

BoG engages banks on sustainable banking

ITC launches coffee processing handbook

A Daily Graphic publication on the launch of the ITC handbook

Capacity Building for Coffee Smallholder Farmers and Agro-processors

A capacity-building work and action plan were developed to facilitate the training of coffee agro-processors and other value chain actors in the country. Using the ITC coffee handbook as the primary guide and reference, a total of 104 coffee agro-processors and value chain actors from across the coffee-producing regions in Ghana were trained (Table 3). Interestingly, 66% of the trainees were males and 34% females. There were 71% coffee farmers, 16% coffee processors, 7% coffee farmers/processors, 3% hullers, 1% aggregators, and 2% other value-chain actors among the trainees (Figure 1). Coffee processors refer to SMEs who roast, mill, and package coffee for sale. All the processors in the Volta Region use the traditional open pan and firewood method for roasting the coffee, whereas processors in the Eastern and Ashanti regions use the rotating drum roasters. The majority (50%) of the trainees were 50 years old, with only 9% under 30 years old, an indication that the majority of the youth are not involved in coffee agro-processing.

Table 11. Farmers and agro-processors in the coffee-growing communities who were trained

Region	Community	Number trained
Volta	Ziavi	15
	Kpoeta	8
	Hohoe	17
Eastern	Koforidua	3
	Akuapem-Akropong	17
Ashanti	Adomfe	11
	Kumasi	9
	Bohyen	4
	Barniekrom	12
Ahafo	Duayaw Nkwanta	11
TOTAL		**104**

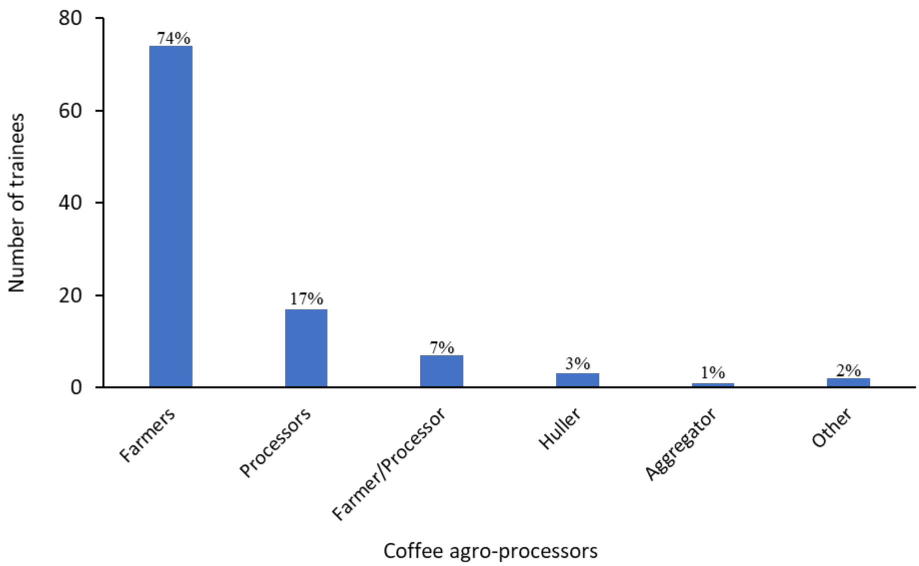


Figure 3. Job description of the trained agro-processors

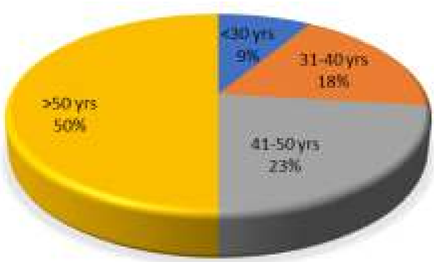


Figure 4. Age distribution of the trained agro-processors

The training focused on best harvesting practices, post-harvest management, roasting and milling, packaging, food safety and quality, good manufacturing practices (GMPs), equipment maintenance, packaging, branding, and labelling. The training was tailored to the intended audience. Training for the farmers, hullers, and aggregators focused more on best harvesting practices, post-harvest management, food safety and quality, and good hygienic practices. The training for processors focused on food safety and quality, GMPs, coffee processing and equipment maintenance, packaging, labelling, branding, and the 5S (S for Seiri, Seiton, Seiso, Seiketsu, and Shitsuke) concept in food processing. To ensure that both coffee farmers and agro-processors understand the importance of finance in farming and processing activities, the training also covered record-keeping, cash flow, and savings. The training was done in the local language of the community. In places where the trainers were not fluent in the local language, a translator was used to translate from English to the local language. Training materials used included PowerPoint presentation and A2 printout where applicable.

Dr. John Kongor explains good postharvest management of coffee through a translator

Dr. Margaret Owusu explains the importance of food safety and hygiene

Dr. Ampah educating the trainees on the need for regular equipment maintenance

Group photograph of trainees and facilitators after the training in Hohoe

Ms. Janet Addo educating trainees on the need for record keeping and savings

Ms. Evelyn Ayeh educating trainees in Akwapem Akropng on food contaminations

Monitoring and Evaluation of Training Results

Monitoring and evaluation (M&E) were done to determine the adoption and application of the lessons learned by coffee agro-processors during the training sessions. The activities of about 30 coffee agro-processors who received training on best harvesting practices, post-harvest management, roasting and milling, packaging, food safety and quality, good manufacturing practices, and equipment maintenance would be monitored and evaluated. Currently, the activities of 15 agro-processors, which include 14 coffee farmers and 1 processor have been monitored and evaluated (Table 4). The M&E was done with a simplified M&E questionnaire, field visits, and discussions.

Table 12. Farmers and agro-processors interviewed in coffee-growing communities

Region	Community	No. interviewed	Job	Received training
Ashanti	Adomfe	4	Farmers	Yes
	Bohyen	1	Processor	Yes
	Barniekrom	5	Farmers	Yes
Ahafo	Duayaw Nkwanta	5	Farmers	Yes
TOTAL		**15**		

Interviewing coffee farmers in Adomfe using an online M&E questionnaire

All of the farmers and agro-processors had received training in postharvest management and coffee processing, primarily from ITC/CSIR-FRI and COCOBOD. Although the majority (66.7%) of the farmers have now resorted to picking the coffee cherries as the method of harvesting in comparison to the 2021 and 2022 seasons, some farmers, particularly in Barniekrom, are still stripping the coffee cherries during harvesting (Figure 3). The responses also showed that some of the farmers do not sort the harvested coffee cherries before drying, resulting in the drying of both the ripe and green (unripe) coffee cherries (Figure 4). This practice has been aged old and more training is required to ensure that all the farmers use picking as the preferred harvesting method and sort out all the unripe coffee cherries before drying. The responses also revealed an improvement in the drying of

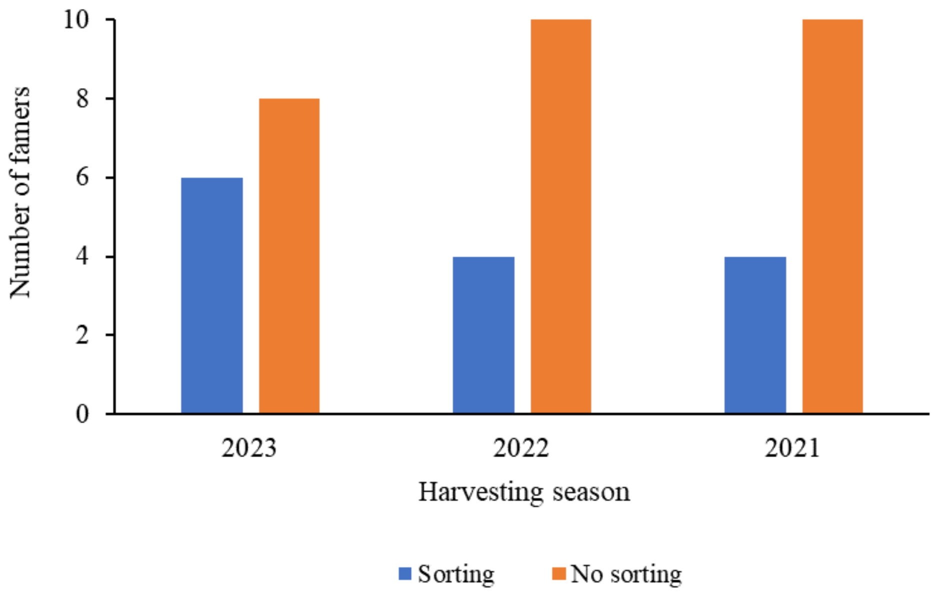


Figure 6: Number of farmers sorting the harvested coffee cherries before drying

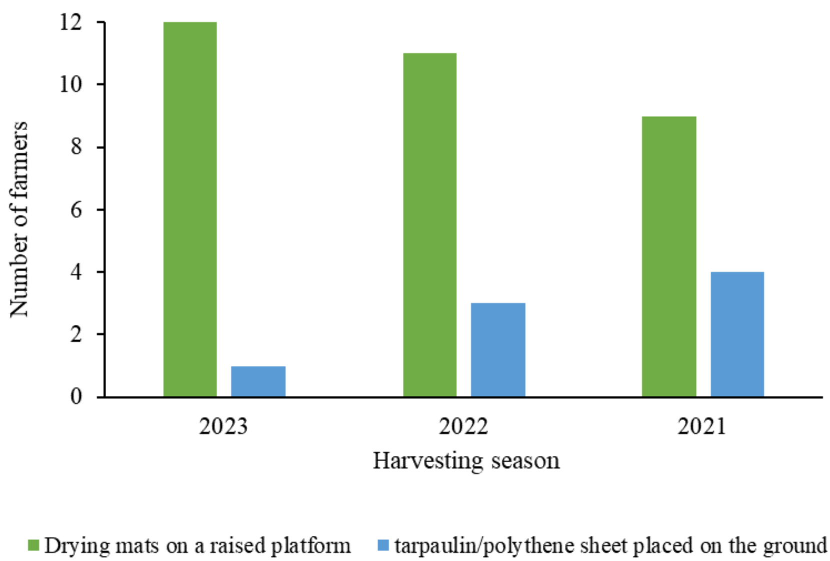


Figure 7: Mode of drying the harvested coffee cherries

Drying of the unsorted coffee cherries after harvesting

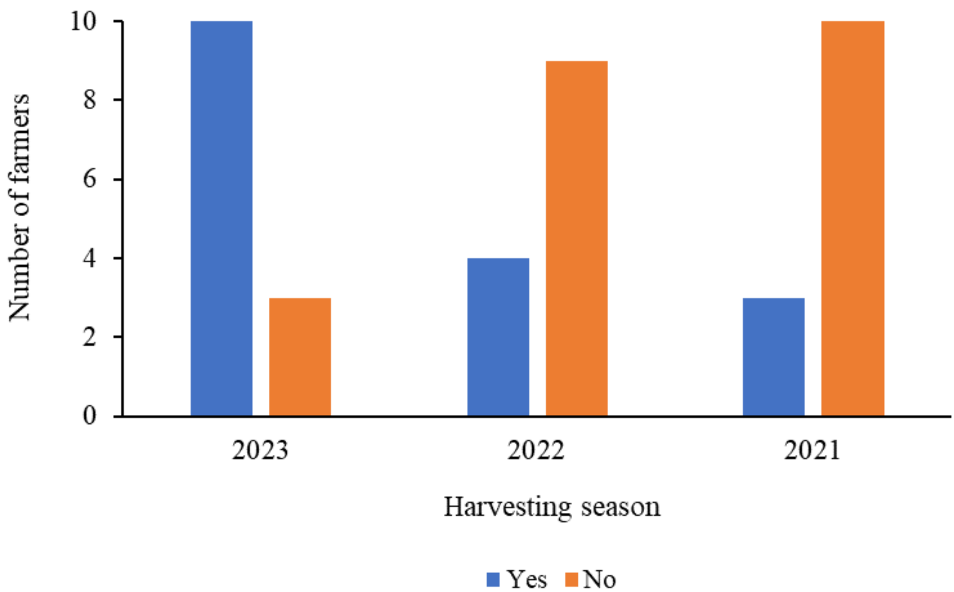


Figure 8. Farmers keeping records of farming activities

coffee cherries, with the majority of farmers drying the coffee on drying mats placed on a raised platform in comparison to the 2021 and 2022 seasons (Figure 5). The majority of the farmers are now keeping records of their farming activities as compared to the 2021 and 2022 seasons.

Figure 5. Coffee cherries harvesting method for the harvesting seasons 2021-2023

A coffee farmer in Adomfe demonstrating the picking method of harvesting coffee cherries

Following the farmer interviews, there were discussions and a visit to some of the coffee farms. The discussions with the farmers provided us with an opportunity to explain the significance of harvesting only mature and ripe coffee cherries and manually sorting the harvested cherries to remove any unwanted materials. The majority of farmers lamented the scarcity of labourers in the communities to help with farm work, particularly harvesting, as well as the presence of ants on the coffee trees during harvesting. This frequently leads to the stripping of coffee cherries during harvesting. Both interviews and discussions revealed that all the farmers sell the dried coffee cherries in the unhulled state, as there are no hulling facilities in their communities.

Discussions and interactions with farmers in Duayaw Nkwanta after the interview

Coffee value-added product development

Product development is critical in coffee processing because it adds value to coffee and diversifies its applications. Approximately 20 coffee products are currently being developed at the Product Development Laboratory at CSIR-Food Research Institute. These primarily include product fortification and recipe development with roasted ground coffee. The products under development include coffee bread, coffee candies, fruit leather, etc. Trials on the use of coffee husks (a byproduct of coffee) as a substrate for mushroom cultivation are also underway. Product development is currently in the initial phase. This will be followed by validation of the recipe, sensory evaluation of the developed products and some physicochemical analyses.

Table 13. Coffee products under development

No.	Coffee product	No.	Coffee product
1.	Fruit leather	11.	Coffee tiger nut milk
2.	Coffee crackers	12.	Coffee barbeque powder
3.	Hot habanero coffee sauce	13.	Coffee candies
4.	Coffee cookies	14.	Coffee waffles
5.	Coffee coconut milk	15.	Coffee gelatin mix
6.	Coffee fruit jam	16.	Coffee bread
7.	Coffee ketchup	17.	Coffee soymilk
8.	Coffee cereal mix	18.	Coffee chocolate spread
9.	Coffee energy bar	19.	Coffee vinaigrette
10.	Coffee rice noodles	20.	Coffee ghee

Development of coffee fruit leather

Trials involving the use of coffee husks in mushroom cultivation

PESTICIDE RESIDUES IN FRESH GARDEN EGGS, OKRA, BELL PEPPER, LETTUCE AND CABBAGE SAMPLED FROM FOUR REGIONS IN GHANA.

Tortoe, C., Ofori, H., Anyebunu, G.
Duration: 12 Months

Introduction

African eggplant, okra, lettuce, bell pepper and cabbage are essential vegetable crops cultivated and consumed both in Ghana and worldwide. African eggplant commonly called garden eggs is important vegetable crop consumed on daily basis by rural and urban communities and serve as a source of income for many households within the forest zones in Ghana (Owusu-Ansah et al., 2001; Danquah-Jones, 2000). Garden egg is nutritionally essential containing protein, fat, carbohydrate, fiber, calcium, phosphorus, iron, vitamin A, B-carotene, ascorbic acid, thiamin and riboflavin (Grubben and Denton, 2004). Okra (Abelmoschus esculentus) is economically important vegetable crop mostly cultivated in tropical and sub-tropical regions across the globe. Immature fruits of okra can be used in the preparation of salad, soups and stews. Okra seeds are potential source of oil and protein with oil yield ranging from 20-40% (Gemede et al., 2015). A review by Gemede et al. (2015) has reported that leaves of okra and lipid component of okra seed oil are good sources of protein, carbohydrate, fat, fibre, calcium, phosphorus, iron, riboflavin, β-carotene, ascorbic acid, thiamin and niacin. Lettuce (Lactuca sativa L.) is among the most widely grown and consumed leafy vegetables worldwide. Lettuce has low content of fat, sodium and calories. Also, lettuce is a good source of fibre, iron, foliate and vitamin C (Kim et al., 2016). It is commonly consumed raw in salad mixes. China is the largest producer of lettuce worldwide, followed by USA and Western Europe (Kim et al., 2016). Bell pepper is consumed for its bioactive compounds and dietary antioxidants. Bell pepper can be used fresh, dried and fermented as colourant, flavourant and as source of pungency in food preparation. A review by Nadeem et al. (2011) on antioxidant potential of bell pepper (Capsicum annum L.), reported that bell pepper has both nutritional and nutraceutical importance. Also, it contains anticoagulant that helps in prevention of blood clot that can cause heart attack. In addition, bell pepper is a good source of vitamin C and important polyphenols (Nadeem et al., 2011). Cabbage is one of the oldest grown vegetables in the world. Globally, cabbage is among the top twenty vegetables and essential source of food. Previous study by Verma et al. (2023) investigated the interaction effect of plant spacing and varieties on growth, yield and quality of cabbage and reported that cabbage is an excellent source of vitamin C, protein, carbohydrate, calcium, iron and sodium. Also, a report by FAO (2000) has stated that cabbaged is rich in vitamin A and C. In addition, Baslam et al. (2011) has reported a rise in demand by consumers for foods that go beyond nutritional needs but also promote well-being, reduce diseases, and increase life span. Furthermore, epidemiological studies have reported a correlation between increased vegetable consumption and reduced risks of chronic diseases, including cancer, cardiovascular disease and age-related functional decline (Hung et al., 2004; Morris et al., 2006; Pavia et al., 2006). All these health benefits are thought to be influenced by macronutrients, micronutrients and bioactive compounds present in vegetables (Kris-Etherton et al., 2002; Soetan et al., 2010).

Pesticide residues, both natural and synthetic have been reported in vegetables and other food commodities (Essumang et al., 2008; Donkor et al., 2016). Pesticides are classified as insecticides, fungicides, nematicides, acaricides, and herbicides depending on their use in agriculture (Donkor et al., 2016). The presence of resistant pests and diseases has resulted in overdose use of pesticides by farmers in agricultural production. The use of higher dosage than recommended may be the cause of high accumulation of pesticide residues in vegetables including garden eggs, okra, bell pepper, lettuce and cabbage (Kariathi et al., 2016). The accumulation of pesticide residues in vegetables and excessive use of pesticides in agricultural production is a public health concern to consumers because pesticides have potential harmful effect on non-targeted organisms. The effect of chronic exposure to organophosphate pesticide residues include metabolic disorders such as genotoxicity, carcinogenesis, neurological disorders, and endocrine disruption (Engel et al., 2017; Muñoz-Quezada et al., 2016; Philippe et al., 2021 and Rani et al., 2021). Chen et al. (2011) investigated pesticide residues in fruits and vegetables sampled from Xiamen in China and reported Acephate concentration ranging from < DL – 4. 082 mg/kg), Chlorpyrifos (< DL – 2.545 mg/kg) and Dimethoate (< DL – 4.210 mg/kg) in cabbage, eggplant and lettuce. According to Chen et al. (2011), cabbage recorded a mean Acephate concentration of 0.0008 mg/kg, Chlorpyrifos (0.0175 mg/kg) and Dimethoate (0.0019 mg/kg); eggplant obtained mean Acephate content of 0.0009 mg/kg, Chlorpyrifos (0.0004 mg/kg) and Dimethoate (0.0004 mg/kg); lettuce recorded mean Acephate concentration of 0.029 mg/kg, Chlorpyrifos (0.0052 mg/kg) and Dimethoate (0.0051 mg/kg).

This study sought to determine the levels of pesticide residues in eggplant, bell pepper, cabbage, okra and lettuce sampled across four (4) major growing regions in Ghana.

Key activities and achievements

A total of 182 fresh vegetables were collected from major vegetable growing regions in Ghana. These vegetables include fresh eggplant (51), okra (47), bell pepper (28), lettuce (24) and cabbage (32) 1 kg each was sampled from farms, aggregators, open markets and supermarkets in selected districts within Greater Accra, Volta, Central and Eastern region of Ghana.

Pesticide extraction in all 182 fresh vegetable samples were carried out using QuEChERS method and Gas Chromatography-Mass Spectrometry (GC-MS) analysis performed on all 182 organic extracts.

A total of forty-three (43) pesticides were monitored in eggplant, bell pepper, okra, cabbage and lettuce collected from major vegetable growing regions in Ghana. The pesticides monitored include; Acephate, Acetamiprid, Ametryn, Allethrin, Amicarbazone, Atrazine, Aclonifen, Azinphos-Ethyl, Boscalid, Bensulfuron-methyl, Chlorfevinphos, Chlorpyrifos, Difenoconazole, Methamidophos, Carbendazim, Methomyl, Monocrotophos, Thiamethoxam, Clothianidin, Imidaclopid, Dimethoate, Sulfoxaflor, Pyrimethanil, Terbutryn, Spiroxamine, Metalaxyl, Prochloraz, Triadimenol, Dimethomorph, Promecarb, Emamectin benzoate, Triadimefon, Tebuconazole, Fluopyram, Metolachlor, Tebufenozide, Pirimifos-methyl, Kresoxim methyl, Indozacarb, Trifloxystrobin, Propaquizafop, Fluazinam, and Pyriproxyfen.

Table 1, Table 2, Table 3, Table 4 and Table 5 shows levels of pesticide residues recorded in fresh eggplant, bell pepper, okra, cabbage and lettuce respectively. Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5 details the percentage eggplant, bell pepper, okra, cabbage and lettuce respectively containing pesticide residues.

Table 14. Levels of pesticide residues detected in egg plant

Name	Use	Mean	Range (mg/kg)	MRL (mg/kg)	No. of samples
Acetamiprid	Insecticide	0.145	0.009 - 0.739	0.3	28
Carbendazim	Fungicide	0.025	0.013 - 0.036	0.5	2
Chlorpyrifos	Insecticide	0.176	0.001 - 0.502	0.01	3
Indoxacarb	Insecticide	0.006	0.003 - 0.008	0.5	2
Tebufenozide	Fungicide	0.065	0.029 - 0.082	0.5	3
Aclonifen	Herbicide	0.006	ND - 0.006	0.3	1
Methamidophos	Fungicide	0.001	ND -0.001	0.5	1
ND means not detected					

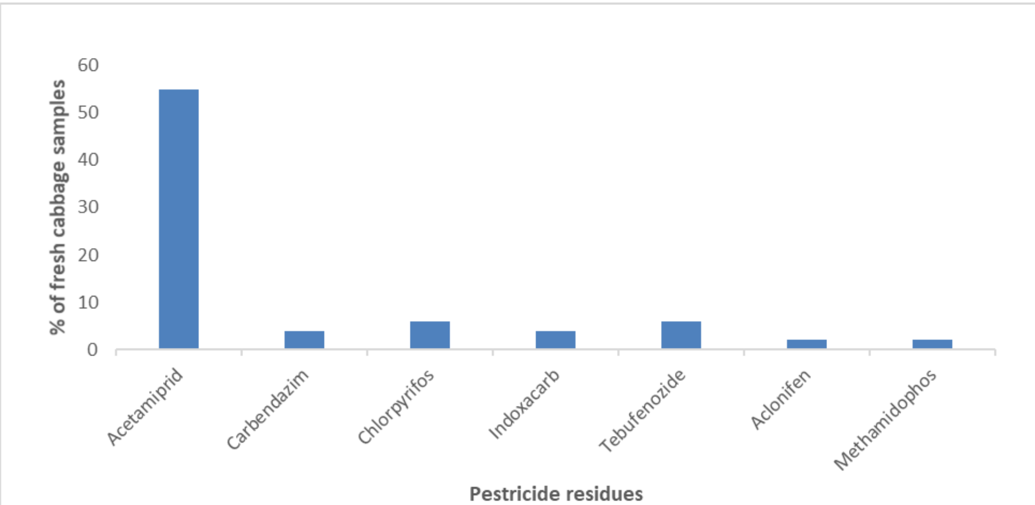


Figure 9. Percentage of fresh eggplant with pesticide residues

Table 15. Levels of pesticide residues detected in Bellpepper

Name	Use	Mean	Range (mg/kg)	MRL (mg/kg)	No. of samples
Acetamiprid	Insecticide	0.088	0.008 - 0.166	0.3	6
Allethrin	Insecticide	0.008	0.004 - 0.015	0.01	7
Chlorpyrifos	Insecticide	0.269	0.069 - 0.469	0.01	2
Difenoconazole	Fungicide	0.099	0.033 - 0.229	0.5	4
Imidacloprid	Insecticide	0.021	0.005 - 0.030	0.5	3
Metalaxyl	Fungicide	0.069	0.001 - 0.180	0.5	5
Methomyl	Insecticide	0.382	0.130 - 0.633	0.2	2
Sulfoxaflor	Insecticide	0.383	ND - 0.383	0.2	1
Tebuconazole	Fungicide	0.001	ND - 0.001	0.1	1
Carbendazim	Fungicide	0.031	0.018 - 0.043	0.5	2

ND means not detected

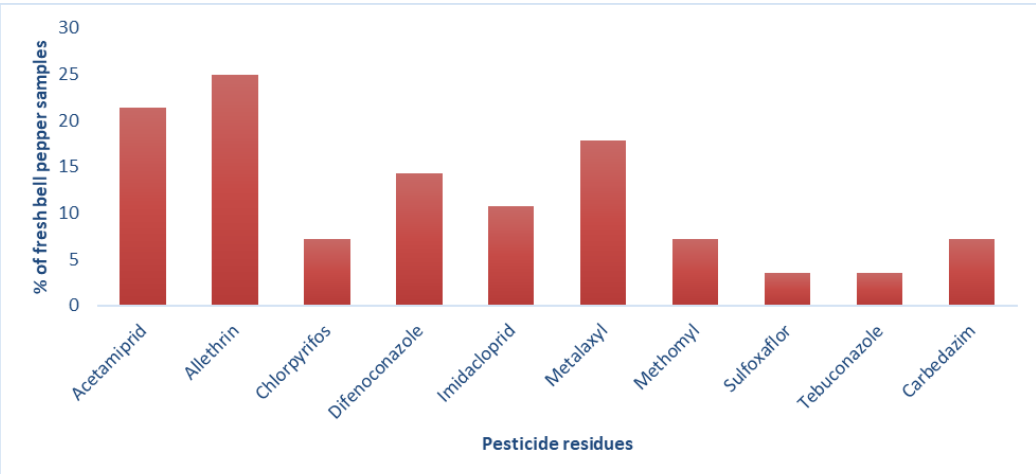


Figure 10. Percentage of fresh bell pepper containing pesticide residues.

Table 16. Levels of pesticide detected in okra

Name	Use	Mean	Range (mg/kg)	MRL (mg/kg)	No. of samples
Acetamiprid	Insecticide	0.125	ND - 0.125	0.3	1
Carbendazim	Fungicide	0.004	ND - 0.004	0.5	1
Chlorpyrifos	Insecticide	0.009	0.004 - 0.024	0.01	4
Tebufenozide	Fungicide	0.004	ND - 0.004	0.5	1
Imidacloprid	Insecticide	1.047	0.033 - 2.061	0.5	2
Thiamethoxam	Insecticide	0.147	0.028 - 0.266	0.01	2
Emamectin benzoate	Insecticide	0.004	ND- 0.004	0.5	1
Metalaxyl	Fungicide	0.014	ND - 0.014	0.5	1
Difenoconazole	Fungicide	0.034	ND - 0.034	0.5	1

ND means not detected

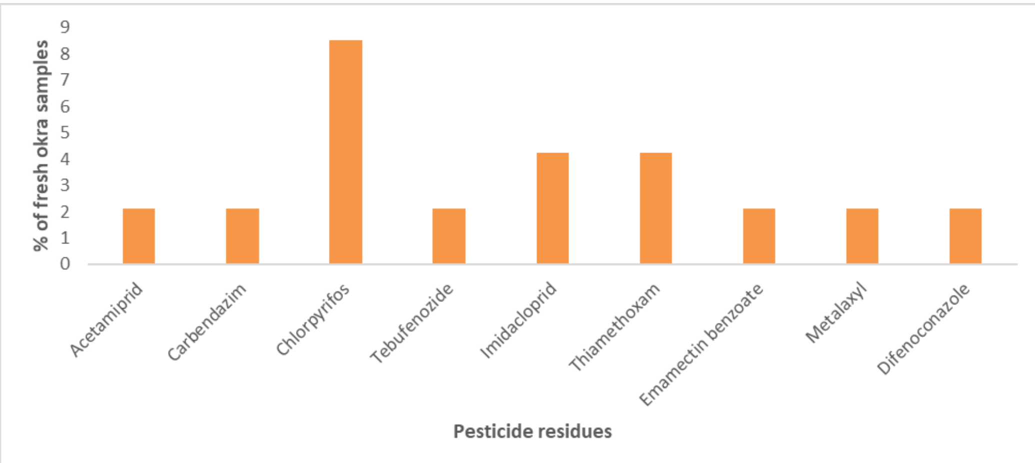


Figure 11. Percentage of fresh okra containing pesticide residues.

Table 17. Levels of pesticide residues detected in cabbage

Name	Use	Mean	Range (mg/kg)	MRL (mg/kg)	No. of samples
Acetamiprid	Insecticide	0.06	0.011 - 0.229	0.3	6
Chlorpyrifos	Insecticide	0.011	0.008 - 0.014	0.01	3
Emamectin benzoate	Insecticide	0.101	0.001 - 0.200	0.5	2
Metalaxyl	Fungicide	0.029	0.004 - 0.052	0.5	4
Difenoconazole	Fungicide	0.002	ND - 0.002	0.5	1

ND means not detected

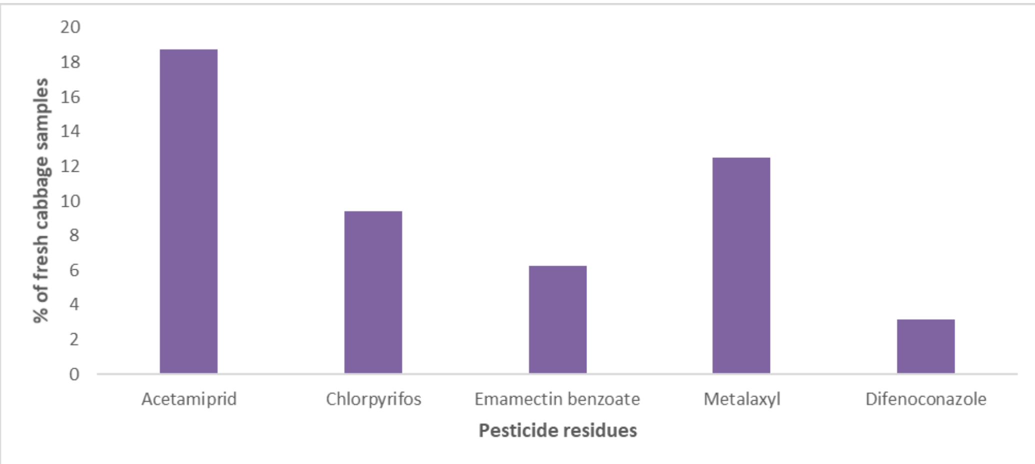


Figure 12. Percentage of fresh cabbage containing pesticide residues

Table 18. Levels of pesticide residues detected in lettuce

Name	Use	Mean	Range (mg/kg)	MRL (mg/kg)	No. of samples
Acetamiprid	Insecticide	0.295	ND - 0.295	0.3	1
Chlorpyrifos	Insecticide	0.011	0.001 - 0.025	0.01	6
Difenoconazole	Fungicide	0.226	0.001 - 0.544	0.5	7
Carbendazim	Fungicide	0.033	ND - 0.033	0.5	1
Emamectin benzoate	Insecticide	0.044	0.023 - 0.065	0.5	2
Dimethomorph	Fungicide	0.015	ND - 0.015	2	1
Allethrin	Insecticide	0.092	ND - 0.092	0.01	1

ND means not detected

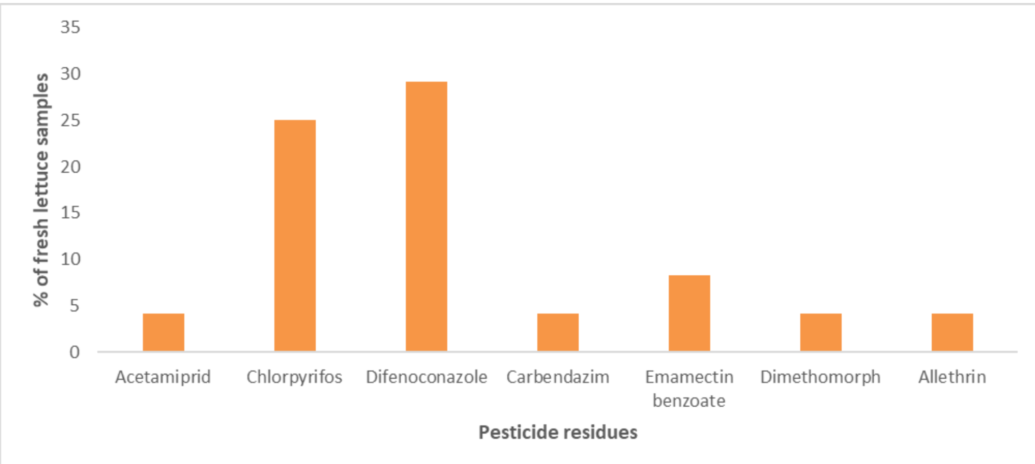


Figure 13. Percentage of fresh lettuce containing pesticide residues.

PERFORMANCE OF YELLOW CASSAVA IN FOOD APPLICATION: DEVELOPMENT OF INSTANT FLAKES, CAROTENOID STABILITY DURING PROCESSING AND STORAGE, AND PRODUCT SHELF STABILITY ESTIMATION.

Akornor, P,T., Arthur, W., and Glover, R. K.
Duration: 18 months

Introduction

Cassava is a major root and tuber crop in Ghana which forms the raw material for a rich diversity of food and industrial applications. It serves as food for many people in Ghana, where in 2019 alone, 22m MT was produced (FAOSTAT, 2020). Traditionally, it is an indispensable source of carbohydrate and is heavily relied on for many local diets. Unfortunately, cassava roots have a very short shelf life and begin to deteriorate a few days after harvest. This can be overcome by processing of the roots into shelf stable forms. Through bio-fortification, elite yellow flesh cassava cultivars containing 1-100 g/g total carotenoids have been developed (Montagnac et al., 2009). Yellow cassava is a potential food base for tackling vitamin A deficiency (VAD) in Ghana and other sub-Saharan African countries where the condition is pervasive. It has marginal levels of key nutrients such as protein, vitamins and minerals thus it is important that this cassava variant is integrated into the Ghanaian food system since it is envisaged to contribute to reducing the incidence of Vitamin A deficiency. Given the importance of β-carotene in human nutrition, it would be useful to promote the adoption and consumption of the biofortified yellow cassava.

The adoption of yellow cassava roots into food processing systems is key to translating its positive impact to consumers. It is therefore imperative to reengineer traditional products or develop and produce value added food products from this cassava variant, as an entry strategy into local food systems. Value addition to yellow cassava will contribute to actualizing its role in the food-based approach to mitigating VAD. Actors along the cassava value chain such as farmers will benefit immensely from the unexploited profit to be accrued by improving the crop's economic potential through value addition. Processors and consumers will also benefit through product diversity, and ultimately adoption of yellow cassava.

Efforts to improve the nutritional status of cassava has led to the development of yellow cassava which is rich in β-carotene. This cassava variant appears to be popular in countries such as Indonesia and Brazil (Anggriaini et al., 2009, Berni et al., 2014). However, a different situation pertains in Ghana and other parts of Africa, where consumer acceptance remains a major challenge for adoption. It is less popular because of restricted widespread consumption and cultivation. Its utilization is poorly diversified and the potential of developing value-added cassava-based food products remain underexplored. Because of its sensitivity to heat and light, it is important that denaturing of β -carotene is minimized during processing. This may be achieved by high-temperature-short-time (HTST) processing techniques such as drum drying. Drum drying has a marginal effect on -carotene (Wu et al., 2008), and it presents a good opportunity to process YF cassava. Understanding the dynamics of carotenoid loss in drum drying is crucial for controlling and predicting -carotene levels during processing.

The main objective of the study was to develop instant flakes from yellow cassava and determine the carotenoid stability, processing and storage stability.

The specific objectives of the project were to optimize the drum drying of yellow cassava flakes using response surface methods, determine the degradation, digestibility and bioavailability of carotenoids of cassava flakes and establish the keeping properties of the product and stability of β-carotene in storage.

Key Activities and Achievements

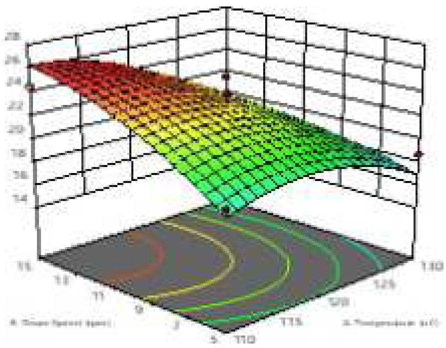
The aim of this study was to optimize the processing conditions for the production of drum dried cassava flakes using response surface methodology, determine the impact of processing and storage on carotene breakdown and study the keeping properties of the flakes. Drum temperature (110 – 130 °C), Speed of rotation (5 – 15 rpm) and slurry solids concentration (20 – 40%) were used to optimize the process using numerical methods, in which definite criteria were set for the dependent variables (physicochemical and sensory attributes). Physicochemical, functional and sensory properties of the product were determined using standard procedures. Also, breakdown of β-carotene during processing and in storage were modelled using a first order kinetic reaction and shelf life of the product was estimated through regression. Non-linear regression indicated that the processing conditions and their interactions affected the various physicochemical and sensory attributes differently. The optimum conditions for processing instant flakes with a good consumer appeal (overall liking of 6.5 on a 7-point hedonic scale) were Drum temperature of 116 °C, Speed of 12 rpm and solids concentration of 20%. Microstructural analyses indicated a product with a flat geometry and high porosity. During processing, an increase in temperature heightened the destruction of carotenoids, whereas high drum speed (shorter drying time) had a protective effect, with carotene retention ranging between 16 to 79%. The best packaging for keeping the product was determined to be an opaque material which could be sealed airtight to restrict the entry of light and oxygen. Overall, the product was estimated to have a shelf life of 22 months.

Figure a: Sliced Yellow Cassava

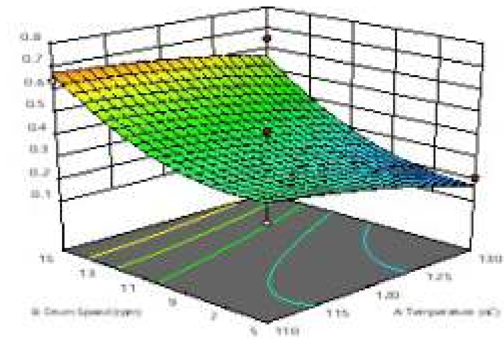
Figure b: Blanched Yellow Cassava Flakes

Figure c: Drum Drying

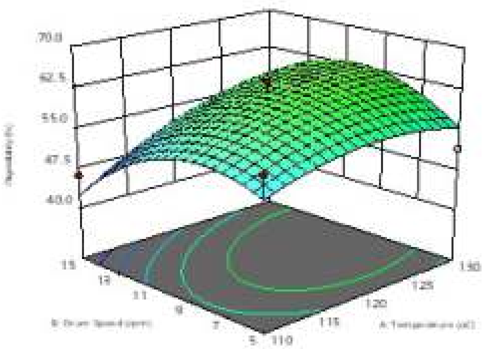
Figure d: Yellow Cassava Flakes



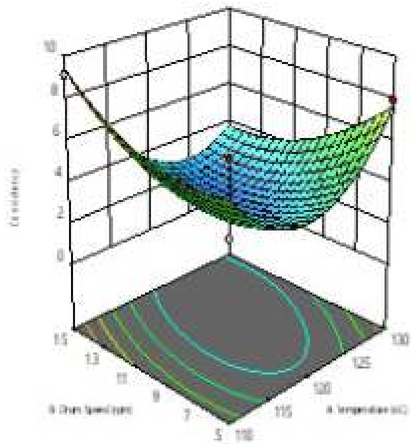
a) Yellowness (b*)



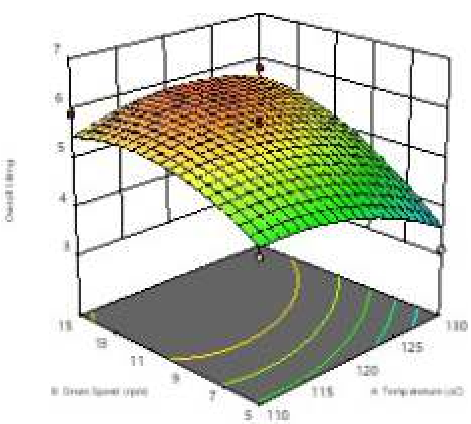
b) Water Activity



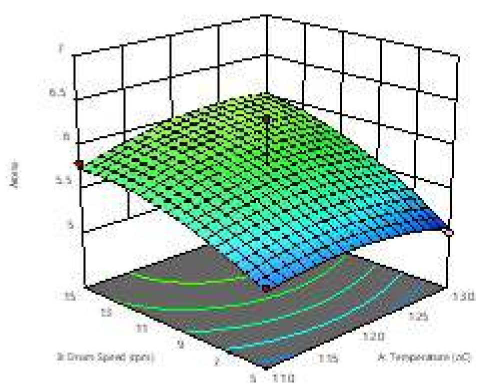
c) Digestibility



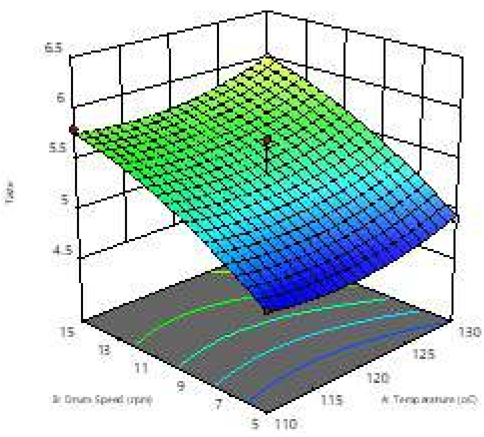
d) Consistency



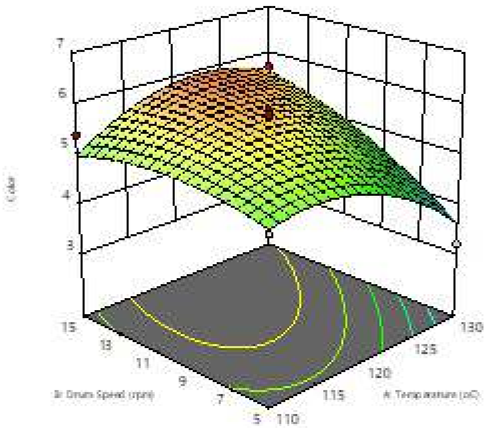
a) Colour



b) Aroma



c) Taste



d) Overall Likeness

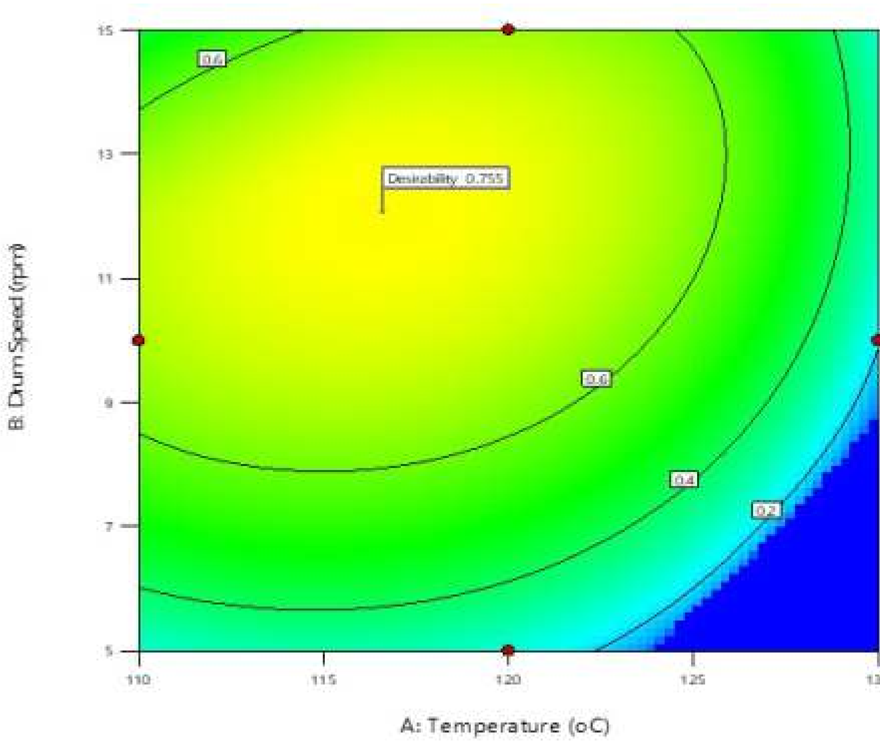
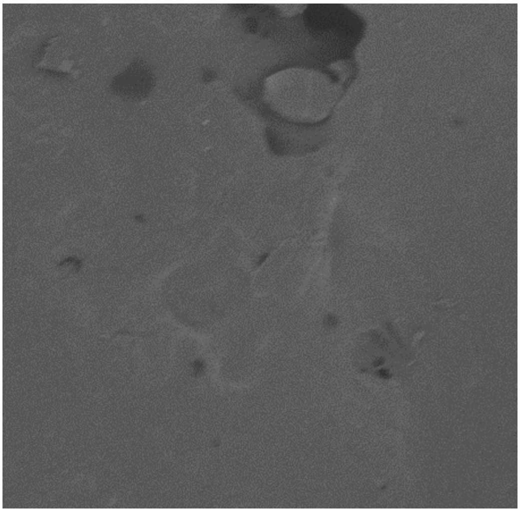
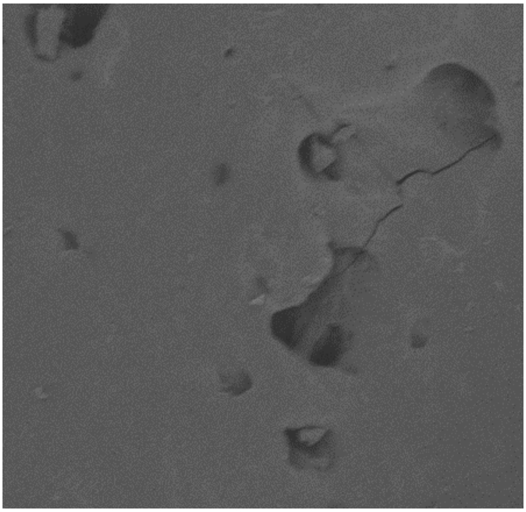


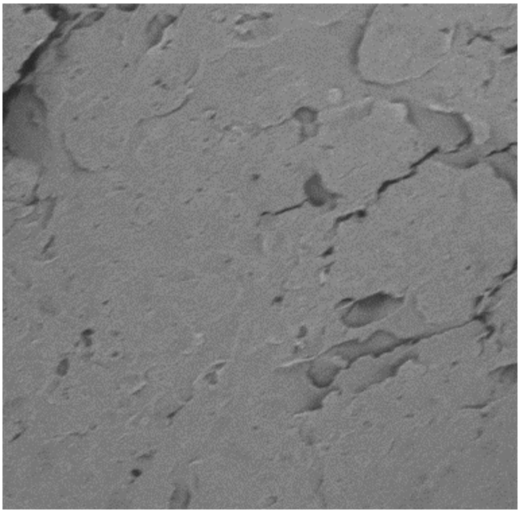
Figure 14. Optimum processing condition (indicated by the flag) for cassava flakes
Microstructure of drum dried flakes



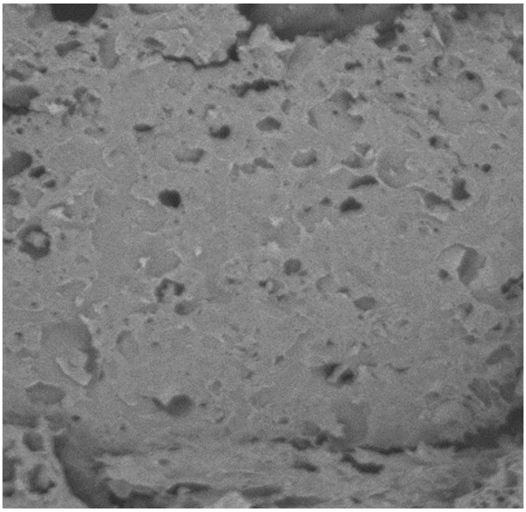
a) 130 °C, 10 rpm, 40%



b) 120 °C, 5 rpm, 40%

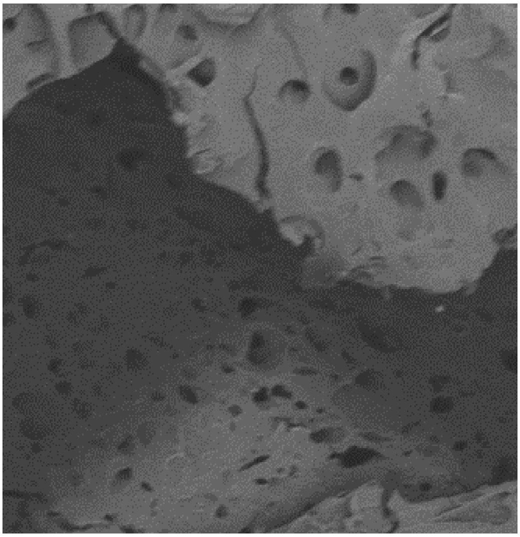


c)130 °C, 15 rpm, 30%

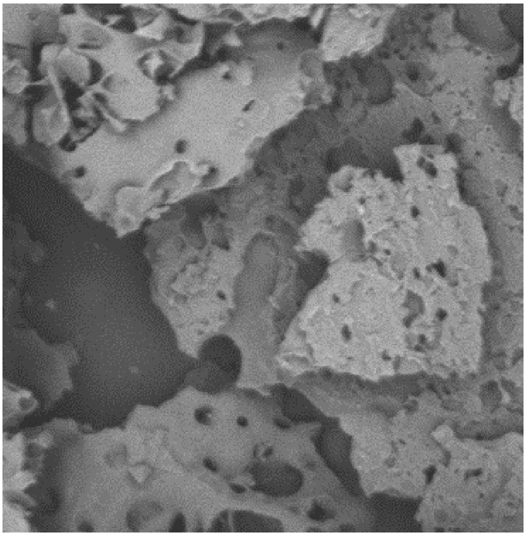


d)110 °C, 10 rpm, 20%

Electron micrographs of drum dried flakes



e) 110 °C, 5 rpm, 30%



f) 120 °C, 10 rpm, 30%

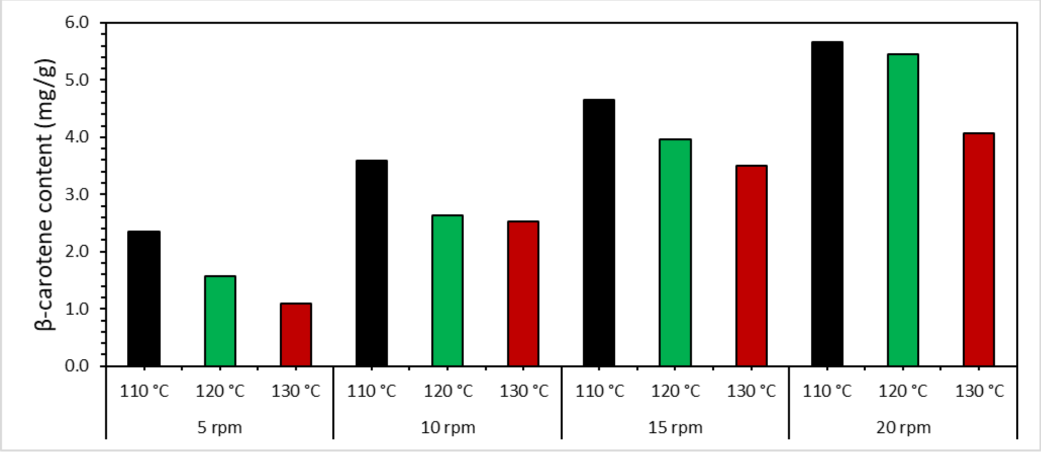


Figure 15. β-carotene content of drum-dried flakes as a function of drum drying temperature (°C) and drum rotational speed (rpm)

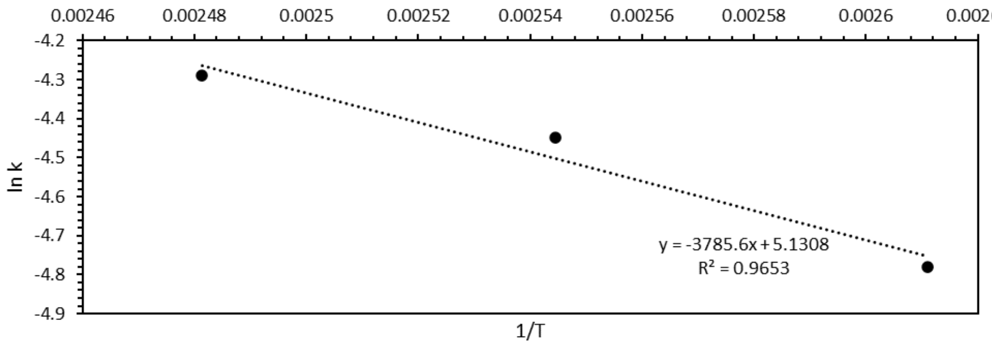


Figure 16. β-carotene degradation rate as a function of drum dryer temperature

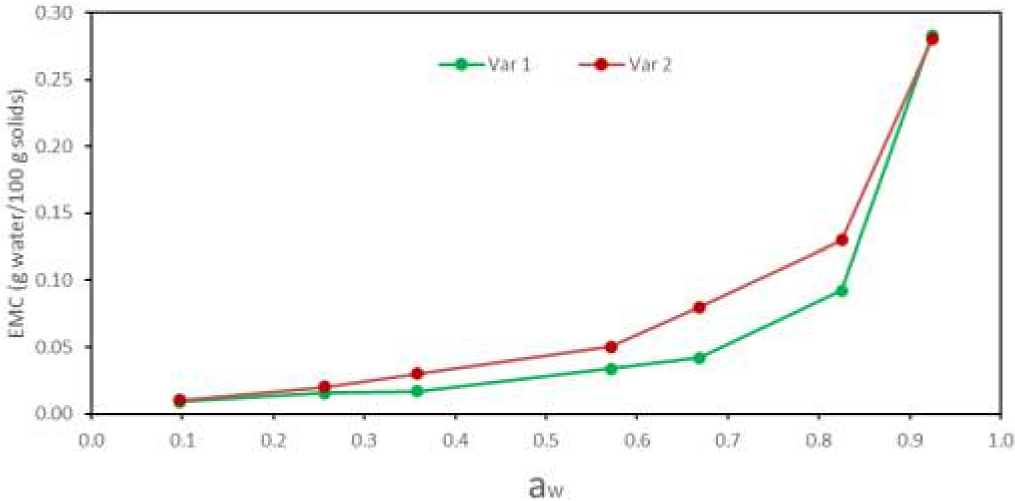


Figure 17. Moisture sorption isotherm of flakes from two yellow cassava varieties

ABSTRACTS FROM PUBLISHED PAPERS

Granular structure, physicochemical and rheological characteristics of starch from yellow cassava (Manihot esculenta) genotypes

Akonor, P. T., Osei Tutu, C., Arthur, W., Adjebeng-Danquah, J., Affrifah, N. S., Budu, A. S., Saalia, F. K.

This study examined the structural and physicochemical characteristics of starch isolated from seven yellow cassava genotypes. The structural properties of yellow cassava starch from these cultivars were elucidated by scanning electron microscopy, X-ray diffractometry and Fourier Transformed Infrared Spectroscopy (FTIR). Their water interaction properties, digestibility and viscoelastic behavior were also compared, and principal component analysis was used to establish factors associated with the variability in properties of the starch. All the starches were of the A-type diffraction pattern, with crystallinity ranging between 31 and 37%. Most of the granules exhibited spherical and oval shapes, some with a flat surface on one side. They had smooth surfaces and their sizes ranged from 4 µm for round granules to 23 µm for the major axis of oval-shaped granules. Significant differences ($p < .05$) were observed in amylose content, in-vitro digestibility, peak and breakdown viscosity of the starches, and these ranged between 13.6–18.1%, 11.4–18.5%, 354–520 BU and 233–366 BU, respectively. Significant differences were also recorded in the hydration and textural behavior of starches from these cassava cultivars. The differences observed in granular and physicochemical properties are likely to influence the performance of these cassava cultivars in food applications.

Heavy metal, microbial and pesticides residue contaminations are limiting the potential consumption of green leafy vegetables in Ghana: an overview

Atitsogbey, P.; Kyereh, E.; Ofori, H.; Johnson, P. N. T.; Steiner-Asiedu, M.

Green leafy vegetables (such as cocoyam (Colocasia spp) leaves, spinach (Spinach spp), amaranths (Amaranthus spp), roselle leaves (Hibiscus spp), and lettuce (Lactuca spp)) form a major part of Ghanaian meals providing essential vitamin such as A, B and C and minerals including iron and calcium as well as essential bioactive compounds. However, the practices involved in the production, distribution and handling of these nutrient rich

vegetables, by most value chain actors in Ghana, unfortunately pre-dispose them to contamination with pathogens, heavy metals and pesticides residues. These have therefore raised public health concerns regarding the safety and quality of these green leafy vegetables. Understanding the current perspectives of the type of pathogens, heavy metals and pesticide contaminants that are found in leafy vegetables and their health impacts on consumers will go a long way in helping to identify appropriate mitigation measures that could be used to improve the practices involved and thereby help safeguard human health. This review examined reported cases of microbial, heavy metal and pesticides residue contamination of green leafy vegetables in Ghana from 2005 to 2022. Notable pathogenic microorganisms were Ascaris eggs and larvae, faecal coliform, Salmonella spp., Staphylococcus aureus Streptococci, Clostridium perfringes, and Escherichia coli. In addition, Lead (Pb), Cadmium (Cr), Chromium (Cr), Zinc (Zn), Iron (Fe), Copper (Cu) and Manganese (Mn) have been detected in green leafy vegetables over the years in most Ghanaian cities. Pesticides residues from organochlorine, organophosphorus and synthetic pyrethroid have also been reported. Overall, microbial, heavy metals and pesticide residue contamination of Ghanaian green leafy vegetables on the farms and markets were significant. Hence, mitigation measures to curb the contamination of these vegetables, through the food chain, is urgently required to safeguard public health.

The processing, preparation, and cooking practices of small fish among poor Ghanaian households: an exploratory qualitative study.

Agyei-Mensah, Y. O., Annan, T., Overå, R., Atter, A., Hatløy, A., Andersen, P., Obiri, K. O., Ansong, R. S., Janananda, B., Steiner-Asiedu, M., Kjellevold, M.

Small fish are an important part of the diet in Ghana, but malnutrition rates remain high. The nutritional quality of fish consumed in Ghana may be affected by food processing and cooking practices, but the extent to which these processes are practiced among poor Ghanaian households along the coastal belt is unknown. This study explored how poor Ghanaian households process, prepare, and cook meals containing small fish. This exploratory qualitative study used Attride-Stirling thematic network analysis. Respondents were purposively sampled from fishing communities in the coastal regions of Ghana. One-on-one interviews were performed by trained field assistants, audio recorded and videotaped, and transcribed for further data analysis. The most common small fish species identified were anchovies and herrings. Anchovies were fried and eaten whole. Herrings were eaten either smoked or fresh; for fresh herring, the head, fins, and viscera were removed before boiling. Herrings were smoked with the head and viscera; however, both the head and viscera were removed before being added to boiling soup and were not consumed. Anchovies were fried for 10 min, and herrings were boiled for 15–30 min. Processing methods and further meal preparation depend on the small fish species. Nutrient composition and contribution of small fish depend on the processing method, preparation method, and what tissues are eaten. Thus, these results will be of importance for sampling schemes for food composition tables and for the calculation of nutrient intake from small fish.

CSIR- WORLD FOOD DAY CELEBRATIONS

World Food Day is held annually on 16th October since 1945, to commemorate the day the Food and Agriculture Organization of the United Nations (FAO) was founded. The day is celebrated widely by many other organizations such as the CSIR-Food Research Institute who are concerned with hunger, poverty and food security. The day has been dedicated to promoting the idea of feeding the world and eliminating poverty in nations. The global theme for 2023 World Food Day was "Transforming Food Systems for Nutrition, Health, Wealth and Sustainability, For All". In commemoration of the World Food Day, the Council for Scientific and Industrial Research - Food Research Institute (CSIR-FRI) in collaboration with Food and Agriculture Organization (FAO) organized a three (3) days celebration with a Food Fair exhibition. The event was held from Wednesday 12th to Friday14th of October 2023 at the forecourt of the CSIR-FRI, Accra.
The program was in three (3) parts consisting of a Master class, an innovative challenge, and an exhibition.

As part of the Food Fair 2023, the Master class was organized to educate and inform Small Medium Entrepreneurs (SMEs) on how to start a food processing business in Ghana. A start-up business, they required careful planning, adherence to regulations, and effective execution. The master class was for participants to gain valuable insights, practical knowledge to navigate the intricacies of the industry, empower them to make informed decisions and set up businesses for success in a vibrant food processing sector in Ghana.

The official opening of the Food Fair was on Thursday, 13th October 2023 with a two (2) day exhibition from Thursday, 13th October 2023 to Friday 14th October 2023. The Food Fair took place at the Forecourt of the CSIR- Food Research Institute at 10am with a cultural display ushering in the dignitaries. Amongst them were bigwigs from both industry and academia, the embassies, the regulatory bodies as well as government officials including:

1. Hon. Kweku Afriyie – Minister for Environment, Science, Technology and Innovation
2. Prof. Paul Pinnock Bosu – The Director General, CSIR
3. Prof. Charles Tortoe– Director, CSIR- Food Research Institute
4. Nana Osei Bonsu - CSIR_-FRI Board Chairman (CEO of Private Enterprise)
5. Her Excellency Gomez Iniala - (Peru Ambassador to Ghana)

There were about sixty (60) exhibitors from various institutions ranging from CSIR-Institutes, the Embassies, SMEs, Fish mongers Association, Mushroom Cultivators and cooked food vendors.

The Innovation Challenge as part of the world food day celebrations was organized as part of the 2023 CSIR Food Fair event took place at the Director's Conference Room within the hours of 13:30 to 16:30 GMT. The aim of this competition was to promote innovative technologies that address food production, safety, postharvest losses, nutrition, and environmental issues while creating wealth, employment, and poverty reduction especially in rural areas. Awards was given in the following categories: Food Safety Innovation award; Most Innovative Food Business Start-up award; Best Artificial Intelligence and Digitization Solution for the Food Industry.

The fair was supported by International Trade Centre, Food and Agricultural Organization, BlowChem Industries Limited, Sir Cool -CSIR-Water Research Institute, and Cocoa Processing Limited.

Mushroom Association Group at the exhibition

Director of CSIR FRI with some Dignitaries

An SME at the exhibition

Dignitaries at the exhibition

Display of food products at the exhibition

Innovation challenge participants with judge

MTN Telco at the exhibition

Minister of Food and Agriculture engaging the media

Director General of CSIR engaging cultural troupe

COMMERCIAL SUMMARY

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

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

Product development session for a client

Staff conducting microbial analysis on food samples.

Mushroom training session

Soymilk production session

A group of women at a traing session

A group of women participants at a training

FRI new products are now registered with FDA under the brand name Foodsearch

MARKETABLE TECHNOLOGIES

CSIR-FRI developed thirty-five (35) value added products, which have been taken up by entrepreneurs. Products included:

1. Snail in sauce
2. Cassava cake
3. Vacuum-packed jollof
4. Vacuum-packed fried rice
5. Granola bars
6. Sweet potato pudding
7. Orange-fleshed sweet potato (OFSP) pudding
8. Snail in brine
9. Spiced prekese syrup
10. Tilapia hot pepper sauces
11. Frozen spiced Tilapia
12. Tilapia in tomato sauce
13. Tilapia in oil
14. Gari mix
15. Canned snail
16. Instant maize grits
17. Instant tom brown
18. Instant maize cereal
19. Ginger spice Paste
20. Pepper spice Paste
21. Garlic spice Paste
22. Sweetened groundnut paste
23. Wheat crackers
24. Rice cookies
25. Wheat cookies
26. Rice crackers
27. Wheat/ Rice cookies
28. Wheat/ Rice crackers
29. Cassava chips
30. Instant maize grits
31. Spice seasoning
32. Mixed spices
33. Fruit bar
34. Pumpkin soup

Within the year 6,255 analytical services were rendered to industry/stakeholders on various number of samples. 48% of analysis were on microbial analysis while 40% and 12% were on chemical and mycotoxin analysis, respectively as shown in **Figure 18.**

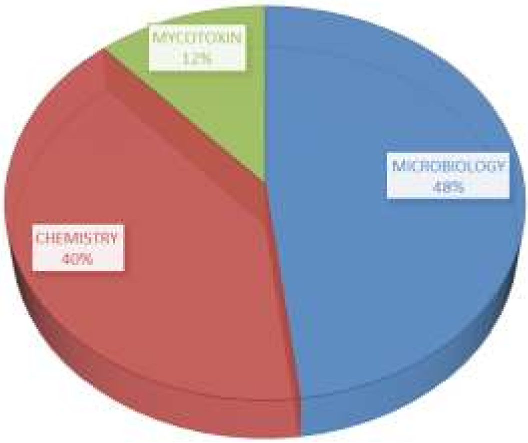


Figure 18: Proportions of analytical services rendered to clients.

FINANCIAL SUMMARY

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

The Institute generated a sum of $ 289,916.84 representing 78% of Funds as Internal Generated Funds (IGF) and $ 81,466.00 representing 22% was received as Donor funds for Research and Development. Donor agencies within the year included: ITC (ACP Coffee), FAO (FAO Consultancy), CABI International (Pesticide residues in fresh tomatoes) and ECOWAS project (ECOWAS)

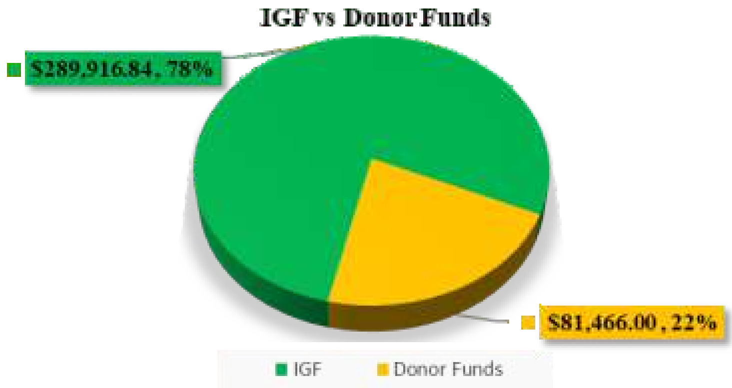


Figure 19: Comparing Donor funds and IGF

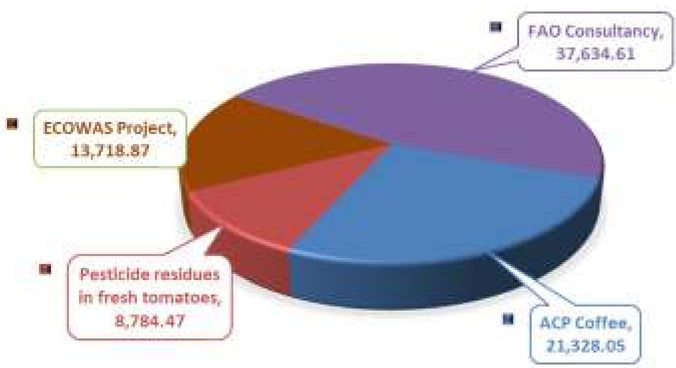


Figure 20: Representation of donor funds received within the year.

ADMINISTRATIVE ACCOUNT

CSIR-FRI has a staff strength of one hundred and fifty-seven (157), comprising of 56% male and 44% female. Staff are grouped under Junior staff, Senior staff and Senior members (made of Research Staff, Principal Technologists and Administrators). The proportions of staff category are as shown in Figure 21.

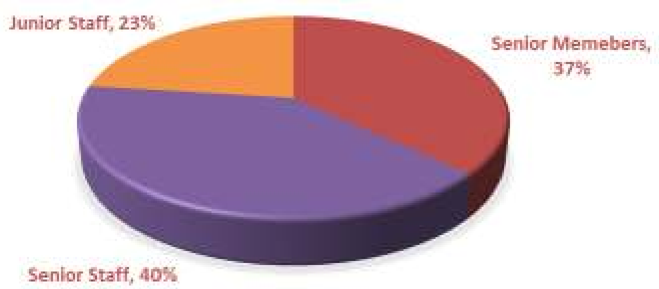


Figure 21: Percentage distribution of staff

Promotions

The following staff were promoted effective January, 2023

NO.	NAME	OLD GRADE	NEW GRADE
Senior staff			
1.	Ms. Judith Narkie Larweh	Principal Marketing Assistant	Chief Marketing Assistant
2.	Mrs. Angela Addy	Principal Stores Supt.	Chief Stores Supt.
3.	Ms. Walase Efordzi	Principal Stores Supt.	Chief Stores Supt.
4.	Mrs. Ruth Naa Gumah	Technical Officer	Senior Technical Officer
5.	Mrs. Alice Padi	Principal Tech. Officer	Chief Technical Officer
Junior Staff			
6.	Mr. Jeff Wilson Afenu	Tradesman Grade II	Artisan
7.	Mr. Ebenezer Tieku	Security Assistant Grade I	Senior Security Assistant
8.	Mr. Emmanuel K. Tetteh	Artisan	Senior Tech. Assistant
9.	Mr. Samuel Adjei	Junior Foreman	Foreman
10.	Ms. Vicentia Mienuye	Supervisor Grade I	Technical Assistant Grade I

Upgrading

The following underlisted staff were upgraded to Accountant, Marketing Officer and Assistant Research Scientist grade after completion of their Masters' degree programmes in 2023.

No.	Name	Area of Study/Training Institute	New Grade/Effective Date of Upgrading
1.	Ms. Janet Abena Addo	MBA, Accounting and Finance, UPSA	September, 2023
2.	Mrs. Getty Appia-Agyei	MBA, Marketing, University of Ghana	August, 2023
3.	Mr. Paul Godwin K. Fordjour	MBA, Marketing, University of Ghana	August, 2023
4.	Ms. Jackline Boateng	M.Phil., Food Science and Technology, CCST	September, 2023
5.	Ms. Emefa Gblende	M.Phil., Food Science and Technology, CCST	September, 2023
6.	Mr. Badaru Deen Yahaya	M.Phil., Food Science and Technology, CCST	March, 2023
7.	Mr. Philip K. Mensah	M.Phil., Food Science Technology, C CST	March, 2023
8.	Mr. Emmanuel Mensah	M.Phil., Food Science Technology, CCST	March, 2023

Transfers

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

1. Mrs. Rita Tsiquaye, Senior Public Relations Officer was transferred from Head Office to the Institute effective 29th January, 2023.

Retirement

The underlisted staff proceeded on compulsory retirement during the year:

1. Mr. Ebo Eyeson, Chief Technical Officer
2. Mr. Raphael Kavi, Librarian
3. Mr. Anthony W.K. Sevor, Snr. Assist. Trans. Officer
4. Mr. Bob Atulibok, Snr. Security Asst.

OUR STAFF

DIRECTORATE

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

ADMINISTRATION DIVISION

1.	Mrs. Vivian Anane	-	Senior Admin. Officer (Head, Administration)
2.	Mrs. Victoria A. Asunka	-	Admin. Officer (Head, HR Section)
3.	Ms. Gloria Ghansah	-	Senior Admin. Assistant
4.	Ms. Esther Lamptey	-	Admin. Assistant
5.	Ms. Rebecca Sefiah Drah	-	Admin. Assistant
6.	Ms. Doris Menuye	-	Front Desk Officer
7.	Mr. Emmanuel Kofi Bediako	-	Administrative Assistant

Transport Section

9.	Mr. Eric K. Ofori	-	Administrative Officer (Head of Section)
10.	Mr. Anthony Sevor	-	Snr. Asst. Transport Off.
11.	Mr. Gariba Alimyao	-	Snr. Asst. Transp. Officer
12.	Mr. Samuel Tettey Odjao	-	Snr. Asst. Transp. Officer
13.	Mr. Seth Achuson	-	Assistant Transport Officer
14.	Mr. Daniel Ayiku	-	Driver Gd. I

15.	Mr. Moses Narh	-	Driver Gd. II
16.	Mr. Philip Tetteh	-	Driver Gd. II
17.	Mr. Carlos Babonye	-	Driver Gd. II

Estate Section

18.	Mr. Edmund Mensah-Yemoh	-	Chief Works Supt. (Head of section)
19.	Mr. Abel Sogbe	-	Snr. Tech. Assist.
20.	Mr. Samuel K. Adjei	-	Junior Foreman
21.	Mr. Joseph Adivor	-	Supervisor Gd I
22.	Mr. Daniel Obeng Oduro	-	Supervisor Gd I

Security Section

23.	Mr. Philip Agyaye	-	Prin. Security Off. (Head, Security Section)
24.	Mr. Samuel Quaye	-	Snr. Security Off.
25.	Mr. Thomas Annor	-	Security Officer
26.	Mr. Justice Blankson Dadzie	-	Snr. Security Asst.
27.	Mr. George Tetteh	-	Snr. Security Asst
28.	Mr. Francis Azure	-	Snr. Security Asst.
29.	Mr. Abass Abdulai	-	Snr. Security Asst
30.	Mr. George Ankwa	-	Snr. Security Asst
31.	Mr. Bob Atulibok	-	Snr. Security Asst
32.	Mr. Ebenezer Tieku	-	Security Asst. Gd I
33.	Mr. Kojo Adamu	-	Security Asst. Gd I
34.	Mr. Sunday Akantokdingin	-	Security Asst. Gd I
35.	Mr. Edmund Gyampoh	-	Security Asst. Gd I
36.	Mr. Gabriel K. Buluka	-	Security Asst. Gd II

FINANCE DIVISION

1.	Mr. Gladstone S. Cudjoe	-	Prin. Accountant (Head of Division)
2.	Mr. Derrick Victor Sallah	-	Accountant
3.	Mr. Christian Amegah	-	Accountant
4.	Ms. Judith Dogbegah	-	Chief Accounting Asst

Deceased

1. Mr. Sunday Akantokdingin - Security Asst. Gd I

Study Leave

The underlisted staff were granted Study Leave-with-Pay to undertake various courses at the graduate level:

No.	Name	Duration of Course	Grade	Course/Level
1.	Stacy Ayitey	2 years	Technical Officer	MPhil, Food Science and Technology
2.	Naomi Agyabeng	2 years	Principal Account. Assistant	MBA, Accounting and Finance
3.	Mr. Kofi Amegah	3 years	Accountant	PhD, Business Admin. (Accounting)
4.	Mr. Felix Afotey	2 years	Technical Officer	MPhil, Food Science

National Service/Internship Training

The Institute received 86 National Service Personnel in 2022-2023 academic year. The breakdown is as follows:

Year	Total	Female	Male
2023-2024	86	38	50
Percentage			

Resignations

The following staff resigned from the service of the Council in 2023.

1. Mrs. Nancy Nelly Brew-Sam - 1st Novemer, 2023
2. Mr. Ahmed Rufai Braimah - 15th February, 2023

5.	Ms. Wolase Efodzi	-	Prin. Stores Supt.
6.	Mrs. Angela Addy	-	Prin. Stores Supt.
7.	Mrs. Naomi Agyebeng	-	Prin. Accounting Asst.
8.	Ms. Judith Narkie Larweh	-	Prin. Marketing Asst.
9.	Ms. Regina Tsotsoo	-	Snr. Accounting Asst.
10.	Mr. Gasu Aikins	-	Snr. Accounting Asst.
11.	Ms. Eclipseena N. O. Johnson	-	Accounting Assistant
12.	Ms. Janet Abena Addo	-	Accounting Assistant
13.	Ms. Rejoice Abla Fiazorli	-	Accounting Assistant
14.	Mr. Prince K. Akuffo	-	Senior Accounts Clerk

COMMERCIAL DIVISION

1.	Mr. Stephen Nketia	-	Scientific Secretary / Head of Division
2.	Mr. Thomas Najah	-	Marketing Officer
3.	Mr. Jeremiah Lartey- Brown	-	Principal Technologist
4.	Mr. Solomon Dowuona	-	Snr. Technologist
5.	Mr. Richard Takli	-	Snr. Technologist
6.	Mr. Philip.O. Baidoo	-	Chief Marketing Asst.
7.	Ms. Justina Thompson	-	Chief Marketing Assist.
8.	Ms. Joana B. Dzikunu	-	Chief Admin. Officer
9.	Mrs. Getty Appiagyei	-	Chief Technical Officer
10.	Mr. Ofori Brempong	-	Prin. Technical Officer
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.	Ms. Carris Dogbeda Ackuaku	-	Snr. Tech. Officer
16.	Mrs. Rose Agorkor	-	Snr. Technical Officer
17.	Mr. Deladem Ahiabor	-	Accounting Assistant
18.	Mr. Godson Agbeley	-	Technical Officer
19.	Mr. Paul Boadi	-	Technical Officer
20.	Mr. Foster Akplaga	-	Technical Officer
21.	Ms. Lydia Owusu Sekyere	-	Technical Officer
22.	Ms. Jackline Boateng	-	Technical Officer

23.	Ms. Stacy Ayitey	-	Technical Officer
24.	Ms. Sophia Apenteng	-	Technical Officer
25.	Ms. Naomi Taye	-	Technical Officer
26.	Mr. Paul Godwin Fordjor	-	Marketing Assistant
27.	Mr. Stephen Kofi Antwi Amoah	-	Senior Technical Assistant
28.	Ms. Elizabeth Attah	-	Tech. Asst. Gd. II
29.	Mrs. Ernestina Armah	-	Tech. Asst. Gd. II
30.	Mr. Ababase Akanzinam	-	Supervisor Gd. I
31.	Mr. Daniel Nuertey	-	Traffic Supervisor
32.	Ms. Vicentia Mienuye	-	Supervisor Gd I
33.	Ms. Rose Kornu	-	Supervisor Gd I
34.	Mr. Emmanuel T. Kpabitey	-	Supervisor Gd I
35.	Mr. Moses Mensah	-	Supervisor Gd I
36.	Mr. Richard Ohemeng	-	Supervisor Gd I
37.	Mr. Jeff Afenu	-	Supervisor Gd I
38.	Mr. Nuru A. Abdulai	-	Tech. Assist Gd. II

FOOD TECHNOLOGY RESEARCH DIVISION

1.	Mr. Paa Toah Akonor	-	Snr. Research Scientist/Head of Division
2.	Dr. Gregory A. Komlaga	-	Snr. Research Scientist
3.	Mr. Kwabena Asiedu Bugyei	-	Snr. Research Scientist
4.	Mr. Raphael Kavi	-	Snr. Librarian
5.	Mrs. Evelyn S. Buckman	-	Snr. Research Scientist
6.	Mr. Jonathan Ampah	-	Research Scientist
7.	Dr. John Edem Kongor	-	Research Scientist
8.	Dr. Fransica Ansah	-	Research Scientist
9.	Ms. Winifred Arthur	-	Prin. Technologist
10.	Mrs. Leonora C. Baffour Gyasi	-	Prin. Technologist
11.	Ms. Nancy Nelly Idun-Acquah	-	Prin. Technologist
12.	Mr. Emmanuel Adokwei Saka	-	Prin. Technologist
13.	Mrs. Jemima Dowuona	-	Prin. Technologist
14.	Mr. Ebenezer Assimah	-	Prin. Technologist
15.	Ms. Dorcas Naa Norley Thompson	-	Prin. Technologist

16.	Mr. Enoch Aryeetey	-	Prin. Technologist
17.	Mr. Felix Ebo Eyison	-	Chief Tech. Officer
18.	Mrs. Edna Mireku Essel	-	Prin. Technologist
19.	Mrs. Helen Ama Annan	-	Prin. Technologist
20.	Mr. Frank Peget Mboom	-	Snr. Technologist
21.	Mr. Solomon Dowuona	-	Snr. Technologist
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6.	Mr. Theophilus Annan	-	Research Scientist
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9.	Mr. Michael Amoo-Gyasi	-	Prin. Technologist
10.	Mr. Richard Y. Otwey	-	Prin. Technologist
11.	Mr. Alexander Henry K. Appiah	-	Snr. Technologist
12.	Ms. May A. Boham-Dako	-	Snr. Technologist
13.	Mrs. Ruth Fosu	-	Prin. Technologist
14.	Mr. Badaru Deen Yahaya	-	Technical Officer

15. Mr. Felix Afotey - Technical Officer
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5. Mrs. Hannah Oduro Obeng - Research Scientist
6. Dr. Benjamin K. Mintah - Research Scientist
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13. Mrs. Mercy Ted Coffie - Prin. Technologist
14. Mrs. Dorothy Narh - Prin. Technologist
15. Ms. Emefa Gblende - Prin. Tech. Officer
16. Ms. Ruth Naa Gumah - Technical Officer

PUBLICATIONS

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2. Azagba Nyako, J 2(022). Fish in school meals: Utilising innovations in the local fish food systems to promote optimal nutrition and health Policy Brief
3. Najah, T. (2023). Technical report on exhibition at the Indian millet festival 2023, p. 17. CSIR-FRI/RE/NT /2023/001
4. Kongor, J. E., Owusu, M., Ampah, J., Ayeh, E. and Addo, J. (2023). Technical report on stakeholders` forum on the validation of the International Trade Centre (ITC) coffee manual for farmers and agro-processors, CSIR-Food Research Institute, Accra, 1st March 2023, p. 17. CSIR-FRI/RE/KJE/2023/002
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9. Dowuona, J and Aryeetey, E. (2023) A Training on the Production of Baobab Milk Beverage on 30th August, 2023. CSIR-FRI/TT/DJ/2023/001
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