

Preserving African Food Microorganisms for Green Growth

LogFrame Matrix – “Preserving African Food Microorganisms for Green Growth” Completion report

	List approved objectives/outputs/outcomes	Indicators and means of verification	Progress/results achieved
Objective # 1	To identify food value chains with potential for green growth.	Training course in business models and food value chain analysis and reports describing mapped out value chains for each food value chain.	<p>KU-FOOD: Coordination of activities and assisting in writing of scientific paper on the value chain analysis from UAC.</p> <p>DTI: Training courses in food value chain analysis in all West African partner countries, completed in 2014. All the partners have completed technical reports on the value chain analyses of their selected products. One paper on the value chain analyses of mawè from Benin been accepted for publication in Food Chain. Two more papers are due to be submitted for publication on value chain analyses. The PhD student from FRI was trained in business model development at DTI in autumn 2016. Training courses for the West African partner countries in business models are completed. Report from the training workshops is included (Midterm report 2, 2016-2017, attachment 3).</p> <p>FRI: Consumer study for value chain analysis completed, analysis of economic factors of value chain completed. Key challenges and opportunities across the fura value chain for green growth have been identified. The report on the value chain analysis results is finished (Midterm report 2, 2016-2017, attachment 5). Training courses held at UDS, DTA and UAC in business model development by the FRI PhD student is completed in November to December 2016.</p> <p>UDS: Studies on value chain analyses of dairy production and milk processing in Northern Ghana has been completed. Challenges in setting up an efficient, hygienic and economic dairy chain in northern Ghana have been identified. Similarly, potentials/opportunities for growth (green-growth) of the dairy value chain have also been identified. The report describing the findings of the value chain study is completed (Midterm report 2, 2016-2017, attachment 6).</p>

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			<p>Training course held at UDS in business model development by the FRI PhD student is completed in November 2016.</p> <p>DTA: The exploratory study on lait caillé value chain conducted in 2016 allowed to identify the actors, their sources of provision and their distribution (Midterm report 1, 2015-2016, attachment 3). During the period of July - December 2018, an additional survey was conducted on the consumption and the perception of lait caillé by the consumers. The level of lait caillé consumption, the perception of consumers on lait caillé quality as well as the position of lait caillé in comparison with a competitive product such as yoghurt have been determined. The constraints related to lait caillé processing, preservation and commercialisation and the elements of strategy for the development lait caillé have been identified. The results have been compiled in a report (Completion report, attachment 3).</p> <p>Training course was held at DTA by Mr Stephen NKETIA (FRI's PhD student) and Mr Moses MENGU (project team leader at DTI) in collaboration with DTA researchers in October 2017 on business model canvas development for product and services. A total of 21 participants including 14 SMEs operating in the processing and distribution of lait caillé (11) and processing of soubala (03), personnel from the Ministry of Agriculture (01), National Agency of Standardization (01) and DTA researchers (05) have been involved in this training and built their knowledge (Midterm report 2, 2016-2017, attachment 3).</p> <p>UAC: Mawè and derived products were identified for value chain study because mawè is a fermented maize-based intermediate product widely used in Benin for the preparation of several cooked dishes. The value chain study was performed through literature search and field survey in southern Benin. Six kinds of mawè and six categories of derived products were encountered. These products are processed,</p>

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			marketed and consumed through traditional and traditional-to-modern chains. The chains actors are predominantly young, illiterate and Christian who operate mostly in urban areas. Consumers are willing to buy more in traditional network because of the product affordability of this chain. The value chain report on mawè was completed by December 2014 (First year report, 2014-2015, attachment 5). Training course held at UAC in business model development by the FRI PhD student is completed in December 2016.
Objective # 2	To enable the West African countries to fully utilize their microbiological heritage.	Culture-collections (biobanks) established in each of the three countries. Relevant cultures transferred to the culture-collections.	<p>KU-FOOD: The purchased freezers for the bio-banks have been installed in the West African partner countries in 2014. A procedure for culture-collection management is completed in collaboration between DTA and KU-FOOD and has been implemented at GreenGrowth bio-banks in West Africa, (Midterm report 2, 2016-2017, attachment 7).</p> <p>FRI: The freezer is installed and fully functional, placed in an air-conditioned room the research lab at the Food Microbiology Division. Solar panels, already installed and fully functional at FRI, have been connected to the freezer as backup power. FRI cultures from fura and other fermented foods are stored in the biobank (Completion report, attachment 5 and 19) and copies of the cultures sent to Quadram Institute, UK for whole genome sequencing. Cultures from UDS have been received and are now kept in a separate shelf in the freezer.</p> <p>UDS: A total of 77 yeast strains isolated from nunu, lait caillé and mawè and 100 lactic acid bacterial strains isolated from nunu have been deposited in the biobank at Food Research Institute, Accra. Copies of all strains have been prepared for transfer to other bio-banks at UAC, Benin and DTA, Burkina Faso under the GreenGrowth project (Completion report, attachment 6).</p> <p>DTA: The freezer is installed and fully functional. Cultures are deposited and previously isolated cultures are being transferred to the</p>

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		Cultures selected and developed for production and made available for use by stakeholders.	<p>freezer. Further, back up storage of DTA cultures are in place at FRI and UAC and cultures from UAC and FRI have been received. Electric power back up was installed with the financial support of African Development Bank (BAD) in 2017 through a project (PATECE) of the Ministry in charge of industries and trading of Burkina Faso. The results on the bio-bank establishment as well as back up storage were compiled as technical documents (Completion report, attachment 7). With the collaboration of KU-FOOD, two standard operating procedures have been finalized and implemented at all West African partner institutions: one procedure for handling, maintenance and preservation of microbial isolates in cultures collection (Midterm report 2, 2016-2017, attachment 7), the other on sampling and identification of microbial isolates from fermented food products (Midterm report 2, 2016-2017, attachment 15).</p> <p>UAC: The biobank is installed and fully functional. The -80°C freezer is placed in an air-conditioned room protected from the high ambient temperature. To avoid any power cuts, photovoltaic solar panels system is installed as power back-ups. A copy of all microbial strains (approximately 700), isolated from mawè fermentations during the PhD study is deposited in the culture-collection (Completion report, attachment 8).</p> <p>FRI, DTA, UAC: Back-up storage through MoUs have been established, ensuring that each bio-bank has back-up copies in the two other bio-banks (Completion report, attachment 28, 29, 30 and 31).</p> <p>All partners: Isolates from lait caille, mawè and nunu have been identified at KU-FOOD during the exchange stay of the PhD students Romaric Bayili, Marcel Hougbedji, Oliver Awu and Grace Motey (DTA, UAC and UDS) in 2015-2016. The technological properties of selected isolates from lait caille, mawè and nunu were investigated by the PhD students Romaric Bayili, Marcel Hougbedji and Grace</p>

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			<p>Motey (DTA, UAC and UDS) during their training visit at KU-FOOD in 2016-2017. Additionally, LAB and yeasts from fura fermentation has been identified by the PhD student George Anyebuno at FRI. Scientific papers are published or in preparation on the results obtained based on the identification (see dissemination and publication list, appendix 3c).</p> <p>FRI: Fura starter culture was developed, based on the isolates, in MPhil project work of Cosmos Amankoana and was made known to stakeholders through a stakeholders forum and contacts with SMEs (Completion report, attachment 9 and 10).</p> <p>UDS: Cultures for starter have been selected and are being developed for production. These will be made available for use by stakeholders by end of December, 2018 (Completion report, attachment 11).</p> <p>DTA: For lait caillé stakeholders LAB starter cultures were developed and for soumbala stakeholders <i>Bacillus</i> spp. starter cultures were developed. Trial productions of lait caillé (Completion report, attachment 12) and soumbala (Completion report, attachment 13) with the developed starter cultures have been done at laboratory, pilot plant and SMEs level, followed by sensorial evaluation of the obtained fermented products by a panel of consumers.</p> <p>UAC: Starter cultures for mawè, akpan (a maize derived beverage) and lafun (a cassava derived product) have been selected and procedures for freeze-drying three LAB and two yeasts among the UAC isolates stored in the bio-bank was established. The freeze-dried cultures will be distributed for use to SMEs (Completion report, attachment 14).</p>
Objective # 3	To characterize technological properties of microorganisms	Published results of isolated microorganisms and important technological properties.	KU-FOOD: Together with the West African partners, microorganisms in the selected fermented food products have been identified and work initiated as described below. KU-FOOD has supervised the West

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	targeted the West African food sector.		<p>African PhD students from UDS, DTA and UAC throughout their stays (of 56 months in total) in molecular biology techniques for identification of microorganisms, advanced microbiological techniques for characterisation of technological properties of microorganisms, sequencing techniques, database searches, experiment planning, scientific writing and oral presentations. Further, KU-FOOD facilitated that the PhD students were able to participate in the course on responsible conduct of research offered to all PhD students at KU. The PhD students have participated in international conferences as well as in seminars, workshops and symposiums together with KU-FOOD. KU-FOOD have supervised the PhD students in writing of scientific papers for publication in international peer-reviewed journals, based on the obtained results during the stays at KU-FOOD.</p> <p>FRI: Studies on development of a starter culture for the fermentation and preservation of fura has being carried out together with studies on reengineering fura processing targeting both the local and foreign markets. Additionally, work has been undertaken to improve the sensory quality, safety and shelf life of wagashie, a traditional cottage cheese.</p> <p>UDS: Four publications related to isolated microorganisms and technological properties have been published: i) Owusu-Kwarteng et al. 2017, Technological properties and probiotic potential of <i>Lactobacillus fermentum</i> strains isolated from West African fermented millet dough has been published under the project (Midterm report 1, 2015-2016, attachment 5). ii) Owusu-Kwarteng et al. 2017, Prevalence, virulence factor genes and antibiotic resistance of <i>Bacillus cereus sensu lato</i> isolated from dairy farms and traditional dairy products (Midterm report 2, 2016-2017, attachment 16), iii) Akabanda et al. 2018, Effects of mechanical</p>

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			<p>dehulling on microbiological characteristics and chemical changes during the processing of <i>Parkia biglobosa</i> seeds into dawadawa, a West African alkaline fermented condiment (Completion report, attachment 33) and iv) Owusu-Kwarteng et al. 2018, Prevalence and characteristics of <i>Listeria monocytogenes</i> isolates in raw milk, heated milk and nunu, a spontaneous fermented milk beverage, in Ghana (Completion report, attachment 34). Probiotic potential of yeasts isolated from traditional fermented milk and cereals was studied by Grace Motey during her study stay at KU-FOOD in 2017. A publication on her results is in preparation for publication. Further, results were presented at two international conferences, FoodMicro2018 (Completion report, attachment 38) and IAFP (Completion report, attachment 39).</p> <p>DTA: The isolated microorganisms from fermented milk in Burkina Faso have been identified at KU-FOOD. Results on identified microorganisms isolated from lait caille were presented at the international conference FOODMicro in July 2016 (Midterm report 2, 2016-2017, attachment 11). Publication on the isolated microorganisms from lait caille is in preparation. Technological properties of selected microorganisms appropriate for starter culture development was studied at KU-FOOD during the second study stay of Romaric Bayili and a publication on the results is in preparation. Publication on microbial quality of Gappal, a fermented milk and millet beverage from Burkina Faso has been published, Tankoano et al. 2017 (Completion report, attachment 35).</p> <p>UAC: Isolation of microorganisms from mawè in Benin has been performed and identification was performed at KU-FOOD. Results were published in Food Microbiology 76 (2018): 267-278 (Houngbedji et al. Occurrence of lactic acid bacteria and yeasts at species and strain levels during spontaneous fermentation of different</p>

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			<p>mawè types, a cereal dough produced in West Africa). Results on identified microorganisms and microbial successions during mawè fermentations were presented with a poster at the international conference FoodMicro in June 2016 (Midterm report 2, 2016-2017, attachment 13). Investigations on the technological properties using HPLC to study the aroma profile of mawè was carried out at DTA during summer 2016. During the second stay at KU-FOOD, the PhD student investigated yeast diversity and susceptibility to organic acids during mawè fermentations. A manuscript on these results is in preparation “Intrinsic stress factors of mawè and their influence on viability and physiological responses of yeasts”. The study was presented at three international conferences; ISSY33-2017 (poster presentation, Midterm report 2, 2016-2017, attachment 12), ISSY34-2018 (oral presentation, Completion report, attachment 36) and FoodMicro 2018 (oral presentation, Completion report, attachment 37). Moreover, studies on antifungal activity of isolated LAB against pathogenic yeast <i>C. glabrata</i>, free amino acid release ability and QPS status of LAB and yeasts isolated from mawè were performed and a manuscript is in preparation.</p> <p>FRI: Isolated microorganisms from fura and spontaneous fermentation of fresh milk for wagashie production and their important technological properties were published in the two MPhil theses of Cosmos Amankoana and Akua Arthur, respectively.</p> <p>(see dissemination and publication list, appendix 3c).</p>
Objective # 4	To implement starter cultures at SMEs.	Obstacles for implementing starter cultures identified in the value chain report.	All partners: A discussion was carried out during project leader meeting in Copenhagen 2015 on how to plan a study dealing with the acceptance and knowledge of starter cultures at the SME level. The south partners have included the obtained results as part of the value chain reports, FRI (Midterm report 2, 2016-2017, attachment 5), UDS (Midterm report 2, 2016-2017, attachment 6), DTA

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			(Midterm report 1, 2015-2016, attachment 3) and UAC (First year report, 2014-2015, attachment 5).
Objective # 5	To implement business models at the SME level.	Workshops and training courses with SME's regarding upgrading of business model of selected fermented food products for green growth.	<p>DTI: From 12-27 October 2016, a team of DTI and CSIR-FRI staff conducted training workshops for SMEs and key national stakeholders on the use of new business models to promote and commercialise their products. The workshops raised awareness among the SMEs on the positive aspects of adopting the new starter culture technologies. By bringing the key national stakeholders and SMEs together in the workshops, they were able to exchange information and raise awareness of non-technical problems confronting SMEs, e.g., with access to finance, compliance with hygiene and food safety guidelines, compliance with business registration and tax declaration, etc. The SMEs were also made aware of available government support programmes for SMEs.</p> <p>FRI: Stakeholders platform meeting which included SMEs, has been organized. SMEs have been assisted by Stephen Nketia PhD candidate who is also responsible for commercialization at FRI to develop business plans (Completion report, attachment 15).</p> <p>UDS: A one-day stakeholder meeting and training workshop in value chains and business models for SMEs in yoghurt production was held on 25 October 2017 at Navrongo, Ghana. The training sought to create/introduce new business opportunities for production and commercialization of yoghurt. Stakeholders and participants at the workshop included representatives from Research/Academia, Ministry of Food and Agriculture (Women in Agricultural Development-WIAD), Municipal Assembly Business Advisory Centre, Ghana Food and Drugs Authority, and Small and Medium Scale Enterprises (SMEs) (Completion report, attachment 16).</p>

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			<p>DTA: Workshop for training course has been organized at DTA by Mr Stephen NKETIA (FRI) and Mr Moses MENGU (DTI) in collaboration with DTA researchers in October 2017 on business model canvas development for product and services. A total of 21 actors including 14 SMEs of lait caillé and soubala (Completion report, attachment 17).</p> <p>UAC: Training course of SMEs in business model generation for products and services was held at UAC during 19-20 October 2017. Dr Moses Mengu (DTI) and Mr Stephen Nketia (FRI) were the trainers (Completion report, attachment 18).</p>
Objective # 6	To ensure research capacity strengthening, dissemination and knowledge transfer.	<p>Completion of PhD and masters theses.</p> <p>Publications in peer-reviewed journals, workshops and seminars with stakeholders and SMEs.</p>	<p>All partners: Human capacity was strengthen with the enrolment of 6 PhDs and completion of 11 master students at the West African partner institutions. Furthermore, Wilfrid Padonou was appointed PostDoc at Université d'Abomey-Calavi (UAC), Faculty of Agricultural Sciences, Department of Nutrition and Food Sciences, Benin (included in the midterm report 2015-2016).</p> <p>All partners: Seven scientific papers are already published in international peer reviewed journals. Eight scientific papers are in preparation for publication in international journals and one has been accepted for publication. The GreenGrowth results have been presented at 10 times at international conferences and 19 times at national conferences in partner countries. Project presentations were carried out to public and private stakeholders in partner countries (see dissemination and publication list appendix 3c).</p>
Output # 1.1	Report on food value chain in Ghana, Burkina Faso and Benin.	Reports for each of the value chains and identification of SMEs for starter culture implementation, including consumer groups for interviews and observational studies.	All partners: Value chain analyses are finalised for milk products at UDS, for mawè at UAC, for sour milk at DTA and fura at FRI. The value chain reports for all partners have been completed. Included as (Midterm report 2, 2016-2017, attachment 5) and (Midterm report 2, 2016-2017, attachment 6) for FRI and UDS, respectively and for UAC (First year report, 2014-2015, attachment 5) and for DTA

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			(Midterm report 1, 2015-2016, attachment 3). At DTA elaboration of the initial value chain analyses focusing on the consumption of lait caillé and the perception of consumers on lait caillé quality have been compiled in a report (Completion report, attachment 3). A scientific paper based on the value chain results obtained at UAC has been written in collaboration with KU-FOOD and DTI, which has been accepted for publication in Food Chain. Further, two scientific papers based on the results obtained from the value chain analysis at FRI and DTA is in preparation.
Output # 2.1	Culture storage facilities at FRI, DTA and UAC.	Purchase and installation of the -80°C freezer, including power supply and back-ups, including training of West African staff members in management of culture-collections.	<p>KU-FOOD: Purchase of -80°C freezers and organisation of transport and installation in the three West African partner countries is completed and all freezers are installed and functional in the West African partner countries. Staff members responsible for the GreenGrowth bio-banks in the West African countries have completed a course in culture-collection management at the commercial Belgian culture-collection BCCM in September 2017. A procedure on culture-collection management is finalised in collaboration between DTA and FOOD-KU, which has been implemented at GreenGrowth bio-banks in West Africa (Midterm report 2, 2016-2017, attachment 7).</p> <p>FRI. The freezer is installed in the newly renovated laboratories, which relies on electricity supply by the national grid. As backup power supply the freezer is also served by the diesel generator of FRI and also connected to a solar energy generator. Report on cultures available in the bio-bank has been finalised (Completion report, attachment 19).</p> <p>UDS: Culture storage facility is established in collaboration with FRI. Report on cultures available in the bio-bank has been finalised (Completion report, attachment 20).</p>

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			<p>DTA: The -80°C freezer purchased and installed for the storage of microbial cultures, is fully functional at DTA Microbiology laboratory. To avoid power cuts, electric power back up was installed in 2017 through PATECE project with funded by African Development Bank (BAD). A procedure for culture-collection management, including maintenance of microbial cultures was finalised in collaboration with KU-FOOD (Midterm report 2, 2016-2017, attachment 7). Report on cultures available in the bio-bank has been finalised (Completion report, attachment 21).</p> <p>UAC: The -80°C freezer was purchased and installed. The -80°C freezer is placed in chilled room protected from the high ambient temperature. To avoid any power cuts, a photovoltaic solar panels system is installed as power back-ups. There are three sources of energy supplying the freezer: the national network, academics generators and solar photovoltaics system. Report on cultures available in the bio-bank has been finalised (Completion report, attachment 22).</p> <p>FRI, DTA, UAC: A report on the experiences from the training course at the commercial culture-collection “Belgian Coordinated Collections of Microorganisms” (BCCM) for the handling and preservation of microorganisms was compiled by the attendees (Completion report, attachment 4).</p> <p>FRI, UDS, DTA, UAC: West African partners have signed MoU as part of the back-up storage plan of isolates in the bio-banks (Completion report, attachment 28, 29, 30 and 31).</p>
Output # 2.2	Procedures for documentation and maintenance of microbial cultures.	Procedures written for lactic acid bacteria and yeasts and acknowledged by all partners.	KU-FOOD, FRI, UDS, DTA and UAC: A procedure for culture-collection management is finalised primarily through collaboration between DTA and KU-FOOD, including a visit to DTA by P. Johansen, KU-FOOD in May 2015. A draft of the procedure was presented and discussed among the GreenGrowth partners at the

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			annual consortium meeting in May Accra 2016 and were finalised based on approval by all partners in September 2017 (Midterm report 2, 2016-2017, attachment 7). The standard operating procedure on handling, maintenance and storage of microorganisms in culture-collection has been implemented at all GreenGrowth bio-banks. Furthermore, a procedure for sampling and identification of microbial isolates has been developed in collaboration between KU-FOOD and DTA (Midterm report 2, 2016-2017, attachment 15).
Output # 3.1	Identification of West African microorganisms to promote green growth.	Publication on identified microorganisms including characterisation of important technological properties.	KU-FOOD, FRI, UDS, DTA and UAC: Seven papers have been published on identified microorganisms or technological properties of the microorganisms (see publication and dissemination list appendix 3c). Isolation of microorganisms during processing of the selected food products has been performed by the PhD students on the GreenGrowth project, prior to their first training visit at KU-FOOD. During the first training visit the PhD students from UDS, DTA and UAC identified the isolated microorganisms, supervised by KU-FOOD. One paper is published on the results on identification of microorganisms from mawè (Completion report, attachment 32). Characterisation of the technological properties of the isolated microorganisms from lait caille, mawè, nunu and fura has been performed at the West African partner institutions as well as during the training visit of the PhD students at KU-FOOD. Eight papers are in preparation on the results on identification of microorganisms and their technological properties.
Output # 3.2	Optimisation of technological properties of microorganisms targeted West African foods.	Optimisation of technological properties for selected cultures including establishment of pilot trials.	FRI: Studies on optimisation of fura processing has been carried out, including preparation of dehydrated fura as a convenience product, which could be reconstituted into ready-to-eat fura. Report on the results on optimisation of technological properties for selected cultures, including establishment of pilot trials has been generated (Completion report, attachment 10).

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			<p>UDS: Studies on the contribution of yeasts to aroma characteristics of nunu, and the probiotic potentials of yeasts has commenced. Optimization of technological properties have been carried out in the laboratory with pilot fermentation trials in progress now (Completion report, attachment 11).</p> <p>DTA: Trials fermentations of lait caillé were carried out by the PhD student with eleven selected LAB strains, at laboratory level. The cultures with fast rate of acidification, good rheological properties and the most acceptable taste, determined by the panel of tasters, were selected for pilot plant trials. From these trial fermentations, three LAB strains have been selected and used for trial fermentations at SME level (GARIKO) (Completion report, attachment 12). Master student (Tamboura D.) conducted trial fermentation of soumbala with <i>Bacillus</i> spp. starter cultures (Completion report, attachment 13). In both cases GMP were implemented during the processing in order to optimise the quality of the end products.</p> <p>UAC: Selected strains of lactic acid bacteria and yeasts were investigated for their ability to growth under low pH, ability to ferment mawè (rapid acidification), ability to inhibit the growth of opportunistic pathogen <i>Candida glabrata</i> and ability to improve free amino acid content during mawè production. The relevant QPS microorganisms with promising multifunctional property were selected and developed to a defined multifunctional starter culture (Completion report, attachment 14). Further, from the microorganisms screened, one LAB was tested at pilot plant level with SMEs under improved conditions to optimise the preparation of Akpan, a fermented local beverage and a mixed culture made of two LAB strains and one yeast was used to optimise lafun fermentation (Completion report, attachment 25), both products widely consumed in Benin.</p>

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Output # 3.3	Installation and up-grading of research equipment at the four West African partners.	Report on installed and implemented research equipment including the freezer.	<p>All partners: Plans for upgrading of research equipment were discussed with the four West African partners during the project meeting in Accra May 2016. 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 instead, in order to enable the West African partners to produce and distribute the microbial starter cultures to SMEs (approved by email 6 October 2017).</p> <p>FRI: Report on the installed freezer (Completion report, attachment 19).</p> <p>UDS: Freezer, distillation machine and freeze dryer have been installed at the microbiology laboratory of UDS to support research and production of starter cultures (Completion report, attachment 20).</p> <p>DTA: A freezer has been installed since 2014 and is running. Further one fermenter and one freeze-dryer have installed on May 2018 in the DTA microbiology laboratory as a complementary equipment to enable DTA to produce and distribute starter cultures to SME. Persons responsible of all equipment have been appointed (Completion report, attachment 21).</p> <p>UAC: Equipment for microorganisms preservation and utilization (a -80°C freezer and a freeze-dryer) were purchased and installed at the Laboratory of Food Sciences, University of Abomey-Calavi (UAC) (Completion report, attachment 22).</p>
Output # 4.1	Documentation of starter cultures in pilot plants and SMEs.	Reports on starter culture performances and consumer	At the consortium meeting in Copenhagen 2015 planning of studies dealing with the acceptance and knowledge of starter cultures at the

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		preferences in pilot plant and SME fermentation trials.	<p>SME level were discussed. The south partners have included the obtained results as part of the value chain reports.</p> <p>FRI: The starter cultures developed were transferred to the SME Selassi Foods for production of fura (Completion report, attachment 9).</p> <p>UDS: Starter culture performance and consumer preference in pilot plant and SME fermentation trials is currently underway PhD student Grace and MSc student Ibrahim Idrissu (Completion report, attachment 11).</p> <p>DTA: Selected <i>Bacillus</i> spp. and LAB starter cultures have been implemented at pilot plant at DTA and at SME, respectively, for lait caillé and soumbala for trial fermentations as well as the evaluation of consumer preferences of the fermented end products (Completion report, attachments 12 and 13).</p> <p>UAC: Experimentation with SMEs at pilot plant level of the use of starter cultures made of lactic acid bacteria for the preparation of mawè (Completion report, attachment 14). The use of starter cultures from the UAC culture collection to ferment cassava for lafun production by Alitech Industries, a medium scale food processing company in Benin (Completion report, attachment 25).</p>
Output # 4.2	Procedures for production, packaging and distribution of starter cultures to SMEs.	Carrier materials and procedures for distribution of starter cultures identified.	FRI: Carrier materials for dehydration and storage of <i>Lactobacillus fermentum</i> and <i>Saccharomyces cerevisiae</i> as starter cultures were investigated. Carrier materials investigated were whole maize flour, dehulled maize flour, whole soybean flour and dehulled soybean flour with skim milk and sucrose used as protectants during drying in a cabinet dryer (Completion report, attachment 23).

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			<p>UDS: Investigations on carrier materials is currently underway by MSc student Ibrahim Idrissu. Expected to be completed by end of December, 2018.</p> <p>DTA: Procedures for production, packaging and distribution of starter cultures to SMEs have been described during the implementation of starter cultures in pilot plants and SMEs. <i>Parkia</i> dehulled seeds have been used as carrier materials for <i>Bacillus</i> spp. after fermentation drying and grinding in appropriate conditions and followed by distribution of the powder in plastic bags (5 and 10g) to perform controlled fermentation of soumbala. Pasteurized fresh milk have been used as carried material for LAB cells to perform controlled fermentation of lait caillé. Fermentation trials using liquid starter cultures (LAB) and solid starters cultures (<i>Bacillus</i>) were successfully performed at pilot plant and SMEs (Completion report, attachment 12 and 13).</p> <p>UAC: Skim milk was used as carrier materiel for the production of freeze-dried starter cultures. Experimentation on the use of soluble starch as carrier material is in progress (Completion report, attachment 24).</p>
Output # 4.3	Quality Management Systems for processing of fermented foods.	Quality Management Systems for implementing starter cultures.	Initiated in 2017, but not completed yet.
Output # 5.1	Guidelines and business models for sustainable food production.	Documented guidelines and business models for sustainable food production.	Based on the knowledge obtained during the PhD from FRI's visit to DTI, local partners in the West African Institutions have been trained in business model (autumn 2017). Results from this and local workshops with SME's gave inputs to guidelines and business models for sustainable food production.

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Output # 5.2	Guidelines for green technologies to improve marketability of indigenous foods.	Overview document of available technologies and benefits, as part of the concept plan.	Initiated with DTA visit at DTI in 2016 focused on biodegradable packaging for fermented food products.
Output # 6.1	Key recommendations on sustainable exploitation of West African foods.	Policy brief drafted.	During the final project meeting in Benin November 2018, topics to be included in the police brief was discussed. The policy brief will be finalised during spring 2019.
Output # 6.2	Plan for the dissemination and IPR protection.	Web page and dissemination plans for project results as well as plan for exploitation of results including IPR rights.	<p>Dissemination plans and plans for exploitation of results for all partners was initiated at the onset of the project and have been updated continuously throughout the project period.</p> <p>A project website has been launched: www.greengrowth.dk. In accordance with the policies of Danish Technological Institute, the website is GDPR compliant.</p> <p>Guidelines for the recording of dissemination and communication activities were prepared by DTI and distributed to partners in 2015.</p> <p>During the workshops on business models and commercialisation, guidelines for the use of IPR to protect the project results were given to all partners. Partners have been advised to contact their respective national IPR agencies for further assistance.</p>
Outcome # 1	Increased in-come generation in the West African countries by identifying food value chains with the strongest potential green growth, increasing SME competitiveness.	Value chain analyses mapping the West African food sector from a new interdisciplinary perspective opening up to new regional development.	The West African partners have been trained to conduct value chain analyses by interdisciplinary teams in order to offer this as a service for the West African food industry. The establishment of stakeholder platforms for the selected food products improved the exchanges between the actors themselves and the West African partner institutions for their technical assistance and advices that contributed to improve the competitiveness of the SMEs. The education of skilled staff members will be an important step in the upgrading of the regional food sector.
Outcome # 2	Establishment of microbial culture-collections in the West African countries to preserve and explore	Implementation of biobanks in the three countries for microbial culture-collections.	Bio-banks are established in the three West African partner countries at DTA, FRI and UAC. These bio-banks ensures the availability of cultures for research work for enhancing traditional fermented food

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	List approved objectives/outputs/outcomes	Indicators and means of verification	Progress/results achieved
	inherent microbiota of West African fermented foods.		processes and quality. 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” in September 2017 (Completion report, attachment 4). A procedure on culture-collection management is finalised in collaboration between DTA and FOOD-KU, which has been implemented at the GreenGrowth bio-banks at FRI, DTA and UAC (Midterm report 2, 2016-2017, attachment 7)
Outcome # 3	Defined and novel West African starter cultures scientifically characterised and specifically targeted West African fermented foods, ensuring quality and safety.	Starter cultures of relevant QPS microorganisms with optimal technological properties tested in fermentation trials.	Starter cultures are developed, especially designed for fura, nunu, lait caillé and mawè, with microorganisms originating from the respective products, selected based on their technological properties for ensuring quality and safety of the targeted fermented products. The bio-banks forms an important basis for implementation of starter cultures at the SME level. The implementation of starter culture at the SMEs has been highly appreciated and approved by the SME personnel, because of the improved quality of the obtained products. The facilities given by the installed equipment (fermenter, freeze-dryer) offer the possibility to develop freeze-dried starter cultures. PostDocs, PhDs and master students have been trained as part of the GreenGrowth project in advanced microbiological techniques and molecular methodologies, significantly adding to the knowledge generation within these areas. The knowledge obtained will add to the definition of West African starter cultures with characterised technological properties.
Outcome # 4	Technologies and procedures for sustainable production, storage, distribution and implementation at SME level of novel West African starter cultures designed to upgrade	Procedures for production, packaging and distribution of starter cultures for SMEs described and quality assurance guidelines specified.	Specific procedures for production, packaging and distribution of starter culture are not finalised but simple procedures using available carrier material were generated and used during trials fermentation at the SMEs. The standard procedure will be completed and will include quality assurance guidelines.

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	List approved objectives/outputs/outcomes	Indicators and means of verification	Progress/results achieved
	the West African food sector from spontaneous to controlled fermentation technologies ensuring safer and more nutritious food with prolonged shelf life and increased consumer preferences.		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.
Outcome # 5	New sustainable business models for commercialisation of fermented foods allowing growth in existing SMEs within the food value chain.	<p>Concept plan for sustainable packaging and implementation of green technologies at SME level</p> <p>SMEs trained in new business model generation and in packaging technology and distribution methods for food.</p>	<p>After the visit of DTA researchers to DTI in 2016, it was concluded that the available technologies for producing biodegradable packaging for locally fermented foods, especially, liquid products, were not matured for such practical applications at the moment. However, there are matured technologies for corrugated fibre-based packaging materials for raw food materials, as well as for 2-D open items such as single-use plates, cups, containers, etc. DTI is currently working with several Danish and European partners to develop suitable fibre-based biodegradable packaging solutions.</p> <p>The selected SMEs in each partner country have been 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. They were taught basic marketing techniques and customer relations management. The developed models have been published as part of the value chain reports by the African partners. The workshop gave practical hands on training enabling all partners to develop their business model on a drawn out business model canvas.</p> <p>FRI: Training of four SME/MME in Ghana (Completion report, attachment 15).</p>

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	List approved objectives/outputs/outcomes	Indicators and means of verification	Progress/results achieved
			<p>UDS: Training of six SMEs in Navrongo Ghana (Completion report, attachment 16).</p> <p>DTA: SMEs training courses on business model canvas, packaging and distribution held on 2016 and 2017 (Completion report, attachment 17).</p> <p>UAC: SMEs trained in October 2017 (Completion report, attachment 18).</p>
Outcome # 6	Strengthening the research capacity at the university level, at the company level as well as to enhance the knowledge about fermented food production for any relevant stakeholder through dissemination and knowledge transfer.	Formulation of key recommendations for utilisation, dissemination and exploitation of project results among relevant stakeholders will be included in the final policy brief	<p>Guideline for setting up stakeholder platforms were generated (Midterm report 2, 2016-2017, attachment 4). Stakeholder platform has been established in Ghana by FRI with members from the Ministry of Food and Agriculture, the Ministry of trade and Industries, Ghana National Board for Small Scale Industries, Registrars General Department, Ghana Food and Drug Authority as well as SME and university representatives. Similar platforms have been established in Burkina Faso (Completion report, attachment 26) and Benin.</p> <p>Plan for dissemination was generated and updated continuously throughout the duration of the project.</p>

TERMS USED:

Objectives/ impact: What the project aims at reaching in the long run. Achieving the objectives constitutes impact.

Outputs: What the project produces as a direct result of its activities, e.g. seminars, publications and PhD degrees.

Outcomes: What the project aims at achieving in the short-term and medium-term. Outcomes are the result of the project outputs but as such outside the direct control of the project. This may include change of policies and/or practices of stakeholders/users of the project outputs.