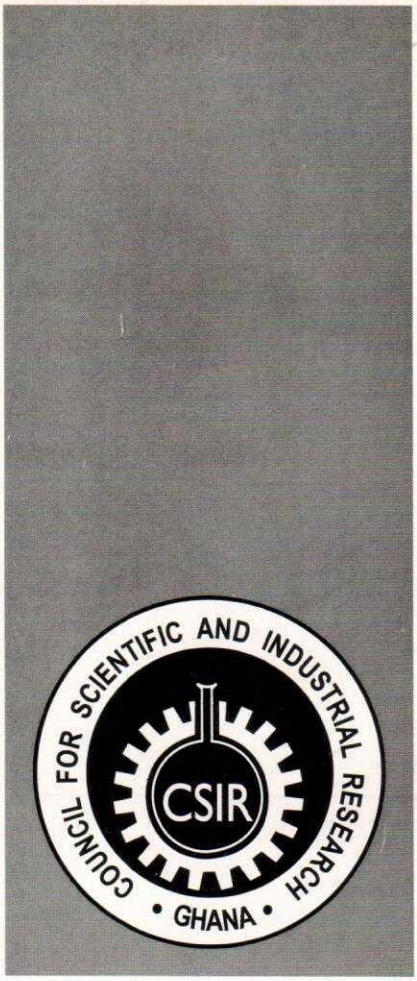
2016 ANNUAL REPORT

CSIR-FOOD RESEARCH INSTITUTE

P. O. Box M20, Accra, Ghana.
Adjacent Ghana Standards Board,
New Golf House, Near Tetteh Quarshie
Interchange, Gulf St, Accra, Ghana.



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AWARD	-	African Women in Agricultural Research and Development
BNARI	-	Biotechnology and Nuclear Agriculture Research Institute
C: AVA	-	Cassava: Adding Value in Africa
CD	-	Commercialization Division
CORAF	-	West and Central African Council for Agricultural Research and Development
CSIR	-	Council for Scientific and Industrial Research
FARA	-	Forum for Agricultural Research in Africa
FRI	-	Food Research Institute
GAEC	-	Ghana Atomic Energy Commission
HQCF	-	High Quality Cassava Flour
IGF	-	Internally Generated Funds
IGCF	-	Industrial Grade Cassava Flour
IIR	-	Institute of Industrial Research
KNUST	-	Kwame Nkrumah University of Science and Technology
PEER	-	Development of edible and medicinal mushrooms as functional foods in Ghana
PEF	-	Private Enterprise Federation
SANAS	-	South African National Accreditation System
SMEs	-	Small and Medium Scale Enterprises
UDESWA	-	Upscaling the Nigerian flash drying experience for sustainable regional trade and income generation in West Africa
USAID	-	U.S Agency for International Development
WAAPP	-	West African Agricultural Productivity Programme

MANAGEMENT BOARD MEMBERS

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Ms. Janet Aggrey-Yawson	-	Head/Administration, CSIR-FRI	-	Secretary

GREETINGS FROM MANAGEMENT

Greetings from the Management of CSIR-Food Research Institute (CSIR-FRI). The year 2016, was exciting with various achievements in the face of new opportunities and challenges.

We continued our quest to fulfilling our vision as the leading Science and Technology Institute in the transformation of the Food Processing Industry in Ghana. In partnership with our donors, private sector and industry players we churned out more technologies to strengthen our impact on the socio-economic development of the nation. A total of four new products are ready for uptake by entrepreneurs. This ranged from cashew fruit juice, cashew cereal blend for infants, mushroom soup and mushroom cereal blend with orange fleshed sweet potato. In addition, we installed the first ever six cyclone flash dryer at our Pokuase site. The CSIR-FRI continued to provide technical and analytical services, contract research and consultancy services to micro-medium and multinational agro-food processing industries and international development agencies.

These successes would not have been achieved without the hard work and commitment of the staff. We wish to thank them for their invaluable contributions to the attainment of our goals. We anticipate that in 2017, we will enjoy an overflow of innovative ideas from staff and the year will be more impactful with results seen in the attainment towards food security in the areas of value added products on the market and poverty alleviation.

Thank you.

EXECUTIVE SUMMARY

The CSIR-Food Research Institute (FRI) achieved its aims and objectives for the year in line with its strategic plan. Its activities were geared towards aiding poverty alleviation through creation of various opportunities for income generation, contributing to food security, foreign exchange and promoting of cost-effective food processing technologies. In the year under review, it provided consultancy, technical and analytical services, contract and collaborative researches to agro-food processing Industries, government agencies and international development agencies.

The Institute carried out various Research and Development activities through projects. Specific activities included training on utilization of roots and tuber composite flours for baking enterprises, production of crackers from fish and soybeans, development of rice noodles and rice biscuits, and production of mushrooms using rice straw as substrate. One thousand two hundred and fifty five (1,255) women processors were trained on rice parboiling and good practices for the processes. Research was carried out and technology transferred on the drying of fruits (mango, pawpaw, coconut and pineapple) using wooden gas cabinet dryers fabricated by the Institute in collaboration with CSIR-Institute of Industrial Research. Research commenced on the optimization of *fura* preparation process in order to obtain starter cultures for the commercial production of *fura*. Ready-to eat cashew apple, enriched cereals, cashew apple juice and dried fruit snacks were developed and technology disseminated to stakeholders. The Institute also carried out its annual mushroom cultivation trainings for interested stakeholders. Trainings were generally carried out under various research and project activities in order to aid in bridging training gabs and needs in the country. Through its R&D activities, the Institute published a total of seventy-two publications. Publications within the year composed of seventeen (17) Journal papers, thirteen (13) Research reports, five (5) Consultancy reports, six (6) Manuals, eight (8) Conference papers & posters and four (4) Extension leaflets.

The Institute generated a total income of GH¢ 6,683,053.00. Out of the total income, Internally Generated Fund, which was 15.79% of the total income was GH¢ 1,201,872.00. This showed a growth of 10.26% compared to that of 2015.

INTRODUCTION

Mandate

The CSIR-FRI is mandated to conduct applied market oriented research into 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 and also to advise government on its food policy.

Vision

The 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 the food Research Institute will conduct 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.

OverallGoal

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.

Products and Services

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

4. **Fabrication of Food Processing Equipment** (Fabricating strong & reliable food processing equipment and industrial dryers)
5. **Food Processing** (Processing of high quality natural food products and Contract productions)
6. **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 grouped under the following:

Thematic Area 1 (TA 1) -Food Security and Poverty Reduction

Thematic Area 7 (TA 7) - Science and people.

Seven projects were carried out under Food Security and Poverty Reduction, whilst two (2) projects were executed under Science and People. The projects and their achievements are outlined below:

FOOD SECURITY AND POVERTY REDUCTION

To live a healthy and productive life, there must be availability and access to nutrient rich food at all times for all people. When poverty is reduced and food security is achieved, it enhances the socio-economic status of the nation. The areas under which this is being addressed by the CSIR-FRI are through research and development activities of Cereals and Legumes, Roots, Tuber, Horticultural (Vegetables and Fruits) and Industrial crops and Biotechnology. Key activities and achievements of this thematic area under the auspices of various projects are as outlined.

Project 1:

Upscaling the Nigerian flash drying experience for sustainable regional trade and income generation in West Africa (UDESWA)

Increase in agricultural productivity is imperative to achieving the Millennium Development Goal to halve poverty. To help achieve this the project focused its activities to minimize postharvest losses of root & tuber crops (cassava, yam, cocoyam, etc) through development, pilot scale demonstration, adoption and dissemination of innovative and adaptable drying technology. This was to promote efficient and proven drying technologies for sustainable food security and poverty alleviation in Ghana.

Key Activities and Achievements

Through a capacity building exercise, stakeholders were trained on the design and fabrication of a six-cyclone flash dryer and how it functions (detailing the heat exchanger of the dryer).

The six-cyclone flash dryer has been installed at CSIR-FRI's Root and Tuber processing plant at Pokuase, in Accra.

Cleaning and Assembling components

Coupling Cyclone to Blower

Fully operational flash dryer

The flash dryer was formally launched through a sensitization forum which brought together over 100 stakeholders including potential investors, Engineers, Fabricators, Financiers, Ministries and Departments, Civil Society Organizations, Development Partners and Trade Facilitation Agencies.

Launching of flash dryer and Sensitization forum held at Pokuase, Accra

Challenges foreseen include the fact that, most cassava processing enterprises operate below 250kg/hr capacity of the dryer; the cost of the dryer is beyond the capability of most of these enterprises and most enterprises operate from smaller buildings as such the physical size of the dryer may pose an accommodation challenge. The six-cyclone dryer is therefore most suitable for uptake by large industries and investors aiming at building large flour processing plants.

Project 2:

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

This project significantly boosts the incomes of small-scale Ghanaian farmers by linking them to new markets. This is done through the use of innovative interventions to capacitate farmers, village processing units and market intermediaries to competitively deliver high quality cassava-based products to a well sensitized market. The focus is on cassava, with a view to maximizing achievements in the cassava sub-sector. Hundreds of smallholder households have benefited from trainings, forums and market linkages, including women and disadvantaged groups. It promotes the use of HQCF as a versatile raw material for which diverse markets exist.

Key Activities and Achievements

The project has focused on three types of value chains; the first value chain involved the scaling-out and scaling-up of the development of High Quality Cassava Flour (HQCF) and Industrial Grade Cassava Flour (IGCF) value chains. This was done in order to create a demand for 749,353 tons of fresh cassava roots from smallholder farmers and processors. The

second involved developing new profitable value chains based on market and investment studies undertaken in the first phase of the project, C:AVA I. This was done for additional dried cassava products, such as improved chips and grits for inclusion in livestock and fish feeds. By so doing, demanding 304,039 tons of fresh roots from smallholder farmers and processors. The third value chain involved facilitating profitable and sustainable smallholder-inclusive supply chains for 472,606 tons fresh cassava roots primarily for large HQCF, starch and ethanol industries using lessons learned from the project.

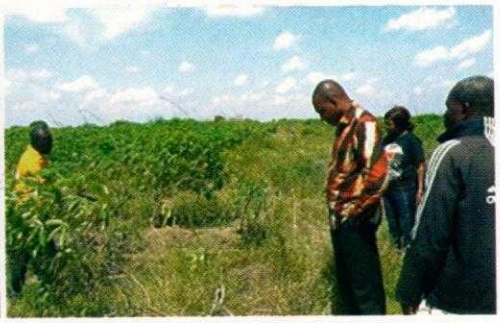
There has been the promotion of the adoption of some level of efficient processing technologies and the creation of networks of cassava suppliers (out-growers and freelance farmers) to increase yields of production, this makes processing more competitive and profitable. Cassava supply chain information dissemination strategy was developed to support decision making at the producer, processor, end-user and project management levels. This provides clear visibility of the flow of products, services and information.

Entrepreneurs and investors have been assisted to develop business plans in securing loans from funding agencies in order to establish processing Units to process cassava into finished and marketable products. There has been the implementation of a system for identifying signals of changing market demands and instituting appropriate response measures.

A total of 13,500 smallholder farmers have been engaged in this project. By 2019, C:AVA would have created and helped meet demand for 1,525,998 tons of fresh cassava roots for production of HQCF, IGCF, high quality cassava chips, starch, ethanol and gari, for use in the bakery, brewery, paperboard, plywood, livestock feed, fish feed and beverage industries in Ghana.

Activities during different training sessions

Out-grower training at Begro, Fantiakwa District



On farm training on Green Acre farms

Project 3:

West Africa Agricultural Productivity Programme (WAAPP2A)

The target of activities is to improve agricultural productivity by emphasizing sub-regional integration to promote shared growth and reduce poverty. The components of this program include enabling conditions for regional cooperation in the generation, dissemination and adoption of agricultural technologies; national Centre of Specialization and funding demand-driven technology generation and adoption. About 700,000 beneficiaries are targeted in Ghana, with an expected 40% been women.

Key Activities and Achievements

Cassava: Technology for processing three (3) intermediate products of cassava transferred and adopted by 1500 primary out-processors.

Trained groups of cassava processors of High Quality Cassava Flour (HQCF), grits, chips and gari under WAAPP2A within the Western and Brong Ahafo regions were beneficiaries of cassava presses and cassava graters. Five (5) graters, four (4) pressing machines, three (3) motors, two (2) engines and one (1) milling machine were distributed. In the Brong Ahafo region one grater, one presser and a milling machine was given to Nyamebekyere Cassava Processing Group (Ayigbe town-ship, Wenchi district-Brong Ahafo region). All the cassava graters and presses were assembled and test-run after distribution to beneficiaries.

Distribution of cassava processing equipment in the Brong Ahafo region

In order to commercialize HQCF, grits, chips and gari by trained cassava processors, a processing centre was constructed to house equipment (presses and graters) supplied to the processing groups formed in Adzedukope village.

Constructed housing and installation of WAAPP equipment

Training of cassava processors on how to process raw cassava into High Quality Cassava Flour (HQCF) was conducted at Adzedukope (forty-eight (48) processors) and Adaklu Ablornu (thirteen (13) processors) in the Volta region. This involved processing raw cassava within 24 hours of harvest to prevent flour from fermenting and becoming off-white instead of white in colour. The processors were also taught Good Hygienic Practices to prevent contamination of the HQCF.

Training on processing of HQCF

Other Roots and Tubers: Technology for developing and utilizing composite flour from yam, cocoyam and sweet potato successfully transferred and adopted by flour and bakery enterprises.

Bakery and pastry groups were formed and trained in the Ashanti, Brong Ahafo and Northern Regions of Ghana. Ashanti region had Fourteen (14) groups of 404 members (372 women, 32 men and 167 youth); Brong Ahafo also had fourteen (14) groups comprising of 457 members (448 women, 9 men and 232 youth) and the Northern region had ten (10) groups of 361 members (343 women, 18 men and 189 youth). The training conducted focused on composite flour processing and utilization. Composite flours were developed from root and tuber crops consisting of white yam, water yam, yam, cocoyam and sweet potato in combination with wheat. Percentage compositions of 5, 10, 15 and 20% of composite flours were developed and formulated into bread, biscuits, cakes, chips and doughnuts.

Trainees after training on composite products

Ten sets of bakery equipment consisting of a mixer, roller and an oven with accessories have been fabricated for 10 selected trained bakery groups in the Volta and Eastern regions. The beneficiaries' locations were Kpando, Adidome, Ho, Akatsi and Hohoe in the Volta Region and Suhum, Nsawam, Asamankese, Somanya and Koforidua in the Eastern region.

Project 4:

Gains from Losses of Root and Tuber Crops (GRATTITUDE)

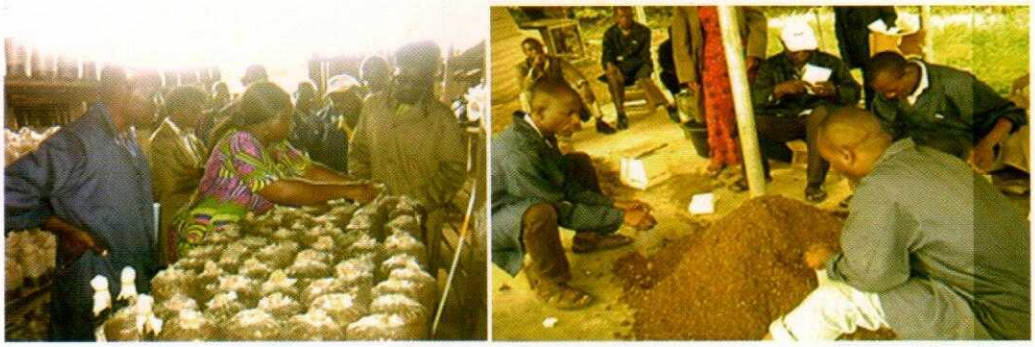
Cassava and yams are important food security crops in much of sub-Saharan Africa because, their presence in the cropping system increases the resilience of farmers in the face of climate change, drought and fluctuations in the price of durable commodities. Post-harvest losses of cassava and yams are significant and come in three forms; physical losses, economic losses and from the bio-wastes. This project targets the reduction of these three types of post-harvest losses in order to enhance the role that these crops play in food and income security for small-holder households.

Key Activities and Achievements

In dissemination of technologies to curb post-harvest losses, best strategies for post-harvest handling of yam and cassava tubers has been established. Appropriate storage structures for beneficiaries were set up and documented. Furthermore, food safety baseline assessment was documented and reported. HACCP system was used to identify Critical Control Points in the development of products from cassava and yam. The safety and quality attributes of these products at Critical Control Points were monitored.

Improved barn storage structures

To utilize wastes from these tubers and to scale up mushroom production as a commercial enterprise, peels of yams and cassava were used as substrates in the cultivation of mushrooms. Scaling up also included developing training manuals for the mushroom production with peels of yam and cassava as well as training materials for yam storage and yam flour technologies. Dissemination of these methods were through training sessions on up scaling of mushroom production technology in Volta and Brong Ahafo regions of the country.



Training on mushroom production using yam and cassava wastes

Project 5:

Enhancing food security in Africa through the improvement of rice post-harvest handling, marketing and the development of new rice-based products.

Improved harvest and post-harvest rice processing practices and technologies were introduced to upgrade the quality and marketability of locally produced rice in order to meet urban consumers' preferences. There was also the promotion of the development and adoption of new rice-based products.

Key Activities and Achievements

A survey carried out revealed that rice processors were using improper and unscientific methods of postharvest operations such as drying on cemented floors and tarpaulin, representing 50% each, storage in the mill house, home and market representing 73%, 20% and 6.75 respectively. Major challenges identified were a lack of postharvest machinery, mechanization of postharvest activities and access to financial resources.

AfricaRice expo stand and some exhibits at conference.

Locally available raw ingredients were used to formulate a nutritious weaning meal rich in both macro and micro-nutrients (especially vitamin A and iron). The commodities used were broken rice fractions from a rice milling center in Afife, groundnuts, soyabeans (Glycine max), cowpea, eggs, mango and palm oil. Different types of porridges were developed from various formulated L-Rich Weaner. Nutritional analysis, moisture content, microbial analysis and pasting characteristics were carried out. A sensory analysis was carried out by care-givers with children between 6-59 months.

Rice noodles were formulated using 30% rice and 70% wheat flour, 40% rice and 60% wheat flour, and 50% rice and 50% wheat flour.

Training of rice farmers on rice noodles production (Nkawei –Toase Kumasi)

Pleurotus ostreatus was cultivated on rice by-products. Data collected on fruiting bodies on both *Pleurotus ostreatus* and *P. eous* based on their biological conversion efficiency indicated that rice by-products are suitable substrates for the cultivation of both mushroom species.

Making of compost bags from rice straw, quicklime and rice bran.

Mineral and proximate analyses of *P. ostreatus* were comparable with International standards. Molecular studies using PCR Techniques were carried out. This involved extracting the DNA of the dry mushroom using conventional molecular techniques. Thereafter PCR amplification was performed with ITS 1 and ITS 4 primers to characterize the ITS region of the samples.

Project 6:

Development of edible and medicinal mushrooms as functional foods in Ghana (PEER)

Edible mushrooms have attracted much interest as functional foods due to their antimutagenic, anti-tumor and anti-viral properties. Food product development must address these changing consumer demands; the development of a convenient mushroom-based functional food is one example. Thus, the focus of this project was towards documenting indigenous knowledge of edible and medicinal mushrooms in four regions of Ghana; characterizing the mushrooms; determining the biochemical composition of these mushrooms, ascertaining the quantity of β-glucans and antioxidants in the mushrooms; cultivating five selected cultivable species on agricultural residues and finally transferring the technology to 100 youths in the communities of the four regions.

Key Activities and Achievements

Characterization of mushroom species

Pictures of the mushrooms from the four forests visited were taken *in situ* to pictorially document their natural habitat and approximate size as seen below. Some fruit bodies collected were cultured and the rest were sun-dried on the field for further biochemical analysis (nutrient profile and antioxidant activity) and for experiments on the formulation of the mushroom-based infant weaning food.

Pleurotus albidus *Termitomyces sp* *Pleurotus tuber-regium* *Ganoderma sp*

Cockenia sp *Auricullaria sp.* *Pleurotus saju caju* *Cclavulinopsis sp.*

Some Mushroom species growing in the forests

Termitomyces biodiversity was assessed during two trips to Ayum and Atiwa forests. *Termitomyces sp* collected during the biodiversity assessment and samples bought from a hawker were cultured on malt extract agar supplemented with glucose at 20 g/L (MEAG) on plates/ slants in bottles. Macromorhpological characteristics of mycelia observed during incubation in the dark at 25 $\pm 2^{0}$C included color of the mat, mycelia elevation and advancing zones as well as the mat texture. The growth rate on the media was also observed. Proximate composition of the dried fruit bodies of *Termitomyces* sp. were analyzed for ash, fat, protein and carbohydrate contents. Energy and minerals such as iron, calcium and phosphorus were also analyzed.

Ganoderma sp.

Molecular characterization of 27 *Ganoderma* samples were carried out, to ascertain their variability and phytochemical properties. A new *Ganoderma* species was identified and named as *Ganoderma mbrekobenum*.

Ganoderma mbrekobenum sp. nov. growing in the wild

Process and product development of mushroom breakfast cereal and sweet potato mash. Mushroom cereal blend was formulated with locally grown rice, peanut, soybean and mushroom. Mushroom sweet potato mash was formulated from locally grown orange fleshed sweet potato, fish powder, tomatoes and mushroom powder. A four component mixture design was used in the formulation of mushroom Orange Fleshed Sweet Potato (OFSP) mash and mushroom soup mix. Mushrooms used were *Pleurotus ostreatus* strain EM1, *P. sajor-caju* strain PSCW and *P. tuber-regium* strain PTR.

Initial sensory evaluation was carried out on six mushroom powers (*Ganoderma*, *Pleurotus ostreatus* strain EM1, *P. sajor-caju* strain PSCW, *P. tuber-regium* strain PTR, *Termitomyces* and *Auricularia* species). For all foods tasted, the weanimix product with mushroom was more acceptable to caregivers than yellow fleshed sweet potato products with mushrooms. The weanimix products were more normal foods that caregivers considered will be accepted by the targeted children. Flavour profile of mushroom samples showed that, EMI and PSCW may be used interchangeably in product development projects based on the aroma and flavour profiles of these mushrooms. EMI mushroom flavoured yellow fleshed sweet potato products had a more positive response from the caregivers compared with the PSCW flavoured products.

The project set up mushroom growing Demonstration Centers at Hohoe in the Volta Region, Kukrantumi in the Eastern Region and Accra in the Greater Accra Region.

Project 7:

Cashew fruit: Adding value for food security

In Ghana, cashew nuts have been recorded as a high economic-earner export commodity, with about 196 million USD worth of cashew being exported in 2016 alone. Despite this huge figure, it represents almost 20% decrease from the quantity exported in 2015. Observation shows that in many of the cashew farms in the country, a lot of the fleshy apples are left to go waste, as a result of the less economic value people place on the fruit. In addition, the fruit has a very delicate skin which makes it highly perishable and unstable for transportation. The loss of revenue from such sources through the inability of economic players to add value to the apple and nuts limits the potential of the crop as a foreign exchange earner, source of employment and income as well as food in the form of value added cashew products. With economic empowerment of farmers in mind, this work aimed at transforming Ghana's cashew fruit sector from a no-priced commodity to an exporter of high quality cashew apple products in the near future. It specifically explores the consumer acceptability of value-added cashew fruit products as well as the level of awareness of farmers in the economic and food-product potentials of cashew, particularly the fresh fruit.

Key Activities and Achievements

Fresh and dried cashew fruit

In Ghana, the mean level of Tannin in fresh fruit was 17.23mg/100g, Vitamin C was 83.96mg/100g, Protein was 1.04g/100g and Sucrose was 0.36g/100g. In Brazil, the fresh BRS-189 clone had the highest Tannin content (377.53mg/100g) while the CCP-76 clone had the lowest tannin content (176.76mg/100g). 4g of 20% HQCF/1L water/1Kg of fresh fruits reduced tannin by 71.2%, Vitamin C by 15.5% and protein by 23.9%. 2.5g of 10% Gelatin/1L water/1Kg of fresh fruits reduced tannin by 58.7% and Vitamin C by 11.9% but increased protein by 38.6%. In dried Fruits, mean level of Tannin was almost 14 times that of the fresh fruit, vitamin C increased about 8 times and proteins increased about 6 times that of a similar weight of fresh fruit. To reduce the darkening of the cashew apple fruit, samples were placed in 1% ascorbic acid solution or in a 1% citric acid solution before oven drying at 65°C. The best results were obtained with the ascorbic acid treatment.

Preparation of dried apple under the Cashew

Cashew apple enriched cereal

After storing formulated samples (honey-sweetened cereals containing high quality cassava flour treated cashew fruits and sugar-sweetened cereals containing untreated cashew fruits) for 6 months, levels of *E. coli*, yeast & mould, aerobic microorganisms, coliforms and *Staph. aureus* were all within acceptable limits set by the Ghana Standards Authority (GS 955). Honey-sweetened cereals containing high quality cassava flour treated cashew fruits, showed decreased levels of vitamin C. However, highest loss (47.7% loss) was observed in the sugar-sweetened cereals containing untreated cashew fruits). Sugar-sweetened gelatin treated cashew fruit enriched cereal had the highest consumer acceptability.

Formulation of cashew apple-enriched cereal

Cashew apple juice

Juice treated with gelatin and pasteurised at 100°C for 3 minutes had the highest consumer overall acceptability. Spray dried cashew juice 19.2% solids, using maltodextrin as the carrying agent was found as the ideal lower limit for juice dehydration in terms of fineness of powder and output by spray drying. However, the yield was low.

Cashew apple juice

Use of gelatin and HQCF for reducing tannins and drying of the fruits

It was realised that fruits treated with HQCF had lower tannin content in the dried fruits than other fruits which did not undergo any treatment or were treated with gelatin. In addition, Vitamin C content was not significantly affected by the drying and tannin reduction methods. Furthermore, the chemical properties of the fruits were higher in dried fruits than in fresh fruits. This was due to concentration of the chemicals in the dried fruits (i.e. Tannins, Protein,Vitamin C, Reducing sugars, Sucrose and Total sugars) but there was no significant differences among the differently treated fruits.

Microbial and nutritional properties of formulated Cashew-fruit Ready-to-eat breakfast cereals

Aerobic microorganisms present in the six samples were all less than 10^3 which is within acceptable limits. Similarly, coliforms and yeasts and moulds were also less than 10^2 in all samples which is also within acceptable limits. No *Salmonella, E. coli* or *Cl. perfringens* was

isolated from the samples. The samples which contained untreated cashew fruits were higher in vitamin C, carbohydrates and fiber contents than other samples which contained cashew fruits treated with Gelatin or HQCF. Lead was not detected in any of the six samples. However, samples with cashew fruits treated with gelatin or HQCF were higher in protein content than the sample with untreated cashew fruits.

Spray drying of cashew juice

Use of maltodextrin as carrying agent produced a better yield and product quality as compared to the use of gum Arabic or a combination of both. However, 15% maltodextrin produced the best product quality in terms of fineness and solubility of powder.

SCIENCE AND PEOPLE

The CSIR as the scientific arm of government has tailored its research activities to significantly impact the National Development Plan. The impacts made by CSIR-FRI is driven towards socio-economic development by capacity building, technology transfers, job creations, fostering market linkages, improving value chains and helping resolve food industry challenges. The areas under which this thematic area is achieve by the Council are Policy and Governance; Technology for livelihood and Wealth creation; Culture, Indigenous Knowledge and Community Improvement, Statistics, Social and Economic Research and Value Chain Promotion.

Project 1:

Preserving Africa food microorganism for green growth (GREENGROWTH)

CSIR-FRI has carried out numerous researches into the preservation of food microorganisms through starter culture isolations. Actions undertaken include identification of food value chains, full utilization and preservation of microbiological heritage and implementation of procedures, quality guidelines and business models for food innovation. The traditional products under study in the project are *Fura* and *Wagashie*. The project aims to upgrade the traditional processes involved through the use of starter cultures for fermentation and also optimize the processing parameters.

Key Activities and Achievements

Identification and analysis of value chains

For identification and mapping of value chain and SWAT analysis, millet farmers, millet millers, *fura* producers and consumers in the Tamale metropolis and surrounding towns and villages were interviewed. The field study provided information on existing business models for commercialization of local foods and sustainability of the practices. It also provided information on the social and economic impact of technology transfer on the status of traditional food processors. This will provide elements for developing business models for upgrading and commercialization of traditional foods.

Interview of millet farmers in Tamale

Development of starter culture for *fura* fermentation & preservation by gamma radiation

Fura

A study was conducted to develop a starter culture for the fermentation of millet into *fura* and to extend the shelf life of *fura* by gamma radiation. The isolation, characterization and identification of Lactic Acid Bacteria (LAB) and yeasts responsible for *fura* fermentation was carried out using physiological methods. The lactic acid bacteria identified were *Lactobacillus fermentum* (33.33%), *Weissella confusa* (20%), *Lactobacillus brevis (16.67), Pediococcus acidilactici* (13.33%), *Lactococcus lactis ssp lactis 1* (10%) *and Lactococcus rafinolactis* (6.67%). Yeasts were characterized and identified as *Saccharomyces cerevisiae* (43.75%); *Candida krusei* (25%) *Candida albicans* (18.75%) and *Candida membranifascians* (12.5%). Three LAB isolates (*Lactobacillus fermentum, Lactobacillus brevis* and *Weissella confusa*) exhibited the fastest rates of acidification with the least pH values and corresponding high percentage titratable acidity values and therefore have the potential to be used as starter cultures for *Fura* production.

Fermented and unfermented *fura* samples were given different treatments involving, vacuum packaging and irradiation and stored at ambient temperature. The combination of irradiation and vacuum packaging had the most significant effect on *fura* and samples were wholesome after 6 weeks. Samples which were irradiated but not vacuum packed were also whole some after 6 weeks but had higher microbial counts.

Wagashie

To modernize production procedure of wagashie, studies were carried out to replace its traditional method of milk coagulation with commercial rennet used in cheese production. A fermentation step was introduced in the production process to improve its bland taste. The rheology of wagashie which involves Texture Profile Analysis (TPA) was carried out on the improved product which were rennet coagulated fresh and smoked wagashie samples.

After a confirmatory affective test where wagashie samples were processed by frying and smoking, sensory analyses showed that, all samples were liked moderately using a 9-point hedonic scale.

In a quantitative descriptive analysis, sensory results showed higher intensities for desirable attributes in the improved wagashie (milky aroma, milky taste, cheesy aroma, cheesy taste, yoghurt aroma). The undesirable descriptors (bitter taste, bland taste, spoilt milk aroma, fermented cassava dough aroma) were rated high in market samples.

The safety of the improved wagashie samples was enhanced with fermentation and smoking. The result of the shelf life study showed that preserving wagashie samples with vacuum packaging and irradiation extended the shelf life from 3 days to 3 weeks of storage under ambient conditions.

Concept development for improving green growth at the SME level.

Trainings were carried out on invention, innovation and technology transfer processes, business model canva development for partners' fermented food products and commercialization of the technologies developed.

Trainings held in University of Development Studies- Navrongo, Department of Food Technology-Burkina Faso, and University of Abomey Calavi-Benin.

Project 2:

Improving livelihood of small holder cassava farmers through better access to growth markets (CASSAVAGMARKETS)

Cassava roots are bulky and contain more than 60% moisture, making it susceptible to spoilage within a few days after harvest. This makes processing into dry and more stable forms

attractive. Recent attempts in Ghana to add more value to the root crop and make it a useful raw material for both domestic and industrial applications has led to production of unfermented flour from the crop.

This project ensures safety and quality of processed cassava products in market oriented production and expand the range of uses of High Quality Cassava Flour (HQCF) to meet identified market demand and to establish, document and disseminate best practices in cassava value chain development. It involves improving the livelihood of small holder cassava farmers through better access to growth markets.

Key Activities and Achievements

Functional uses of High Quality Cassava Flour (HQCF) has been established and new uses on a laboratory scale was examined. Innovative new products as a result have been tested with identified end-user industry partners. These innovative applications include the development of cassava crackers, cassava snacks and reformulation of foods like *banku* and *tuo-zaafi*. HQCF has been used successfully to replace up to 50% of fermented cassava dough in production of *banku* and 60% of maize flour in *tuo-zaafi*. This reformulated *banku* and *tuo-zaafi* have been tested to have identical taste and texture (elasticity) as that made from the traditional formula and is widely accepted by consumers.

Crackers from HQCF (using prawn powder, fish powder or soybean powder as a protein source) have been developed. The snack serves as a rich source of nutrients such as carbohydrates, protein and fat.

There have also been the evaluation of the market potential for innovations has been carried out.

Prawn Crackers

CONSULTANCIES AND TRAININGS

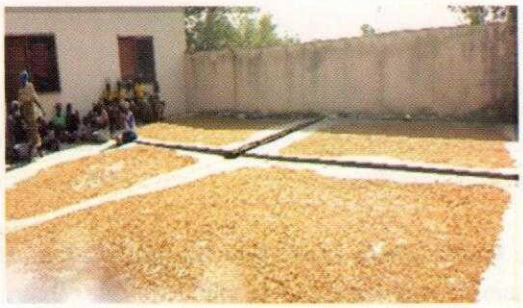
1. *Monitoring and evaluation of rice parboiling technology & economics*

Trainings for master trainers were held in the Upper East Region (Bolgatanga) and in the Northern Region (Tamale). Trainings were carried out on primary and secondary processing of rice, understanding of the role of processors in production of quality rice, use of improved parboiling vessel and critical unit operations in the parboiling process that adversely affect the quality of parboiled rice.

Picture Block Presentation

Participant in a training Session

Steaming



Patio Drying

Milling

Packaged samples

2. *Product development*

- Knowledge transfer and training was held for an SME on the extraction of coconut milk from coconut product.
- Successful development of cocoa-dawadawa mixture.

Roasted and dehulled dawadawa

3. *Feasibility studies*

Feasibility studies was carried out for individuals and upcoming industries interested in the production of Plantain flour, Cassava chips, Cassava flour and Starch productions.

4. *Mushroom cultivation and product formulation*

Training programmes were carried out for 60 caregivers in Hohoe and Kukrantumi on:

- how to grow and harvest mushrooms (*Pleurotus ostreatus* strain EM1 and *P. sajor-caju* strain PSCW) using agricultural wastes (Cassava peels, sawdust and grass (Juncao) with the plastic bag method.
- formulation of the developed mushroom based cereal blend weanimix (baby food).

5. *Mushroom training program*

Two training programmes were held in CSIR-FRI on mushroom cultivation. Participants for the training included lecturers, retirees, housewives, medical doctors, students and other professionals.


Scientists of the Mushroom Unit taking participants through training on mushroom cultivation

6. *Transfer of fruit drying technology- wooden cabinet dryer*

Solar cabinet dryer efficiency was evaluated for drying tomato slices. Parameters considered were moisture content, ambient and dryer temperature, area of collector, specific heat capacity of air and solar radiation. A gas wooden cabinet dryer was installed at Quarcoo Initiatives, Madina-Accra, this was followed by training on fruit drying technology. The training involved use of mango, pawpaw, coconut and pineapple drying using the gas cabinet dryer.

Drying of pawpaw, mango and pineapples in a gas cabinet dryer

7. *Utilization of cashew fruits*

Farmers and potential investors were sensitized in a workshop on utilization of cashew fruits in 2 regions of Ghana with over 100 participants.

8. *Training on HACCP AND GMPs*

Training of a *fufu* vendor on HACCP and GMPs involving a stepwise preparation of *fufu* using a fufu machine.

9. *Training Industry quality department staff*

Quality assurance personnel from a catering company were trained on microbiological safety of foods.

Training for quality assurance staff of Newrest Catering Ltd and presentation of certificate.

10. *Students' training programme*

The Institute encourages knowledge transfer and practical training of students to help them link theory to practicals. Students from various tertiary Institutions benefit from this industrial attachment programme. For added impact, CSIR-FRI through a contract, annually hosts, 3rd year Food Science and Technology students from KNUST and Level 200 and 300 students from the Department of Nutrition and Dietetics, University of Ghana for hands-on practicals.

Students undergoing training

COMMERCIALIZATION OVERVIEW

Accreditation by SANAS (South African National Accreditation System) was reinstated after completion of refurbishment of some of the Institute's laboratories. This was done to ensure that, methods used for analyses are standardized and strictly adhered to in order to provide the best results for clients. CSIR-FRI continuously prioritizes its clients and thus, expanded its scope of analysis by including *Listeria* for microbiology and Cadmium for chemistry analyses.

To provide not only the best services but also best products, the Institute commercializes some of its products developed from research. These products include: Plantain, Cocoyam and Yam *fufu* flours, Cereal Mix (Rice/Maize), Optimized and improved *Kokonte* flour, Groundnut paste, Maize grits, *Banku* mix, Gari, Cowpea flour, Mushroom spawns and Mushroom compost bags.

Unit operation services such as drying, milling, roasting, dehulling, blending and packaging were provided to agro-processing companies.

Installation of a drum dryer to be used as a commercial dryer option for clients and projects.

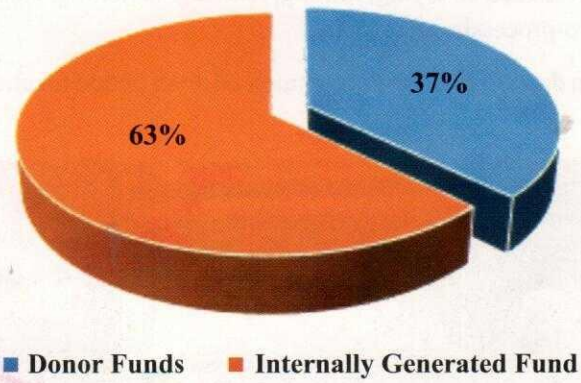
Fufu flour drying trial using newly stalled drum dryer

FINANCIAL SUMMARY

Research and Development activities of CSIR-FRI are carried out with funds from donors in the form of projects. This year, donor agencies we worked with include Export Trade, Agriculture and Industrial Development Fund, CORAF/WECARD, Bill and Melinda Gates Foundation, World Bank, DANIDA, European Commission, Canadian International Development Agency (CIDA), Partnerships for Enhanced Engagement in Research (PEER), USAID, Market Place Agricultural Innovations, Christian Aid and FARA.

Total amount received from donors this year was GH¢ 716,121 and total income the Institute generated was GH¢ 6,683,053 (3% less than 2015). Income from Internally Generated Fund (GH¢ 1,201,872.00) showed a growth of 10.26% compared to that of 2015.

Ratio of donor funds and IGF 2016



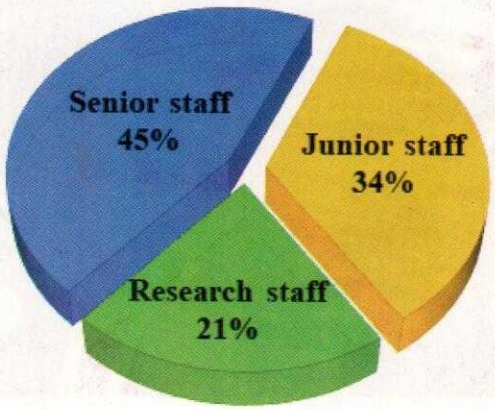
Comparison of Internally generated funds and donor funds

ADMINISTRATIVE ACCOUNT

The driving force of the Institute is its human resource. The successes of its research and development activities is attributed to the quality of its knowledge pool which comprises of knowledgeable, talented, skilled and diligent staff at all levels. The staff strength totals one hundred and fifty-six (156), made up of thirty-three (33) Senior Members, seventy (70) Senior Staff and fifty three (53) Junior Staff. Out of the number of Senior Members and Senior Staff, thirty one (31) are Research Scientists and fifteen (15) Technologists respectively. Specializations of our research staff include Food Microbiologists, Molecular biologists, Food Scientists, Food Technologists, Biochemists, Chemists, Toxicologists, Mechanical Engineers, Nutritionist, Business Developers and Information Scientists.

Promotions are an integral aspect of administrative activities resulting from upgrading of skills and knowledge of staff. In this year, 23 staff were promoted to various levels as others retired after long service; most memorable was the retirement of our Director, Dr. Nanam Tay Dziedzoave after serving in the Institute for 34 years.

STAFF STRENGTH



To be current on modern technologies and research trends, research staff are encouraged to undertake short courses and trainings in various fields. Such knowledge acquisitions are carried out across the globe. Researchers also travel abroad and to other African countries to gain more insight and to share scientific knowledge through conferences, seminars and workshops.

Mrs. Deborah Narh Mensah during an AWARD Research Attachment at the Laboratoire des Symbioses de Tropicales et Mediterraneennes (LST&M), Montpellier, France.

Ms. Matilda Dzomeku on a mushroom farm during a research visit to the USA as part of the PEER Project

OUR STAFF - SENIOR MEMBERS AND SENIOR STAFF LIST

Directorate

Dr. Mrs. Mary Obodai	-	Prin. Res. Scientist (Director)
Dr. Charles Tortoe	-	Prin. Res. Scientist (Deputy Director)
Dr. Lawrence Abbey	-	Quality Manager
Mrs. Anthonia Andoh –Odoom	-	Deputy Quality Manager
Ms. Faustina Somuah	-	Chief Admin. Assistant
Ms. Mariam Yakubu	-	Technologist/Scientific Secretary
Ms. Marmatha Yakubu	-	Prin. Admin Assistant

Administration Division

Ms. Janet Aggrey-Yawson	-	Admin. Officer
Mr. Eric K. Ofori	-	Chief. Admin. Asst.
Mr. Patrick Ofosu Mintah	-	Chief Tech. Officer
Mr. Edmund Mensah-Yemo	-	Chief Works Supt.
Mrs. Beullah Sallah	-	Chief. Admin. Asst.
Mrs. Victoria A. Asunka	-	Prin. Admin. Asst.
Ms. Anita Adusah	-	Prin. Admin. Asst.
Mr. Moses Ollennu	-	Snr. Asst. Transport Officer
Ms. Esther Lamptey	-	Admin. Assistant

Finance Division

Mr. David – Hayford Ahiabor	-	Snr. Accountant/Head. Finance
Ms. Judith Dogbegah	-	Chief Accounting Asst.
Mr. Christian Amegah	-	Chief Accounting Asst.
Mr. Derrick Victor Sallah	-	Prin. Accounting Asst.
Mr. James Cromwell	-	Snr. Stores Supt.
Ms. Mabel Aryee	-	Snr. Accounting Asst
Ms. Wolase Efodzi	-	Snr. Stores Supt.
Mrs. Angela Addy	-	Snr. Stores Supt.
Ms. Regina Tsotsoo	-	Snr. Accounting Assistant
Ms. Joana B. Dzikunu	-	Prin. Admin. Assistant
Ms. Judith Larweh	-	Snr. Tech. Officer

Commercialization Division

Mr. Stephen Nketia	-	Head of Division/Scientific Secretary
Mr. Michael Amoo-Gyasi	-	Prin. Technologist
Mr. Nelson Y. Amey	-	Prin. Technologist
Mr. Richard Takli	-	Snr. Technologist
Mrs. Helene Annan	-	Snr. Technologist
Mr. Solomon Dowuona	-	Snr. Technologist
Mr. Alexander Henry K. Appiah	-	Snr. Technologist
Ms. May A. Boham-Dako	-	Snr. Technologist
Mr. Emmanuel Adokwei Saka	-	Technologist
Mr. Philip.O. Baidoo	-	Prin. Accounting Asst.
Mr. Jeremiah Lartey- Brown	-	Chief Technical Officer

Mrs. Agartha Amuzu	-	Prin. Tech. Officer
Mr. Thomas Najah	-	Prin. Tech. Officer
Mr. Peter Dalabor	-	Prin. Works Supt.
Ms. Makafui Torgbui	-	Technical Officer
Mrs. Alice Padi	-	Snr. Tech. Officer
Mr. Godwin Armah	-	Snr. Tech. Officer
Mr. Emmanuel Tettey Agblo	-	Snr. Works Supt
Mrs. Belinda Quaye	-	Snr. Tech. Officer
Mr. Frank Dogbey	-	Snr. Tech. Officer
Mr. Ebenezer Tawiah	-	Snr. Tech. Officer
Ms. Emefa Gblende	-	Snr. Tech. Officer
Mrs. Dorothy Narh	-	Snr. Tech. Officer
Mr. Ofori Brempong	-	Snr. Tech. Officer
Ms. Syndy M. Williams	-	Snr. Tech. Officer
Ms. Ruth Fosu	-	Prin. Technical Officer
Ms. Mary Assimah	-	Prin. Admin. Assist.
Ms. Getty Afuukar	-	Snr. Admin. Assist

Food Technology Research Division

Mrs. Charlotte Oduro-Yeboah	-	Snr. Research Scientist/Head of Division
Mr. Joseph Gayin	-	Snr. Research Scientist
Mr. Gregory A. Komlaga	-	Research Scientist
Mr. Peter Adoquaye Addo	-	Research Scientist
Mr. Elvis A. Baidoo	-	Research Scientist

Mr. Raphael Kavi	-	Librarian
Mr. Kwabena A. Bugyei	-	Scientific Info. Officer
Mr. Paa Toah Akonor	-	Research Scientist
Mr. Jonathan Ampah	-	Research Scientist
Mr. Joseph Akoto	-	Prin. Works Supt.
Mr. Seidu A. Sampare	-	Chief Tech. Officer
Mr. Desmond Mensah	-	Prin. Tech. Officer
Ms. Edna Mireku	-	Sen. Technologist
Ms. Jemima Ofori	-	Sen. Tech. Officer
Mr. Rufai Braimah	-	Technical Officer

Food Microbiology Mushroom Research Division

Dr. Margaret Owusu	-	Snr .Research Scientist/Head of Division
Ms. Matilda Dzomeku	-	Research Scientist
Mrs. Anthonia Andoh	-	Research Scientist
Mrs. Amy Atter	-	Research Scientist
Ms. Deborah L. Narh	-	Research Scientist
Mrs. Nina Bernice Ackah	-	Research Scientist
Mr. Evans Agbemafle	-	Asst. Research Scientist
Mr. Theophilus Annan	-	Research Scientist

Food Chemistry Nutrition Research Division

Mr. George A. Anyebuno	-	Research Scientist/ Head of Division
Mr. Charles Diako	-	Research Scientist
Mr. Hayford Ofori	-	Research Scientist

Mrs. Lynda Hagan	-	Research Scientist
Ms. Hannah Oduro	-	Research Scientist
Mr. Kofi Kwegyir Essel	-	Snr. Technologist
Mr. Frank Peget Mboom	-	Snr. Technologist
Mr. Vincent Kyei-Baffour	-	Snr. Technologist
Ms. Constance Boateng	-	Prin. Tech. Officer
Ms. Vida Awidi	-	Prin. Tech. Officer
Ms. Mary Abena Okai	-	Prin. Tech. Officer