2019 ANNUAL REPORT

CSIR- FOOD RESEARCH INSTITUTE

CONTACT

Prof. (Mrs) Mary Obodai

The Director

CSIR-Food Research Institute

P.O. Box M20 Accra, Ghana

LOCATION

Adjacent Ghana Standards Authority, Gulf Street,

Golf House, Near Tetteh Quarshie Interchange, Accra, Ghana

E-mail: info@foodresearchgh.org or director@foodresearchgh.org

Website: www.foodresearchgh.org

Telephone: +233 302 962 068/ +233 30 251 9091/+233 30 296 2068

COMPILED BY:

Mariam Yakubu

Stephen Nkatia

EDITED BY:

Prof. (Mrs.) Mary Obodai

Prof. Charles Tortoe

Ms. Mariam Yakubu

Mr. Kwabena Bugyei

Mr. Ebo Eyison

DESIGNED & PRINTED BY

CSIR - INSTI

+ 0302-780708\9

www.csir-insti.org

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ACRONYMS

AEAs	Agricultural Extension Agents
AGRA	Alliance for a Green Revolution in Africa
AU	African Union
BMGF	Bill and Melinda Gates Foundation
BNARI	Biotechnology and Nuclear Agriculture Research Institute
CCST	CSIR College of Science and Technology
DAEs	Directorate of Agricultural Extension Services
DANIDA	Danish International Development Agency
EU	European Union
FAO	Food and Agriculture Organization
FCNRD	Food Chemistry and Nutrition Research Division
FMMRD	Food Microbiology and Mushroom Research Division
FTRD	Food Technology Research Division
GAEC	Ghana Atomic Energy Commission
GHPs	Good Hygienic Practices
GMPs	Good Manufacturing Practices
HQCF	High Quality Cassava Flour
IFAD	International Fund for Agricultural Development
IIR	Institute of Industrial Research
MAG	Modernizing Agriculture in Ghana
MoFA	Ministry of Food and Agriculture
NAES	National Agricultural Extension System
NARS	National Agricultural Research System
PEF	Private Enterprise Federation
PFC	Pioneer Food Cannery Ltd
RELC	Research Extension Farmer Linkage Committees
RSA	Research Staff Association
SANAS	South African National Accreditation System

SDF	Skills Development Fund
SMEs	Small and Medium Enterprises
SSA	Senior Staff Association
SWA	Staff Welfare Association
TUC	Trades Union Congress
WIAD	Women in Agricultural Development

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"Prof. (Mrs.) Mary Obodai"

DIRECTOR, CSIR-FOOD RESEARCH INSTITUTE

FOREWORD

CSIR-Food Research Institute continued to excel in achieving its goals and implementation of its strategic plan for the year. The strategic goal was to create value and achieve excellence for and with its stakeholders. Technical support by research staff of the Institute continued to be given on an increasing scale to several organizations and a considerable number of private firms, with seventeen (17) new companies set up including snack bar production and frozen yam chips.

On the administrative front, the Institute attaches great importance to good corporate governance as a means to sustaining the long-term viability of its activities. In the conduct of its activities, the Institute endeavours to comply with all statutory requirements and adopts best practices to protect the environment and its employees. It also adheres to standard accounting practices and ensures sound internal controls to facilitate transparency of business transactions and reliability of financial statements.

As a result, the Institute continued to follow its system of management control to ensure effective, efficient and proper utilization of resources in pursuit of its Vision and Mission with due regard to the interest of the Council and its stakeholders. And for this, we appreciate the immense assistance of a member of the Management Board, Mr. Manu Obeng-Koranteng, a Chartered Accountant. This gives further assurance that, our accounting records are in conformity with generally accepted accounting principles and auditing standards.

Of the many individuals and institutions that visited the Institute, during the reporting period, special mention may be made of the visit by a team from Hungary Embassy led by Deputy Head of Missions. It is my fervent hope that the deliberations that ensued will contribute to the national and international dialogue on the role of and the relevance of Science and Technology at a time when the responsibility of promoting S&T binds us together more than any other in our history.

On behalf of the Management Board and on my own behalf, I wish to express my sincere gratitude to our Stakeholders and clients for their goodwill and support and to Management and Staff of the institute for their dedication to duty during the year.

Thank you and God bless us all.

EXECUTIVE SUMMARY

From its establishment in 1963, CSIR-Food Research Institute has played the key role in conducting research into food processing and preservation, food safety, food storage, food marketing, distribution and food utilization. It also focuses on addressing national food and nutritional security in support of the food Industry and socio-economic development of communities. It is constantly on the quest to provide scientific and technological support for the growth of the food and agricultural sectors of the country.

To provide optimum support, core activities are executed under R&D and Commercialization Divisions. Commercial activities within the year included providing technical and analytical services, technology transfers, resolving industrial challenges and establishment of seventeen (17) start-up companies. Noteworthy R&D activities involved consumer acceptability of pearl millet sourdough bread, development of efficient fish drying platforms and post-harvest handling of small fish. The Institute also participated in strengthening links between research and extension services through its active participation in the development of relevant extension materials and training of extension officers and processors. Study on developing bacteriophage cocktails as fish disease bio-control agents continued with execution of work packages in Ghana and Uganda. There was a successful collaboration with Mondelez on fermentation and drying of cocoa beans. The Institute also carried out trainings on mushroom cultivation; cassava value addition; preparation of fish based waffles and fish nuggets as well as other product development activities.

CSIR-FRI generated GHC 1,608,450.45 from laboratory services, sale of research products and other services. It successfully won and received GHC 1,801,072.69 as research grants from different donor agencies.

Within the year under review, the Institute had a staff strength of one hundred and forty-nine (149). With the diversity of skills set and research focus of its staff, CSIR-FRI generated thirty-nine (39) publications comprising of fourteen (14) journal publications, fourteen (14) technical reports, four (4) extension leaflets, three (3) conference abstracts, two (2) conference posters and one (1) handbook.

INTRODUCTION

CSIR-Food Research Institute was established with a mandate to conduct applied market-oriented research into resolving challenges of food processing and preservation; food safety; food storage, marketing, distribution and utilization as well as national food and nutritional security in support of the food Industry.

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.

Programs of the Institute are designed and structured to assists in poverty alleviation through creation of opportunities for income generation for micro, small, medium and large scale food industries. Key programs of focus include: Root and tuber products program; Cereal, grains and legumes products program; Meat, fish and dairy products; Fruit, vegetable and spice products program and a technology business incubation program.

Activities are operated under three (3) key pillars:

- 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.)

FOOD SECURITY AND POVERTY REDUCTION

The R&D activities of CSIR-FRI are geared towards addressing food security issues and alleviation of poverty from Industry through to the grass root level. Through its skills development and capacity building interventions, the Institute has fostered use of underutilized crops, development of nouvelle products, preservation and storage, food quality and safety interventions and transfer of post-harvest technologies. Summarised below are noteworthy activities towards food security and poverty alleviation by some projects and consultancies within the year under review.

UP-SCALING MILLET SOURDOUGH TECHNOLOGY IN WEST AFRICA FOR EXTRUDED PRODUCTS

Obodai, M., Oduro-Yeboah, C., Dziedoave, N., Nyarko, J., Amoo-Gyasi, M and Mireku-Essel, E.

Duration: 1 year

Introduction

With the increase in bread consumption in Ghana, efforts have been made to promote the use of composite flours made from locally grown root crops and cereals. The composite flours are partially substituted with wheat flour for bread making. This composite flour programme would thereby minimize the demand for imported wheat; produce protein- enriched bread conserve foreign reserves and widen the utilization of indigenous crops in food formulation. The nutritional characteristics and low cost of millet has aroused much interest in recent times. Millet does not contain gluten and is known for its low carbohydrate concentration and low glycemic index.

Fermentation is known to improve the nutritional value of raw materials. Studies have found improvement of in vitro protein digestibility; increase in starch digestibility, total free amino acids and minerals; as well as significant reduction in phytic acid content and trypsin inhibitor activity. Sourdough fermentation is a type of solid state fermentation that impacts unique characteristics on ground cereals or starchy raw materials. It is useful as a tool for adding value to locally available agriculture produce as well as foster cultural and geographical distinctiveness. Use of sourdough in breads has acquired popularity as a means to improve the quality, flavor and shelf life of breads.

The project therefore aimed to:

- Develop and promote commercializable novel millet sourdough products using baking and extrusion technology adaptable to West African production.
- Determine the effect of consumption of millet sourdough bread and extruded snacks on the nutritional and health status of school children in selected West African countries.
- Determine the shelf life of millet sourdough bread and extruded snacks during storage.
- Build capacity and promote training of bakers, SMEs and other beneficiaries.

Key Activities and Achievements

At the on-set of the project, a survey was conducted to gather information on existing baking technologies, existing millet products and millet extruded products. This was done by administering questionnaires for

millet producers, traders, SMEs processors and consumers. The questionnaires were pre-tested using 20 Pearl millet Farmers from Manga in the Upper East Region of Ghana, 20 millet processors, 20 millet traders, 20 SMEs and 30 millet consumers from the Greater Accra Region of Ghana. A total of 110 actors were used for the pretesting. The questionnaires were modified per the suggestions obtained from the pre-testing survey. The modified questionnaires were used for the actual survey which was held in both the Northern and Greater Accra Regions. The final survey was comprised of 200 pearl millet farmers, 100 processors, 80 traders, 200 consumers and 50 SMEs. As shown in figure 1, there are less number of SMEs in the target locations of the project.

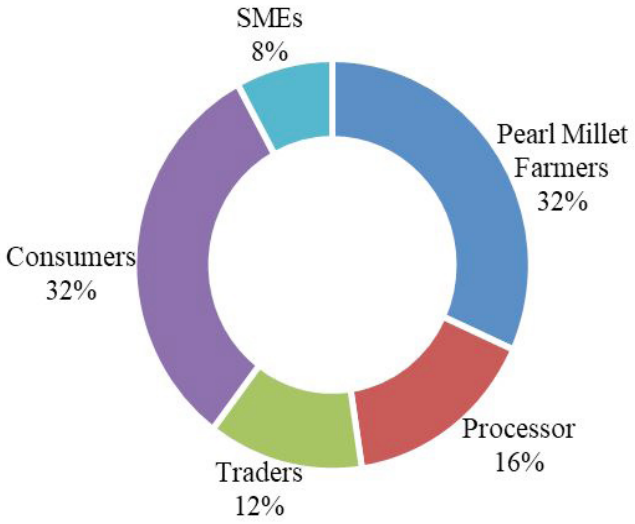


Figure 1: A survey on pearl millet stakeholders

Preparation Of Millet Sourdough Bread

Two varieties of pearl millet grains (Early and Late Pearl millet) were used in the production of the sour dough. The ingredients used are as shown in table 1.

Table 1: Ingredients and weight used for millet sour dough preparation

Ingredients	Weight (g)
Millet Sourdough	240
Wheat flour	360
Water	180
Sugar	20
Salt	10
Margarine	20
Nutmeg	0.1
Vanilla essence	2.5mls

To develop an optimum product, different formulations of millet sourdough to wheat flour were used as shown in Table 2 below.

Table 2: Formulations of millet sour dough bread

	Millet sour dough	Wheat flour
90%	90	10
80%	80	20
70%	70	30
60%	60	40
50%	50	50
40%	40	60
30%	30	70
20%	20	80
10%	10	90

NB: the more sourdough, the lesser the water used

The sourdough was prepared prior to the formulation of the sourdough bread. This involved fermenting of millet flour for 2 days as shown in the flow chart (figure 2).

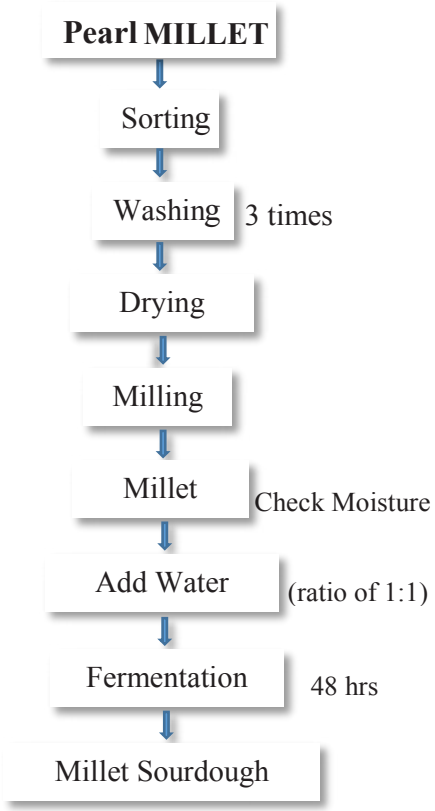
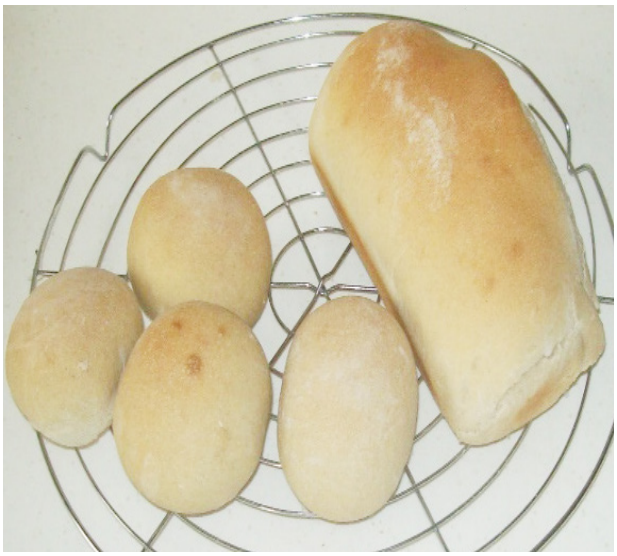


Figure 2: Flow chart for the production of pearl millet sourdough

The prepared sourdough is mixed with other ingredients and a proportion of wheat flour to produce the sourdough bread as seen in figure 3.

Figure 3: Flow chart for preparation of millet sourdough bread



20% Sourdough

30% Sourdough

50% Sourdough

Early Pearl millet sourdough bread

Late Pearl millet sourdough bread

Sensory Evaluation

Consumer Acceptability Of Pearl Millet Sour Dough Bread

Fifty (50) consumers were selected and used in the study according to criteria of familiarity with the product. The consumer tests were carried out using seven (7) different formulations of the millet sourdough in the sensory science laboratory of the Institute. Samples were evaluated on a nine-point hedonic scale (1- dislike extremely, 5- neither like nor dislike and 9- like extremely), based on the attributes of appearance, colour (crust), colour (crumb), aroma, taste, sponginess, after taste and overall acceptability (Table 3). Samples were served to consumers in two (2) days, four (4) samples and three (3) samples respectively. Consumers were offered mineral water and cucumber to rinse their mouths between samples.

Table 3: Results of sensory evaluation of sourdough bread

Millet sourdough samples	Appearance	Colour (crust)	Colour (crumb)	Aroma	Taste	After taste	Sponginess	Overall acceptability
Control	7.8±1.02^{a}	7.7±0.80^{a}	7.1±1.32^{a}	7.6±1.17^{a}	7.7±1.05^{a}	7.7±1.06^{a}	7.2±1.18^{a}	7.9±1.06^{a}
40%	7.2±1.21^{abc}	7.0±1.25^{abc}	6.8±1.26^{a}	6.8±1.24^{bc}	6.2±1.58^{b}	5.7±1.61^{b}	6.5±1.39^{ab}	6.4±1.51^{bc}
50%	7.3±0.87^{ab}	7.2±1.00^{ab}	6.8±1.10^{a}	6.8±1.00^{ab}	6.3±1.34^{b}	5.8±1.47^{b}	6.5±1.41^{ab}	6.7±1.48^{b}
60%	6.4±1.47^{c}	6.3±1.49^{cd}	6.7±1.22^{a}	6.0±1.70^{c}	4.9±1.78^{cd}	4.7±1.87^{c}	6.2±1.54^{b}	5.5±1.59^{c}
70%	6.6±1.14^{bc}	6.4±1.35^{bc}	6.5±1.21^{a}	6.3±1.46^{bc}	5.5±1.52^{bc}	5.0±1.48^{bc}	5.8±1.39^{b}	5.7±1.58^{c}
80%	5.0±1.90^{d}	5.0±1.95^{e}	5.1±1.93^{b}	4.9±1.97^{d}	3.5±1.95^{e}	3.5±1.98^{d}	4.0±1.79^{c}	3.6±1.93^{d}

90%	5.5±2.08^{d}	5.5±2.11^{de}	5.0±1.98^{b}	5.0±1.66^{d}	3.9±1.84^{de}	3.5±1.49^{d}	4.4±1.92^{c}	4.3±2.01^{d}

Values within columns with different letters are significantly different at $p < 0.05$

From Table 3, as expected, the control sample (30% millet flour and 70% wheat flour) performed better in all the parameters evaluated, having a score range of 7.1 to 7.9 followed by sample of 50% millet sourdough, recording a score range of 5.8 to 7.3. The sample of 80% millet sourdough was the least preferred among all samples evaluated.

The appearance of the sourdough bread samples revealed that all the samples were significantly different except for 80% and 90% bread samples. This implies that the appearance of 80% and 90% sourdough bread samples were similar but different from the other samples. Consumers least preferred the appearance of samples with 80% and 90% sourdough. The appearance of the control sample was liked most (7.8, liked very The appearance of the sourdough bread samples revealed that all the samples were significantly different except for 80% and 90% bread samples. This implies that the appearance of 80% and 90% sourdough bread samples were similar but different from the other samples. Consumers least preferred the appearance of samples with 80% and 90% sourdough. The appearance of the control sample was liked most (7.8, liked very much) followed by sample 50% (7.3, liked moderately).

The colour of crusts of samples underwent a similar trend as results for appearance of samples. The control sample was most preferred (7.7) followed by 50% (7.2), with 80% being the least preferred (5.0). Concerning the colour of the crumb, control sample scored the highest (7.1) followed by 50% (6.8) and 40% (6.8). Sample with 90% sourdough scored the least (5.0). The aroma of the control sample was most preferred (7.6, liked very much), followed by 50% (6.8) and 40% (6.8), after which taste and sponginess followed a similar trend. Regarding taste, control sample was the most preferred followed by sample 50%. The taste of sample with 80% sourdough was the least preferred (3.5, disliked slightly).

Overall, the control sample was the most accepted, with the highest overall acceptability score of 7.9 (liked very much), followed by 50% sample recording a score of 6.7 (liked moderately). Sample 80% recorded the least overall acceptability score of 3.6 (disliked slightly).

Loaf Volume Tests

Loaf volumes of samples were calculated and presented in Table 4. Millet composite bread 90% and 80% samples were found to have lowest loaf volume readings (110 and 200 respectively) and thus having low specific volumes 0.41 and 0.70 respectively. Control and 40% bread samples made using high proportions of wheat flour gave highest loaf volumes and thus higher specific loaf volumes compared to other samples (1190 and 810) and (2.61 and 2.44) respectively. It was observed that, increase in the percentage of millet sourdough in bread resulted in decrease in loaf volume and specific loaf volume. This might be due to large particle size and damaged starch percent of millet sourdough. Decrease in loaf volume with increasing levels of millet sourdough may be ascribed to reduced carbon dioxide (CO2) retention in millet sourdough bread sample as explained by. It was also obvious that substitution of wheat flour with other flours reduced the gluten fraction which is a source of elasticity in dough. This elasticity helps in retaining CO2 produced during fermentation. Reduced gluten fraction in 90%, 80%, 70%, 60% bread samples caused a compact, compressed, less aerated texture and decreased raise in loaf size.

Similar trend of results was obtained for specific volume of loaf in the current research. Specific volume of millet sourdough bread (cm3/g) ranged from 0.41cm3/g to, 2.61cm3/g. Specific volume of bread with 90% and 80% formulation was significantly lower ($p<0.05$) than that of 40% and control. It is apparent that bread

Table 4: Results of loaf volume

Sample	Weight (g)	Volume (cm3)	Specific volume (cm3/g)
Control	456.3	1190	2.61
40%	332.2	810	2.44
50%	323.8	644	1.99
60%	316.5	394	1.24
70%	303.5	390	1.29
80%	286.9	200	0.70
90%	271.6	110	0.41

Show case of gluten-free sourdough bread during the Institute's Open day

samples with reduced volumes resulted in reduced specific volumes. Increased substitution of wheat flour with other flours resulted in decrease in loaf volume and specific volume.

SMALL FISH AND FOOD SECURITY (SMALLFISHFOOD): TOWARDS INNOVATIVE INTEGRATION OF FISH IN AFRICAN FOOD SYSTEMS TO IMPROVE NUTRITION

Atter,A., Owusu, M., Ampah, J., Andoh-Odoom, A. and Akonor, P.T.

Duration: 3 years

Introduction

Small fish like any other fish are a rich source of protein and plays an important role in improving the nutritional requirements of consumers. Small fish can be found in all aquatic environments from large marine ecosystems to seasonal ponds, as well as in market places and low-income household diets. However, their significance is underrated and little understood as they are consumed locally and often go unrecorded in catch statistics. Climate change has affected rainfall and weather patterns, which has in turn, affected yields of aquatic life.

Poverty breeds food insecurity, which hinders development of communities and households. Investing in smallholder farmers and markets has been proven to be important and effective in addressing food insecurity. Small fish can be used for human consumption and well-being to promote poverty reduction and resolution of food security issues. To aid achieve this goal along the fish value chain, the project focused on improving primary processing of small fish and developing new products. This was achieved by engaging and supporting women fish processors (who trade in sun-dried fish) to provide safe and hygienic fish to consumers. In addition, opportunity and direction were given to the women to enable them access larger markets in order to earn the much-needed income.

Fish simply sun-dried and consumed whole, is the most high-yielding, eco-friendly, low CO2-emission and nourishing way of utilizing aquatic resources. Aside the nutritional benefits derived from small fish - depending on the processing method employed- some hazards such as microbial contamination may affect the quality of the fish.

Key Activities and Achievements

Survey

The CSIR-FRI chapter of the project sought to provide value added small fish food products through improved techniques for fish sun drying and reduced post-harvest losses. The team also ultimately sought to increase public awareness of the value of small fish in improving the nutritional status of consumers. With these objectives in mind, a feasibility study was conducted at the James Town, Tema New Town, Moree and Adina landing sites located in the Greater Accra, Central and Volta regions of Ghana. The team established the common varieties of fish harvested within the listed localities, the types of drying methods employed and the bio-data information of the fish processors.

The common practices observed at landing sites were that, fish were sun-dried on the bare ground, mostly on the beach, at the mercy of environmental conditions and adverse weather. Sun-dried fish therefore becomes contaminated with sand and high counts of microorganisms.

Drying of small fish on bare ground at Tema and Adina

Most of the fish are washed away by the rain, in the attempt to dry fish (on the ground) in the rainy season. Those that are salvaged by processors become unwholesome and the consequence is a huge loss of capital to the fish processors (mostly women). Another challenge faced by the processors is the unavailability of land for drying; for instance, in the James Town area, small fish are dried on pavements by major streets. Post-harvest losses experienced by these fish processors takes a toll on their incomes and also affects availability of rich sources of nutrients by consumers.

Technology Transfer To Processors

Pilot scale drying platform and racks constructed at CSIR-FRI

Utilization of the raised off-the-ground platform results in a better quality and hygienically dried small fish; the sun-dried small fish is free from sand and other debris and is of a better microbial quality.


Drying racks and platforms constructed at Moree and Tema New Town

Drying racks on which the fish are placed have been designed to prevent flies (vectors of disease) from having access to the fish. Handles on the racks also allow for easy transportation of racks to places of shelter and allow the rack to be easily flipped over to for thorough drying.

The project also saw the need to support fish processors with equipment that would enable them valorize their fish. Hammer mills were therefore provided to stakeholders at the landing sites to enable them mill dried fish into a fine powder for use in the development of value-added products. Sealing machines were also


Handing over equipment (hammer mill, Sealer) in Moree

Training Of Processors

Processors were trained on Good Manufacturing Practices (GMPs) and Good Hygienic Practices (GHPs) prior to drying. They were also trained on the importance of de-heading and de-gutting dried fish to prevent bitter taste in milled powder which would be used for product development. The training session at Tema New Town was reported in the daily graphic page 8 on 11/01/2020 under the caption 'CSIR trains fish processors in improved techniques'.

De-heading and de-gutting of sun dried anchovies and bumper for product development

Dried, milled fish powder has many uses. It can be used as a condiment in foods to enhance taste and at the same time provide the needed nourishment for consumers. It can be added to stews, soups and sauces such

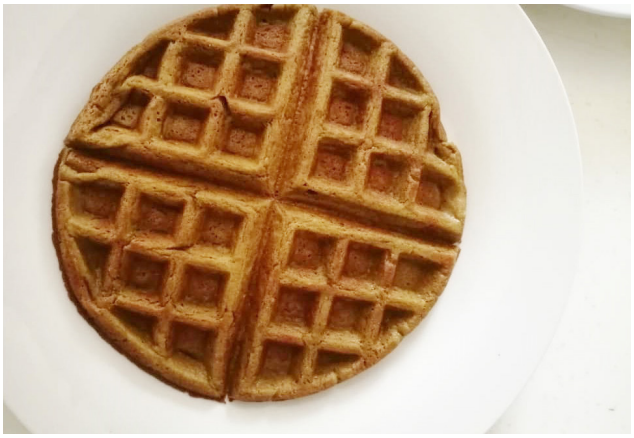
Dry waffle mix

Instant Cereal with sun-dried fish

Sundried fish pepper

Processors were trained on how to prepare fish nuggets and waffles to provide them with alternative sources of incomes and alternative menu's for their families; this would provide the much needed nutrition, especially for the development of their children

Training on preparation of fish waffles and fish nuggets



Fish waffles

Fish nuggets

Improved hygienic and safe fish consumption is an integral component of food security. Improved small fish products provide access to larger markets yielding higher incomes for fish processors. The project has made great strides in an attempt to improve nutrition, provide safe sun-dried fish, increase the range of sun-dried fish products and improved livelihoods of the women in fishing communities along the Ghanaian coast.

Feedback from the fish processors indicated that they were very delighted with the technology. They also expressed interest in replicating the drying platforms and racks as they are made from inexpensive materials.

The Tema Metropolitan Assembly has obtained funding to replicate the platform at Tema New Town. This would provide employment and support to the drying businesses of fish processors and serve as goals, to poverty reduction. The Assembly have also requested the fabrication of additional hammer mills to support the women improve their financial situations.

MODERNIZING AGRICULTURE IN GHANA (MAG)

Oduro-Yeboah, C., Obodai, M., Komlaga, G., Akonor, P.T., Dzomeku, M., Buckman, E., Baffo, C.L., Arthur, W., Amponsah, S., Ampah, J., Acquah, I.N-N.

Duration: 4 years

Introduction

Applied agricultural research Institutions need strong collaboration with extension services to effectively respond to farmers' identified problems. Furthermore, the extension services need the backstopping of strong applied agricultural research institutions to effectively serve the farming communities and other stakeholders. Unfortunately, weak linkages exist among, research and extension services in the country. To address this problem, MoFA and the CSIR, in 1994, established Research Extension Farmer Linkage Committees (RELCs) to serve as an interface between the National Agricultural Research System (NARS) and the National Agricultural Extension System (NAES). The objectives of the RELCs among others include ensuring that research activities, especially adaptive research respond to farmers' constraints. These constraints are identified through the regional/district planning sessions as well as review of progress made by RELCs in solving farmers' problems and efforts made to promote proven technologies and best practices.

The RELC has since its inception been in the fore front of demand-driven technology generation and dissemination by providing a platform for key stakeholders in the agriculture sector to address constraints emanating from farmers all over the country. However, one major constraint that has always undermined the operations of the RELCs has been insufficient funds to implement its activities and demand driven research emanating from the RELCs and other sources. It further seeks to ensure that MoFA releases agreed funds regularly and on time for RELC activities to facilitate appropriate technology generation and dissemination for enhanced productivity.

The focus of this project is to produce technical bulletins and collaborate with MoFA to produce relevant extension materials for training and dissemination purposes, to address the constraints identified at the RELC regional meetings.

Its activities are also geared towards impact measurement and capacity building across the districts and regions of Ghana

In the year under review, the project has focused on technology transfer training programs organized to address the constraints identified in districts and regions in collaboration with district and regional agriculture offices. This would aid in reducing postharvest losses and ameliorate food security issues. Agricultural Extension Agents (AEAs) and WIAD officers were trained under a training of trainers' program to enable them transfer technologies to farmers and farmer processors

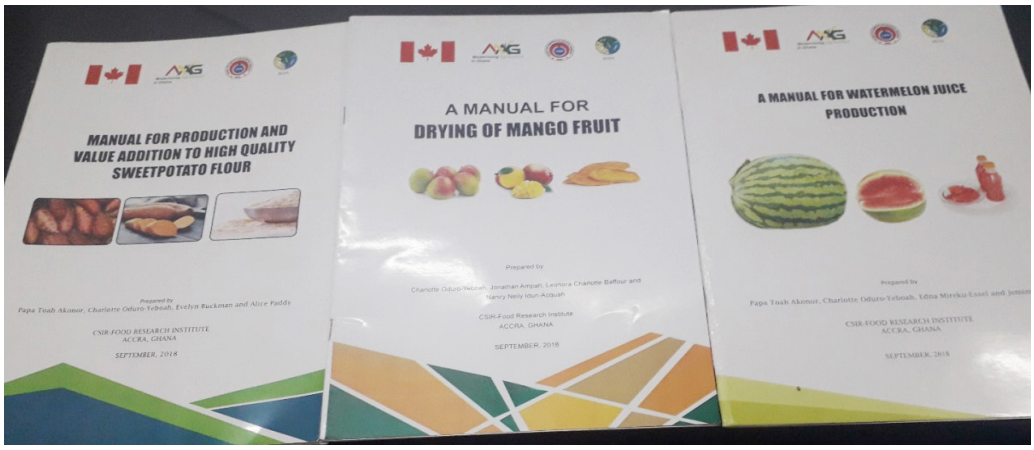
Key Activities and Achievements

Mag Sensitization Workshop

A sensitization workshop was organized for CSIR MAG team members including scientists, technologists and accountants. The focus of this workshop was to brief the CSIR team on requirements and expectations to facilitate the smooth running of the project.

Manuals For Training

Promotional and extension manuals were developed and distributed to beneficiaries in order to enhance trainings on Drying of Mango Fruit, Mango Juice Production, Production and Value Addition to Cassava Flour, Production and Value Addition to Sweet potato Flour, Watermelon Juice, Spawn Multiplication Technology. In collaboration with MoFA-DAEs, CSIR- FRI served as resource persons for the trainings.



Samples of the printed extension materials

Training Of Trainers' Workshop

The project conducted a training of trainer's workshop for seventy-eight (78) participants in Koforidua and Winneba on handling postharvest losses of some selected fruits (watermelon, citrus and mangoes) in season. Trainees included agriculture extension officers, processors and WIAD officers. This was done to explore the adoption of new innovations within the agriculture sector on handling postharvest management of some fruits in Ghana. Emphasis were laid on the need for field officers to be equipped with the requisite knowledge and skills to effectively train farmers in the agriculture sector across the districts and regions of Ghana.

Hands-on training and practical sessions were adapted to involve all participants of the workshop. Topics including Basics of food processing, Importance of Food Preservation, Processing of fruit juice, Food safety, Food packaging, and Drying of Fruits (mangoes) were extensively discussed.

Presentations by facilitators


Hands-on sessions on processing of fruits to juices

Finished juices and packaged juices

At the end of workshop, participants were empowered to define the key concepts involved in the postharvest management of fruits. They were equipped in understanding the techniques involved in the processing of fruit juices. Participants unanimously outlined the beneficial impact of the workshop on them and reiterated the need to transfer the acquired skills and knowledge to farmers.

Spawn Multiplication Technology Training Workshop

This training of lead mushroom farmers was held in Koforidua- Eastern Region; it focused on mushroom spawn multiplication technology.


Session on mushroom spawn production

Inoculation of bottled sterile grains by trainee

Training On The Use Of Cassava Peels For Cultivation Of Mushrooms

Cassava processors were trained on the use of farm waste (cassava peels) as substrate for mushroom cultivation. The aim of this exercise was to generate value added products from wastes arising from cassava value chain and to expand new market opportunities for new products developed from the waste of cassava.

Drying of cassava peels

Mixing of cassava wastes with additives

Making compost bags from mixture

Inoculation after sterilization of bags

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

Agbemafle, E., Mensah, N.L.D., Akonor, P., Etornyo, A., Tetteh-Doku, E., Anan, A.F., Damanka, S., Okyere, I. and Clokie, M.

Duration: 3 years

Introduction

This project aims at developing bacteriophage cocktails as fish disease biocontrol agents for improved aquaculture productivity among tilapia farmers, for economic and social development by addressing food and nutrition safety in Ghana and Uganda. Specifically, the project objectives include (1) determination of the microbial safety and quality of the inputs and outputs of the tilapia fish farms by identifying and enumerating the pathogenic and spoilage bacteria; (2) establishment of local host cell banks for production of strains and seed banks for bacteriophages isolated against the most common and economically significant fish bacterial pathogens; (3) formulation of bacteriophage cocktail products and evaluate their effectiveness through laboratory scale challenge experiments with known pathogens and tilapia larvae/matured fish; (4) assessment of the performance of the phage products applied on selected fish farms; the consumers acceptability and adoption by the fish farmers.

Key Activities and Achievements

Field Survey

Field data was obtained through interviews and administering questionnaires to the owners or managers/caretakers of the selected farms. Majority of the farmers practiced polyculture, a risk of one fish species acting as a reservoir of disease; thirty-six (36) of the seventy-seven (77) farmers reported disease cases and very few applied antibiotics. Limited use of antibiotics may imply limited pressure for antimicrobial resistance development. Farmers were not aware that fish fall sick although they acknowledged having observed some disease symptoms. Risks associated with phage use was one of the challenges envisaged by the farmers.

A total of nine hundred and eighty-eight (988) samples were delivered to the Veterinary Microbiology research laboratory at the College of Veterinary Medicine Animal Resources and Biosecurity. The sample types included fish (667), pond sediment (154), pond water (140) and fish feeds (27). Considering the Regions, farms and isolate type, three hundred and fourteen (314) bacterial isolates from fish were archived. From other samples; 150 isolates from pond sediment; 200 isolates from pond water; and 100 isolates from feed samples; have been isolated and archived. Tentatively, Aeromonas spp and Edwardsiella spp have been encountered on all farms. Some other bacteria isolated belong to the genera Flavobacterium, Pleisomonas and Klebsiella. Therefore, Aeromonas spp and Edwardsiella spp are targets for phage cocktail development. Evaluation of geospatial distribution of the isolates belonging to Flavobacterium, Pleisomonas and Klebsiella will inform on selection of the third genus of fish pathogens for phage isolation.

So far, bacteriophage isolation was done in case of Aeromonas spp, and five crude isolates have been archived. Phage purification procedures will yield more pure bacteriophage isolates.

Tilapia farms visited by Research team and some lab Assistants in the Eastern, Volta and Greater Accra regions of Ghana

Training workshop

The Phages for Global Health organised and funded the first West African Phage training workshop at the Kwame Nkrumah University of Science and technology, Kumasi. This was attended by selected project members.



Phage training workshop

CONSULTANCIES

CASSAVA VALUE ADDITION

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

Introduction

With decades of experience in the research of various food commodities, CSIR –FRI has successfully championed post-harvest management of roots and tubers in the areas of processing technologies and value addition. The Institute optimizes and standardizes production processes of all food commodities and transfers these technologies to different stakeholders along the food value chain including factories, SMEs, start-ups, farmers, processors, etc. Technologies developed are market- driven and transferred through capacity building exercises, workshops and training sessions.

In collaboration with the Skills Development Fund (SDF), CSIR-FRI embarked on skills building exercises focused to assist gari processing community groups on the production of quality gari, fortified gari and High Quality Cassava Flour (HQCF). They were also trained on packaging, branding, importance of registration of products and how to register products. These exercises took place in the Eastern and Ahafo Regions.

Trainers explaining ways to improve quality of products

Washing and milling cassava for processing

Milled cassava

Pressing milled cassava

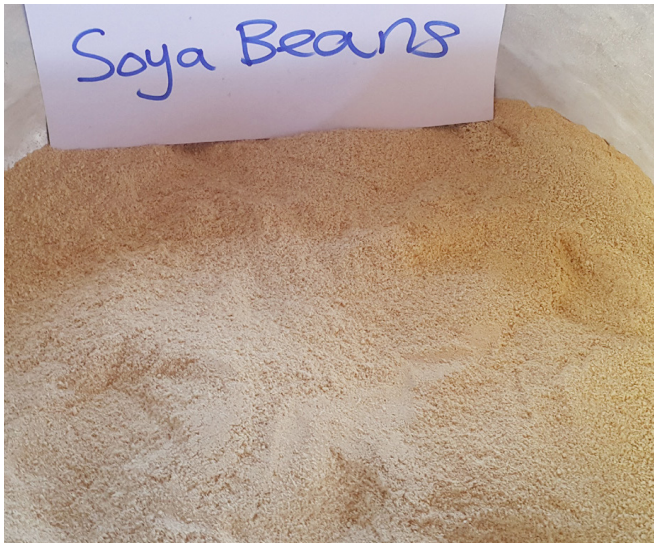
Sifting of pressed cake

Cleaning pans before roasting

Roasting of gari

Gari sample of group before training

Improved gari after training



Gari fortified with soyabean flour

Gari fortified with coconut grits

COCOA FERMENTATION

Owusu, M., Kongor, E., Appiah, A., Badaru Deen, Y., Arthur, B.A., Blessie, E.J., Amoo-Gyasi, M and Annan, T.

Introduction

This work sought to monitor cocoa fermentation and drying on two cocoa farms in the Suhum area of the Eastern Region of Ghana. The focus of this work was to:

enumerate microbial populations within the fermentation using classical microbiological techniques. In addition, enumerate populations of yeasts and molds, enterobacteria, lactic acid bacteria, acetic acid bacteria.

characterize representative microbial isolates using classical microbiological techniques

preserve selected strains for further characterization.

Techniques used included Gram staining, Catalase testing, Measurement of external and internal pH of fermenting cocoa beans.

Fermentation of the beans was done by heaping the fresh beans on a mat of banana leaves and also covering the heap with similar leaves. On each day of the fermentation, temperature measurements were taken with temperature probes from three levels of the fermenting heap on each farm: top, middle and bottom. Acidity (pH) of the fermenting heap was measured daily with a portable hand-held pH meter. Data loggers were also placed at three levels of the heap in each farm.

The heap of fermenting beans was turned on the third day, i.e. day 2 of fermentation. Turning (mixing) was done by bringing the beans down the heap, which looked less fermented and white up, and those on top that had started developing the brown colouration down the heap. This was done to ensure even fermentation. About 100 g of fermenting bean samples were aseptically taken for microbial analysis whilst about 1 kg was taken for preservation and for pH analysis. Cocoa drippings from the fermenting heaps were also collected on Days 1 and 2 of fermentation for preservation. On day 1 of fermentation, about 4.5 kg of cocoa drippings was collected in a bucket each from the two cocoa farms.

All samples were transported to the CSIR-FRI Microbiology Laboratory in an ice chest with ice packs. Once in the Laboratory, bean samples meant for shipment were aliquoted into ziplock bags whilst drippings were aliquoted into centrifuge tubes, labelled and stored at -80°C.

Cocoa beans ready to be fermented

Covering of heap of cocoa beans with banana leaves

Collecting cocoa drippings during fermentation of cocoa beans

Collecting cocoa drippings during fermentation of cocoa beans

Drying And Collection Of Samples

Drying of the fermented cocoa beans was started on the seventh day following six days of fermentation on all farms. Drying was done on wooden platforms. The fermented beans were poured on the platform and spread whilst rubbing on them with the hands. Each platform had a mat of raffia and tarpaulin which were used to cover the beans in the evening after sunset and in case of a wet weather.

Drying was done for five days. Drying bean samples were collected for cut test and to be preserved for shipment for other tests. At the end of the drying period, about 30 kg each of cocoa beans from the two study farms (Francis and Emmanuel) and from a third farm (David), were collected and sent to CSIR-FRI to be shipped for further work.

Spreading of cocoa beans on a platform for drying

Completely dried cocoa beans

Classical Microbiological Techniques For Identification Of Isolates

Initial tentative identifications of isolates were done using colony and cell morphology, gram reaction and catalase test. Gram reaction was determined using 3% freshly prepared Potassium hydroxide solution. The tip of a cover slip was used to pick a pure colony of LAB and added to a drop of Potassium hydroxide solution on a slide. The colony was mixed thoroughly with the solution using the cover slip and drawn for

the production of slime. Formation of a slime indicated Gram negative reaction and non-slimy reaction indicated Gram positive reaction.

Catalase test was done by placing a drop of 3% freshly prepared Hydrogen peroxide solution on a clean glass slide and a single colony of the pure culture picked and emulsified. This was then observed for bubbles or effervescence resulting from the liberation of free oxygen as gas bubbles. This indicated the presence of the enzyme catalase in the culture and vice versa. Colonial morphology of the cultures was also documented. Characterization of isolates were then carried out (Table 5).

Table 5: Count of microorganisms (CFU/g) isolated from cocoa during fermentation and drying from the three farms

Fermentation	Sample Code	APC	Enterobacteriacae	Acetic acid bacteria	Lactic acid bacteria	Yeast	Mould
Day 0	ETD 0	1.88 x 107	1.06 x 107	ND	1.06 x 107	7.6x106	1x105
	FLD 0	2.36 x 107	8.9 x 106	ND	1.5x106	7x105	6x105
Day 1	ETD1	9.8 x 108	3.7 x 104	ND	2.24x108	3.7x106	ND
	ETDD 1	8.6 x 109	4.9 x 104	9.1 x 106	3.99x108	3.1x108	ND
	FLD 1	1.09 x 109	5.1 x 105	5.54 x 105	4.14x106	2.3x106	ND
	FLDD 1	9.4 x 109	8.0 x 102	ND	1.67x107	3.3x107	ND
Day 2	ETD 2	8.9 x 109	ND	ND	4.6 x 108	6x106	ND
	FLD 2	7.5 x 109	ND	ND	6.0 x 108	3x105	ND
	DAD 2	9.3 x 109	ND	ND	1.71 x 109	6x106	ND
Day 3	ETD 3	1.76 x 108	ND	ND	2.68 x 109	ND	ND
	FLD 3	3.9 x 107	ND	ND	2.4 x 108	ND	ND
Day 4	ETD 4	NT	ND	2.7 x 105	5.0x109	7.1x107	ND
	FLD 4	NT	ND	1.9 x 105	4.3x109	9.8x107	ND
Day 5	ETD 5	5.1 x 108	ND	ND	3.8x107	ND	ND
	FLD 5	9.8 x 107	ND	ND	1.45x107	ND	ND
Day 6	ETD 6	6.6 x 107	ND	ND	1.2x107	ND	ND
	FLD 6	2.2 x 107	ND	ND	7.0 x107	ND	ND
	DAD 6	1.0 x 108	ND	ND	5.8x107	3.2 x104	ND

Day 7	ETD 7	9.3 x 108	ND	TNC	NT	NT	NT
(drying)	FLD 7	7.7 x 108	ND	9.5 x105	NT	NT	NT
Day 8	ETD 8	2.2 x 109	NT	NT	NT	NT	NT
(drying	FLD 8	2.7 x 108	NT	NT	NT	NT	NT

Key: ND - Not Detected, NT - Not Tested, TNC- Too Numerous To Count, APC – Aerobic Plate Count, FLDD1- Fermentation drippings for day 1 from FL Farm, ETDD1- Drippings for day 1 from ET Farm

Determination of internal bean pH

The pH of cocoa nibs was determined on each day of fermentation (Figures 4 &5) at the General Chemistry Laboratory of CSIR-FRI. Cocoa beans were de-shelled and 10 g of cocoa nibs were homogenized with 90 ml of hot distilled water. The mixture was stirred for 30 s and then filtered using a filter paper. The filtrate was then cooled to about 25°C. About 25 ml was aliquoted into a beaker and the pH measured. This was done in triplicate and the average taken (Table 6).

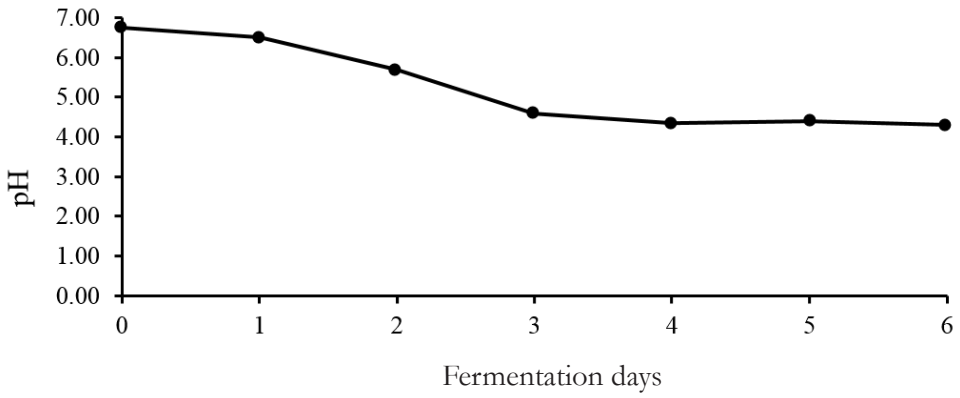


Figure 4: Internal pH of cocoa beans from farm ET during fermentation

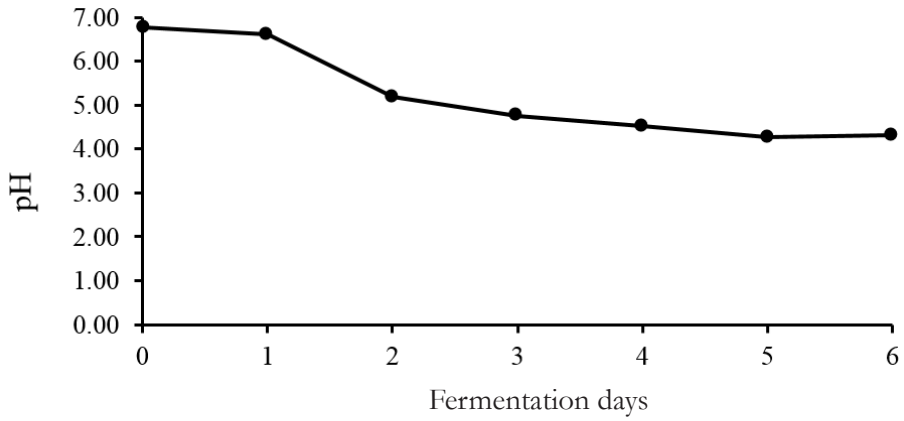


Fig 5: pH of cocoa beans from farm FL during fermentation

Table 6: Internal pH of fermenting cocoa beans

Sample	pH1	pH2	pH3	Mean	St.dev
FLD0	6.72	6.77	6.73	6.74	0.02
FLD1	6.5	6.51	6.48	6.50	0.01
FLD2	5.68	5.7	5.68	5.69	0.01
FLD3	4.6	4.58	4.61	4.60	0.01
FLD4	4.34	4.35	4.36	4.35	0.01
FLD5	4.4	4.38	4.39	4.39	0.01
FLD6	4.3	4.31	4.3	4.30	0.00
FLDD5(final)	4.78	4.77	4.78	4.77	0.00
ETD2	5.24	5.17	5.16	5.19	0.04
ETD3	4.81	4.73	4.75	4.76	0.03
ETD4	4.6	4.5	4.48	4.53	0.05
ETD5	4.27	4.26	4.3	4.28	0.02
ETD6	4.33	4.31	4.29	4.31	0.02
ETDD5(final)	4.66	4.63	4.63	4.64	0.01
DAD 2	5.23	5.24	5.24	5.24	0.00
DAD 6	4.25	4.26	4.24	4.25	0.01

Colour Determination

The colour of the fermenting beans was determined on the Day 0 and Day 1 of fermentation at the Chemistry Laboratory of CSIR-FRI using the Lovibond Tintometric Method. This was however discontinued due to lack of personnel to continue this analysis.

Table 7: Colour determination of fermenting cocoa beans on Days 0 and 1

Fermentation	Sample code	Colour determination			
		Yellow	Red	Blue	Total
Day 0	ETD0	10.0	7.0	5.0	22.0
	FLD0	11.0	8.2	5.0	24.2
Day 1	ETD1	10.0	6.5	5.0	21.5
	FLD1	10.0	10.0	6.5	26.5

Beans from FL Farm had more initial redness and this developed faster on the second day of fermentation than beans from the ET Farm. Total initial colour in beans from FL Farm was higher (24.2) than those from ET Farm (22.1). The former had a bigger increase in colour recording a total of 26.5 on day 1 of fermentation. This may indicate a faster rate of fermentation of the beans from FL Farm than ET Farm.

Temperature And Ph Of Fermenting Heap

Temperature and pH of the fermenting heap were taken from two levels: top and middle of the heap on the farm. Temperature records were taken after mixing of beans (turning of heap). The results showed that, a decrease in temperature often corresponded to an increase in pH on both farms. The temperature at the top of the heap was often higher than that in the middle of the heap of the fermenting beans.

Sniffing Of Beans To Describe Aroma Notes

About 1 kg of the fermenting beans in a zip-lock bag was shaken for about 30 s. The bag was then held open over the nose to sniff. The aroma notes perceived by at least two personnel were described.

Sniffing of fermenting bean samples to describe aroma notes

Table 8. Aroma descriptions of fermenting beans

Fermentation day	Sample code	Aroma note
Day 3	FLD3	Fruity, alcohol, acetic
	ETD3	Fruity, alcoholic, acetic (more than FLD3)
Day 4	FLD4	Fruity, acetic
	ETD4	Fruity, acetic, herbal, smelly feet, putric
Day 5	FLD5	Fruity, acetic, fresh/clean smell, very pungent
	ETD5	Fruity (more fruity than FLD5), acetic, smelly feet, woody
Day 6	FLD6	Acetic (strong and distinct), slightly cheesy, fruity
	ETD6	Acetic, some herbal note, fruity
	DAD6	Fruity, sweet smell, less acetic, low in aroma generally

Moisture Determination Of Dried Fermented Samples

The moisture content of the final dried cocoa beans from all the farms was determined using the Air-oven method. The determination was carried out in triplicate for each sample. Moisture content of the three dried cocoa bean samples ranged from 7.1 -7.5 g/100g.

Table 9: Moisture content of final dried cocoa bean samples

Sample	*Mean moisture content (g/100g)
FL	7.1
ET	7.5
DA	7.4

*Mean of three replicates

There was not much difference between the moisture content of the dried beans from the three farms (FL, ET and DA), although beans from FL Farm had the lowest moisture content of 7.1 g/100g, followed by beans from DA Farm with a value of 7.4 g/100g

Cut Test

A quick/modified cut test was done on each sample of fermenting beans. Ten randomly picked bean samples were taken from each lot and cut longitudinally using a sharp pen-knife to reveal the cotyledons. Pictures taken showed that the slaty unfermented beans developed into purple and finally to fermented brown chocolate coloured beans steadily as the fermentation progressed. There was a clear separation of the cotyledon from the cell of the beans with oozing of a brownish juice from the beans on cutting.

Cut test on fresh unfermented cocoa beans

Cut test on final day of drying

ABSTRACTS FROM PUBLISHED PAPERS

Physicochemical Changes In Plantain During Normal Storage Ripening

Adi, D., Oduro, I. N., and Tortoe, C
Scientific African 6. DOI: 10.1016/j.sciaf.2019.e00164.

This study was to establish the relationships between the physicochemical properties of plantain ripened at tropical temperature, as a predictive tool for ripening quality and usage. A batch of mature plantains (Musa ABB), was obtained from the local market at the dark green stage. They were ripened on benchtops in the laboratory at ambient temperature and mean relative humidity of 72%. Three fruits were sampled every 2 days and evaluated for the peel colour, unpeeled fruit texture, pulp: peel ratio, pulp moisture, pH, acidity and Brix. There was a strong positive relationship between the ripening stage and weight changes in the whole fruit, pulp and peel as well as a strong negative correlation between the ripening stage and the pH and dry matter. The a-values and the total colour difference (ΔE) were the best predictors of the ripening stage of the plantain fruit. At the onset of senescence, the fruit is soft and sweet, and it is characterized by senescent spotting with peel colour (L = 58.72; a = 4.37, b = 33.44), soft texture (973.39 gforce) significant weight loss (over 20%) a reduced dry matter (about 30%), high total soluble solids (25.30°Brix), low pH (4.82) and acidity (0.29). These simple measurements can serve as a pre-dictive tool of the fruit ripening stage in addition to the colour chart.

Keywords: Plantain, Ripening, Weight loss, Physicochemical, Texture

Physicochemical properties and sensory attributes of local snacks fortified with powdered fish processing by-products and an underutilised fish species.

Abbey, L. D., Glover-Amengor, M., Hagan, L., Mboom, F. P.
Ghana Journal of Agricultural Science, 54 (2), 26-35. 2019.

Fish processing by-products and small pelagic fish could provide minerals and protein in diets of vulnerable populations as these could be more affordable than seafood. The study objectives were to determine the proximate nutrient content of tuna processing by-products and burrito fish and also assess the acceptability of fish powder-fortified local carbohydrate snacks. Tuna trimmings, gills, frames and burrito were dried at 55oC for eight hours to moisture levels of 4.8% (trimmings), 8.9% (frames), 6.8% (gills) and 6.9% (burrito). The products were milled and incorporated at varying levels into four local snacks namely: mpotompoto, yakayake, abolo and yam balls. Proximate nutrient levels of both fortified and non-fortified snacks were determined by Official Methods of Analysis (AOAC). Protein contents of mpotompoto-fortified fish products ranged from 3.75% to 8.5%. Ash also ranged from 1.12% to 5.54%. The control contained 1.17%. Acceptability tests were conducted on the fortified snacks using a 5-point hedonic scale. On the whole, fortified products showed significantly higher levels of protein and ash over the non-fortified snacks. Acceptance of the snacks by pupils (11-12) years was high enough to warrant incorporation of the fish powders into a school lunch menu.

Keywords: Tuna, Gills, Trimmings, Frames, Local snacks, Fortification, Physicochemical properties, Sensory evaluation, Fish processing

Identifying Biomass-Based Value Webs for food security in Sub-Saharan Africa: A Systems Modeling Approach

Anderson, C. C., Denich, M., Neumann, K., Amankwah, K., Tortoe, C.
Sustainability, 11(10), 2885; DOI:10.3390/su11102885. 2019.

Food security in Sub-Saharan Africa (SSA) is dependent on complex networks of interconnected actors and the flows of resources (biomass, capital) and information among them. However, the degree to which actors and value chains of different crops are in fact interconnected and their current systemic influence on food security are unclear. Therefore, the concept of "value webs" to better capture the complexity within the networks emerges. Biomass-based value webs of selected crops in Ghana, Nigeria, and Ethiopia are modeled using the systems analysis software iMODELER and by eliciting factors as well as their interconnections through participatory stakeholder workshops. Furthermore, a generic model was created compiling the country models to identify overarching system dynamics with supporting and hindering factors impacting food security in SSA. Findings from the country models show highly complex value webs, suggesting that the predominant value chain approach may oversimplify actual structures and resource flows in real life settings. However, few interconnections within the value webs link the actors and flows of different crops, contradicting predictions emerging from other research. Results from the generic model allow for a critical reflection on the relation between value web dynamics and food security policy in SSA. Current national and regional policy trends targeting market integration, mechanization, and reduction of post-harvest losses are supported by model results.

Keywords: Availability; Access; Ghana; Nigeria; Ethiopia; Value Chain

Physicochemical, Microstructural And Rheological Characterization Of Tigernut (Cyperus Esculentus) Starch

Akonor, P. T. Tortoe, C. Oduro-Yeboah, C. Saka, E. A. Ewool, J.
International Journal of Food Science, 1-7. 2019.

The aim of this study was to characterize the physicochemical properties of starch isolated from two varieties of tigernuts. The results showed wide variations between the two types of tigernuts. Mean granule sizes were 11.1 and 6.1 μm, respectively, for starch from the yellow and black while amylose content ranged from 19 to 21%. Starch gels from the yellow variety were more stable to freeze-thaw and recorded 37.1% syneresis, compared to 56.5% after the first storage cycle. Pasting properties were significantly different ($p < 0.05$) among starch from the two tigernut varieties, with black recording higher peak viscosity, lower breakdown, and higher setback viscosity. Gels made from the yellow variety were clearer, softer, more adhesive, and more cohesive. Both gels showed a pseudoplastic flow behavior without thixotropy.

Keywords: Physicochemical, Microstructural, Rheological, Tigernut, Cyperus esculentus, Starch

Assessing The Suitability Of Flours From Five Pearl Millet (Pennisetum Americanum) Varieties For Bread Production.

Tortoe, C. Akonor, P. T. Hagan, L. Kanton, R. A. L. Asungre, P. A. Ansoba, E. Y .
International Food Research Journal, 26(1), 329 – 336. 2019.

Flour of five new varieties of improved certified pearl millet (Pennisetum glaucum) were evaluated for their physicochemical, functional properties and performance in bread products. The formulated breads were evaluated by 50 untrained panellists. The flours had colour values of L*(60.0 to 70.4), a* (+0.3 to +1.1) and b*(+4.3 to +10.5), low mean water solubility (3.8 ± 0.1) and swelling properties (4.5 ± 0.1) but high water binding capacity (121.4 ± 2.1). SAR002 (Naaad Kohblug) had the highest protein (11.1%), fibre (1.3%), ash (1.2%) and lower fat (3.6%). SAR001 (Kaanati) had the highest fat (4.3%) and ash (1.5%) but the lowest protein (7.9%). The bread showed no interactive effect ($p > 0.05$) between variety and replacement level with millet flour. Rather, a significant difference ($p < 0.05$) was observed for the two factors. Increasing proportions of millet flour in the composite flour resulted in a decrease in attribute and acceptability scores of bread. A mean score of 6.4 (slightly like) was obtained for attribute rating and acceptability of bread to 20% proportion of millet flour. Bread produced from SAR001 was the most accepted.

Keywords: Pearl millet, Bread, Physicochemical, Nutritional, Sensory properties

The Adoption Of Improved Cowpea Varieties In Northern Ghana

Wahaga, E.
Acta Scientific Agriculture, 3(7), 14-20. 2019.

Cowpea, the first crop to be harvested in semi-arid regions is an important food crop that bridges that hunger gap that exists before cereal crops are harvested. This paper assesses the adoption of improved cowpea varieties with farmers in Northern Ghana. Semi-structured interviews were administered to 250 farmers: 230 male and 20 female farmers. A multistage sampling procedure was used to select 4 districts, 8 communities and17 households in each community where quantitative and qualitative data was gathered. Farmers who had a history of cowpea production and communities with a history of access to improved cowpea seeds were interviewed. The questionnaire covered demographic aspects of the survey farm households, their production environment, the factors that influence the adoption or non-adoption of improved cowpea varieties, among other things. Results indicated that all farmers adopted cowpea varieties. With typical adoption attitudes, farmers adopt these varieties gradually which eventually peaks and drops depending on yield, amount of pesticides needed and the incidence of insect pest and diseases. In conclusion, due to the persistence of some pest and diseases on some crops, drought related problems, degrading soil fertility, dwindling farm land due to farm lands being taken over as residential plots, and low yields, farmers have found solace in the cultivation of improved varieties which are mainly high yielding, insect/disease resistant and drought tolerant.

Keywords: Early maturing, Smallholder farmers, Food, Mixed cropping, Crop rotation, Ghana, Cowpea

Comparison Of The Microbial Composition Of African Fermented Foods Using Amplicon Sequencing

Diaz, M., Kellingray, L., Akinyemi, N., Adefiranye, O. O., Olaonipekun, A. B., Bayili, G. R., Ibezim, J., Du Plessis, A. S., Houngbédji, M., Kamya, D. Mukisa, I. M., Mulaw, G., Josiah, S. M., Chienjo, W. O., Atter, A., Agbemafle, E., Annan, T., Ackah, N. B., Buys, E. M., Hounhouigan, D. J., Muyanja, C., Nakavuma, J., Odeny, D. A., Sawadogo-Lingani, H., Tefera, A. T., Amoa-Awua, W., Obodai, M., Mayer, M. J., Oguntoyinbo, F. A. and Narbad, A.
Scientific Reports, 9(1), 1-8. 2019.

Fermented foods play a major role in the diet of people in Africa, where a wide variety of raw materials are fermented. Understanding the microbial populations of these products would help in the design of specific starter cultures to produce standardized and safer foods. In this study, the bacterial diversity of African fermented foods produced from several raw materials (cereals, milk, cassava, honey, palm sap, and locust beans) under different conditions (household, small commercial producers or laboratory) in 8 African countries was analysed by 16S rRNA gene amplicon sequencing during the Workshop "Analysis of the Microbiomes of Naturally Fermented Foods Training Course". Results show that lactobacilli were less abundant in fermentations performed under laboratory conditions compared to artisanal or commercial fermentations. Excluding the samples produced under laboratory conditions, lactobacilli is one of the dominant groups in all the remaining samples. Genera within the order Lactobacillales dominated dairy, cereal and cassava fermentations. Genera within the order Lactobacillales, and genera Zymomonas and Bacillus were predominant in alcoholic beverages, whereas Bacillus and Lactobacillus were the dominant genera in the locust bean sample. The genus Zymomonas was reported for the first time in dairy, cereal, cassava and locust bean fermentations.

Keywords: African fermented foods, Fermented foods, Microbial composition, Amplicon sequencing

Starches Of Two Water Yam (Dioscorea Alata) Varieties Used As Congeals In Yogurt Production.

Tortoe, C., Akonor, P. T. and Ofori, J.
Food Science & Nutrition, 7(3), 1053-1062. 2019.

The physicochemical properties of water yam (Dioscorea alata var. Akaba and Matches) starches were determined prior to their use as congeals for yogurt production. The moisture content ranged from 9.34% to 15.8% for A100 (100% Akaba) and M100 (100% Matches), respectively, indicating lower moisture content in the Akaba variety compared to Matches variety. Similar trend was observed for their water activity. The pH ranged from 5.88 to 6.93 indicating low acidity of the water yam starches. The water absorption capacity (WAC) ranged from 4.10 to 4.89 g/g, seemingly restricted reflecting protein–moisture interaction of the starches. Although the swelling power did not differ significantly ($p > 0.05$) ranging from 10% to 14%, they were quite restrictive as the WAC. The L* values of the starches were predominantly lightness in color, highest for A100 sample. The pasting temperatures of Akaba (A100), Matches (M100), and A50:M50 were not significantly different ($p > 0.05$). Peak viscosity of the water yam starches was in a range of 509–528 BU. The highest attributes were for taste (6.4), mouthfeel (5.4), flavor (5.4) sourness (4.6) and consistency (5.9), which were obtained from 1.5 % Matches, 0.5 % Akaba + 0.5 % Matches, 1.0 % Akaba + 1.0 % Matches samples. The overall acceptability (5.8) was higher than the control yogurt (4.7), indicating sample 0.5% Akaba + 0.5% Matches as the best-bet yogurt.

Keywords: Congeal, Dioscorea alata, Starch, Yogurt

Enhancing The Food Security Status Of Yam (Dioscorea Spp.) For Smallholder Farmers Through An Improved Farm-Gate Storage Structure In Ghana

Tortoe, C., Dowuona, S., Akonor, P. T., and Dziedzoave, N. T.
African Journal of Science, Technology, Innovation and Development
DOI: 10.1080/20421338.2019.1636488.

Yams (Dioscorea spp.) are a good source of food in Ghana. This study investigated the storage of seven (7) key yam varieties in an improved farm-gate yam storage structure. Seven freshly harvested key yam varieties identified as Pona, Lariboko, Dente, Mutwumudoo, Serwah, Matches and Akaba were used in a Complete Block Design technique of 3 blocks and stored in an improved farm-gate yam storage structure for 146 days. Formation of buds, pests and diseases, wholesomeness, regeneration of sprouts, temperature and relative humidity were monitored. After the storage period, mean number of buds formed varied between 1.3 and 2.7. Matches, Mutwumudoo and Dente yam varieties recorded the highest number of buds compared to Pona, Laribokor and Serwah, which recorded a mean of 1.3, 1.4 and 1.5 buds, respectively. Pona and Lariboko yam varieties were more highly susceptible to pests and diseases than Matches, Akaba, Dente and Serwah. Wholesome tubers were higher in Serwah, Matches, Akaba, Mutwumudoo and Dente varieties than Pona and Lariboko yam varieties, as the former were less attacked by pests and diseases. Serwah yam variety was observed to store best among the seven (7) key yam varieties even though regeneration of buds observed in Serwah yam variety was the highest.

Keywords: Dioscorea Spp, Improved Yam Storage Structure, Food Security, Ghana

Hulled Varieties Of Barley Showed Better Expansion Characteristics Compared To Hull-Less Varieties During Twin-Screw Extrusion

Baidoo, E. A. Murphy, K. Ganjyal, G. M.
Cereal Chemistry, 96 (2), 391-404. 2019.

Background and objectives Consumption of food barley is increasing due to its health and nutritional benefits. Whole grain flours of two hulled barley varieties, Lyon and Muir, and three hull-less barley varieties, Havener, 09WA-265.12, and Meg's Song, were extruded with a co-rotating twin-screw extruder. The impacts of feed moisture, screw speed, and die temperature on functional properties of extrudates were investigated. Findings Expansion ratio (ER) of barleys was slightly lower compared to the reported numbers for cereals such as corn. Hulled varieties showed significantly higher ER compared to the hull-less varieties. Havener was the only hull-less variety having comparable ER with hulled varieties and moderate levels of ß-glucan. ER correlated positively with water solubility index ($r = 0.680$, $p < 0.01$), specific mechanical energy ($r = 0.633$, $p < 0.01$), and negatively with unit density ($r = -0.729$, $p < 0.01$). Conclusions Hulled varieties are better suited for extrusion expansion. Feed moisture and die temperature had a strong influence on expansion, while screw speed showed marginal effects. Significance and novelty Understanding the properties of hulled and hull-less barley extrudates will enable process industry to utilize them for the development of novel extruded foods, while taking advantage of their nutritional values.

Keywords: Hulled barley, hull-less barley, Extrusion processing, ß-glucan

Consumer Preference and Quality Expectations of Senescent Plantain Products

Adi, D. D., Oduro, I. N. and Tortoe, C.
Journal of Culinary Science & Technology. DOI: 10.1080/15428052.2019.1703868. 2019.

This study was aimed at determining important sensory attributes and buying indicators of senescent plantain products (kaaklo, ofam and tatale) as a basis for developing a senescent plantain powder mix for making these products. A semi-structured questionnaire was administered to 437 randomly selected respondents in Kumasi, Ghana, to assess their preferences and sensory expectations for the three senescent plantain products. Respondents' buying indicators and willingness to purchase powdered mix were also evaluated. Most respondents preferred Kaaklo (70.7%). They expected senescent plantain products to be sweet, soft with a smooth mouthfeel and mild stickiness. Majority (73%) were willing to buy powdered mix, and their buying decision will be influenced by taste (4.72), appearance (4.62) and ease of preparation (4.53) of the end product. Encouraging total utilization of plantain through consumer-led product development from senescent plantain is a good step toward enhancing food sustainability.

Keywords: Senescent Plantain, Consumer Preference; Ofam, Kaaklo, Tatale

Assessing the awareness and usage of reference management software (RMS) among researchers of the Council for Scientific and Industrial Research (CSIR)

Bugyei, K. A. Kavi, R. K. Obeng-Koranteng, G.
Ghana, Journal of Information & Knowledge Management, 18 (3), 1950031. 2019.

The study seeks to ascertain the levels of awareness and usage of reference management software (RMS) among researchers of the Council for Scientific and Industrial Research (CSIR), Ghana. The purpose and benefits as well as challenges associated with the use of these tools were also discussed. Descriptive survey methodology was employed for this study. A web-based questionnaire consisting of both multiple-choice and open-ended questions was used to collect data from 110 scientists in 13 research institutes of the CSIR, Ghana. Results show that overwhelming majority of scientists (80%) are aware and know about RMS. However, the adoption and usage of these tools are low. The percentage of non-usage was higher among the older scientists (22% for over 51 years) as against the younger researchers (9% for 31 to 40 years). Overall, 33.6% do not use RMS at all, and scientists occasionally used RMS. Mendeley was the most popularly used software among respondents. Results also show that most of the respondents got to know about RMS through training workshops and seminars. Most of the respondents had not received any training and for those who had attended a training workshop or seminar, majority of them noted that it was very easy to use. The main purpose of using these tools were for research work and literature review. Major benefits of using RMS packages are automatic generation of references list, electronic creation of bibliographies and changing of referencing style by a click of a button. Challenges associated with the use of these tools were slow internet connection, lack of training, and technical support. The study recommended that CSIR should make the effort to acquire these tools. Scientists should also be given the necessary training and technical support in order to effectively use these softwares.

Keywords: Reference management software, Bibliographic management software, Ghana Researcher, Information management, CSIR

Assessing The Information Literacy Skills Among Undergraduate Students At The University Of Mines And Technology (Umat), Tarkwa. Ghana

Kavi, R. K. Anafo, P. Bugyei, K. A. Ofori, Y.
Library Philosophy and Practice (e-journal), 2918. 2019.

Information literacy skills have become a topical issue in the academic lives of university students. It is a skill needed to be able to identify an information need, knowing the sources of information, effectively searching for information and ethically using information in this era of the information age. Various studies have observed that university students lack the basic skills needed to make them effectively search for academic information and how to apply them. This situation, if not checked, would negatively affect the academic lives of students. This paper, therefore, sought to examine the level of information literacy skills among incoming first-year undergraduate students of the University of Mines and Technology, Tarkwa so as to suggest ways of improving upon them. The level of information literacy skill, possession of basic information and communication technology (ICT) skills, awareness of various search strategies were examined by analyzing responses obtained from the administration of the questionnaire. It was found out that the majority of the students possessed basic ICT skills, however, their knowledge of various search strategies was low. Again, there was no course designed to introduce them to the acquisition of information retrieval skills. Various ways of improving information literacy skills among students have also been suggested.

Keywords: Information Literacy, Search strategy, Information Retrieval, Library Instruction

Assessment Of New Academic Programmes At The University Of Ghana And Their Implication On Library Services: Case Study

Andoh, K. Kavi, R. K. Obeng-Koranteng, G. Bugyei, K. A.
Library Philosopy and Practice (e-journal) 2917. 2019.

The study focused on the implication of the introduction of new academic programmes on the resources of Balme Library in University of Ghana, Legon. The case study methodology was used with a study population of 47 staff constituting both senior members and senior staff of Balme Library and the Director of Academic Affairs respectively. Data collection instruments used were questionnaire and interview. The responses were analyzed using the Statistical Package for Social Science (SPSS). The study revealed that, the Balme Library was not consulted or involved during the introduction of new academic programmes. In addition, student enrolment was increasing every year due to the introduction of new academic courses as well as general increased in access to tertiary education, but there was no corresponding increase in resources like staff, materials and space at the Balme Library. Also special funds are not allocated to Balme Library to support the introduction of new academic courses. In order to improve the service and resource base of Balme Library to support the introduction of new academic programmes it was recommended that the University of Ghana should consider establishing a virtual library, increase staff strength, expand physical infrastructure, seek alternative source of funding and ensure collaboration between the Balme Library with satellite libraries on campus to ensure quality academic output.

Keywords: Academic libraries, Academic programmes, Library services, University education, Ghana

Assessment Of Soil Fertility And Quality For Improved Cocoa Production In Six Cocoa Growing Regions In Ghana.

Kongor, J. E. Boeckx, P. Vermeir, P. De Walle, D. V. Baert, G. Afoakwa, E. O. Dewettinck, K. Agroforestry Systems, 93 (4), 1455-1467. 2019.

Inadequate or lack of prudent soil fertility management by cocoa farmers leads to nutrient depletion in cocoa production fields. The objective of this study was to assess current soil fertility status of cocoa farms from six cocoa growing regions in Ghana and to derive an integrated soil quality index (SQI). Composite soil samples from 0 to 30 cm depth were collected from 100 selected farms covering the six cocoa regions. Soil pH, %C, %N, total and available P, cation exchange capacity (CEC), and exchangeable cations (Ca, Mg, K) were measured. These parameters were analyzed using principal component analysis, normalized, and integrated into a weighted-additive SQI. Soil pH of majority (59.0%) of the farms was within 5.6–7.2, suitable for cocoa production. Available soil-P in most (82%) of the farms was < 20 mg kg-1. Soil quality in most farms was generally low, with an average SQI of 0.41 ± 0.14. Soil quality in Western region farms was relatively high, followed by farms in Brong Ahafo and Volta regions. Farms in Eastern, Central and Ashanti regions had the least soil quality. Soil pH, CEC and available P showed great influence on SQI. Given the latter observation, diagnostic yield response experiments should be conducted, which include: application of locally generated liming materials, organic residues and agro-mineral base fertilizers such as phosphate rock and dolomite.

Keywords: Cocoa, Soil fertility, Ghana, Sustainable intensification, Soil quality index

QUALITY MANAGEMENT

The CSIR-FRI has established a management system since 2007 based on ISO 17025, in order to ensure that tests carried out and results communicated to customers are of satisfactory quality. The policies of the FRI Management System, the general procedures and technical instructions for carrying out all activities under the Management System are documented in the Quality Manual and Technical Manuals for the Food Chemistry, Food Mycotoxin and Food Microbiology laboratories. These Manuals are available to the Directorate, the Research Staff, Technologists/Technicians directly or indirectly involved in carrying out tests for customers.

Implementation of this International Standard in the CSIR-FRI involves the Directorate of the Institute as well as the Food Microbiology and Mushroom Research Division, Food Chemistry and Nutrition Research Division, Commercialization Division and the Finance and Accounts Division.

Contribution Of Quality Management To Food Security And Export In Ghana

Quality is a prerequisite for successful market access and for improving the competitiveness of exporters. For this reason, standards and conformity assessments have been recognized as trade barriers for many years. Regulatory authorities and commercial buyers of foreign products frequently require testing at the point of import or delivery by their own designated laboratories even when adequately tested in the country of manufacture.

Such policies are regarded as technical barriers to trade because they add cost through duplication and delays. If the testing carried out at the point of manufacture is performed competently and in accordance with the requirements of the customer or of the import market, then there is no technical reason for the product to be retested unless conditions during transit may cause the product to deteriorate.

The implementation of Quality Management in public and private organization in Ghana such as and especially CSIR-FRI has benefited Ghana in that, it has:

- Helped to overcome challenges from free trade and globalization: The Institute has contributed tremendously to this regard by providing accredited testing services to small, medium and large scale food processing companies.
- Enabled access to international markets and preserved domestic markets: CSIR–FRI's implemented Quality Management System has for the past thirteen years helped to reduce or remove technical barriers to trade, thus strengthening domestic markets and opening up foreign markets.
- Advanced economic development: With twelve (12) of our test methods being South African National Accreditation System (SANAS) accredited, our Quality Management System has helped to promote sustainable development by providing opportunities to make domestic products and services more competitive in both national and international markets paving the way towards further integration of the partner countries in the interests of a fairer global trade regime.
- Promoted innovation and competitiveness.

COMMERCIALIZATION SUMMARY

Under its commercialization drive, CSIR-FRI conducts technical and analytical services, technology transfer trainings, contract productions, feasibility services for start-up companies, food safety and quality services, sale of research products etc. The Institute continues to offer developed technologies to the food Industry. These include product development, process standardization, storage, preservation and other postharvest losses management technologies. Annual mushroom cultivation training programs were successfully executed within each quarter of the year. Some products developed and transferred included mushroom based mixed spices, pancake flour mix, turmeric based mixed spices, fish based waffles, honey and sesame oil flavoured peanut butter, bread for persons with special dietary needs, etc. Through knowledge and technology transfer training sessions, CSIR-FRI has assisted in the establishment of seventeen (17) start-up companies within the year. Contract productions for the processing of semi-finished productions also continued within the year under review. These products include groundnut paste and food flours such as fufu flours, cereal flours and other roots and tuber flours.

CSIR-FRI also runs an incubation programme; this involves housing a start-up company within the Institute and provided technical assistance when required over an agreed period of time. Currently, there are three (3) of such start-ups within its premises; a company that produces dried coconuts for supermarkets and for export, one that produces vacuum packed frozen yams and another that produces cereal based snacks for supermarkets.

FINANCIAL SUMMARY

The Finance Division manages and oversees the finances of the Institute. R&D and Commercial activities are the main sources of income generation. R&D contributes to the financial pool mainly through donor funded projects, whiles contributions from commercialization are from sale of research products, laboratory services, technical services, contract productions, consultancy services, feasibility studies and assisting in establishing processing plants/units, etc.

The Institute generated 47% of its income, i.e. GHC 1,608,450.45 as Internal Generated Funds (IGF) and received 53% as Donor funds, i.e. a total of GHC 1,801,072.69 for its R&D activities (Figure 6). Within the year under review, donor agencies included European Union (EU) [SmallFish and 2FAS Projects], African Union (AU) [SafeFish Project], Danish International Development Agency (DANIDA) [GreenGrowth Project], Alliance for a Green Revolution in Africa/ Bill and Melinda Gates Foundation (AGRA/BMGF) [Ghana Cassava Project], Canadian Embassy [MAG Project], Mondelez Global [Cocoa Fermentation Consultancy] and Skills Development Fund (SDF) [Roots and tuber value addition Consultancy].

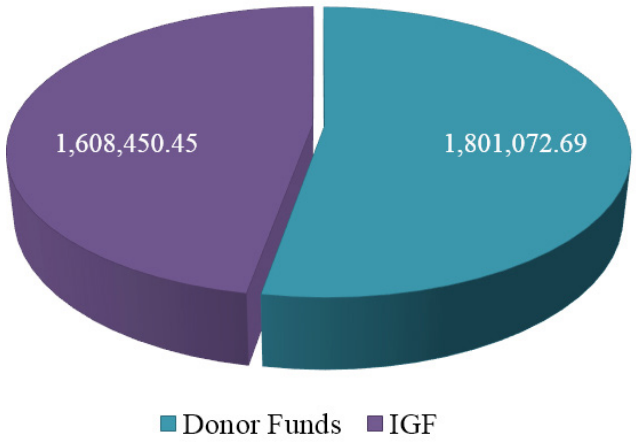


Figure 6: Comparison of Donor funds and IGF

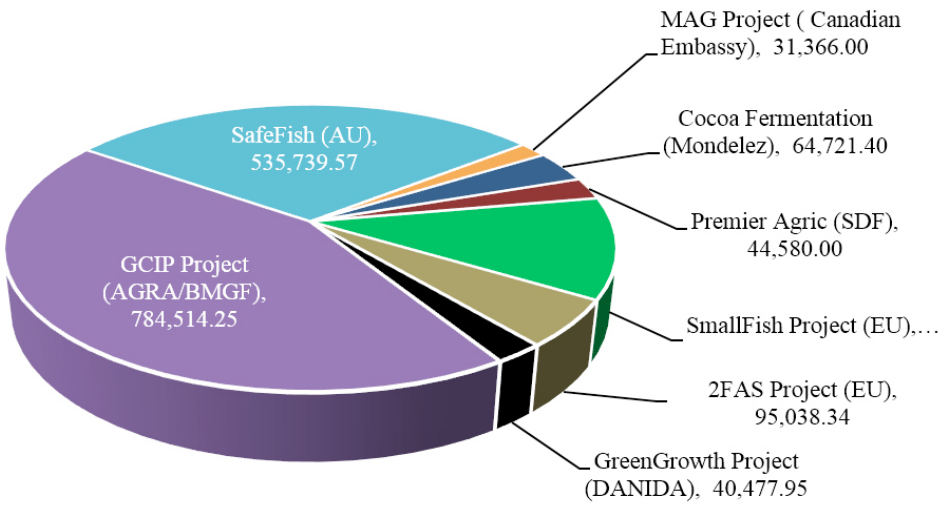


Figure 7: Representation of Donor funds received

ADMINISTRATIVE ACCOUNT

The Administration Division provides administrative support for other Divisions and among Divisions. It also oversees human resource matters including national service and internship programs. The Institute had a total of 149 members of staff comprising fifty-one (51) Senior members, sixty-six (66) senior staff and thirty-two (32) Junior staff (Figure 8).

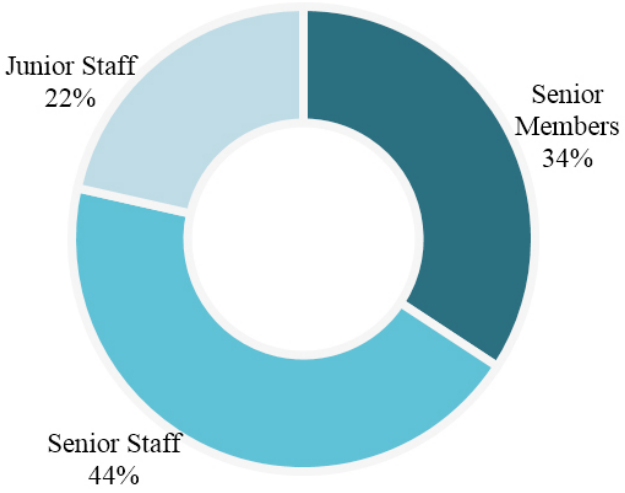


Figure 8: Percentage distribution of staff

Senior members are separated into two main groups, core (with core science background) and non-core (with administration and finance background) members. Core and Non-core Senior Members represent 28% and 4% respectively, as shown in Figure 9. Specializations of Researchers (Core Senior members) include Mycologists, Roots and tuber experts, Cereal and legumes experts, Fruit and vegetable processing and preservation experts, Food Safety and Quality Control experts, Sensory scientists, Toxicologists, Molecular Biologists, Food Microbiologists, Fish post-harvest management experts, Product development experts, Food Nutritionists, Community Nutritionists, IT experts, Agric./Mechanical Engineers, etc.

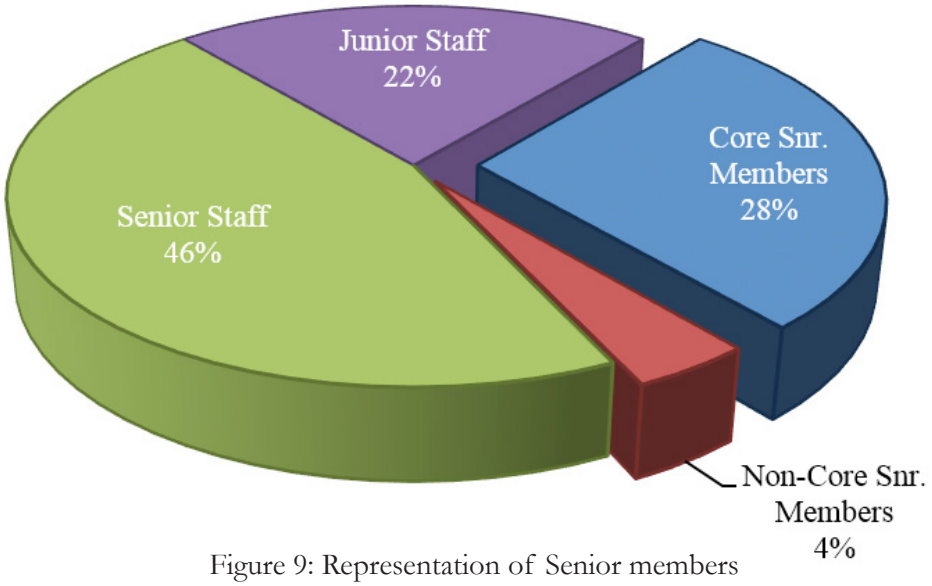


Figure 9: Representation of Senior members

OUR STAFF

Directorate

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

Administration Division

Mrs. Gifty N.D. Aryee	-	Snr. Admin. Officer/ Head of Division
Ms. Anita Adusah	-	Admin. Officer
Mrs. Victoria A. Asunka	-	Admin. Officer
Mr. Eric K. Ofori	-	Chief. Admin. Asst.
Mr. Edmund Mensah-Yemoh	-	Chief Works Supt.
Mrs. Beullah Sallah	-	Chief. Admin. Asst.
Mr. Philip Agyaye	-	Snr. Security Officer
Mr. Gariba Alimyao	-	Snr. Asst. Transport Officer
Mr. Anthony Sevor	-	Snr. Asst. Transport Officer
Ms. Esther Lamptey	-	Admin. Assistant
Ms. Gloria Ghansah	-	Admin. Assistant
Ms. Doris Menuye	-	Front Desk Officer
Mr. Samuel Tettey Odjao	-	Asst. Transport Officer
Mr. Samuel Quaye	-	Snr. Security Officer
Mr. Daniel M. Mustapha	-	Security Officer
Mr. Foster Bosompem	-	Security Officer
Abel Kojo Sogbe	-	Junior Foreman
Samuel K. Adjei	-	Junior Foreman

Seth Achuson	-	Traffic Supervisor
Daniel Amarlai Ayiku	-	Driver Gd. 2
Paul Kpotor Tetteh	-	Senior Security Asst.
Afara Avuto	-	Senior Security Asst.
Daniel Nuertey	-	Driver Inspector
Francis Azure	-	Senior Security Asst.
George Ankwa	-	Security Asst. Gd. I
Justice Blankson Dadzie	-	Senior Security Asst.
Abdulai Abass	-	Security Asst. Gd. I
George Tetteh	-	Supervisor Gd. 1
Sunday Akantokdingin	-	Supervisor Gd. I
Bob Atulibok	-	Security Asst Gd. 1
Jeff Wilson Afenu	-	Snr. Labourer
Edmund Gyampoh	-	Snr. Labourer
Richard Ohemeng Boateng	-	Snr. Headman
Daniel Oduro Obeng	-	Snr. Headman
Joseph Adivor	-	Snr. Headman
Kojo Adamu	-	Snr. Headman

Finance Division

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Ms. Judith Dogbegah	-	Chief Accounting Assistant
Mr. Christian Amegah	-	Chief Accounting Assistant
Ms. Joana B. Dzikunu	-	Prin. Admin. Assistant
Ms. Mabel Aryee	-	Snr. Accounting Assistant
Ms. Regina Tsotsoo	-	Snr. Accounting Assistant
Ms. Wolase Efodzi	-	Snr. Stores Superitendant.

Mrs. Angela Addy	-	Snr. Stores Superitendant
Ms. Judith Larweh	-	Snr. Tech. Officer
Mr. Alians Gasu	-	Snr. Accounting Assistant
Mrs. Naomi Agyebeng	-	Snr. Accounting Assistant

Commercialization Division

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Mr. Thomas Najah	-	Marketing Officer
Mr. Solomon Dowuona	-	Snr. Technologist
Mr. Richard Takli	-	Snr. Technologist
Mr. Jeremiah Lartey- Brown	-	Chief Tech. Officer
Mr. Philip. O. Baidoo	-	Chief Accounting Assistant
Ms. Getty Afuukar	-	Prin. Technical Officer
Mr. Ofori Brempong	-	Prin. Technical Officer
Ms. Mary Assimah	-	Prin. Admin. Assistant
Ms. Justina Thompson	-	Prin. Marketing Assistant
Mr. Peter Dalabor	-	Prin. Works. Superintendent
Mr. Emmanuel Agblo	-	Snr. Works. Superintendent
Ms. Makafui Torgbui	-	Snr. Tech. Officer
Ms. Sindy M. Williams	-	Snr. Tech. Officer
Ms. Benedicta Plahar	-	Admin. Assistant
Mr. Godson Agbeley	-	Technical Officer
Mr. Paul Boadi	-	Technical Officer
Mr. Emmanuel Agyei-Amon	-	Works Superitendent

Food Technology Research Division

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Mr. Elvis A. Baidoo	-	Snr. Research Scientist
Mr. Paa Toah Akonor	-	Snr. Research Scientist
Mr. Kwabena A. Bugyei	-	Snr. Research Scientist
Mr. Raphael Kavi	-	Snr. Librarian
Mr. Peter Adoquaye Addo	-	Research Scientist
Mr. Jonathan Ampah	-	Research Scientist
Mrs. Evelyn S. Buckman	-	Research Scientist
Dr. Godfred Ameyaw Asiedu	-	Research Scientist
Dr. John Edem Kongor	-	Research Scientist
Ms. Winifred Arthur	-	Prin. Technologist
Mrs. Leonora C. Baffour Gyasi	-	Prin. Technologist
Ms. Nancy Nelly Idun-Acquah	-	Prin. Technologist
Mr. Emmanuel Adokwei Saka	-	Prin. Technologist
Ms. Jemima Ofori	-	Prin. Technologist
Mr. Ebenezer Assimah	-	Prin. Technologist
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Mrs. Helen Ama Annan	-	Snr. Technologist
Mr. Frank Peget Mboom	-	Snr. Technologist
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Mr. Desmond Mensah	-	Chief Tech. Officer
Mrs. Agartha Amuzu	-	Chief Tech. Officer
Mr. Ofori Brempong	-	Prin. Tech. Officer
Mr. Rufai Braimah	-	Prin. Tech. Officer
Ms. Constance Boateng	-	Chief Tech. Officer
Mrs. Alice Padi	-	Prin. Tech. Officer

Ms. Carris Dogbeda Ackuaku	-	Snr. Tech. Officer
Joyce Agbezudor	-	Snr. Tech. Asst.
Luke Anak	-	Snr. Tech. Asst.
Elizabeth Attah (Ms)	-	Tech. Asst. Gd. I
Rose Afua Agorkor (Mrs)	-	Tech. Asst. Gd. I
Nuru A. Abdulai	-	Tech. Asst. Gd. II
Ernestina Armah (Ms.)	-	Tech. Asst. Gd. II
Emmanuel A. Tetteh	-	Tech. Asst. Gd. II
Ababase Akanzinam	-	Snr. Tech. Asst.
Emmanuel T. Kpabitey	-	Supervisor Gd. I
Mienuye Vincentia	-	Snr. Headman
Rose Kornu Emefa	-	Snr. Headman
Moses Mensah	-	Snr. Headman

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Mrs. Deborah L. N. Mensah	-	Research Scientist
Mr. Evans Agbemafle	-	Research Scientist
Mr. Theophilus Annan	-	Research Scientist
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Mrs. Akua Boatemaa Authur	-	Prin. Technologist
Mr. Michael Amoo-Gyasi	-	Prin. Technologist
Mr. Alexander Henry K. Appiah	-	Snr. Technologist
Ms. May A. Boham-Dako	-	Snr. Technologist
Mrs. Ruth Fosu	-	Prin. Tech. Officer

Mr. Badaru Deen Yahaya	-	Snr. Tech. Officer
Mr. Emmanuel Bortey Mensah	-	Tech. Officer
Mr. Philip Kwabena Mensah	-	The. Officer

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Dr. Emmanuel Kyereh	-	Research Scientist
Mrs. Hannah Oduro Obeng	-	Research Scientist
Mr. Kofi Kwegyir Essel	-	Prin. Technologist
Mr. Hillary K. Ketemepi	-	Prin. Technologist
Mrs. Juliet Vickar	-	Prin. Technologist
Mr. Nelson Y. Amey	-	Prin. Technologist
Mr. Ebenezer Tawiah	-	Prin. Technologist
Mr. Vincent Kyei-Baffour	-	Snr. Technologist
Mrs. Mercy Ted Coffie	-	Technologist
Ms. Vida Awidi	-	Chief. Tech. Officer
Mrs. Belinda Quaye	-	Chief Tech. Officer
Mrs. Dorothy Narh	-	Prin. Tech. Officer
Ms. Emefa Gblende	-	Snr. Tech. Officer

PUBLICATIONS

Journals

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Conference Abstracts

Nakavuma, J., Walakira, J., Wamala, S., Kamya, D., Alafi, S., Nalweyiso, M., Mugasa, M. C., Mayanja, M., **Agbemafle, E., Mensah, N. D.**, Agbeko, E., Okyere, I., Damanka, S. and Clokie, M. (2019). Building Capacity for Phage Applications in Management of Livestock Production Diseases: Au-Project on Tilapia Fish Disease Management on Aquaculture Farms in Ghana and Uganda. Submitted to Evergreen Phage Lab: Home of the biennial Evergreen International Phage Biology Meeting, Evergreen State College, USA.

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