COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
CSIR
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CSIR-FOOD RESEARCH INSTITUTE

ANNUAL REPORT 2018

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CSIR-FOOD RESEARCH INSTITUTE

2018

ANNUAL REPORT

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CONTENTS

ACRONYMS

BMGF	Bill and Melinda Gates Foundation
BNARI	Biotechnology and Nuclear Agriculture Research Institute
C:AVA	Cassava: Adding Value for Africa
CCST	CSIR College of Science and Technology
DANIDA	Danish International Development Agency
DFID	Department for International Development
EU	European Union
FAO	Food and Agriculture Organization
FCR	Fresh Cassava Roots
FUNARBE	Fundação Arthur Bernardes
GAEC	Ghana Atomic Energy Commission
HQCF	High Quality Cassava Flour
IFAD	International Fund for Agricultural Development
IIR	Institute of Industrial Research
SDG's	Sustainable Development Goals
NRI	Natural Resources Institute
PSI	Presidential Special Initiative
RTIMP	Roots and Tubers Improvement and Marketing Project
SMEs	Small and Medium Enterprises

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1. Nana Osei Bonsu	- CEO, Private Ent. Federation	- Chairman
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7. Mrs. Gifty N. D. Aryee	- Head/Administration, CSIR-FRI	- Secretary

FOREWORD

A remarkable operational year for the CSIR-Food Research Institute has ended. The year which marked the 60th Anniversary of the establishment of the CSIR through its forerunner, the National Research Council in 1958, was commemorated with many activities. The Open Days slated for the CSIR Institutes offered us the opportunity not only to highlight our achievements but also to inform the public about our projections for the immediate and long-term future. Through the Open Days, the Institute was positioned for effective media coverage during the year under consideration.

Another significant event during the year was the inauguration of the 10th Management Board of the Institute. The Board, which has since become operational, was inaugurated on 5th March 2018.

A number of newly appointed Board members were welcomed and added their fresh inputs and perspectives to the team. Also the renewal of Nana Osei Bonsu's term of office as Chairman of the Board acknowledges his performance and will ensure consistency in the management and leadership of the Institute. It is a pleasure to be working with the Chairman and the rest of the Board members in the interest of an Institution that stands to play such a significant role in this country.

The Food Research Institute's collaboration and partnership with local and international institutions, in its R&D activities were deepened during the year by several visits from delegates from Norway, US congress, Namibian Parliamentary team and finally a delegation from the Zambian Ministry of Commerce, Trade and Industry in September 2018.

The Institute continued to record various degrees of achievement in executing its research programmes as outlined in this Report.

Indeed the Management Board, the Internal Management Committee and Members of staff of the Institute deserve a grand applause for the fact that, in the face of flagrant handicaps, the Institute responded positively to the commercialization challenge during the year. As shown in this report, the Institute succeeded in generating eleven (11) new technologies through its commercial activities by way of contract research, consultancy services, laboratory and field technical support.

On behalf of the CSIR-FRI management and staff, I wish to thank all those who in diverse ways made us attain all the successes of the year.

Thank you

EXECUTIVE SUMMARY

The CSIR-Food Research Institute continues to contribute significantly to the food post-harvest management system and socio-economic development of the country. The importance of its impact is felt more today as it expands its activities into contract productions, technology incubation, capacity building, resolving industrial challenges, carrying out feasibility studies for start-up companies and many more. Its contributions are as a result of its rich pool of knowledge with staff strength of one hundred and fifty-two (152). Within the year, thirty two publication were generated. These comprised of - twenty (20) refereed papers which were published in reputable journals, ten (10) technical reports, one (1) handbook and one (1) manual.

Project activities resulted in key successes from directly impacting communities with scientific interventions focused at food security. Within the year, gluten-free millet sour dough bread was developed as a value-added product of the underutilized millet grain. *Fura* production process was optimized to produce a more quality and shelf stable product as well as the development of a convenience food in the form of a ready-to-eat *fura* powder. A millet cleaning machine was designed and the technology transferred to SMEs. Cassava farmer yields and incomes were improved through adoption of good agronomic practices and market linkages. Over 457,000 tonnes of fresh cassava was mobilized across the cassava value chain. Demonstration farms were established for communities of C:AVA focused regions.

Commercial activities included product development e.g. development of health energy snack bars, flavoured peanuts; feasibility studies on commercial production of *kenkey* and commercial production of *fufu* flours; upgrading skills of shea butter processors to produce shea butter of high quality; consumer preference tests for rice and chicken meat; trainings on mushroom cultivation technologies, product standardization, etc.

The Institute commercialized eighteen (18) of its technologies within the year, thirteen (13) of its research findings were adopted by Industry and numerous technology start-up companies were established.

CSIR-FRI received a total of GHS 1,988,275.34 from donors and generated GHS 1,793,571.95 from laboratory services, sale of research products and other services.

INTRODUCTION

Food Research Institute (FRI) is an affiliate Institution of the Council for Scientific and Industrial Research (CSIR) of Ghana. It is mandated to conduct market-oriented research that can be applied to problems of food processing and preservation, food safety, storage, marketing, distribution and utilisation, and national food and nutritional security in support of the food industry. It is also mandated to advise government on its food policy.

Vision

CSIR-Food Research Institute's vision is to be recognised nationally and internationally as an S&T institution that is playing a key role in the transformation of the food processing industry to be internationally competitive with particular reference to product safety, quality and presentation.

Mission

The Institute's mission focuses on providing scientific and technological support to the growth of the food and agricultural sectors of the national economy in line with corporate prioritisation and national objectives. Primarily, the CSIR-FRI's mission is to conduct market-oriented applied research and provide technical services and products profitably to the private sector and other stakeholders. To do this CSIR-FRI conducts business in a conducive and transparent working environment with a cadre of highly qualified and motivated staff for timely delivery of quality services and products to clients.

Overall Goal

The overall goal of the Institute is to assist in poverty alleviation through creation of opportunities for generating and increasing incomes within the micro, small, medium and Large-scale food industry; contribute to food security, foreign exchange earnings and the application of cost-effective food processing technologies that are environmentally friendly.

CSIR-FRI has successfully and actively contributed to the post-harvest management and socio-economic development of the Ghanaian economy through its involvement in food product development, food processing trainings, capacity building exercises, food quality and safety.

Operations

The Institute operates under three (3) pillars. These are:

- Research
- Commercialization
- CCST – MPhil in Food Science and Technology

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.)

CSIR Research Thematic Areas.

Under the CSIR research thematic areas, the flagship projects carried out in the Institute are identified under Food Security and Poverty Reduction as well as Science and people.

FOOD SECURITY AND POVERTY REDUCTION

Introduction

Ghana's operationalization of the Sustainable Development Goals (SDGs) intensified the country's quest to eradicate hunger and poverty. Government Institutions such as the CSIR has since incorporated activities aimed at enhancing food security and poverty reduction to its strategic plans. CSIR-FRI's core activities continues to contribute to this agenda addressing issues under SDG's 1 and 2 through actions including, training SMEs on marketable technologies developed, research into indigenous and underutilized commodities, expanding its scope of activities into innovative biotechnology etc.

Project 1:

Upscaling millet grain technology for sustainable livelihood in West Africa (MBoSS project)

Pearl millet (*Pennisetum glaucum*) is one of the important crops in semi-arid areas of Africa and India. The pearl millet crop has a wide adaptability to local environments for its properties of being tolerant to drought and heat. It is currently the world's sixth most important cereal grain and is grown extensively in Africa, Asia, India and the Near East and is a staple source of nutrition for millions of people. India is the largest producer of pearl millet, both in terms of area and production.

Millet (*Pennisetum glaucum* (L.) is a small cereal with seeds of 1.2-1.8 mm in diameter, a light brown-to-brick red colored seed coat with an undulated surface. Millet is a word derived from "mille", which signifies a thousand grains. The major millet species in the world is pearl millet, followed by foxtail, proso and finger millet. Pearl millet is a food that supplies a major proportion of calories and protein to large segments of populations in the semi-arid tropical regions of Africa and Asia. Millet is a gluten-free and low-cost cereal (approximately 40% lower than the price of corn), which is resistant to drought and nutrient-poor soils. According to FAO, in 2011, the global millet production was approximately, 27.5 million tonnes. Countries in Africa and Asia produced 56% and 41% of the total world production, respectively.

World -wide bread consumption accounts for one of the largest consumed foodstuffs, with over 20 billion pounds (9 billion kg) being produced annually. This demand has been driven by consumers seeking convenient fresh products that provide a source of nutritional value. Consequently, freshness is a key component in consumer acceptability and choice of bread. However, the freshness perception is not easily described, particularly as it is likely to vary from one bread type to another. Sourdough is an intermediate product of bread preparation and

contains metabolically active microorganisms. The sourdough fermentation has a wide range of beneficial effects that include prolonged shelf life, quicker volume gain, deferred staling, enhanced bread flavor and good nutritional value. Sourdough also improves sensory characteristics such as loaf volume, evenness of baking, color, aroma, taste, and texture of breads, and has also been reported to contribute to extended shelf life by inhibiting spoilage bacteria and mould growth.

The objectives of the project are:

- To develop and promote commercializable novel millet sourdough products using baking and extrusion technology adaptable to West African production.
- To determine the effect of consumption of millet sourdough bread and extruded snacks on the nutritional and health status of school children in selected West Africa countries.
- To determine the shelf life of millet sourdough bread and extruded snacks during storage.
- To assess the prevalence of celiac disease in the selected countries.
- To build capacity and promote training of bakers, SMEs and other beneficiaries.

Key Activities and Achievements

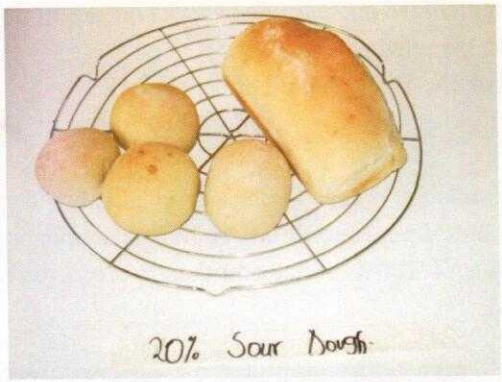
Processing trials were conducted on the millet sourdough bread. Various samples of bread were formulated using different ratios of millet to wheat composite flours. A key accomplishment during the trails was the successful formulation of 100% millet sourdough bread, thereby resulting in the development of gluten-free bread.

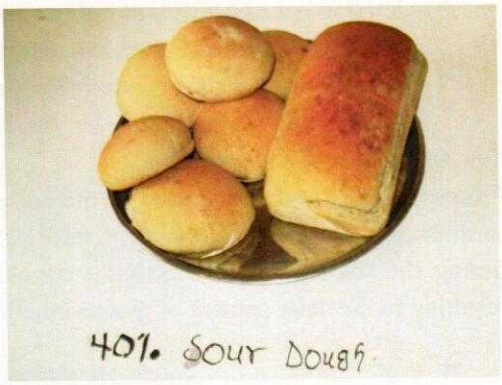
Pearl millet

Pearl millet flour

Late millet sour dough bread

60% millet sourdough bread





20% and 40% millet sourdough bread

100% millet sourdough bread

A 200-250kg/h extrusion line was purchased to produce snacks from millet. The extruder consists of a mixer, screw conveyor, KS-70 double screw extruder matched with 5 different dies of

different shapes, screw conveyor, an electric dryer with 5 layers, a flavouring system and a semi-automated packaging machine.

Samples of extruded forms by extruder

Trial operation of extruder

Project 2:

Cassava: Adding Value for Africa (C: AVA II) Project-Ghana

Cassava is the most widely cultivated crop in Ghana, with 90% of all rural households involved in its production. The crop is produced in all regions of Ghana as it is well-adapted to diverse soil and agro-ecological conditions. Ghana produces about 18 million metric tons of cassava annually and ranked the 6th leading producer of cassava in the world. Cassava contributes 22% to Ghana's agricultural GDP. Cassava's emergence as a cash crop has however, been quite recent and due mainly to growing urban demand for processed cassava products as well as its potential industrial utilisation.

Cassava: Adding Value for Africa (C:AVA) project was initiated to complement efforts in commercializing the cassava sub-sector by scaling up successful pilot initiatives undertaken by Natural Resources Institute (NRI) of University of Greenwich, UK, the CSIR-Food Research Institute (CSIR-FRI) and other partners of NRI under various projects funded by the DFID and the EU. C:AVA's main objective is to increase the incomes of smallholder cassava farmers in the five African countries (Ghana, Nigeria, Tanzania, Uganda and Malawi) where the project run simultaneously. Project activities were implemented in the Volta, Brong Ahafo, Central, Ashanti and Eastern regions of Ghana.

The project seeks to leverage and/or complement other initiatives in the cassava sub-sector, including the Presidential Special Initiative (PSI) on Cassava and the Roots and Tubers Improvement and Marketing Project (RTIMP) funded by IFAD. It also seeks to technically

support stakeholders/partners across the entire cassava value chain i.e. production, processing and value addition and end use levels. At production level, the C:AVA project team supports farmers and farmer organisations by providing technical support in good agronomic practices, facilitation of improved planting materials and proper book keeping of farm records. The support to farmers aims at improving cassava yields per hectare on farmer fields and eventually improving the incomes of farmers. At the processor level, processors are trained on cassava processing into various products, quality management systems and good records management of their processing activities. Processors have also been supported with quality monitoring of their products by the project experts. At the end market level, businesses continue to be supported by the C:AVA team with development of business plans, facilitation of market linkages and facilitation of start-up capital for businesses.

Key Activities and Achievements

Improvement in farmer yields and incomes

The national average of cassava yields per hectare improved from 14-15 tonnes/ha in 2010 to an average of 35–38 tonnes/ha on C:AVA farmer fields. This was achieved by adoption of good agronomic practices especially planting on ridges by farmers.

Fresh cassava roots from a C:AVA farmer's field

Mobilization of fresh cassava roots (FCR) for processing

The C:AVA Ghana team through its facilitation, have mobilized over 457,504 tonnes of FCR across various cassava value chains. This generated substantial income for smallholder cassava farmers in the project catchment areas in Ghana by 2018.

Cassava processing facility set up

Two (2) trainees of the Graduate Self Employed group members who were trained by the C:AVA Ghana team at the premises of CSIR-FRI cassava processing facility, Pokuase, have established cassava processing facilities. Most processors who previously had problems with quality of their

cassava products to end markets now supply High Quality Cassava Flour (HQCF) and other products with less quality issues due to the interventions of the C:AVA project.

Flash dryer locally designed, fabricated and installed for a C:AVA partner

Drying of cassava products is one of the major bottlenecks of cassava processing activity in Ghana. A flash dryer with reasonable initial capital investment was designed, fabricated by local fabricators, installed and test-ran at a processing facility in Abura Dunkwa, Central region. The test results were very promising. Final efficiency trials are yet to be carried out to allow for outdooring of the new flash dryer for a Ghanaian cassava processor. C:AVA also facilitated the establishment of cassava businesses across the country and linked other businesses for the supply of fresh cassava and its products.

Smallholder farmers and Processors are able to access credit from financial institutions

Farmers hitherto were not assisted with farming or processing loans from financial institutions. Due to the interventions of C:AVA experts on good book keeping and financial flows of the processors and farmers, smallholder farmers and processors were provided with loans from rural banks in Brong Ahafo region. This intervention would support the sustainability of the cassava industry after the exit of the C:AVA project.

C:AVA demonstration farm

SCIENCE AND PEOPLE

Introduction

Decades of innovation and technology have proven science as a strong backbone for development. Transfer of technologies and knowledge to the people directly contributes to the socio-economic advancement of a nation. CSIR-FRI focuses its research areas towards people and societal advancements through its efforts in assisting start-up food companies, developing market-oriented technologies, communicating food safety issues, trainings etc.

Project 1:

Preserving Africa food microorganism for Green Growth (GreenGrowth)

The Greengrowth project funded by DANIDA involves some West African countries (including Ghana, Benin and Burkina Faso). The primary focus of the Ghana chapter is on prevention of loss of raw materials, optimization of fermentation processes, nutritional value, food safety, consumer needs, food spoilage and extension of shelf life of optimized products. It is also aimed at implementing procedures, quality guidelines and business models for food innovation including reduced cooking times, sustainable packaging and commercialization of products; in order to increase competitiveness of SMEs.

Key activities and achievements

Optimized *fura* production

The project activities included standardization of the *fura* production process and optimization of *fura* samples. This component of the project involves inoculating millet dough with isolated and cultured Lactic Acid Bacteria and to produce a quality improved product for adoption by SMEs. A key advantage of the optimized process is a reduction of fermentation time from 72 hours to 24 hours. Convenient, ready-to-eat *fura* in the powdered form was also produced using a drum dryer. The improved products were monitored for microbial counts, pH changes and titratable acidity. This component of the project activities has successfully collated the traditional practices and perception on *fura* production and distribution practices, determined sensory properties and consumer acceptance of the product on the market as well as determined the physico-chemical, rheological and nutritional properties of *fura.*

Milled millet and spices

Improved *fura*- balls

Ready-to-eat *fura* flakes

Ready-to-eat *fura* powder

Support for Small-Medium Enterprises (SMEs)

SMEs with strong potential and interest for production of *fura* were identified. These are enterprises that already use millet in the production of porridge (*hausa koko*) and have unsuccessfully attempted the production and export of *fura*. The major challenges encountered by the enterprises have been the short shelf life of the product and poor analytical results when tested. A key intervention of this project is to assist SMEs solve post-harvest management gaps identified along the millet value chain. The involvement of the project has been to develop cleaning equipment towards reducing the drudgery of cleaning millet after harvest and to develop a re-engineered *fura* by enhancing starter culture that would aid in decreasing the number of days for fermenting millet. These technologies aim at improving the millet sour dough quality by reducing to a minimum, and/or eliminating microbiological, chemical and physical contaminants. The SMEs would also benefit from trainings on Standard Operation Procedures, Good Manufacturing Practices and Good Hygienic Practices.

Transfer of technology to an SME

Prototype of millet cleaning machine by FRI

SOME ABSTRACTS FROM PUBLISHED PAPERS

1. APPLICATION OF A VALUE CHAIN APPROACH TO UNDERSTANDING WHITE KENKEY PRODUCTION, VENDING AND CONSUMPTION PRACTICES IN THREE DISTRICTS OF GHANA.

Oduro-Yeboah C., Amoa-Awua W., Saalia F.K., Bennett B., Annan T., Sakyi- Dawson E. and Anyebuno G.

Afr. J. Food Agric. Nutr. Dev., 18(2): 13406-13419. DOI: 10.18697/ajfand.82.17090

Traditional processing and street vending of foods is a vital activity in the informal sector of the Ghanaian economy and offers livelihood for a large number of traditional food processors. Kenkey is a fermented maize 'dumpling' produced by traditional food processors in Ghana. Ga and Fante kenkey have received research attention and there is a lot of scientific information on kenkey production. White kenkey produced from dehulled maize grains is a less known kind of kenkey. A survey was held in three districts of Ghana to study production, vending and consumption of white kenkey and to identify major bottlenecks related to production, which can be addressed in studies to re-package kenkey for a wider market. Questionnaires were designed for producers, vendors and consumers of white kenkey to collate information on Socio-cultural data, processing technologies, frequency of production and consumption, product shelf life, reasons for consumption and quality attributes important to consumers using proportional sampling. The survey was conducted in white kenkey production zones and trade centers. Results showed that production of white kenkey is done on small-scale levels by middle-aged women in households with 10-50 kg of dehulled maize processed into white kenkey, 1-3 times weekly. A third (28%) of the women processed up to 50-100 kg of maize per week. Although 62% of vendors sell 50-100 balls of white kenkey daily, 15% of them sell more than 170 balls. Majority of consumers (45.9%) liked white kenkey because of its convenience (ready-to-eat). Texture and taste were quality attributes desired by kenkey consumers. Producers did not have written records of process controls and product throughputs. Inspite of their cottage nature, production of white kenkey is a profitable employment for producers and vendors and is popular among consumers. Product improvement, process and product characteristics could offer scale-up criteria for development of white kenkey production using standardized procedures for steeping times, steeping temperature and fermentation times.

Keywords: Maize, White kenkey, Value chain, Traditional, Product development, engineering, Ghana.

2. EVALUATION OF COCOYAM-WHEAT COMPOSITE FLOUR IN PASTRY PRODUCTS BASED ON PROXIMATE COMPOSITION, PHYSICOCHEMICAL, FUNCTIONAL AND SENSORY PROPERTIES.

Akonor, P. T., Tortoe, C. and Buckman, E. S.
Journal of Culinary Science & Technology, 16 (1), 52–65

This study characterized the nutritional and functional properties of cocoyam flour and evaluated the sensory properties of model products made from cocoyam-wheat composite. Proximate composition of cocoyam flour, physicochemical, functional, and pasting properties of cocoyam-wheat composite blends were determined by standard methods. Sensory evaluation of doughnuts, bread, and cookies was done by 50 panellists. Protein and ash content of cocoyam flour were 8.5% and 2.4%, respectively, whereas fat was less than 1%. Increasing cocoyam flour significantly increased ($p < 0.05$) water binding capacity, swelling power, and bulk density of composite blends. Peak viscosity of blends increased nearly two folds, when the proportion of cocoyam flour was increased from 5% to 30%. Addition of cocoyam flour gave composite flour with high breakdown and setback viscosities. Sensory evaluation showed that for cookies, up to 30% of wheat flour could be replaced by cocoyam flour, whereas 20% is acceptable in doughnuts and bread.

Keywords: Cocoyam, Composite flour, Functional properties, Sensory properties, Pastry products

3. TRACE METAL CONCENTRATIONS IN THREE PASTRY PRODUCTS PREPARED FROM ROOT AND TUBER AND CEREAL CROPS COMPOSITE FLOURS.

Tortoe, C., Ofori, H., Akonor, P. T. and Oduro-Obeng, H.
Cogent Chemistry, 4: 1429157. https://doi.org/10.1080/23312009.2018.1429157

The concentrations of Arsenic (As), Lead (Pb), Mercury (Hg), Copper (Cu), Iron (Fe), and Zinc (Zn) in doughnuts, cookies, and bread prepared from root and tuber and cereal crops composite flours were quantitatively measured by Atomic Absorption Spectrophotometry. Varying concentrations of trace metals were identified in three pastry products. Concentration of Hg was <0.01 mg/kg wet weight in all three pastry products. The As levels in all three pastry products ranged between <0.01 and 0.03 mg/kg. Concentrations of Pb was <0.01–0.05 mg/kg, far lesser than 10 mg/kg recommended limit by World Health Organization (WHO). The highest Fe level

of 66.3 mg/kg occurred in cookies made from millet composite flour, whereas the lowest value of 10.4 mg/kg was in doughnuts made from water yam composite flour. Concentrations of Cu (1.03–1.83 mg/kg) and Zn (5.49–13.72 mg/kg) were lower than the tolerance limit of 40 mg/kg set by WHO. The presence of trace metals at varying concentrations in all three pastry products demonstrates the need for observing food safety controls in sourcing for raw materials and during processing of flours from root and tuber and cereal crops.

Keywords: Trace metals, Composite flour, Bread, Doughnuts, Cookies, Root and tuber, Cereal crops

4. BIOPROSPECTING OF POWDERED PINEAPPLE RIND AS AN ORGANIC SUPPLEMENT OF COMPOSTED SAWDUST FOR *PLEUROTUS OSTREATUS* MUSHROOM CULTIVATION.

Narh Mensah, D. L., Addo, P., Dzomeku, M. and Obodai, M.
Food Science & Nutrition, 6 (2), 280-286

Pineapple rind is a by-product of the pineapple processing industry and contains nutrients and other compounds which must be utilized as a bioresource for socio-economic benefits while preventing the potential problems of improper agroindustrial biomass disposal methods. Pleurotus ostreatus is an edible oyster mushroom with medicinal properties and can be cultivated on various agroindustrial biomass, including sawdust containing supplements. Pineapple rind was powdered and used as a supplement of composted sawdust at 2%, 5%, 10%, 12%, 15%, and 20% (w/w) on dry weight basis. A control treatment consisted of composted sawdust supplemented with rice bran at 12% (the most utilized composition in Ghana). P. ostreatus strain EM-1 was cultivated on these treatments. Factors investigated included the spawn run period, yield, fruiting body weight and size, biological efficiency, and nutritional composition (proximate composition and Copper, Zinc and Lead content) of fruiting bodies harvested from selected high-yielding treatments and the control treatment. Full colonization of all treatments occurred by the 34th day of incubation. Enhanced yield, fruiting body weight and size, and biological efficiency were generally recorded with supplementation at lower concentrations (2% and 5%) compared to treatments supplemented at higher concentrations. There was also a supplement concentration-dependent alteration of the nutritional composition of the mushroom. Powdered pineapple rind can be utilized as an organic supplement at relatively low concentrations in composted sawdust for P. ostreatus strain EM-1 cultivation.
The use of lower concentrations of powdered pineapple rind in composted sawdust is advantageous as relatively less input will be required to produce higher P. ostreatus strain EM-1 yields.

Utilization of pineapple rind for mushroom cultivation will extend the pineapple plant value chain, intensify mushroom production in a sustainable way, and minimize agricultural losses.

Keywords: Biological efficiency, Fruiting body, Nutritional composition, Yield, Pleurotus ostreatus, Mushroom cultivation

5. DETERMINATION OF THE CHEMICAL AND FUNCTIONAL PROPERTIES OF YAM BEANS (PACHYRHIZUS EROSUS (L.) URBAN) FLOUR FOR FOOD SYSTEMS.

Buckman, E. S., Oduro, I., Plahar, W. A. and Tortoe, C.
Food Science & Nutrition, 6 (2), 457-463

Many plant species that are suitable for food across the world are neglected and underutilized. In order to increase their diversified food uses and thus help enhance food and nutrition security, we studied the chemical and functional properties of Pachyrhizus erosus (yam bean), which is a neglected and underutilized legume species. The chemical properties of flour produced from the yam bean include 5.8% moisture content, 5.7% crude fat, 6.2% crude fiber, and 85% available carbohydrate, indicating appropriate shelf-stable flour, low fat, and abundant energy. The results also showed a reducing sugar content of 2.0% and 21.0% starch. Pasting temperature was 70.6°C with peak viscosity of 14.5 BU, which supports ease of cooking of the flour. The swelling power obtained was 752.9 g/100 g at 85°C with a solubility index of 54%. Water holding capacity (WHC) obtained for the flour was 363.88%, whereas swelling volume was 14.0 ml and makes the flour appropriate for the production of infant foods. The P. erosus flour therefore exhibits good functional and chemical properties that would make the flour quite suitable as a substitute for other flours in food systems.

Keywords: Chemical, Flour, Functional properties, Pachyrhizus erosus, Yam bean.

6. NUTRITIONAL, MICROBIAL AND SENSORY ATTRIBUTES OF BREAD FORTIFIED WITH DEFATTED WATERMELON SEED FLOUR.

Anang, D. A., Pobee, R. A., Antwi, E,Obeng, E. M., Atter, A., Ayittey, F. K. and Boateng,J. T.
International Journal of Food Science and Technology, 53, (6), 1468-1475

The utilisation of natural food supplements to fortify staples is considered as one of the effective means of dealing with global food nutrient deficiency. Herein, we report the nutritional, microbial and sensorial characteristics of defatted watermelon seed fortified bread. The protein content and level of micronutrients such as phosphorus, potassium, iron and calcium increased with increasing proportion of watermelon seed flour in the bread. Notably, calcium resulted as the highest micronutrient in the bread samples, whereas the content of iron in the fortified samples improved significantly. The defatted watermelon seed flour had a high iron content of about 12.1 mg/100 g as compared to the normal (unfortified) bread of 0.01 mg/100 g. The total microbial count results for all the fortification levels complied with the acceptable microbial quality requirement. Lastly, the consumer acceptability test did not show any significant difference between all levels of fortification with watermelon seed flour.

Keywords: Bread acceptability test, Fortified bread, Microbial count, Nutritional content, Sensory attributes Watermelon seed flour.

7. MYCOFLORAL PROFILE AND THE RADIATION SENSITIVITY (D10 VALUES) OF SOLAR DRIED AND GAMMA IRRADIATED PLEUROTUS OSTREATUS (JACQ. EX. FR.) KUMMER FRUITBODIES STORED IN TWO DIFFERENT PACKAGING MATERIALS.

Kortei, N. K., Odamtten, G. T., Obodai, M. and Wiafe-Kwagyan, M.
Food Science & Nutrition, 6 (1), 180-188

The presence of fungi in our foods poses serious health risks as some genera of fungi may produce certain mycotoxins which have carcinogenic, mutagenic, teratogenic, and immunosuppressive effect on humans and animals alike. Fruitbodies of Pleurotus ostreatus were solar dried at a moisture content of 12.5 ± 0.2% and stored in polythene and polypropylene packs, gamma irradiated at doses of 0 (control), 1, 2, 3, 4, and 5 kGy at a dose rate of 1.7 kGy/hr from a Cobalt 60 source (SLL, 515, Hungary) and stored at room temperature 28–30°C for a period of 12 months. Mycological analyses were done at intervals of 0, 3, 6, and 12 months. A total of eleven (11) fungi belonging to eight fungal genera were isolated on both Cooke's and DRBC media; Aspergillus (A. niger, A. flavus, A. fumigatus, A. tamarii), Rhizopus (R. oligosporus), Mucor

(M. racemosus), Fusarium (F. oxysporum), Penicillium (Penicillium sp.), Trichoderma (T. viride), and Rhodotorula sp. were recorded. There was a significant ($p < .05$) reduction in initial mycofloral population by an average of 2.2 log cycles as well as in species numbers with increasing doses of radiation. Radiation sensitivity (D10 values) also ranged between 1.68–2.78 kGy. Gamma irradiation treatment is one way which can enhance food safety through the reduction in potential pathogens and has been recommended as part of a comprehensive program to enhance food safety.

Keywords: Fruitbodies, Gamma irradiation, Mycoflora, Pleurotus ostreatus, Packaging materials, Polypropylene, Polythene.

8. WIDESPREAD EXPOSURE TO INFECTIOUS BRONCHITIS VIRUS AND MYCOPLASMA GALLISEPTICUM IN CHICKENS IN THE GA-EAST DISTRICT OF ACCRA, GHANA.

Ayim-Akonor, M., Obiri-Danso, K., Akonor, P. T. and Sellers, H. S.
Cogent Food & Agriculture, 4: 1439260. https://doi.org/10.1080/23311932.2018.1439260

Infectious bronchitis, a major challenge to the global poultry industry, is an acute and highly contagious disease of the respiratory and urogenital tract of chickens which causes significant economic losses to poultry producers. In addition, Mycoplasma gallisepticum (MG) is another respiratory pathogen that remains a concern to producers. This study investigated the sero-prevalence of IBV and MG in commercial chickens in Ga-East district of the Greater Accra Region, Ghana, using sera obtained from 440 broiler and layer chickens showing no signs of disease. IBV and MG specific antibodies were determined using commercial ELISA kits. Majority (85%) of the samples tested positive for at least one of the 2 pathogens investigated, with 30% testing positive for both. Overall sero-prevalence of IBV and MG were 85.5 and 29.5% respectively suggesting a higher IBV than MG field challenge in the study area. IBV prevalence was significantly higher in layers (100%) than broilers (42%). Age of bird had a significant influence on IBV prevalence among broilers. The MG prevalence in layers and broilers were 39.4 and 0% respectively. This data supports the need to institute control measures to mitigate IBV associated losses and improve poultry production in Ghana.

Keywords: Infectious bronchitis virus, Mycoplasma gallisepticum, Sero-prevalence, Chickens, Ghana.

9. ASSESSING SOURCES OF INFORMATION FOR URBAN MUSHROOM GROWERS IN ACCRA, GHANA.

Kavi, R. K., Bugyei, K. A., Obeng-Koranteng, G. and Folitse, B. Y.
Journal Of Agriculture & Food Information, 19 (2), 176-191

This study assessed information sources for urban mushroom farmers in Accra, Ghana.One hundred farmers were sampled, and a structured questionnaire was administered to solicit information from the respondents. Results showed that the majority of farmers were male (71%) and most (60%) with university education. The majority (44%) had 1–5 years of experience in mushroom cultivation. Co-farmers (89.8%), the Mushroom Growers Association (79.6%), training workshops (73.5%), and the Farmers' Forum (29.6%) readily served as information sources for farmers. The research revealed that, for 52% of farmers, ignorance of information sources was a major hindrance in their quest for information.

Keywords: Information sources, Mushroom cultivation, Accra, Ghana, Information needs, Agricultural information, Urban farming.

10. INVESTIGATING THE ADOPTION OF THE ROOT AND TUBER COMPOSITE FLOUR (RTCF) TECHNOLOGY TRANSFERRED AMONG MICRO- AND SMALL-SCALE ENTREPRENEURS (MSES) IN THE BAKERY INDUSTRY IN GHANA.

Quaye, W., Onumah, J. A., Tortoe, C., Akonor, P. T. and Buckman, E. S.
African Journal of Science, Technology, Innovation and Development, 10 (2), 137-145

A survey was conducted to investigate the extent of adoption of root and tuber composite flour (RTCF) technology transferred among micro- and small-scale entrepreneurs (MSEs) in the bakery and pastry industry in Ghana. A total of 268 respondents were surveyed from the Brong Ahafo, Ashanti, Eastern, Volta, Western and Central regions in Ghana. The overall adoption rate of the RTCF technology among the 268 respondents was estimated at approximately 40%; Ashanti (75.7%), Eastern (43.1%), Volta (41%) and Brong Ahafo (21.4%). Results confirmed that adoption rate of the RTCF was tied to availability, accessibility and affordability of the RTCF in the local communities. Modelling adoption decision of the RTCF technology using the Probit model indicated that process innovation and age of bakers had significant positive influence on the decision to adopt the RTCF technology. Younger bakers with less experience also increased the probability of adoption It is therefore important to encourage bakers to be innovative through the adoption of best practices and technologies that have the potential to

increase productivity and efficiency. Adoption of the RTCF technology has significant implications for enhanced food security situation in Ghana.

Keywords: Adoption, Technology, Food security, Ghana

11. SENSORY ATTRIBUTES OF THREE EDIBLE TROPICAL MUSHROOMS AND THEIR USE IN FORMULATING FOOD PRODUCTS FOR CHILDREN 2 -5 YEARS OLD.

Hagan, L. L., Johnson, P. N. T., Obodai, M., Blay, A. M. Y., Simons, C. and Dzomeku, M.
International Journal of Nutrition and Food Sciences, 7 (3), 100-109

Mushrooms are important sources of proteins and vitamins, but have unique sensory properties in appearance, flavour and texture that can lead to polarized liking amongst consumers. Children between the ages of 2 to 5 years can be picky eaters and adding vegetables such as mushrooms into their diets can be a challenge. Objective: This study involved the development of mushroom-based food products acceptable to children within this age bracket through a stepwise approach. Materials and Methods: Sensory attributes of three tropical edible mushrooms, *Pleurotus ostreatus* (EMI), *Pleurotus sajor-caju* (PSCW) and *Auricularia* spp. (ART), were characterized using quantitative descriptive analysis (QDA), using 30 descriptors. The QDA revealed that all three mushrooms differ distinctly from each other in appearance, mouthfeel and aftertaste. The aroma and flavour profiles of EM1 and PSCW mushrooms were comparable. From the QDA, EMI and PSCW were selected and used to formulate six mushroom-based food prototypes; three of which included cereals and the other three had orange–flesh yellow potato flour as main components. The 6 prototype foods were then assessed by three sets of focus groups of caregivers and mothers on the suitability of using the mushrooms in the preparation of foods for children of the target age. Two mushroom-based food products, one with cereal blends and the other with 30% orange flesh yellow potato flour were further subjected to consumer-liking tests involving 83 children 2-5 years old. and this final test established the mushrooms can be incorporated into children's diet. Conclusion: The study established two of the mushrooms could be used as flavourant; EMI mushroom suitable for fish or savory-flavoured products whilst the PSCW mushroom was preferred for nutty-flavoured products and these two when used in mushroom-based foods were highly acceptable to children 2 to 5 year old

Keywords: Edible tropical mushrooms, Sensory attributes, Consumer-linking test, Children feeding

12. EFFECT OF GREEN LEAFY VEGETABLES POWDER ON ANAEMIA AND VITAMIN-A STATUS OF GHANAIAN SCHOOL CHILDREN.

Egbi, G., Gbogbo, S., Mensah, G. E., Glover-Amengor, M. and Steiner-Asiedu, M.
BMC Nutrition, 4: 27, 1-10

Background: Nutritional anaemia and vitamin-A deficiency are public health issues confronting Ghanaian children. Their adverse effects are likely pronounced during the dry season when green leafy vegetables, rich-sources of iron and provitamin-A are scarce. This study assessed the effect of dried green leafy vegetables on anaemia and vitamin-A status of Ghanaian school children. Method: This was 3 months pretest, posttest nutrition intervention study. Children 4–9 years were randomized to receive or not receive supplement. High Performance Liquid Chromatography and Haemocue hemoglobinometer were used to determine vitamin-A and haemoglobin concentrations respectively. Malaria-parasitaemia and helminthes were examined by Giemsa-staining and Kato-Katz respectively. Nutritional status was assessed by anthropometry. Student's t-test was used to establish significant differences between groups. Results: At baseline, the mean haemoglobin concentrations of control and supplemental were 116.9 ± 9.9 g/l and 117.6 ± 12.7 g/l respectively. At end-line, it was 121.9 ± 13.5 g/l for supplemental and 113.4 ± 8.5 g/l for control, significant at $p = 0.001$. At baseline prevalence of anaemia was 37.3 and 41.5% in control and supplemental respectively. At end-line it was 33.3% in supplemental against 57.5% in control, significant at $p = 0.024$. At baseline mean retinol concentrations were 16.79 ± 8.74 μg/dl and 16.97 ± 7.74 μg/dl for control and supplemental respectively. Mean retinol concentrations for control and supplemental were 24.35 ± 5.50 μg/dl and 26.96 ± 6.86 μg/dl respectively at end-line. At end-line 60% of control against 64.0% of supplemental had low vitamin-A status. At end-line, anaemic-control had mean retinol concentration of 23.78 ± 5.23 μg/dl and anaemic-supplemental had 27.46 ± 7.28 μg/dl. Prevalence of low vitamin-A status was 64.3 and 84.2% in anaemic-control and anaemic-supplemental respectively at baseline but it became 23.1 and 21.1% respectively, at end-line. The mean haemoglobin concentrations of anaemic-control and supplemental were 105.7 ± 7.5 g/l and 113.6 ± 13.6 g/l respectively at end-line. The change in prevalence of anaemia between the anaemic groups was 12.2%, significant at $p = 0.042$.

Keywords: Anaemia, Green leafy vegetable, Powder, School children, Vitamin-A, Deficiency, Prevalence.

13. EFFECT OF MANUAL SORTING ON AFLATOXINS CONTENT IN PEANUTS (ARACHIS HYPOGAEA, L.) FROM A GHANAIAN MARKET

Anyebuno, G. A. A., Kyei-Baffour, V. and Narh, D.

Ghana Journal of Agriculture Science, 52, 5-15

Aflatoxins have been of major public health concern ever since they were discovered. A simple physical manual sorting procedure and blanching to facilitate the elimination of aflatoxins in raw peanuts was designed, conducted and verified using workshop participants. Two processors were then trained on the technology. Six streams of kernels namely, raw unsorted kernels, pre-sorted kernels (immature and shrivelled kernels), three levels of bad discoloured kernels (≤10% discoloured kernels, ≤50% discoloured kernels and >50% discoloured kernels) and good kernels were obtained during the verification exercise. Analyses carried out on these samples using High Performance Liquid Chromatography (HPLC) gave total aflatoxin levels ranging from none detected to 60.42 µg/kg for good kernels and very, very bad kernels, respectively. Total aflatoxin content of the testa recorded 5.34 µg/kg. During the training session for the two processors, shrivelled and immature kernels were found to be the most susceptible to aflatoxin contamination. Thorough manual sorting of blanched kernels, offers a practical possibility in reducing significantly, aflatoxin levels to below regulatory limits.

Keywords: Aflatoxins, Peanuts, Ghanaian market, Arachis Hypogaea, L.

14. PHYSICOCHEMICAL CHARACTERISTICS AND MICROBIOLOGICAL QUALITY OF SENESCENT PLANTAIN PRODUCTS

Adi, D. D., Oduro, I., Tortoe, C., Kwofie, E. M. and Simpson, B. K.
Cogent Food & Agriculture, 4, 1441596

Senescent plantains have relatively very rapid deterioration rate compared to plantains at other ripening stages. In Ghana, they are used for products which are consumed either as a snack or a main meal. This paper presents results of a study conducted in five regions of Ghana to investigate processing of senescent plantain products and evaluate their physicochemical characteristics and microbial quality. Survey data were collected on product types and processing methods. Freshly prepared products obtained from respondents were packaged in Ziploc bags and transported in a clean ice chest to the lab for physicochemical and microbial analyses. Samples were stored in the refrigerator (5°C) prior to analyses. Products made by respondents include Apitsi or Apiti, Bodongo, Akankyie, Ofam, Kumaku, Agbetenya; which were either baked or steamed. There were variations in cooking methods, time, type and quantity of

ingredients used to produce these products. The products had relatively high moisture (47.63% – 68.42), appreciable crude fat (0.06% – 9.50%), crude protein (1.66% – 7.87%) contents and were good sources of energy (129.64 kcal/g – 241.19/g). The products were slightly acidic, with pH ranging from 4.53 to 5.38. Aerobic plate count, yeast and mold, coliform and E. coli ranged between <10 to 1.7 × 105 CFU/g; 0 and 3.9 × 105 CFU/g; 0 and 1.5 × 102 CFU/g; and 0 and <10 CFU/g, respectively. The bacteriological quality of samples A to I are more superior than samples J and K. Product standardization is required.

Keywords: Senescent plantain, Physicochemical composition, Microbial quality, Process variability, Apiti.

15. VALIDATING A HACCP SYSTEM FOR THE PRODUCTION OF VEGETABLE SHITO

Ackah, N. B., Baidoo, E. A. and Appiah, A. H. K.
Journal of Food Quality, 2018, 1-7

Vegetable shito is a novel pepper sauce product developed to cater for the needs of vegetarians. Due to its increasing popularity, it is prudent to assure its safety through the implementation of a quality management system for its production. This work was aimed at developing and validating a HACCP system for the production of vegetable shito. The HACCP system was successfully developed and validated to ensure that critical limits established for the critical control points were adequate to eliminate identi ed hazards. Validation was done through microbial challenge testing, and results obtained indicated that the HACCP plan developed will be effective in controlling and eliminating microbial hazards related to the vegetable shito. With such a quality management system in place, vegetable shito producers would be able to produce shito products which are safe and have a stable shelf life.

Keywords: HACCP, Vegetable shito, Shito, Quality management system

COMMERCIALIZATION OVERVIEW

The Commercial Division is responsible for overseeing and coordinating commercial activities of the Institute. Commercial areas of focus include analytical services, consultancy and training services, production and sale of research by-products and contract productions. Within the period under review, there were thirteen (13) research findings adopted by industry, eighteen (18) technologies commercialized and twenty-eight (28) technology start-up companies established with the assistance of the Institute. Feasibility studies were carried out for start-ups and business plans drawn out upon request. Some selected activities by this Division are elaborated below.

Consultancies and Trainings

Development of Energy Snack Bar

In recent years, food consumption patterns have been greatly influenced by lifestyles. Busy lifestyles have resulted in consumers adopting ready-to-eat, energy packed snacks. Energy snack bars have high content of carbohydrates, proteins and fats. Healthy energy snack bars contain high fibre content and may contain a mixture of ingredients including wheat, maize, oats, rice, soy, nuts, sugar, whey protein etc. CSIR-FRI developed an energy rich snack bar which can be adopted and up-scaled by the food Industry.



Peanuts are one of the most cultivated commodities in Ghana and wildly used in the production of oil and paste. They are commonly consumed as boiled or roasted snacks. Peanuts are a good source of proteins, fats, polyphenols, vitamins and minerals. They are also known to contain flavonoids, resveratrol and phytosterols. Peanuts can be flavoured with honey, spices, chocolate, caramel, etc. The product developed within the Institute involved flavouring peanuts with black pepper, ginger and moringa.

Feasibility studies on kenkey production

This study was done for the commercial production of vacuum-packed Ga-*kenkey*. It involved standardization of Ga-*kenkey* production process, comprehensive quantitative study on production process, assessing and evaluating infrastructure needs, developing a workflow pattern and plant layout, market analyses of demand and supply of Ga-*kenkey*, production cost and financial analysis.

Upgrading skills of shea butter processors to improve quality

Shea butter processing has been adopted as a trade for rural women in the three Northern regions for decades. Shea butter is one of the few products with increasing local and export demand capable of significantly improving incomes, livelihoods and ultimately contributing to poverty reduction. Shea butter production is mainly done by women; most of whom belong to women groups. The traditional production of the butter has been plagued with numerous quality challenges, therefore, the need to optimize and improve the production process. Shea butter optimization was carried out for Single Mother's Association-Bolgatanga in order to ultimately expand market access by improving quality.

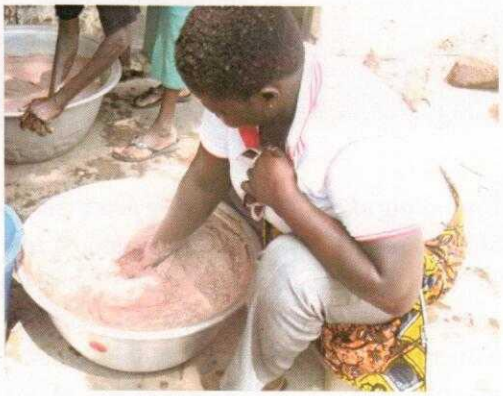
Bad nuts sorted out

Washing of nuts

Drying nuts on concrete platfroms

Introduced roasters for roasting nuts

Installed a mill dedicated solely for shea processing



Kneading of milled shea nut paste

Shea oil from heated extract

Shea oil hardened into butter

Consumer preference for rice and chicken meat from different origins

Though rice is grown in Ghana, rice is one of the major commodities imported into the country. Rice imports have been estimated to be between $300 million and $500 million dollars annually. Chicken meat is also one of the main imports into the country. A bulk of imported chicken is from Europe, USA and Brazil. The main activity of this consultancy, was to conduct a sensory study to assess the product attributes that drive consumer preferences for locally produced or imported rice and chicken meat.

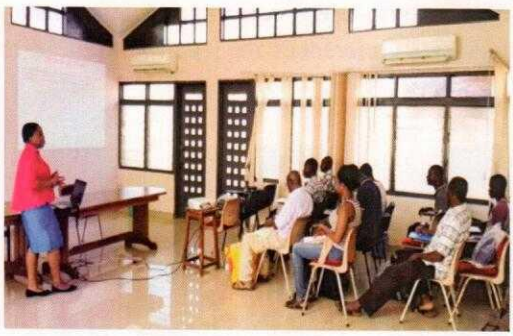
Sensory evaluation on local and foreign rice samples

Sensory evaluation on local and foreign chicken samples

Mushroom Training

CSIR-FRI conducts research on mushrooms and transfers this technology through training programs carried out biannually. These trainings are hands-on and may include field trips to mushroom cultivation facilities owned by some beneficiaries of the mushroom training. The training program is based on existing knowledge, improvements and modifications which are

outputs of research conducted in the Institute's mushroom research laboratory. The content consists of theoretical and practical mushroom cultivation, good agronomic practices in mushroom cultivation, mushroom packaging solutions and business development and key principles and concepts in marketing.



Lecture session on Good Agronomic Practices in mushroom cultivation

Practical session on mushroom spawn multiplication training

Session on composting and bagging (substrate)

Technologies and industries

CSIR-FRI is a hub for various food processing technologies ready to be adopted by Industry. With its technologies, it has aided and contributed to the establishment of over twenty (20) start-up companies in development of products from various commodities. Within the year, technologies commercialized through trainings of individuals and companies included *fufu* flours (plantain *fufu*, cocoyam *fufu* and yam *fufu*), shelf stable and exportable *hausa koko*, *banku* mix, yam chips & chunks, pre-cooked vacuum packaged yams, fruit juices, jams, cereal mix, weaning foods, flavoured chips, etc. The Institute also carried out canning of selected vegetables, processing and packing of selected meat types for clients.

The Institute has positioned itself in the production of semi-finished goods through contract productions for clients. This involves producing research products (eg. Cereal mix, *fufu* flours etc.) of the Institute and products specified by clients.

CSIR COLLEGE OF SCIENCE AND TECHNOLOGY (CCST)

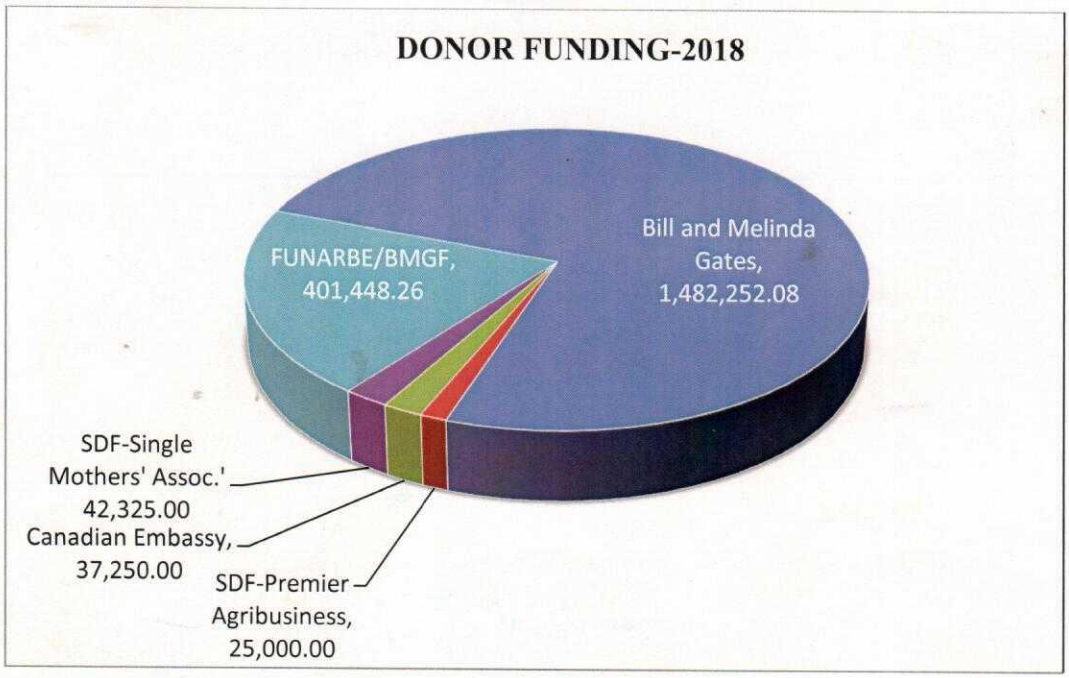
The CSIR College of Science and Technology was established in 2011 and accredited by the National Accreditation Board to equip students in the physical and natural sciences with appropriate skills and attitudes to enhance their contribution to sustainable development in the country. There are two main campuses of the college; one in Accra and the other in Kumasi. The college offers graduate programmes in agriculture and environmental sciences.

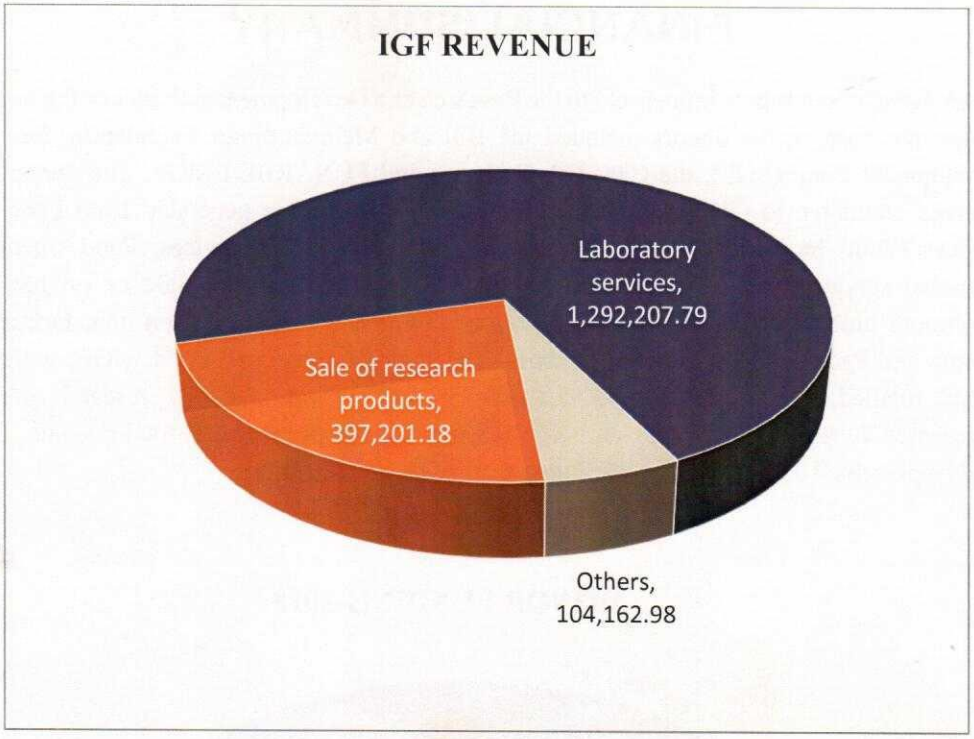
The Department of Agro-processing Technology and Food Bio-sciences of CCST is hosted by CSIR-Food Research Institute with well trained and skilled Research Scientists making up the teaching staff. The Department currently offers an MPhil degree in Food Science and Technology. Courses taught under this programme are based on areas that CSIR-FRI has clear competence and made enormous strides. The programme is designed to offer a unique opportunity for students to have a high level practical training involving food commodity processing, product development and food analysis based on the industrial needs of Ghana. It also seeks to impart knowledge, skills and values to develop employability and produce lifelong learners who can think and act creatively both in industry and research.

Within the year, the MPhil in Food Science and Technology programme has twenty-two (22) students comprising of eleven (11) males and eleven (11) females.

FINANCIAL SUMMARY

Donor agencies contribute immensely to the Research and Development activities of the Institute. Within the year, active donors included the Bill and Melinda Gates Foundation, the Skills Development Fund (SDF), the Canadian Embassy and FUNARBE/BMGF. The donor funds received amounted to GHS 1,988,275.34. Internally, funds were generated from Laboratory services (Food processing lab 1, Food Microbiology-Industrial services, Food Chemistry-Industrial services and Mycotoxin unit); Sale of research products (Sale of products and Mushroom products) and others (Fabrication of equipment, Food Nutrition unit, Operational income and Project Administration income). The Internal Generated Funds (IGF) within the period totalled, GHS 1,793,571.95. Laboratory services and Sale of research products represented 72% and 22% of the total IGF, respectively. With respect to total revenue, Donor funds represented 53% and IGF contributed 47% of the total income.

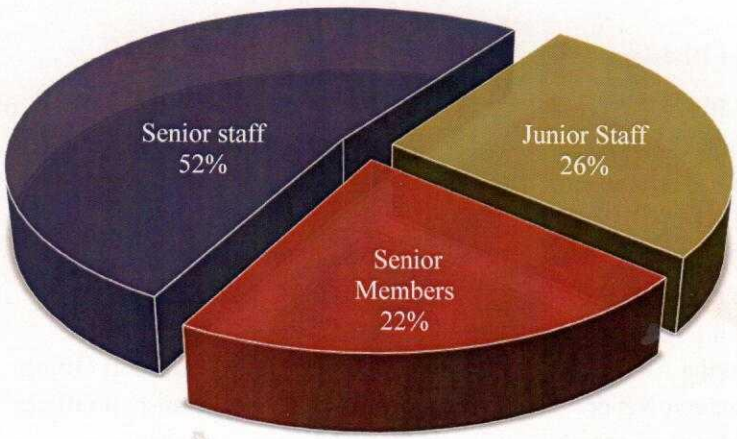



IGF REVENUE
Laboratory services, 1,292,207.79
Sale of research products, 397,201.18
Others, 104,162.98

ADMINISTRATIVE ACCOUNT

The Administration Division runs the human resource affairs of the Institute. CSIR-FRI continued to manage the rich pool of knowledge and talent which is focused on achieving the primary goal of the Institute. Staff strength totalled one hundred and fifty-two (152), with ninety (90) males and sixty-two (62) females. There were thirty-three (33) senior members, seventy-nine (79) senior staff and forty (40) junior staff under the service of the Institute within the period under review. The assiduous effort of staff directly contributed to income generation and integrity of the Institute.

Staff Highlight



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4.	Mr. Kwabena A. Bugyei	-	Snr. Research Scientist
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7.	Mr. Elvis A. Baidoo	-	Research Scientist
8.	Mr. Jonathan Ampah	-	Research Scientist
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16.	Mrs. Helene Ama Annan	-	Snr. Technologist
17.	Mr. Frank Peget Mboom	-	Snr. Technologist
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19.	Mr. Desmond Mensah	-	Prin. Tech. Officer
20.	Mrs. Agartha Amuzu	-	Prin. Tech. Officer
21.	Ms. Jemima Ofori	-	Prin. Tech. Officer
22.	Mr. Ofori Brempong	-	Prin. Tech. Officer
23.	Mr. Rufai Braimah	-	Prin. Tech. Officer
24.	Ms. Constance Boateng	-	Prin. Tech. Officer
25.	Mrs. Alice Padi	-	Snr. Tech. Officer

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3.	Mrs. Amy Atter	-	Research Scientist
4.	Mrs. Deborah L. N. Mensah	-	Research Scientist
5.	Mr. Evans Agbemafle	-	Research Scientist
6.	Mr. Theophilus Annan	-	Research Scientist
7.	Mr. Michael Amoo-Gyasi	-	Prin. Technologist
8.	Mr. Alexander Henry K. Appiah	-	Snr.Technologist
9.	Ms. May A. Boham-Dako	-	Snr. Technologist
10.	Mrs. Ruth Fosu	-	Prin. Tech. Officer
11.	Mr. Badaru Deen Yahaya	-	Snr. Tech. Officer

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1.	Mr. George A. Anyebuno	-	Research Scientist/Head of Division
2.	Dr. Jolene Mateko A. Nyako	-	Research Scientist
3.	Mr. Hayford Ofori	-	Snr. Research Scientist
4.	Mrs. Hannah Oduro Obeng	-	Research Scientist
5.	Mr. Nelson Y. Amey	-	Prin. Technologist
6.	Mr. Kofi Kwegyir Essel	-	Prin. Technologist
7.	Hillary K. Ketemepi	-	Prin. Technologist
8.	Mr. Vincent Kyei-Baffour	-	Snr. Technologist

9.	Ms. Vida Awidi	-	Chief. Tech. Officer
10.	Mrs. Belinda Quaye	-	Prin. Tech. Officer
11.	Mrs. Dorothy Narh	-	Prin. Tech. Officer
12.	Mr. Ebenezer Tawiah	-	Prin. Tech. Officer
13.	Ms. Emefa Gblende	-	Snr. Tech. Officer

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Refereed Journal Papers

1. Ackah, N. B.; Baidoo, E. A. and Appiah, A. H. K. (2018). Validating a HACCP system for the production of vegetable shito. Journal of Food Quality, 2018, 1-7.

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13. Kortei, N. K.; Odamtten, G. T.; Obodai, M. and Wiafe-Kwagyan, M. (2018). Mycofloral profile and the radiation sensitivity (D10 values) of solar dried and gamma irradiated Pleurotus ostreatus (Jacq. Ex. Fr.) Kummer fruitbodies stored in two different packaging materials. Food Science & Nutrition, 6 (1), 180-188.

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2. Amponsah, S. K. K; Nketia, S.; Oduro-Yeboah, C. and Dowuona S. (2018). Storability characteristics of smoked Nile Tilapia (Oreochromis niloticus).

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5. Gyasi, L. C.; Saka, E. A.; Darteh, K.; Oduro-Yeboah, C. and Amuzu, A. (2018). Physical qualities of developed rice samples.

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