



DANIDA FELLOWSHIP CENTRE

A33228, Completion report *

Lene Jespersen

Preserving African Food Microorganisms for Green Growth

*****Report*****

Report for the years 2014-2018

DFC file no. 13-04KU

Project Coordinator

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Responsible institution

University of Copenhagen

Research partner(s)

Food Research Institute (FRI), Council for Scientific and Industrial Research, Ghana; Local coordinator: Wisdom Amoa-Awua, wis.amoa@gmail.com

University for Development Studies (UDS), Dept. of Applied Biology, Faculty of Applied Sciences, Ghana; Local coordinator: James Owusu-Kwarteng, jowusukwarteng@yahoo.co.uk

Departement Technologie Alimentaire (DTA), Institut de Recherche en Sciences Appliquées et Technologies (IRSAT) / Centre National de la Recherche Scientifique et Technologique (CNRST), Burkina Faso; Local coordinator: Hagrétou Sawadogo, hagrétou@yahoo.fr, dta@fasonet.bf

University of Abomey-Calavi (UAC), Faculty of Agricultural Science, Benin; Local coordinator:
Joseph Djidjoho Hounhouigan, hounjos@yahoo.fr, joseph.hounhouigan@gmail.com

Danish Technological Institute (DTI), Centre for Ideas and Innovation, Denmark; Local
coordinators: Moses Dachariga Mengu, mom@teknologisk.dk

Project start and end date

1 January 2014 to 31 December 2017

Adjusted project period with date of approval by DFC, if applicable

The adjusted project period: 1 January 2014 to 31 December 2018, was approved by DFC on
2 June 2016.

MANAGEMENT

A33228 Lene Jespersen

Preserving African Food Microorganisms for Green Growth

Conditions set at the approval of the midterm report, if applicable

Not applicable

PhD students status

Below is a description of PhD student status and MSc enrolled in the different West African partner institutions.

FRI:

PhD student 1: George Anyebuno is enrolled at the Department of Nutrition and Food Science, University of Ghana, Legon, 1 August 2015. Proposed date for submission: 21 July 2019.

Supervisors: Prof. Tano-Debrah, Dr. Wisdom Kofi Amoa-Awua, Prof. Kwesi F. Salia. Program: PhD Food Science. George Anyebuno has attended the requisite courses and his research work has the title: "Re-engineering fura for an expanded market". The main objective of this study was to improve fura production processes and improve the organoleptic, rheological, nutritional, packaging and other properties of the product targeting the local and international markets. Surveys were conducted in the Greater Accra, Northern and Upper East regions to interview fura producers and identify processors who ferment the millet dough during fura production. Eventually only one processor was identified at Paga in the Upper East Region who ferments the spiced millet dough during production. Fura samples were collected during the survey and subsequent physicochemical, microbiological and nutritional analyses were performed. A traditional fura processor was engaged to train the project team members on the production of both fermented and non-fermented fura. The processor also prepared samples for sensory analysis and dehydration trials. Affective sensory testing was carried out on the four products, showing that fermented fura was preferred to unfermented fura, and even reconstituted dehydrated fermented fura was preferred to unfermented fresh fura. In addition to the fura starter cultures prepared by the MPhil student, Cosmos Amankona, further isolations of lactic acid bacteria and yeasts were made from fura samples from the other parts of the country i.e. North, Middle, Eastern and Western parts to give a national character to the starter cultures that was developed. Identification and characterization of the microorganisms has been carried out. Studies on the optimization of the fura process use the Box Behnken

experimental design was performed. Fifteen fura samples using combinations of the variable parameters, steeping time, fermentation time and amount of spices have been produced and assessed by a 25 member trained sensory panel. More fura samples were prepared within and outside the optimization region of the response surface plots for evaluation of the selected panelists for confirmation or otherwise of the results of the sensory analysis. Subsequently, developed starter cultures were used to prepare the fura and sensory evaluation carried out as previously done.

PhD student 2: Stephen Nketia is enrolled at Kwame Nkrumah University of Science and Technology (KNUST) 14 August 2015. Proposed date of thesis submission: March 2019. Supervisors: Dr. Francis Appiah, Dr. Wisdom Kofi Amoa-Awua. Program: PhD. Post Harvest Technology. The title of Stephen Nketia work is: "Development and optimization of fura production for commercialization". The main objective: To use value chain analysis to optimize production of fura for commercialization. The PhD Student Stephen Nketia was trained at the partner institute, the Danish Technological Institute in Taastrup Denmark on the development of business models using the business model canvas from the 9 October to 4 November, 2016. This was to enable Stephen Nketia to develop a business model for the envisaged re-engineered fura to ensure its sustainable commercialization. This was also to enable Stephen Nketia to be trained in business model development and innovation, and develop a teaching compendium to be used in the training of the other African partners, thus assisting them in the development of business models for their selected products. Stephen Nketia, therefore, subsequently organised training workshops for the project partners at the UDS in Navrongo, DTA in Burkina Faso and UAC in Benin. The topics covered under the each workshop were; i) Invention, Innovation and Technology Transfer Processes, ii) Business Model Canvas Development for Partners' fermented food Products, iii) Commercialization of the Technologies Developed under GreenGrowth project and any other products. The training at the UDS was organised on 17 - 18 November, 2016 for 20 participants. The training at the DTA, Burkina Faso was organised on 29 - 30 November, 2016 for 10 participants and at UAC, Benin on the 15 - 16 December, 2016 for 9 participants. The training workshops enabled the partners to see the difference between inventions and innovations and to realize that invention needed some form of innovation input from customers' value propositions to get them onto the market. The partners also realized that they needed to generate business model using the business canvas model to introduce their technologies onto the market for more revenue streams, greater profit margins with the reduction of production cost using appropriate technologies.

MPhil student 1: Cosmos Amankona enrolled at the Department of Nuclear Agriculture and Radiation Processing, School of Nuclear and Allied Sciences of the University of Ghana in August 2013. He carried out his MPhil thesis under the GreenGrowth project from September 2014. His thesis was titled "Development of starter culture for fura fermentation and preservation of fura by gamma radiation". The thesis was supervised by Prof. Wisdom Amoa-Awua. Cosmos Amankona isolated microorganisms from fura and characterized their technological properties. Based on these results Cosmos Amankona developed a starter culture for fura and his work was made known to the stakeholders through a stakeholders forum and contacts with SMEs. He was awarded an MPhil degree in Radiation Processing (Food Science and Postharvest Technology) by the University of Ghana on 31st July 2016.

MPhil student 2: Akua Boatema Arthur enrolled at the Department of Nuclear Agriculture and Radiation Processing, School of Nuclear and Allied Sciences of the University of Ghana in August 2013. She carried out her MPhil thesis under the GreenGrowth project from September 2014. Her thesis was titled "The production, processing and packaging of Wagashie, a local cheese". It was supervised by Prof. Wisdom Amoa-Awua. Akua Boatema Arthur assessed the microbiological safety of the traditional soft cheese Wagashie, and introduced a fermentation step in its processing to improve both the safety and organoleptic quality of the cheese. She also investigated the use of commercial rennet for the coagulation of the milk in place of the use of plant extract in the traditional process. She compared the fermentation of the milk with yoghurt culture and lactic acid bacteria she isolated and characterized from local sour milk for the fermentation stage. She determined the technological properties of the isolated microorganisms from the local sour milk and is published in her MPhil thesis.

UDS:

PhD student 1: Oliver Awo is enrolled at the Department of Nutrition and Food Science, University of Ghana, Legon in January, 2014. Oliver Awo's studies at the University of Ghana has been formally extended and he is expected to submit his thesis by March, 2019. He has taken and passed the requisite courses. Oliver Awo has carried out a survey of microorganisms involved in Ghanaian traditional yogurt fermentation. Oliver Awo also received a 7-months training in molecular microbiology at KU-FOOD (Faculty of Life Sciences, University of Copenhagen, Denmark) in 2015. The remaining part of his research work was carried out in Ghana at UDS, FRI and University of Ghana where he is under the supervision of Prof. K. Tano-Debrah and Dr. J Owusu-Kwarteng. Oliver Awo has identified 100 lactic acid bacteria isolated from nunu using Matrix-assisted laser desorption/ionization time of flight

(MALDI-TOF) mass spectrometry based on comparison of protein profile with database. Relevant technological properties of twenty-eight selected LAB strains have been carried out in order to select novel starter cultures for nunu fermentation. Technological properties investigated so far include acidification properties, proteolytic activities, exopolysaccharides production, and antimicrobial activities.

PhD student 2: Grace A. Motey is enrolled at the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi in September, 2015 under the supervision of Prof. K Obiri-Danso and Dr. J. Owusu-Kwarteng. Grace Motey has been granted extension by KNUST and expected to submit her final thesis by February 2019. Grace Motey isolated microorganisms from Ghanaian traditional yoghurt fermentation across Ghana as a follow-up to Oliver Awo's work. Grace was trained 11-month in molecular microbiology at KU-FOOD (Faculty of Life Sciences, University of Copenhagen, Denmark) in 2016-2017. Grace has so far characterized yeasts isolated from nunu in Ghana using phenotypic and sequencing of the 26S rRNA genes of the yeasts. Additionally, she has assessed the in-vitro probiotic potentials of yeasts isolated from nunu and other traditional West African fermented foods. Sequencing of the ITS rDNA-region of the yeasts have also been carried out in order to construct a phylogenetic tree to elucidate the relatedness of the different *S. cerevisiae* strains from the different products. A paper on the results is in preparation. Grace Motey attended an international conference (IPC 2017) presenting a poster with the results from her stay at KU-FOOD entitled: "Probiotic potential of *Saccharomyces cerevisiae* and *Kluyveromyces marxianus* strains isolated from indigenous fermented West African foods". Following her return from the 11-months stay at KU-FOOD, Grace Motey has continued to study the probiotic potential and safety of yeasts and LAB isolated from West African fermented foods, which were identified during her stay at KU. Grace Motey has assessed the antibiotic resistance and hemolytic properties of selected strains. Potential starter cultures have also been selected and optimized based on the probiotic and technological properties studies.

MPhil student: Alhassan Wuni enrolled at the Department of Biotechnology, University for Development Studies, Ghana in August 2014. Wuni successfully defended his MPhil thesis on 7 February 2017 and subsequently graduated with MPhil degree in Biotechnology and under supervision of Dr. James Owusu-Kwarteng. Wuni's MPhil research focused on 'Detection of *Listeria* species and *Listeria monocytogenes* in raw milk and milk products in Northern Region of Ghana. Most of his laboratory work was carried out at the biotechnology laboratory of the

Savana Agricultural Research Institute, Tamale. Wuni also played important roles in other GreenGrowth project activities such as the dairy value chain analysis and the prevalence of *Bacillus cereus* in milk in northern Ghana. Wuni's work generally reiterate the need to develop and encourage the use of starter cultures for the fermentation of traditional milk products to reduce the safety risk associated with consuming milk and milk products. The work formed the basis for a scientific publication, which has been published (Owusu-Kwarteng et al. 2018, Completion report, attachment 34).

DTA:

PhD student: Geoffroy Romaric Bayili is enrolled at Université Polytechnique de Bobo Dioulasso (UPB), Burkina Faso. Date of enrolment: May 2014. Expected time of thesis submission: March 2019. Tentative title of Thesis: Identification and characterization of the microbiota involved in the production of "Lait caillé", a sour milk from Burkina Faso, for the selection of starter cultures. The PhD for Geoffroy Romaric Bayili was shifted, at the initiation of the project, from seeds to milk/lait caillé due to the great research potential within this food chain. Geoffroy Romaric Bayili has followed the traditional process of lait caillé at two production sites in Bobo Dioulasso (western region of Burkina Faso) and established the flow diagrams. He has collected samples and isolated microorganisms from raw milk to lait caillé (final product) in both production sites and samples of lait caillé sold at different markets at Bobo Dioulasso for microbiological analysis. Microorganisms involved in the spontaneous fermentation of lait caillé (lactic acid bacteria, yeasts) were characterized and identified using biochemical and molecular methods during his 9 months (1 June 2015 - 28 February 2016) training visit at KU-FOOD. Before his stay Geoffroy Romaric Bayili took English classes to improve his English. Geoffroy Romaric Bayili has been trained on molecular methods for microorganisms identification (GTG5 based rep-PCR, ITS-PCR, Multiplex PCR and sequencing) during his exchange visit at KU-FOOD. The PhD student attended the "Food Micro 2016" conference at Dublin, Ireland (July 2016) where part of the results on the identification of LAB and yeasts involved in the fermentation process for lait caillé production were presented as a Poster entitled " Identification of the microbiota involved in the production of Lait caillé, a spontaneously fermented milk product from Burkina Faso." This Poster has also been presented during two workshops in Ouagadougou (JPO CNRST, 29-30 September 2016; SIST 2016, 24-28 October 2016). The identification of the lactic acid bacteria (LAB) and yeasts from lait caillé has been completed and a paper on the identification of lait caillé microflora is in preparation. Additional strains of LAB and yeasts were sequenced and relevant technological properties, i.e. rates of acidification and rheological properties, of selected LAB were

determined during his second stay at KU-FOOD, October 2016 –Jun 2017. A paper on the results is in preparation. Trial fermentations were conducted in Ouagadougou with five stains of LAB and one of yeasts to measure the rate of acidification, including sensorial tests of the products. A study has been conducted to confirm the performances reported from the laboratory trials in term of fermentation time and reported a general appreciation of lait caillé obtained with starter. The necessity to train and follow up the SMEs in GMP in order to get optimal results has been outlined. Two strains of *Lactococcus lactis* and one strain of *Leuconostoc mesenteroides* collected from lait caillé were selected and developed for production of lait caillé by the stakeholders. Trials productions of lait caillé with the developed starter have been done at laboratory, pilot plan and SMEs level, followed by sensorial evaluation of the obtained fermented products by a panel of consumers. Two posters were presented at two local/national workshops in Burkina Faso i) JPO/Open House days of of the national research centre (CNRST) held on 12-13 October 2017 at Bobo-Dioulasso and ii) Scientific day of the IRSAT (JS) held on 27 April 2018 at Ouagadougou. One poster and one oral communication were presented at two international workshops in Ouagadougou, Burkina Faso, i) International symposium on science and technology/SIST 2017 held on 4-8 December 2017 with certificate and ii) Scientific research and technological innovation forum/FRSIT 2018 held on 20-25 October 2018 and First Price of The Best communication dedicated by the Burkina Faso President. One oral communication was presented at a training workshop on “Analysis of the microbiomes of naturally fermented foods” held in Accra, Ghana, on 05-09 February 2018. The writing of the PhD thesis is ongoing.

MSc Student 1: René Kompaoré. Time for submission: December 2017. René was registered at University of Ouagadougou and is a trainee at DTA laboratory (Ouagadougou) under the supervision of Dr. Clarisse Compaoré and Dr. Hagrétou Sawadogo. The objective of his study was nutritional and microbiological characterization of lait caillé in Ouagadougou. He isolated microorganism (lactic acid bacteria, yeast) during the fermentation of lait caillé from two production sites in Ouagadougou area (Hamdalaye and 14 jaar). These isolates were send to Bayili Romaric (DTA PhD student), for molecular identification, while Bayili Romaric was doing his training visit at KU-FOOD. René also collected lactic acid bacteria and yeasts from fresh milk and fermented milk from different production sites and markets. Samples of fresh milk and the corresponding lait caillé were furthermore collected for physico-chemical and biochemical characterization (pH, Dornic acidity, lipids, proteins, phosphorus, zinc, iron).

Msc Student 2: Djeneba Tamboura. Time for submission: December 2017. Djeneba was

registered at University of Ouagadougou and is a trainee at DTA laboratory (Ouagadougou) under the supervision of Dr. Clarisse Compaoré and Dr. Hagrétou Sawadogo. The purpose of her study was to develop starter culture adapted to SMEs for Soumbala controlled fermentation (soumbala value chain). The ferments constituted of soumbala powder produced with dehulled seeds of *Parkia biglobosa* and the starter culture in monoculture. Microbial count (aerobic bacteria, enterobacteria, yeast and mold) were done on the ferments. Soumbala was then produced using the different ferments (based on traditional method) in monoculture and mixed culture. These soumbala were microbiologically (total count, enterobacteria, yeast and mold) and nutritionally (moisture, ash, proteins, lipids, carbohydrates, essential amino acid) characterized. She also made sensory evaluation of soumbala produced with starter culture. Fermentation trials with the ferments at SMEs level were conducted and the acceptability of the products scored.

UAC:

PhD student: Marcel Hounbedji, University of Abomey-Calavi (UAC), Faculty of Agricultural Sciences, Benin, enrolled on 01/04/2015. Expected time of thesis submission: 30 December 2018. Marcel Hounbedji has three study stays during the GreenGrowth project: KU-FOOD in Denmark from 01/06/2015 to 28/02/2016, DTA from 01/07/2016 to 31/08/2016 and KU-FOOD from 14/11/2016 to 15/12/2017. Marcel Hounbedji took part in the value chain analysis and has drafted the article on value chain of mawè, has edited and submitted it to the journal Food Chain. Marcel Hounbedji isolated microorganisms during production of mawè from eight production sites in Benin, which were identified during his first stay at KU-FOOD. Marcel has drafted and edited the article on mawè microbiota, which has been published in International Journal of Food Microbiology (Completion report, attachment 32). During the second stay at KU-FOOD, survival and viability of the predominant yeast isolated from mawè and *C. glabrata* in stress conditions associated to mawè has been studied. A paper on the results is in preparation. Experiments have been carried out at UAC, Benin and at DTA, Burkina Faso regarding the investigation of multifunctional properties of yeast and LAB isolates involved in mawè fermentation. Data collected so far include free amino acids profile, biomass and organic acids production. Additional data is being collected on the ability of the isolates to grow at low pH and the ability to inhibit opportunistic pathogenic organisms such as *C. glabrata*. A paper on the results is in preparation.

MSc student 1: Ulrich Mevo, enrolled as master student under GreenGrowth project at University of Abomey-Calavi (UAC), has already defended his dissertation entitled

“Technological properties of lactic acid bacteria and yeasts isolated from spontaneous fermentation of mawè”. During his work, Ulrich Mevo screened previously selected LAB and yeasts strains (14 LAB and 11 yeasts) for their acidification ability and biomass production with the purpose of identifying which could be used for multifunctional starter development. The defense took place at UAC on 5 March 2017.

MSc student 2: Hermine Djivoh has already completed the data collection for her study. The title of her master dissertation is “Development and characterization of a less than 5 complementary food made with a blend of fermented maize flour (mawè), soya flour and baobab pulp”. The defense of Mrs Hermine Djivoh’s dissertation took place on 5 December 2017.

MSc student 3: Oswalde El-Madi Dessouassi, another master student enrolled under GreenGrowth project at the University of Abomey-Calavi (UAC), has completed his dissertation entitled “Characterization of rice dough fermentation for the processing of ablo, a steam cooked bread consumed in Benin”. Fermentation is important during ablo processing for giving the end product its unique taste and spongy texture. Several LAB and yeasts strains isolated by Oswalde El-Madi Dessouassi from ablo fermentation are stored in the UAC bio-bank for further investigations. The defense took place 2 February 2018.

MSc student 4: Eugide Ahivodji started in June 2017 a research on sour milk production and consumption in cities located in the southern part of Benin. The title of the thesis is “Comparative characterization of palm sap obtained from natural and improved palm trees in two agroecological areas in south Benin”. Eugide Ahivodji defended his study 5 March 2018.

MSc student 5: Bérénice Assogba developed a proposal on the characterization of the traditional palm wine production. The title of the thesis is “Comparative characterization of palm sap obtained from natural and improved palm trees in two agroecological areas in south Benin”. The objective of this study was to develop a safe and reproducible palm wine production technology based on controlled fermentation, on a basis of a request of local export SMEs”. The defense of Mrs Assogba’s dissertation was in March 2018.

MSc student 6: Tobi Nouhagovi started in July 2017 experimentations on the use of LAB and yeasts from UAC bio-bank to improve fermentation during cassava processing into lafun. The title of her thesis is “Development of a processing technology of Lafun meeting the

international market requirements". The work was implemented in a SME named Alitech Industries. The specific purpose of this work was to hinder the growth of Bacillus species from the onset of the fermentation to obtain an end product containing less than 102 CFU/g Bacillus species. Tobi Nouhagovi defended her dissertation on 28 September 2018.

Project website

No change in project website URL (<http://www.greengrowth.dk/>)

Substantial changes in the project (content and/or persons), if applicable

UDS: the local coordinator at UDS, Ghana, was changed to Dr. James Owusu-Kwarteng following the resignation of Richard Glover from UDS. Request to replace the project coordinator was written by the Dean, Faculty of Applied Sciences, UDS through the project coordinator on 4 June 2014 and approved by DFC in August, 2014.

Two additional PhD students have been admitted at the GreenGrowth project. Enrolment of Steven Nketia (FRI) and Grace Motey (UDS) was approved by DFC on 17 July 2015. The GreenGrowth project will make sure that the General Conditions are followed for the two additional PhD students.

The project has been adjusted to: 1 January 2014 to 31 December 2018, approved by DFC on 2 June 2016.

PARTNERSHIP

Partnership experiences

During the project period, four consortium meetings have been held. The first meeting (kick-off meeting) was hosted by FRI in Accra May 2014 (First year report, 2014-2015, attachment 1 and 2). KU-FOOD hosted the second meeting in Copenhagen March 2015 (First year report, 2014-2015, attachment 3 and 4). FRI hosted the third consortium meeting in Accra May 2016 (Midterm report 1, 2015-2016, attachment 1 and 2 and Midterm report 2, 2016-2017, attachment 1). Originally, the third consortium meeting was planned to be held by DTA in Burkina Faso, however, due to political unrest in Burkina Faso at that time the meeting was held in Ghana, hosted by FRI instead. The fourth meeting was hosted by UAC in Gran Popo November 2018 (Completion report, attachment 1 and 2).

The communication between the managers of the project, the PhD students and other partners involved has been efficiently maintained via internet and telephone calls throughout the period. In addition, amongst the West African partners, excellent communication has been obtained and the collaboration between the partners in South has been very smooth and fruitful. Communication with the supervisors at the local universities has been good.

Throughout the project period, collaboration between partners has comprised a substantial part of the work, in the form of exchange visits, joint research activities, workshops and knowledge sharing. These collaborations have been with North-South partners as well as South-South partners, strengthening the links between all partners of the consortium. Especially establishment of the bio-banks in the three West African countries was a collaborative effort involving all GreenGrowth partners.

Joint research activities

To ensure strengthened South-South cooperation and possibly joint publications all PhD students had at least one exchange stay at one of the other West African partner institutions. The content of the exchange visits has been discussed among the partners.

DTI performed fieldwork during year two in Burkina Faso and the North of Ghana with the local South partner institutions in relation to WP 1. In May 2015, fieldwork was carried out at three different locations in Burkina Faso with DTA and KU-FOOD. Likewise, field work was carried out at three locations in the North of Ghana together with UDS. A joint publication on the value chain of mawè UAC, DTI and KU-FOOD has been accepted for publication in Food Chain (see Appendix 3c).

DTI hosted a visit from DTA from 22 February - 6 March 2016 with the goal to investigate and transfer DTI's knowledge about bio-packaging. Together with the delegation from DTA, the director of FONRID and representatives from the Ministry of Forestry were present, and fruitful discussions were held as to the scientific status of bio-packaging and the possibilities of implementing this type of technology in Burkina Faso. However, preliminary conclusions showed that despite the potential, the technology is still on a research level and it would take some time before the technology is ready for commercialization. Results of the visit were presented by DTA to all the project partners at the consortium meeting in May 2016.

DTA: Within the context of TADP/FSA/UAC project, financed by UEMOA-PAES (2012-2014) involving DTA/IRSAT (Burkina Faso) and FSA/UAC (Bénin), a master student (Abel TANKOANO) has been trained and supervised at DTA. He works on the evaluation of the consumption and the determination of physico-chemical and microbiological characteristics of the local dairy products (raw milk, lait caillé, yogurt) from Burkina Faso and a paper Tankoano et al. 2016 "Evaluation of microbiological quality of raw milk, sour milk and artisanal yoghurt from Ouagadougou, Burkina Faso, AJMR Vol 10(116), 536-541" has been published. The PhD works of Abel Tankoano (supported by Haagrim Grant) has been reoriented on gapaal (cereal and milk fermented product) microflora, making it synergistic and complementary to the work of the GreenGrowth PhD studying lait caillé. The processes and the microbiological quality of gapaal has been studied for 21 producers from seven towns in Burkina Faso. A paper Tankoano et al. 2017 "Study of process and microbiological quality of gapaal, a fermented food from Burkina Faso based on milk and millet dough" was published in International Journal of Multidisciplinary and current Research, Vol. 5 (Completion report, attachment 35). The government of Burkina Faso, through the National research Center (CNRST) capability building program (travel, accommodations and daily allowances costs), funded a three week stay for Dr. Clarise Compaoré – Dawendé, scientist at DTA, to conduct laboratory work at KU-FOOD in August 2017. The results obtained during the stay will be exploited for a joint publication between DTA and KU-FOOD. Based on the results obtained two posters were presented at two local/national workshops in Burkina Faso as joint work of DTA and KU-FOOD. Further, one poster and one oral communication were presented at two international workshops in Ouagadougou, Burkina Faso as joint work of DTA and KU-FOOD. Finally, one oral communication was presented at a training workshop on "Analysis of the microbiomes of naturally fermented foods".

The value chain report on mawè from Benin was substantially revised and is accepted for

publication in the peer-reviewed journal Food Chain with the assistance of DTI. In relation to WP5, DTI in cooperation with CSIR-FRI, Ghana, organized training workshops on new business models and commercialization of the selected products at each partner institute. The workshops took place between 12 and 27 October 2017 in Accra (Ghana), Cotonou (Benin), Tamale (Ghana) and Ouagadougou (Burkina Faso). The workshops were attended by researchers from the partner institutions as well as the SMEs selected for the commercialization of products. The workshops were also used as a forum for formalizing the establishment of the various national stakeholder platforms as part of WP6 on Dissemination of project results. Detailed reports from the various workshops were presented during the final project meeting in Benin, 21 November 2018.

KU-FOOD successfully trained four PhD students from DTA (1), UAC (1) and UDS (2) during stays varying from seven months to one year and nine months. The results generated during these stays lead to one scientific publication Hougbedji et al. 2018, UAC and KU-FOOD (Completion report, attachment 32) and four scientific publications in preparation as collaboration between DTA and KU-FOOD, UDS and KU-FOOD as well as UAC and KU-FOOD. The PhD student from FRI was trained in business model development at DTI in autumn 2016.

Further, the joint research activities resulted in five joint journal article publications, i) Akabanda et al. 2018 UDS and DTA (Completion report, attachment 33), ii) Owusu-Kwarteng et al. 2018, UDS and KU-FOOD (Completion report, attachment 34), iii) Owusu-Kwarteng et al. 2017, UDS, KU-FOOD (Midterm report 2, 2016-2017, attachment 16), iv) Tankoano et al. 2016, DTA and UAC (Midterm report 1, 2015-2016, attachment 4) and v) Owusu-Kwarteng et al. 2015, UDS and KU-FOOD (Midterm report 1, 2015-2016, attachment 5). Additionally, results obtained during the GreenGrowth project have been presented at 10 international conferences and 19 national conference, jointly published, between UDS and KU-FOOD, DTA and KU-FOOD as well as UAC and KU-FOOD (see Appendix 3c).

Partnership lessons

The project has moved very smoothly forward and no major challenges have occurred. The main challenges identified during the project are as follows:

- Upon recruitment of PhD students at the partner institutions it is of significant importance to ensure that the PhD candidates have the required background to carry out the PhD study. For

French speaking countries it is of outmost importance that the PhD students acquire a certain level of written and spoken English in order to carry out scientific communication and to interact with staff members during their stays at KU-FOOD and DTI. Local English courses in their home countries are very useful before exchange visits in Denmark.

- Longlasting and strong partnerships both at the north-south and south-south level are very valuable in the initiation of a new research project and ensure an effective implementation of results.
- Initiatives need to come from the African partners to strengthen sub-regional collaboration across borders. When successful it is very valuable
- On-location field work and knowledge exchange in the South partner countries are important to reach a common understanding of the research. This enables an easier transfer of experience and training activities later on in the project.
- Sharing of ideas between partners during project meetings and through e-mails is helpful in the selection of appropriate methods and design of research activities from the beginning. This is very useful in preventing any unforeseeable error(s) in methodology that could affect the quality of research findings. To further circumvent errors in sampling methodologies a procedure for proper sampling has been developed during the project.
- Bringing the PhD students from DTA, UDS and UAC to a common understanding of responsible conduct of research, as practised at University of Copenhagen, was recognised as valuable. Hence, the PhD students participated in the responsible conduct of research course offered by University of Copenhagen.
- The training workshops for SMEs and various national stakeholders proved very useful for promoting a wider understanding of the project results, which is necessary for the national anchoring of the project's achievements. The workshops also provided an opportunity for researchers to listen to the views of SMEs and other relevant national agencies on the non-scientific issues that need to be addressed for successful adoption of the developed technologies, e.g., issues regarding access to finance, difficulties in business registration, tax documentation, etc.

National and international cooperation

Study stays of the PhD students enrolled in GreenGrowth project took place between North-South partners as well as South-South partners.

KU-FOOD hosted four PhD students, one from DTA, one from UAC and two from UDS during the GreenGrowth project. The stays at KU-FOOD were divided such that the DTA PhD student had two stays of nine months (June 2015-March 2016 and November 2016-July 2017), the UAC PhD student had one stay of nine months (June 2015-March 2016) and a second stay of 13 months (November 2016-December 2017). The PhD students from UDS each had one stay at KU-FOOD of seven (August 2015-March 2015) and 11 months (November 2016-October 2017), respectively. The FRI PhD student was trained one month at DTI (October/November 2016). Following the training at DTI the FRI PhD student follow visits training all West African partners were carried out; UDS 17 to 18 November 2016, DTA 29 to 30 November 2016 and UAC 15 to 16 December 2016 (Midterm report 2, 2016-2017, attachment 3), to implement the study stay results of business model development. The PhD student from UAC was staying at DTA for two months in July to August 2016, a report of his stay is included in Midterm report 2, 2016-2017, attachment 2.

Guidelines for how to set up national stakeholder platforms have been formulated and distributed to the partner institutions and stakeholder platforms has been set up in each of the partner countries. The platforms include private and public partners, which will assist in dissemination and uptake of project results. Additionally, the stakeholder platform can be used to discuss future initiatives and project proposals between the stakeholders.

At DTA a new partnership was established at ministerial level through the visit of Ana d'Auchamp (DTI) on 2015, in collaboration with the Royal Embassy of Denmark in Ouagadougou. This collaboration concerns the domain of biodegradable packaging, starter culture production and ideas exchange on innovation. A strategy of identifying and developing innovations in the platforms was established and integrated into the business model. The partnership with CNSF (National Centre for Forest Seeds, Ouagadougou, Ministry of Environment, Burkina Faso) has been strengthened in the domain of biodegradable packaging and joint exchange visit DTA/CNSF was realized in at research visit to DTI on end of February to the beginning of March 2016. DTA has strengthened the partnership with national organizations on dairy products in Burkina Faso (Table Filière Lait, UMPL B, IPROLAIT) through the training held with lait caillé stakeholders in Ouagadougou.

All West African partner institutions have established national collaborations between the institutions and universities, at which the PhD and MSc students are enrolled. Hence, UDS has established collaboration with a number of Departments at Universities in Ghana, i.e. Department of Nutrition and Food Science of the University of Ghana, Department of theoretical and Applied Biology of the Kwame Nkrumah University of Science and Technology, Kumasi-Ghana, Savana Agricultural Research Institute (SARI) of the Scientific and Industrial Research (CSIR), Tamale-Ghana in Ghana, Department of Applied Physics, UDS and Department of Applied Biology UDS, through the enrolled PhD, MSc and BSc students in the GreenGrowth project. DTA has strengthened the cooperation with the University of Ouagadougou and the University of Bobo Dioulasso (Université Polytechnique de Bobo) through the training and the supervision of the students (PhD, Master and bachelor) under the GreenGrowth project. In Ghana, the parent organization of the GreenGrowth partner, the Council for Scientific and Industrial Research established a postgraduate university college, CSIR College of Science and Technology (CCST) in 2015. The Agro-Processing Technologies and Food Bio-Sciences programme is hosted by the project partner CSIR-Food Research Institute. The Coordinator of programme is the local GreenGrowth project leader, Wisdom Amoa-Awua, and one of the three module heads is the Deputy GreenGrowth project leader, Margaret Owusu. The two GreenGrowth PhD candidates George Anyebuno and Steven Nketia also teach courses in the MPhil programme. Wisdom Amoa-Awua has designed and teaches a course in Traditional Food Processing Technologies, which is based largely on findings from the GreenGrowth project as well as the other Danida and EU projects that FRI has participated in in collaboration with the University of Copenhagen and the other GreenGrowth partners. Steven Nketia teaches a course in Agri-business, which includes value-chain analysis and business canvas module, topics that he has learnt from the GreenGrowth project.

Co-financing in other research projects

Six ICFMH mobility Grants have been awarded to GreenGrowth project partners. Grants for participation in the FoodMicro conferences in 2016 in Dublin and 2018 in Berlin were awarded to James Owusu-Kwarteng (one grant), Marcel Hounbédji (two grants) and Romaric Geoffrey Bayili (one). Furthermore, Marcel Hounbédji was awarded two mobility grants (ICFMH mobility grants 2015 and 2018) for study stays at DTA in summer 2016 and in February-March 2019.

ICFMH organized and funded a training programme for participants from selected African countries on 'Advancing Food Microbiology Research & Microbial Food Safety Surveillance in

Africa' in Accra Ghana from 12-17 December 2017. It was hosted by the GreenGrowth team of the CSIR-Food Research Institute. GreenGrowth partners from the other African counties were participants in the training programme. In 2014 ICFMH had also organized another training workshop in Accra Ghana on 'Improving the microbial safety of African food products towards local and global markets' from 16-20 June 2014 for participants from African countries which was hosted by the GreenGrowth team of Food Research Institute. Prof. Mogens Jakobsen led ICFMH to organize both African training workshops.

Co-financed by the government of Burkina Faso and GreenGrowth project joint exchange visit to DTI of DTA scientists, scientists from CNSF (Ministry of environment) and FONRID (Ministry in charge of research and innovation) was conducted in March 2016 concerning training on biomaterial used for packaging. During the visit, the DTA team held discussions with ecoXpac A/S, a Danish SME engaged in the development of packaging solutions. As a follow-up to this visit, ecoXpac A/S with the assistance of DTI, submitted and obtained project funding under the Danida Business Explorer Programme, to visit Ghana in order to investigate the possibility of establishing pilot facilities for the production of fibre-based packaging.

Funded by the government in Burkina Faso, DTA scientist Charles Parkouda visited KU-FOOD in November 2014, to obtain the microorganisms isolated in previous projects by DTA scientists and PhD students, which has been kept in the freezers at KU-FOOD, to transfer a copy to the newly established bio-banks at DTA. Furthermore, DTA scientist Clarisse Dawende obtained a funding by the government in Burkina Faso (CNRST capability building program) to visit KU-FOOD in August 2017 to identified LAB collected from lait caillé sampled in- and around Ouagadougou (Completion report, attachment 27).

Two SMEs in Ghana, Selassi Foods Ltd and Contrapac Ltd have been assisted by the FRI GreenGrowth team to secure funding from the Social Development Fund for upgrading and expansion of their facilities and implementation of HACCP in their operations. A proposal has also been submitted by a third SME Tayaako Enterprise to the SDF fund.

RESULTS

Project Achievements

Short summary of the project objectives, outputs and outcomes

Bio-banks were successfully established to preserve and fully utilize the microbial food heritage. This included generation of procedures and training at a commercial culture-collection, enabling staff to sustain the bio-banks extending the project period. Determining technological properties of identified LAB and yeasts formed the basis for starter cultures development. These were implemented at SME level to improve food quality and safety. Institutional capacity was built through training of PhDs and master students, exchange visits and implementation of equipment. Value chain analyses of the foods provided the researchers with an understanding of the framework conditions for successful result uptake by industry. This was achieved through establishment of national stakeholder platforms involving SMEs, governmental and regulatory agencies. Selected SMEs were trained in the business model canvas to identify and build relations within value chain actors to enhance quality and profits.

Possible deviations

Training of West African partners in value-chain analyses were six months delayed due to the previous threat of ebola outbreak in the region and uncertainties due to political unrest.

Since all West African partner countries continuously experience an energy crisis leading to frequent power cuts, back-up power from generators has been installed for all bio-bank freezers. Additionally, solar back-up power was installed at UAC and FRI to ensure stable and green back-up power for the freezers.

Back-up storage plan for the microbial cultures in the bio-banks was established by signed MoUs on exchange agreements of microbial cultures between the partner institutions.

The West African partner institutions got approval from Danida to use the money funded for a second freezer to buy lab-scale fermenters and freeze-dryers (approved by email 6 October 2017), which enabled the West African partners to produce the developed starter cultures for fermentation trails at SME level.

Obtained results in relation to the projects objectives, outputs and outcomes

The establishment of bio-banks in Ghana, Burkina Faso and Benin opened up new opportunities for research on fermented foods ensuring the West African microbial heritage. The bio-banks provide strains for research work for enhancing quality and safety of traditional fermented foods. Further, they offer the West African partner institutions the possibility to produce starter cultures for the West African food industry and offer inherent West African cultures for research in all sectors. The appointed staff in charge of the bio-banks at FRI, DTA and UAC were trained in culture-collection management at the commercial culture-collection “Belgian Coordinated Collection of Microorganisms”

A large number of lactic acid bacteria and yeast strains have been isolated from fura, nunu, lait caillé and mawè. Relevant technological properties including acidification and aroma formation have been determined for the microorganisms and further the probiotic potential of some yeasts isolated from nunu, lait caillé and mawè was determined. These results formed the basis for development of multifunctional starter cultures, especially designed for fura, nunu, lait caillé and mawè with microorganisms originating from the respective products to upgrade the West African food sector from spontaneous to controlled fermentation, ensuring safer food products. The implementation of starter culture at the SMEs has been highly appreciated and approved, due to the improved quality of the obtained products. The bio-banks and equipment (fermenter, freeze-dryer) established during the project, forms an important basis for implementation of microbial starter cultures at the SME level.

The knowledge of conducting value chain analyses and business models of the food products being investigated for process upgrading was an important part of the training and education of researchers. It provided them with an understanding of the wider setting into which their scientific results will be applied and the framework conditions for successful research results uptake by industry. It also enabled researchers to map the various actors that were involved in the process at various intervention points. In this project, this was achieved through the establishment of national stakeholder platforms on which SMEs, governmental and regulatory agencies was involved. Value chains for the fermented food products fura and nunu from Ghana, lait caillé from Burkina Faso and mawè from Benin were identified as having a strong potential for green growth.

The selected SMEs in each partner country were trained in the use of the business model canvas to identify and build relations within their value chain in order to control quality and maximise their profits. The workshop gave practical hands on training, enabling all partners to

develop their business models.

Training of PhDs and master students together with exchange visits built the capacity at institutional level.

Communication and outreach

Throughout the project focus has been to spread the knowledge generated and the approach applied in this project, i.e. combining value chain analysis and commercialization through use of business models with research in food science and technology.

Through a stakeholder platform, engaging private and public stakeholders, a stronger linkage has been established between the West African partner institutions and SMEs producing the selected fermented food products. By making them aware of the developments in the GreenGrowth project and assisting them to expand their operations by securing funding, a stronger relationship has been built which will continue to be a conduit for transferring research results to industry.

For this dissemination to occur each of the respective partners established operational plans for dissemination activities. At the local level, the West African partners extended and strengthen links with the existing local producers and SMEs. At the national level efforts were made to reach national agricultural and food extension services, SMEs and associations related to the selected fermented foods. The project results were disseminated in a popular scientific way to food sector audience. The scientific knowledge obtained during the project has been disseminated to MSc and BSc students through teaching at courses at the partner institutions in both West Africa and Denmark. Further, public defense of MSc thesis are also used as channel to let audience know about the project and the results obtained so far. Additionally, scientific dissemination of project results is being ensured through joint publications in international peer-reviewed journals and presentations at international conferences and meetings.

Key recommendations on how to upgrade the West African food sector in a sustainable and more efficient way are compiled as a policy brief, based on the results obtained in the GreenGrowth project.

The GreenGrowth project was mentioned in the policy brief: "Improving diets in an era of food

market transformation: Challenges and opportunities for engagement between the public and private sectors” by Global Panel on Agriculture and Food Systems for Nutrition, Policy Brief No 11, p. 13 in box 2.

Research capacity building

Laboratory facilities have been upgraded by installation of bio-banks and implementation of management procedures as well as lab-scale fermenters and freeze dryers. Additionally, solar panels were installed at UAC and FRI to ensure stable and green back-up power for the freezers.

To enable the partners to operate and maintain the bio-banks, the appointed staff in charge of the bio-banks were trained in culture-collection management at the commercial culture-collection in Belgium collection “Belgian Coordinated Collection of Microorganisms”. The back-up storage plan for the cultures in the bio-banks was facilitated by exchange of cultures between the partner institutions, using MoUs, which established an inter-country system that strengthened collaboration between the partner institutions as well as enhanced knowledge sharing related to culture-collection management among the appointed staff in charge of the bio-banks. Further, a standard operating procedure for handling, maintenance and preservation of microorganisms was generated as collaboration between KU-FOOD and DTA to ensure proper management of the bio-banks.

Training of partners involved in the GreenGrowth project was achieved in several ways. At institution level, all southern partner institutions were trained in value chain analysis methods and enabling them to conduct their own value chain analyses. Of the six enrolled PhD students from south partners in the GreenGrowth project, five had training stays at the north-partners, DTI or KU-FOOD. Hence, one PhD student from FRI was trained at DTI in business model development and subsequently trained the south partners at institutional level. Four PhD students (DTA (1), UDS (2) and UAC (1)) were trained at KU-FOOD, in experiment planning, sampling, use of molecular biology methods, software and databases for identification and characterisation of technological properties of microorganisms, scientific writing and responsible conduct of research, as practised at University of Copenhagen. Additionally, the PhD student from UAC were trained at DTA in amino acid determination using HPLC, hence south-south training. Finally, several MSc and BSc students have been enrolled in the GreenGrowth project and 11 MSc students have finalised and defended their MSc projects during the GreenGrowth project. Moreover, scientists from DTA were trained at DTI on

bio-packaging for food products, and at KU-FOOD in molecular biology methods for identification.

Major lessons learned

A value-chain approach, involving end-user and other stakeholders at the initial stages of research, is important for uptake of research results. The establishment, maintenance and management of the bio-banks in West African partner countries with back-up storage plans was demonstrated, which will preserve and facilitate upgrading of traditional fermented foods. Sharing these resources and knowledge generated will strengthen links among partners. The microbial resources of West African partners can be used for the development and distribution of starter cultures to improve the operations of SMEs involved in the production traditional foods, leading to upgrading of the food value chain. The partners realized that they needed to generate business model using the business canvas model to introduce their technologies at SME level for increased revenue streams with greater profit margins and reduction of production cost.

The project progress on each of project objectives, outputs, and outcomes must be entered into the logframe matrix (Appendix 1) and uploaded to the report in Step 7.

METHODS

Exit strategy, including handing over of equipment, etc.

The three West African partner countries are able to phase out of previous Danida financed projects in a sustainable and profitable way maximizing the utilization of the scientific results obtained due to the establishment of the bio-banks. The four partners will as a result of the project be able to effectively utilize their capacity to establish linkages with local food enterprises through analytical services, consultancy, training and development of starter cultures for other traditional products. These commercial services to the food sector will ensure that there is a local market for these laboratories to grow towards financial self-sufficiency.

The education of PhD students at South partner institutions with training stays at North partner institutions, in research planning, execution, data handling, scientific writing and responsible conduct of research increased their research capacity, which is sustained in the South partner countries through employment of the PhD candidates after ending of the GreenGrowth project.

All equipment obtained under the GreenGrowth project, including freeze dryer and fermenters as well as a water distilling system at UDS, have formally been handed-over to the partner institutions in West Africa to manage and have oversight responsibility (see appendix 3d). Protocols and procedures for handling of equipment, including logbooks have been implemented. Staff members have been appointed to directly manage the usage of the equipment. Continuous training of other staff in laboratory facility management and the skills acquired to handle the equipment will be carried out after the project. The equipment will be used to produce freeze-dried microbial starter cultures for SMEs as well as for research. Additionally, the facilities and equipment acquired under the GreenGrowth project will be incorporated into a start-up development program at UAC, which helps young entrepreneurs, providing basic knowledge about microbial starter culture production for commercialization. Similarly, spin-off companies have been established at FRI to generate extra revenue.

Actual/anticipated employment of the researchers educated

At all West African partner institutions, researchers (PostDocs, PhD, MSc) educated during the GreenGrowth project has been employed:

FRI: Akua Boatema Arthur who was an MPhil student from the University of Ghana on the GreenGrowth project, has been employed at the Food Research Institute by the Council for Scientific and Industrial Research as a Principal Technologist at the Microbiology and

Mushroom Research Division.

UDS: The two PhD candidates enrolled on the GreenGrowth project are already employed as lecturers at the Department of Applied Biology, UDS. The MSc candidate (Alhassan Wuni) is also employed as a science teacher at the Senior High School level and currently enrolled in a PhD. It is envisaged that he will move to the University as lecturer after completing his PhD studies.

DTA: The researchers educated during the project will strengthen DTA team scientific capacities and will be used to promote in their professional career. The DTA PhD student are already employed at DTA in Bobo-Dioulasso.

UAC: The post-doc under the GreenGrowth project in Benin, Dr Wilfrid Padonou, has already obtained a position as lecturer in a novel university, the national university of Agriculture (UNA). After completing his PhD, Marcel Hounbedji will be appointed as post-doc under another project before applying for a position at a national university.

Ability to attract other funding for the research and facilities enhanced

Through the long-term collaboration between the project partners and personnel, there is sufficient experience and desire to continue the research collaboration. The consortium partners have already identified areas requiring further research efforts including methods for development of semi-commercial production, packaging and distribution of starter cultures. They have also identified new investigations into the nutritional and health implications of the use of the developed microbial starter cultures in the local fermented food products. In 2019, members of the consortium will work together with other relevant partners to submit a project proposal to FFU, Danida Window 1, theme 1, call no. R467-A33288-B16337, entitled "Sustaining plant-based foods for improved health" including Ghana and Bukina Faso. Further members of the consortium is submitting a proposal under EU's Horizon2020, call no. LC-SFS-34-2019, entitled "Revival of the West African Food Heritage for green diets, food security, improved nutrition and income generation", including Ghana, Benin and Burkina Faso.

Further, initiated by UAC and Gulu University in Uganda a funding application for African Union, with KU-FOOD as European partner, was submitted in 2018 on nutrition and safety oriented optimization of traditional fermentation technology for production of cassava products

in Eastern and West Africa. Even though the application did not result in funding, the establishment of the consortium could lead to future funding.

Other specific actions taken to secure the sustainability of the capacity built

The human and technical capacities built through implementation of the GreenGrowth project (PhD, MSc/MPhil and BSc; bio-banks, lab-scale fermentor and freeze-drier installed in Benin, Burkina Faso and Ghana) and the inter-links among the partners constitute a favorable field on which other proposals to attract funds can be developed

Enhanced institutional research capacity through the training PhDs and their subsequent employment, substantial scientists exchange program, upgrading of laboratory facilities, and a strong collaboration among West African partners will enable them to secure the sustainability of the capacity built and enable new national and international funding to continue research of national- and regional interest.

Appointing staff members in charge of bio-banks and equipment related to microbial starter culture production will secure correct handling. Continuous training of staff in laboratory facility management and the skills acquired to handle the equipment will ensure that the capacity built during the project will be sustained at the partner institutions.

The Nagoya protocol has now been ratified signed by two of the African partners countries (i.e. Benin and Burkina Faso), which will create greater legal certainty and transparency for both providers and users of genetic resources obtained through the project.

ABSTRACT AND GOOD STORY

Brief popularized abstract

The main purpose of the GreenGrowth project was to turn the food sector in West Africa into a driver of sustainable growth by upgrading food products ensuring quality, safety and marketability. A major part of traditional West African foods are fermented, hence being produced by the activity of microorganisms. In this project, identification of food value chains with potential for green growth formed the basis for selection of fermented foods to upgrade. Microorganisms driving the food fermentations were identified and their relevant technological properties characterized, which formed the basis for development of microbial starter cultures. Implemented at SMEs along with new business models these starter cultures changed the processing from spontaneous to controlled fermentation leading to improved quality and increased safety of the fermented foods. Establishment of bio-banks in the three countries have secured the microbial heritage of the West African countries, which expand the project impact. Through the project, methods for development of semi-commercial production, packaging and distribution of starter cultures were identified as areas requiring further research efforts.

Good story

I am Dr. James Owusu-Kwarteng, local project leader for the GreenGrowth project "Preserving African Food Microorganisms for Green Growth" at the University for Development Studies (UDS), Ghana. My involvement in the GreenGrowth project funded by Danida has helped to develop my personal capacity as a scientist as well as enhanced institutional and local capacities. Personally, the project has given me the opportunity to lead a scientific research group and, in the process, implemented decisions regarding project administration and research approaches. Through the GreenGrowth project, I also got the opportunity to network and learn from leading experts in my field from Denmark and other parts of Africa. These experts, despite their worth of experience and knowledge, treated me as an equal and made me feel very comfortable working on the project. Undoubtedly, my involvements in the GreenGrowth project has contributed immensely to building a solid foundation for my long-term career as a scientist. The GreenGrowth project has also helped to develop my institution's capacity through graduate level training, exchange of scientists and partnerships, and upgrading of laboratory facilities. Our two PhD students stayed at KU-FOOD for nine months each, affording them the opportunity to carry out part of their research work using state-of-the-art equipment in a very conducive academic environment. The results and knowledge gained through the PhD studies and the entire project is benefiting Small and Medium Scale

Enterprises (SMEs) at the local level. The SMEs are applying new business models developed under the project in their businesses to increase market access. SMEs have also been trained in food safety and quality management, handling and use of starter cultures in yoghurt production, and packaging to enhance competitiveness and increase incomes. These are indeed successes from the GreenGrowth project and we at UDS are happy to be part of such good stories.

The research results should be published in open access formats whenever possible. A Policy Brief (Appendix 3b), and a publication and dissemination list (Appendix 3c) must be uploaded in Step 7.

7 ATTACHMENTS

F38/F38R455/F38A33228_big_b30aGreenGrowth_good_story_pic1.jpeg

Good story pic 1. James Owusu-Kwarteng



F38/F38R455/F38A33228_big_bd0aGreenGrowth_good_story_pic2.jpeg

Good story pic 2. After an SMEs training section at UDS, Navrongo, Ghana



GreenGrowth_App3aLogFrameMatrixFormat.docx
0.06 MB. App 3a GreenGrowth LogFrameMatrix

2018App3cPublicationandDisseminationListforCompletionReporting.
0.15 MB. App 3c GreenGrowth publication and dissemination list

2018App3dSignatureHandoverequipment.pdf 4 pages
0.39 MB. Add 3d GreenGrowth signatures of hand over of equipment

2018App3eSignature Page.pdf 2 pages
0.18 MB. App 3e GreenGrowth Signatures

Attactments_GreenGrowthproject_completion report.pdf
21.85 MB. GreenGrowth attachments for completion report