Executive Summary:
GRATITUDE (Gains from Losses of Root and Tuber Crops) seeks to improve the post-harvest management of cassava and yams leading to reduced physical losses, reduced economic losses through value-added processing and valorisation of waste products with the potential for competitive gain that might result from uptake of innovations at scale. To achieve this the project sought to reduce physical post-harvest losses of fresh produce (focussing mainly on yams), reduce economic losses through value added processing (focussing on both cassava and yams) and valorise wastes from the value chain (focussing mainly on cassava). This involves a combination of activities across the consortium of 16 research and private sector organisations spanning Europe, Africa and Asia. It sought to understand value chains for cassava and yams within the context of their role in food security, relating the post-harvest improvements against the initial levels of loss; developing technologies for yams based on increasing their
shelf life and dormancy; develop and validate improved processing and utilisation options for cassava and yam to reduce economic post-harvest losses; add value to wastes from the cassava and yam value chains (peels, liquid waste, spent brewery waste) producing products for human consumption; and support enterprise development to ensure the sustainable uptake of interventions through demonstration activities of technologies and product development. The project also sought to share appropriate technologies amongst the food actors and more widely to encourage similar approaches in different parts of the world and extension to other commodities.

Key findings and innovations arising from GRATITUDE include:
- Methods for evaluating physical and economic losses in Africa and Asia developed. Physical losses were less than expected (12% or less) but economic losses were greater.
- Gender issues were explored in Africa and Asia. There were differences between households in these countries. With commercialisation women tend to be the losers.
- Methods for reducing postharvest losses in yams: Innovations led to method for longer storage, reduced rots and sprouting of fresh yams. If these technologies are taken up by 10% of yam farmers in Nigeria and Ghana the estimated future annual benefit was Euro 20.6 Million annum.
- Improved drying of High Quality Cassava Flour. Four technologies were tested in Africa and Asia. Flash dryer retrofits in Nigeria resulted in a 43% energy reduction leading to a potential saving of Euro2.7 Million /annum with a very high potential for commercial adoption by SMEs. In Ghana, improved bin drying led to a 30% reduction in drying time and could save Euro 0.40 Million /annum. This has a high potential for commercial adoption. Other technologies tested (hybrid solar dryer technology in Nigeria a cabinet dryer in Vietnam) had a lower potential for commercial adoption due to cost and feasibility.
- Cassava for mushroom cultivation: A SME partner in Ghana is adopting the technologies which had improved environmental advantages with a planned output of 650 tonnes / annum in five years.
- Recovery of starch from pulp: Enzyme methods were developed. This could lead to a 6.25% additional starch recovery in Thailand alone with estimated future annual benefits of Euro 173 Million /annum. Two patents have been granted for and a commercial partner is adopting the technology.
- HQCF for gluten free products: Cassava is gluten free and in Thailand products testing by GRATITUDE were acceptable and could access 5% of current gluten free starch market. This would have an estimated future annual benefit of Euro 99 Million /annum with a high potential for commercial adoption.

Taken as whole, the GRATITUDE project estimates the value of impact for the package of innovations tested to be at €300m/annum.

The dissemination of knowledge gained and lessons learned under ‘Gratitude’ has been substantial. Guided by the project’s Communications Strategy, different stakeholder groups have been reached via the website, publications, conference presentations, training materials, press and media releases, video, and dissemination workshops. Awareness of waste reduction and utilisation in root and tuber crops has increased among farmers, processors, researchers, the private sector and policy makers.

Project Context and Objectives:
The project context is important because cassava and yams are important food security crops in much of sub-Saharan Africa and also in Asia because their presence in the cropping system increases the resilience of farmers in the face of climate change, drought, and fluctuations in the price of durable commodities. Tropical root crops are an increasingly important component of agricultural systems in much of the developing world. They are important food security crops for more than 700 million people. They
provide an important part of the diet as they produce more edible energy per hectare per day than any other crop group. In addition, they meet local food preferences, and are important sources of income through direct sale and processing. Post-harvest losses of cassava and yams are significant and come in three forms: (a) physical losses; (b) economic losses through discounting or the need to process into low value products rather than selling fresh or (c) from the bio-wastes such as the peels of the roots.

This project sought to reduce these three types of post-harvest losses in order to enhance the role that these crops play in food and income security for small-holder households. Cassava and yam are amongst the most important root crops, but differ in terms of their sale as fresh produce, the importance of storage and the scale and importance of processing. This project explored these differences to develop a comprehensive approach to reducing post-harvest losses with lessons that could be applied to other perishable commodities, delivering outputs that will benefit millions of producing and consuming households across the developing world.

A key approach to this project was to address both technical and socio-economic aspects of losses and waste management. The development of the entrepreneurial capacities of small and medium-scale enterprises was important to manage and profit from waste management. Managing food losses and waste in less developed countries offers the potential to improve livelihoods, which can contribute to rural development, poverty reduction and food security. In Ghana and Nigeria, women play an important role in the processing, storage and marketing of cassava and yam. There are potential benefits to poor women and women headed households through improved efficiency and profitability of their processing enterprises and through the employment opportunities created. The project took account of gender relations in the household, exploring the impacts of new food products, technologies and training on workloads, time, access and control over resources, and meeting livelihood needs. Assessment of the labour demands and investment levels in relation to new products is important in this context. Over the past few years, the rise and expansion of integrated supply chains, and the renewed emphasis on efficiency and food safety, has spurred a major paradigm shift in the way the post-harvest system, including processing, is conceived from a series of individual components to an integrated value chain linking producers, intermediaries and consumers. By adopting a value chain approach to post-harvest loss reduction and managing wastes, a clearer picture of the various participants and benefits derived along the value chain emerged and this helped the project to suggest sustainable and cost-effective solutions that could be implemented. An important aspect of the project was south-south learning – with joint activities between research partners in sub-Saharan Africa and Asia where the situations are different but may offer opportunities for common learning and accelerated impact. In terms of the comprehensiveness of the approach, technologies and systems were developed, validated, demonstrated and more widely disseminated that focus benefits on small-holder households whilst offering increased income earning opportunities through the development of small to medium scale enterprises and provide an example of a linkage to a large scale user of cassava. These different avenues not only contribute to the comprehensiveness of the approach, but also offer a diverse set of learning opportunities.

Including Asian partners in the consortium added to the comprehensiveness of the project approach in that it enabled the project to take a more holistic and comparative view of post-harvest losses within the context of global food security. Including Thailand and Vietnam allows post-harvest losses to be addressed within the context of the food versus biofuel (bioethanol) debate and in terms of the
substitutability of commodities in the face of global commodity price increases, which in part is influenced by the substitutability of commodities. Cassava in Asia is likely to be better able to produce reliable yields in the face of climate change and be able to substitute for imported or more expensive commodities having therefore national impact on food security. Reducing physical losses, economic losses and losses due to waste is likely to have a major positive impact.

A critical mass of partners with complementary skills from Africa (Ghana and Nigeria), Asia (Thailand and Vietnam) and the EU (UK, Portugal, and the Netherlands) was assembled that includes researchers, the private sector and extension services. This project was built on a previous EC-funded Framework 5 project (CASSAVA-SMES) that resulted in viable cassava-based enterprises producing value added forms of traditional cassava products and high quality cassava flour, and will work in collaboration with an on-going project on the commercialisation of cassava (in the form of high quality cassava flour) funded by the Bill and Melinda Gates Foundation in the Cassava: Adding Value for Africa Project (C:AVA; http://cava.nri.org/). There was also a linkage with work on capacity building of root and tuber crop researchers funded by the ACP Science and Technology Programme (FED/2009/217073). These linkages create the critical mass to have significant impact and wide dissemination.

In the context of losses for these crops, post-harvest physical losses are exceptionally high: in the order of 30% for cassava and 60% for yam. These losses can occur throughout the post-harvest value chain. Losses in economic value of root crops can also be very high. Due to the poor shelf life of fresh cassava (usually less than 2-3 days), the discounting of fresh roots after harvest can be as high as 85% within a couple of days. Wastes can come in various forms e.g. peeling losses can be as high 15-20%. In small-scale processing, these peels from either cassava or yams are largely unused by factories and add to their operating costs through the need for disposal. In several cases, waste from possible processing opportunities has no economic value and this can make the processing itself a marginal or non-viable business proposition.

The project has three main impact pathways:
1. Reduction of physical losses – mainly focussing on losses of yams in storage.
2. Value addition through processing as a means of reducing both post-harvest losses and economic losses though providing alternative opportunities to storage or sale of fresh roots, which could be applied to either yams or cassava. Products could range from high quality yam flour or cassava flour for expanding urban markets and other value added products. Value addition for root and tuber crops requires an improved understanding of management of the crop at household level.
3. Through the improved utilisation of wastes, specifically peels from cassava and yam.

The overall objective of GRATITUDE (Gains from Losses of Root and Tuber Crops) was to improve the post-harvest management of cassava and yams leading to reduced physical losses, reduced economic losses through value-added processing and valorisation of waste products. Related to this, the project has the following general objectives

1. Reduce physical post-harvest losses of fresh produce (focussing mainly on yams).
2. Reduce economic losses through value added processing (focussing on both cassava and yams).
3. Valorise wastes from the value chain (focussing mainly on cassava).

The project had the following specific objectives:
1. To evaluate the value chains for cassava and yams within the context of their role in food security.
2. To benchmark the post-harvest improvements against each other and the initial levels of loss.
3. To develop and validate technologies for reducing losses by up to 50% in fresh produce focusing specifically on yams based on increasing their shelf life and dormancy.
4. To develop and validate improved processing and utilisation options for cassava and yam to reduce economic post-harvest losses.
5. To add value to wastes from the cassava and yam value chains (peels, liquid waste, spent brewery waste) producing products for human consumption.
6. To ensure the quality and safety of products from the value chain.
7. To support enterprise development to ensure the sustainable uptake of interventions through demonstration activities of technologies and product development.
8. To share appropriate technologies amongst the food actors and more widely to encourage similar approaches in different parts of the world and extension to other commodities.

The quantifiable impact of these interventions will be to develop and validate technologies capable of reducing post-harvest losses by the equivalent of 50%. This will be benchmarked as part of one of the work packages. The target has been set at the equivalent of 50% to take into account the adding value activities in some of the work packages.

Beyond these direct results, the lessons learnt and the methodologies for the assessment of reducing losses and increasing the value of what are currently waste products will be shared with other countries from all continents, and also with other groups of countries (Asia, South America) in order to disseminate the results among the research community involved in food research in developing countries.

The project activities were organised in seven work packages (WPs) in order to achieve the objectives. WP8 concerns non-technical management, monitoring and evaluation. The technical work packages are as follows:

WP1 = Value-chain assessment and management. This evaluated value chains for cassava and yams (fresh and processed) from the farm to the consumers in Nigeria, Ghana, Thailand and Vietnam. Specific emphasis was placed on understanding the levels and causes of post-harvest losses and identifying and evaluating alternative options for reducing such losses. It also documented for specific cases the levels of waste generated, examine related value chains for these products and the impact of developing these alternative value chains.

WP2 = Reduced post-harvest losses of fresh produce. Technologies for the reduction of post-harvest losses of fresh yam in particular were developed and validated. This focused on storage losses in yams looking at improved storage systems and controlling dormancy which are major causes of loss.

WP3 = Alternative market development to reduce post-harvest losses. In this WP, alternative novel markets for processed cassava and yam products will be developed and validated that reduce levels of post-harvest loss and provide increased incomes for small-holder farmers. The key issue in this WP will be the development of viable processing options for yam and cassava that provide options for households to sell their produce for reasonable prices and that result in reduced physical or economic losses. There will
be an important balance to strike between products prepared and stored for household use and the generation of income – with the income contributing to food security. Understanding these different processing options and their implications for food security will be an important element of WP1.

WP4 = Adding value to waste products. This WP sought to develop new technologies and products and add value to the waste products from processing (mainly from cassava and to a lesser extent from yam). Work focused on added value products that feed into the human food supply chains, e.g. mushroom production using peels as substrate; use of peels as a raw material for animal feed and using peels as a raw material for added value products, such as sugars and other raw materials such as brewing waste for the food industry.

WP5 = Food safety, quality and compliance. This WP ensured that the new higher value products from waste were safe and that appropriate food safety and quality management systems were in place. This WP worked closely development of viable enterprises to market the value added products identified in Africa and Asia in WPs 3 and 4.

WP6 = Demonstration of technologies with beneficiaries. WP6 supported the demonstration of outputs from the research activities in either rural settings (for example for improved storage technologies in collaboration with extension services) or in collaboration with SMEs. Lessons from these demonstration activities served to support wider dissemination of the technologies developed by the project.

WP7 = Dissemination and support to replication. This WP disseminated the knowledge gained and lessons learned from the validation of the technologies to facilitate replication elsewhere and hence wider scale impact.

Project Results:
The description of the main S&T results will be discussed in order of workpackage.

WP1: VALUE CHAIN ASSESSMENT AND MANAGEMENT
The objective was to ensure that technologies developed by GRATITUDE concerning waste products and ways of reducing losses are commercially viable for key actors in the value chain for yam and cassava products. This was achieved through a combination of value chain analysis, market research, econometric modelling and qualitative research with actors in the value chain.

WP1 undertook five areas of research to address the objective. Firstly, value chain analysis was done on the target markets: mushroom media using cassava waste, High Quality Cassava Flour (HQCF) linked to research conducted with funds from the Bill and Melinda Gates Foundation Cassava: Adding Value for Africa project, animal feed, and snacks from brewery waste. This resulted in the markets for potential uptake by products from the application of technical innovation being quantified and defined as strong or weak opportunities (Task 1.2). Working closely with WP4, additional market research was done on the possible opportunity for High Quality Cassava Flour (HQCF) as a gluten free ingredient.

For cassava, individual value chains had their postharvest losses measured using a combination of value chain analysis and aggregation with available production and postharvest data (Task 1.1). This revealed
locations of large volumes of waste, such as peel, which could be a source of inputs for innovations proposed by other work packages (Task 1.3).

Having located and quantified the losses (Task 1.4) this allowed a theoretical model of loss reduction to be constructed and an assessment to be made of the likely economic impacts of application of loss reduction policies and innovations (Task 1.7).

In applying innovations to the use of waste, it was of concern that intra-household impacts hitherto unknown to research might be triggered. For example, by developing a market for homestead level cassava peels, an important opportunity for a household member might be affected. Qualitative research was conducted in Ghana and Nigeria with illuminating results.

Finally, having estimated the value of loss, knowing the scale of cassava and yam industries and assessing the impact of innovations from the project resulted in developing a notional ‘benchmark’ of the likely gross financial impact of innovation uptake (Task 1.6).

WP1 results in the context of tasks and deliverables

D1.1 Value chains and levels/causes of post-harvest losses for cassava and yam
Key factors affecting the volume of loss and waste in the target countries include: volume of own-consumption and form in which the product is used. In Thailand and Vietnam 94% of cassava roots were industrially processed whereas in Ghana, nearly 50% of roots reach the consumer as a highly perishable fresh product. In Nigeria, 20% of cassava roots were retained on-farm and this substantially reduces losses further up the value chain. Ghana has the highest physical loss in the cassava value chain with 20% of the fresh root sub-chain un-edible and totally lost. In Thailand, losses were higher than expected due to retention of roots and stems on-farm. This is as much as 2.5% of total roots processed. Physical losses in the Vietnamese cassava value chain were concentrated in processing stage. The research showed that aggregate physical losses were highest in Ghana (12% or roots), followed by Nigeria (7%), Vietnam (3%) and Thailand (2%). Ghana cassava physical loss value is US$400 million. This is higher that South West Nigeria (US$30 million), Thailand (US$45 million) and Vietnam (US$20 million) because the loss occurs at the consumer level and therefore has a higher opportunity cost.

The economic value of these losses is disproportionate to the physical losses. We found that, again, Ghana had the highest loss with US$120 million. South West Nigeria’s economic losses were US$20 million, lower than Ghana because of the uptake by the local ‘gari’ and ‘fufu’ industries. Economic losses were lower in Vietnam (US$15 million) and Thailand (US$2 million) reflecting the much higher efficiency of their industrial cassava processing systems and better domestic infrastructure.

Volumes of waste available were important for the success of innovations in other GRATITUDE work packages. We have shown that in South West Nigeria there were 1.1 million tonnes of peels available annually available at cassava processing sites and in Ghana and Nigeria 600,000 and 250,000 tonnes of starch is lost annually through inefficient peeling. Significant volumes of wet peel waste, black starch and starchy water is produced in Thailand and Vietnam.
For yam in Ghana and Nigeria we found that a high proportion of product was retained on farm (60-85%). Losses were estimated to be between 2-5% on farm, but higher in transit (5-15%). Losses from sprouting, transpiration and respiration in storage were measured at 10-20% in Ghana and 5% in Nigeria. Peel waste from yams is within the range of 5-18% of volume in Ghana and 13-18% in Nigeria. A high proportion of the waste was found to be unattainable because it is dispersed at consumption sites.

The method used to collect this information is of considerable interest to researchers of postharvest losses. The work has been presented at the Congress of the European Association of Agricultural Economics and published in international and local peer reviewed journals.

D1.2 Market potential for the range of potential waste product solutions

Four country market studies were conducted with the aim to examine the scale, scope and entry requirements for potential new markets that have been identified for cassava and yam waste. The method used was value chain analysis of target market segments and sub-sectors. This work packaged linked with WP4 to assess the potential market opportunities available to new products being developed: animal feed for goats, mushroom growth media, starch recover and snack foods from brewery waste. For some sectors, such as goat feed, we found that the wide dispersal of raw materials and poor development of the processing sector at scale made success of new products in Nigeria and Ghana rather unlikely.

In market for recovered starch and snacks from brewing waste in Thailand and Vietnam, however, look much more promising. A new market opportunity in South East Asia for gluten free products based on High Quality Cassava Flour was identified and is not being exploited by project partner. In Ghana and Nigeria the potential market for mushrooms looks excellent and this information has fed into business plans developed in WP4.

D1.3 Development and validation of approaches to support household decisions

Concerns about the intra-household impacts of changes to waste utilisation led us to investigate the role of women in using waste in Ghana and Nigeria. South-South interaction on this issue encouraged Vietnam to join using their own resources which allowed interested grow continental comparisons of approaches and results. In terms of allocation of intra-household responsibilities it was found that, in Ghana and Nigeria, men take the final decisions on all aspects of household resource use. This was also found to be the case in Vietnam, though joint decisions were more frequent. Men in all the target countries largely make household decisions about investments on productivity and innovative equipment. This is an important finding that might hold back uptake of innovations that largely benefit women. It was found that women take a particularly strong role in adoption of labour saving innovations.

Cassava and yam peels were ‘owned’ almost exclusively by women in Ghana and Nigeria. The implication of this finding is that commercialisation of peels could cause a switch of this opportunity from women to men, particularly as it was shown that men tend to own innovations and investments.

This work was presented at the GRATITUDE Conference in Porto in November 2014 and has been accepted for publication in the Journal Food Chain.

D1.4 Analysis of the impact of availability on price and competitiveness
Using a case study approach of specific sub-sectors, models were developed to assess the impact of greater cassava and yam availability using reduced postharvest losses were achieved by WP2 and WP3. Date from D1.1 was used combined, where available, with historical production figures. A number of hypotheses were tested. The model showed that using cassava waste would have a positive impact on cassava demand. This supports the contention that measures and policies that promote waste utilisation can drive productivity on-farm.

D1.5 Benchmarking of approaches to reducing post-harvest losses and value addition to waste
The aim of this deliverable is to assess the wider impact of GRATITUDE innovations on reducing postharvest losses and waste in the yam and cassava value chains in the target countries. This is addressed at three levels: the impact of innovations on the economics of the value chain; the likely return on investment; and, the potential for competitive gain that might result from uptake of innovations at scale. The results show that uptake of improved yam postharvest practices were fairly likely and quite impactful. The same can be said of efficiency changes identified for HQCF factories, largely in Nigeria. The most important innovations developed by GRATITUDE were likely to be recovery of starch from pulp using enzymes and uptake of HQCF in gluten-free products.

Innovation/best bets:
- Improved drying of High Quality Cassava Flour. A total of four technologies were tested in Africa and Asia. Flash dryer retrofits in Nigeria resulted in a 43% energy reduction leading to a potential saving of Euro 2.7 Million / annum with a very high potential for commercial adoption. In Ghana, improved bin drying led to a 30% reduction in drying time and could save Euro 0.40 Million / annum. This has a high potential for commercial adoption. Other technologies tested (hybrid solar dryer technology in Nigeria a cabinet dryer in Vietnam) had a lower potential for commercial adoption due to cost and feasibility.
- Cassava for mushroom cultivation: A partner in Ghana is adopting the technologies which had improved environmental advantages with a planned output of 650 tonnes / annum in five years.
- Recovery of starch from pulp: Enzyme methods were developed. This could lead to a 6.25% additional starch recovery in Thailand alone with estimated future annual benefits of Euro 173 Million / annum. A patent has been applied for and a commercial partner is adopting the technology.
- HQCF for gluten free products: Cassava is gluten free and in Thailand products testing by GRATITUDE were acceptable and could access 5% of current gluten free starch market. This would have an estimated future annual benefit of Euro 99 Million / annum with a high potential for commercial adoption
- Cassava for goat feed: Not currently viable

 Taken as whole, the benchmark estimate value of impact for the package of innovations tested by GRATITUDE is estimated at €300m/annum.

WP1 conclusions. We concluded from WP1 that the methods for locating and measuring postharvest losses in the yam and cassava value chains were an important contribution to the field of postharvest loss research. Evidence collected shows that utilisation of cassava waste can drive demand for cassava and therefore have a positive impact on promoting investment on-farm in greater productivity. This finding is important as it demonstrates this effect empirically. Care needs be taken introducing waste and loss reduction innovations as it has been shown that these were important economic opportunities for women. The expected impact of headline GRATITUDE innovations is substantial. This demonstrates the success
of the multi-country, multi-innovation approach to systematically locating and addressing postharvest losses in commodity value chains.

The value chain analysis work has revealed new information about the location and value of losses in the yam and cassava value chain. This was, however, done in a limited range of locations and needs to be validated with additional samples. Results of the gender analysis show that waste in agricultural value chains is often valuable to women. This points to the importance of a gendered approach to future research on postharvest losses and waste utilisation. The research revealed a high level of loss at farm level in more efficient farming systems such as Thailand. This waste represents a new opportunity for recovery. GRATITUDE adopted a dual strategy of reducing losses and utilising waste. Initial results of the ‘benchmarking’ exercise show that this commodity based, holistic approach can have impacts at scale. These results now need to be tested with other commodities. New factors like nutrition and environmental costs could be usefully included in the analysis.

WP2: Reduced Post-Harvest Losses of Fresh PRODUCE

D2.1: Identification of key yam species/varieties and levels of loss on farm within target region

The objective of deliverable 2.1 was to identify key yam species and levels of losses on-farm within Ghana (Ashanti and Brong Ahafo Region) and Nigeria (Lagos, Ogun, Oyo, Ekiti and Ondo). The major activities carried out under this deliverable included the identification of key yam varieties/species utilized, the ideal on-farm storage duration required, and sprout removal strategies presently used by the farmers.

Description of activities for D2.1.
Primary and secondary methods of data collection were employed to gather data on yam varieties in the target areas. Yam wholesalers, retailers, traders, transporters, consumers, input dealers, financiers, extension officers were interviewed. Key informants interviewed included research scientists with specialization in yam and extension officers within the two countries. A semi-structured questionnaire was used as interview guide. Key areas covered included description of the various sectors, key yam varieties of farmers, physical characteristics of the farmer’s yams, storage durability, storage structures and curing methods of yams by practiced farmers.

Results from D2.1
1. Identification of key yam species/varieties and levels of loss on farm within target regions of Ghana and Nigeria

Dioscorea rotundata (white yam) specie is mostly cultivated by farmers and the most preferred variety in both Ghana and Nigeria. In Ghana, eighteen key yam varieties of farmers identified were Pona, Lariboko, Dente/Ponjo, Mutwumudoo/Moonye/Asana/Araba/Mmoniyo, Akaba, Matches/Seidu Ble, Serwah/Afibetua, Maamakumba, Lilee, Loban/Dorban, Asobayere/Auntie Akosua, Serwah/Afibetua, Nooma, Akwa, Kkwaseekohwe, Nanatoc, Enkanfo Chinchinto and Dedee/Enkasei. Dioscorea rotundata (white yam) varieties were the most popular and account for about 80% of the total yam production in both Nigeria and Ghana. Fourteen varieties of Dioscorea rotundata (white yam) were identified the most popular varieties among interviewers were Pona, Dente, Lariboko, Asana, Serwah/Afibetua. The two popular Dioscorea alata (water yam) varieties identified were Matches and Akaba. A variety each of Dioscorea cayenesis (yellow yam) and Dioscorea dumentorum (trifoliate yam) identified was Akwa and Enkanfo, respectively. The results from the Nigerian surveys revealed that while the variety ikokoro were the most preferred for dried chips and
flour production, the efuru variety is mostly preferred for pounded yam.

2. Levels of loss in storage structures in Ghana and Nigeria

Yam storage structures were assessed in the selected regions in Ghana and Nigeria. In Ghana, four major structures were identified among yam farmers. These structures were the pit, under shady trees, local barn and improved barn. The most popular among farmers is the local barn although its storage duration is 6 months compared to 12 months of the improved yam barn. Losses in the structures of stored yams above 3 months storage period ranges between 15-32%. Moreover, on-market storages of yam were done under grass straw of metal mesh. Farmers often used the pit system for short duration of yam storage.

Moreover, the pit structure was found to have one month duration of on-farm storage and a loss percentage of 15% at the end of the storage period (1 month; 15%) while this was found to be (12 months; 15%) for the improved barn. This result was also consistent with what was reported from Nigeria. It was also discovered that in Nigeria, most yam farmers in the south west do not store yam on-farm due to theft, cattle invasion by nomads and cost of constructing modern storage facilities such as the improved yam barns. Finally, on-farm storage losses range between 12.5-21% for the identified yam varieties Nigeria and 20-34.5% for those identified in Ghana.

D2.2: Definition of post-harvest characteristics of key yam species/varieties

The objective of D2.2 was to define post-harvest characteristics of key yam species/varieties. The wound healing efficiency, dormancy period, optimum conditions for curing and subsequent storage of tubers for key yam species/varieties were also determined under this deliverable.

Description of activities for D2.2.

The methodology employed in the study of D2.2 involved the use of controlled conditions (on-station at the NRI). In the first trial done to establish an optimum environment for curing yam tubers, sea-freighted yam tubers were purchased from Ghana and London Market and stored at a temperature of 18°C. To start the analysis, the yam tubers were artificially wounded with six shallow strips cut from the surface. The tubers were then placed in a plastic bag and then in incubators at 25°C, 33°C, 35°C and 40°C. The wounded tubers were stained with phloroglucinol to assess the wound healing process by following lignin synthesis.

The second trial was done to compare wound-healing characteristics of 9 yam varieties, with two varieties from Nigeria and seven from Ghana. The air-freighted yam tubers were stored at 25°C & 30°C for one day. Two artificial wounds were created on each tuber and allowed to heal for 10 days. The wounded tubers were assessed on the 3rd, 7th and 10th days for these parameters - lignification score (0-10 scale), weight loss (%) and disease incidence (% Rotting).

In Ghana, experimental analysis was carried out to assess post-harvest characteristics on the yam varieties identified under D2.1 and to also evaluate the efficacy of identified storage structures.

Results from D2.2.

The NRI studies revealed that yam tubers were able to heal their wounds if placed under appropriate conditions (30 - 35°C, high humidity [85+RH]) which were relatively easy to achieve on-farm. This reduces weight loss and rotting during subsequent storage. Potash was the best bet plant extract for the suppression of bud formation and sprout control. Buds and sprouts of mutwumudoo variety was the most...
controlled by potash. Yam variety Mutwumudoo, which is a Dioscorea rotundata is the best bet yam variety to cure under jute sack for 7, 14 and 21 days of curing. Additionally, the best bet yam variety for curing under the remaining three treatments was Lariboko. In the improved storage structure, the highest number of bud formation occurred in akaba, mutwumudoo and dente and sprouted faster than pona, laribokor and serwah.

Results from the Ghana study revealed that the weights and lengths of the yam varieties were variable and elongated with thick or rough, smooth or hairy skins. Some key varieties had heads protruding out while others have heads curved inwards. Key yam varieties’ on-farm storage durations, tuber loss sprout control and physical characteristics have been documented. The storage assessment also revealed that while the pit storage system is the most common among Ghanaian farmers, the improved yam barn is the most efficient across all parameters assessed.

D2.3: Optimal on-farm strategies for curing, sprout control and storage identified
The main objective of D2.3 is to define optimal on-farm strategies for curing of yam tubers, yam tubers sprout control and storage of yam tubers.

Description of activities under D2.3.
Yam Sprout Control Studies
In Ghana, a 600ppm solution of potash was adopted for on-farm studies by dissolving 600mg in a litre (1000ml) of distilled water. A total of 420 freshly harvested tubers of yams were sampled for the experiment. Yam tubers (60) per each of the seven cultivars namely, pona, lariboko, dente, mutwumudoo, serwah, akaba and matches were used for the studies.

In Nigeria, three varieties (efuru, ikokoro and ewura) were treated with extracts from 3 locally available plant materials used by farmers on the field namely; neem leaves, neem seeds and sweet potato leaves. Each tuber was dipped separately inside the extract up to 5cm apical portions for 2mins and stored in an improved yam barn in replicates of 3 at random locations. Three tubers of each variety not dipped inside the solution served as control. The treated yam tubers and the control were monitored daily for over a period of six months.

Yam Curing Studies
In Ghana, seven artificially wounded yam tubers placed at six different positions and covered with jute sacks for 10 days were studied for wound healing using phloroglucinol staining test on seven cultivars namely, pona, lariboko, dente, mutwumudoo, serwah, akaba and matches. The rest of the samples were assessed for rot over a period of 6 successive months.

In Nigeria, 2 yam varieties (efuru and ewura) free from bruises, cuts, rot, pest and insect infestation were selected for the study immediately after harvest. A 4cm x 5cm cut was made on each tuber, labelled and weighed. They were then arranged in groups of three. Another group of unwounded tubers were used as control. The tubers were then subjected to the following treatments (curing) and stored inside a model storage house for 14 days after which all the tubers were removed from the curing materials and placed under normal uncovered storage conditions within the yam barn. Each tuber was weighed after 14 days, 28 days and 42 days.
Yam Storage (Dormancy) Studies
In Ghana, the improved storage structure was analysed with the traditional yam storage structure adopted for replication. Seven key varieties namely, pona, lariboko, dente, mutwumudoo, serwah, akaba and matches were sampled for the storage experiment and monitored for the necessary parameters monthly over a period of 6 months.

In Nigeria, sixty tubers of each yam variety (ewura, ikokoro and efuru) free from bruise, rot, pest and insect infestation were arranged randomly within the barn made up of bamboo and raffia to simulate what the local farmers used. This same set-up was repeated inside an improved yam barn. A data logger was fixed in a central location within the barn to record the ambient temperature and relative humidity. The tubers were observed daily for over 6-month storage period.

Results from this D2.3
Yam Sprout Control Studies
In Ghana, it was found that the use of potash successfully suppressed the formation of buds and sprout formation on the freshly harvested yam tubers within 30 days of storage. Potash inhibited the formation of buds and sprouts on fresh yams in both storage structures, an indication that yam buds in fresh tubers were formed beyond 30 days.

However, in Nigeria, neem leave extract appeared as the most effective in the sprout control study. Neem leave extract delayed the process of bud formation most while sweet potato extract had the least effect.

Yam Curing Studies
In Ghana, the pona and lariboko were found to be more susceptible to pests and diseases than akaba and matches in both the improved and traditional barn. Stored yams in the improved barn performed generally better than the traditional barn. Dente variety was the mean least affected by pest and disease of 1.8 and highest wholesomeness of 27.20 after curing. The mean highest buds occurred for matches at 18.40.

The Nigerian experiment revealed that ewura tubers were able to heal their wounds and were also more shelf stable compared to efuru. The tubers with wounds had sign of rot compared to unwounded tubers but were more prominent in Efuru variety with about 50% of the tubers showing signs of rot while less than 10% of ewura was observed to have signs of rotting.

Yam Storage (Dormancy) Studies
In Ghana, the freshly harvested yams stored over the period clearly showed that the improved yam barn has an advantage over the traditional yam barn. Storage percentages of freshly harvested yams in the improved storage structure were higher than the traditional storage structure. Mean wholesome tubers after 150 days storage in the improved yam storage were 16.86 compared with 14.0 in traditional storage structure. Mean insects and pest disease were 3.14 in the improved storage structure compared to 6.0 in the traditional storage structure.

However, results from Nigeria indicate that temperature within the modern yam barn ranged from 24.6 – 27.9 °C while that of the traditional yam barn ranged from 25.6 – 28.3 °C. Relative humidity was relatively
higher (80.4 – 91.1%) inside the modern yam barn compared with 74.6 – 90.6% recorded inside the traditional yam barn. After 6 months storage period, all the yam varieties recorded over 50% loss in weight with ikokoro having the highest (62.8%) while ewura recorded the least weight loss of 55.5%. In this study, tubers stored inside traditional yam barn recorded longer dormancy period compared with tubers stored inside modern yam barn whose majority breaks dormancy with the second month of storage. This trend could be attributed to higher temperature and relative humidity recorded inside the modern yam barn.

Conclusion D2.3
Work package (WP2) has established that Dioscorea rotundata (white yam) specie is the most cultivated and preferred variety in both Ghana and Nigeria. In both cured and uncured yam tubers stored, improved structure was found to be better than the traditional structure. Chemical treatment using natural products to suppress formation of buds and sprout was achieved using potash in Ghana and extracts of neem leaves in Nigeria. Finally, healing of wounds in yam is enhanced through the process of curing. In yam storage therefore, a combination of jute sack curing, potash and neem leaves extract treatments and storage of yam tubers in improved storage structure were recommended.

WP3: ALTERNATIVE MARKET DEVELOPMENT TO REDUCE POST-HARVEST LOSSES
The objective was the development of new products from the fresh produces so that physical and economic losses in the value chain were reduced and value added

The WP has three main specific objectives as following
• Development of new products from the fresh produce so that physical and economic losses in the value chain were reduced and value added
• To improve the systems for drying of cassava, increasing the potential to produce higher quality products, with lower levels of loss and more efficient use of fuel.
• To develop new novel market outlets for high quality cassava flour as a versatile raw material for diverse markets.

Description of work performed and results
Development of methods for making high quality yam flour (D3.1)
A survey was conducted in various suburbs of Ghana and Nigeria to determine consumer preference for local yam varieties to select local yam varieties for processing High Quality Yam Flour (HQYF). Nine varieties of yam (five in Ghana and four in Nigeria) were selected to investigate technological parameters of processing yam into HQYF. Technology for High quality yam flour (HQYF) as an alternative novel market for processed yam products in order to reduce levels of post-harvest losses and provide increased incomes for small-holder farmers was developed. HQYF was characterized for its functional properties and the result showed that yam species, pre-treatment and drying methods significantly affected the functional properties of HQYF on the anti-nutritional and vitamin contents of HQYF. The potential use of the flour therefore depends on the storage conditions and packaging materials prior to use. The significant variation observed among HQYF samples could contribute significantly to selection and improvement of the yam varieties for specific food applications to stimulate their production and industrial utilization.

Development and validation of improved drying systems for high quality cassava (HQCF) products
The evaluation of varieties drying system for HQCF was performed in Vietnam, Ghana and Nigeria. In
Vietnam, due to the fact that HQCF is currently not in production therefore the survey was based on the dryer used for cassava starch production at difference scales from household to LE. It was found that at small scale, the use of chamber drying using either gas or electricity is increasing thanks for its simple operation and efficiency in energy consumption. The economic evaluation was not carried out due to the product has not been in production and traded in the market.

In Nigeria, hybrid solar, sun dryer, designed hybrid solar dryer (combination of solar and indirect heating of the drying chamber) and redesigned flash dryer were evaluated. Based on the evaluation, a hybrid solar dryer (combination of solar and indirect heating of the drying chamber) and a redesigned flash dryer were fabricated and evaluated. With hybrid solar dryer, drying temperature ranged from 33 to 54°C. Drying cassava mash took 15 hours from 43% db to 10% db. With the redesigned flash dryer average, the energy consumption of the flash dryer decreased from 6.7 MJ/kg flour (existing dryer) to 2.9MJ/kg (improved dryer); product quality improved: moisture 10% at feed rate 560 kg/h of the cassava mash, much lower the then the conventional dryer.

In Ghana, assessment studies of bin dryers were carried out, resulting to the modifications (lagging) of the bin dryer. Insulation of the furnace and bottom of the bin ensured heat losses and fuel efficiency kept at minimum. Drying time in the modified bin dryer was reduced to 7 hours, removing up to 81% moisture from the chip.

Development and validation of new high value uses of processed cassava based on market demand HQCF was produced according to the current process used in Africa as well as to an adapted process with some modifications including removal of cortex and/or periderm mechanically and chemically. To successfully develop and validate high value uses of high quality cassava flour (HQCF) based on market demand, the functional properties of HQCF were evaluated as a function of production process. In addition, inconsistent paste qualities of HQCF were found as influenced by indigenous α-amylase left in finished flour products. A modification on drying procedure was then introduced to inactivate the activity of indigenous α-amylase in cassava flour. Important functional properties of HQCF produced by modified processes (six samples for different treatment of mechanical and chemical removal of cortex and/or periderm and size reduction and ten samples for different drying procedures) were then evaluated. Produced HQCF samples were then evaluated for their potential uses in bread as partial wheat flour substitute, in extruded snacks as a composite with tigernut flour, in gluten-free bakery products as a complete wheat flour substitute and in banku products as a composite with fermented grain flours from millet, sorghum and corn.

Six HQCF processes were tried and their functional properties were characterized. Six types of HQCF produced have been used to replace wheat flour partially in bread production at different ratios for Vietnamese baguette and sandwich bread. The effects of different HQCF processing on HQCF properties and the characteristics of bread prepared from the composite of HQCF and wheat flour was also investigated. The quality assessment and the sensory analysis showed that Vietnamese baguette was accepted as good at 10% HQCF and sandwich bread at 23% HQCF. The consumer acceptability of these bread samples were conducted with 145 people in Hanoi, Vietnam showed that bread made with HQCF was globally acceptable to the consumers and the addition of HQCF into bread did not decrease significantly the acceptability of bread.
In extruded snack, yellow flesh cassava flour and tigernut flour (TNF) composite blends at different ratios (0-100%) were employed to produce high fibre snacks by a single screw extruder (using the feed moisture of 27%, screw speed of 60 rpm and the barrel temperature of 80°C). Descriptive sensory analysis results showed that increasing tigernut flour resulted in increased colour and sweetness of the extrudates while the hardness decreased with increasing tigernut flour ratios. Results obtained show the possibility of using this composite flour in food formulation and also could be used to produce extrudates with good quality attributes.

HQCF was also applied to develop gluten-free bakery products, i.e. cake for people who have coeliac disease. In this work, gluten-free cake products including chiffon cake, banana cake and brownie were successfully made from cassava flour with no inclusion of wheat flour and their sensory evaluation, i.e. consumer preference test of these products was then conducted using a 9 point hedonic scale for appearance, colour, aroma, texture, flavour/taste and overall liking. All products were acceptable by consumers with the overall liking score ranging from 6.1-7.2. This product can be commercialized in a form of premix.

The sensory qualities of banku made from the combination of HQCF and fermented millet/sorghum/corn was also found to be very acceptable by trained panellists. The banku made from the mixture of HQCF and fermented white sorghum flours was however much preferred for preparation of banku by the trained panellists than those of fermented millet and fermented red sorghum.

Assessment of the storage condition and packaging characteristics of high quality yam flour HQYF was produced according to the technology developed within the WP then stored at different condition and in different material packages. The quality of the flour was evaluated after the storage time. High quality yam flour was produced from yam slices soaked in 0.28 % (w/v) K2SO3 which were then dried at 60°C for 48 hours in a cabinet drier. The dried chips were milled into flour using a laboratory hammer mill. The flour was packaged in plastic containers, high density polyethylene (HDPE) and low density polyethylene (LDPE) and stored in incubators at 4 relative humidity (36%, 56%, 75% and 96%) over three temperatures (25±2, 35±2 and 45±2°C) for 24 weeks to study the effect of storage conditions and packaging materials on the flour. The functional properties, proximate and microbiological analyses of the samples were conducted at interval of 4 weeks during storage. Also, the sorption characteristics of the flour were also determined in the above temperature range and water activity range, 0.11-0.96. It was found that the effect of storage conditions and packaging materials on the storage stability of high quality yam flour was significant: Storage temperature and relative humidity significantly affected the quality attributes of the flour; Minimal loss of quality during storage was recorded at temperature of 25°C and 36% relative humidity; The packaging material with the best barrier properties and hence less losses in quality of water yam flour during storage was plastic containers; Moisture adsorption characteristics of the yam flour were best described by Peleg model irrespective of temperature and water activity; And the sorption process of yam flour was enthalpy driven which signifies minimal change in the flour microstructure during moisture sorption.

Assessment of potential to use feed HQCF into brewing industry
The innovative use of HQCF into brewing industry to produce 100% cassava fermented beverage had
been performed and assessed. The new product had been successfully developed at SAB miller pilot scale and introduced to the stake holders. The product will be further evaluated and adapted to the market of choice.

Conclusions for WP3
Within the WP, number of new markets had been developed to reduce the economic post-harvest losses, namely:
- There were two new processing for the products of yam (HQYF) and cassava (HQCF) developed for alternative market development
- HQYF and HQCF had been characterized, its functional properties assessed and adjusted the process for favourable material for product based on two new material development
- New products from HQCF had been developed: HQCF substitute bread, gluten free cakes, HQCF snack and HQCF fermented beverage. The product technology developed, product sensorial and physicochemical properties characterized, hedonic tested for consumer acceptability had been conducted. The products were seemingly potential and subjected to the validation and market research within the next WP.

WP4: ADDING VALUE TO WASTE PRODUCTS
D4.1 Development of methods for growing mushrooms from waste of cassava & yam
The main objectives were:
- Test which fungi that produce edible mushrooms do grow vegetatively well on waste generated by processing cassava (peels and stems).
- Which mushroom species can be best grown on waste and how should substrate be prepared?

Work carried out:
FRI in Accra (Ghana), FIIRO in Lagos (Nigeria) and PRI in Wageningen (Netherlands) have tested mycelium growth of 3 different mushroom species: lung oyster (Pleurotus pulmonarius), grey oyster (P. ostreatus), king oyster (P. eryngii) and shiitake (Lentinula edodes). The oyster mushroom species (Pleurotus spp.) grow all well on cassava peels and stems and the shiitake showed less good growth. For further testing the best species were used: P. pulmonarius and P. ostreatus. Mainly cassava waste (peels and stems) generated from processed cassava in Ghana and Nigeria were used to generate substrate for the oyster mushroom production. Traditional substrates (saw dust) were mixed in various ratio’s with cassava waste (composted or not composted) and tested for the production of mushrooms under Ghanaian and Nigerian conditions. PRI used dried cassava peels and stems shipped from Ghana and used these ingredients to generate mushrooms.

Results:
Mycelium growth of P. ostreatus and P. pulmonarius were good on waste of cassava (peels and stems). The growth of king oyster and shiitake mycelium was less. Test for mushroom production were therefore restricted to P. ostreatus and P. pulmonarius species. Under Ghanaian and Nigerian conditions, substrate prepared from pure cassava waste produced less than the traditional saw dust based substrates. Mixtures (50 : 50) of composted saw dust and cassava waste (peels and stems) produced mushrooms comparable to traditional substrates.
PRI (Wageningen) used cassava peels and stems to prepare substrates. After a short fermentation period (6 days) substrates were inoculated without sterilisation. Good production was seen comparable to traditional saw dust based or wheat straw based substrates. No infection was seen. Training session has been organised by FRI and FIIRO to disseminate the technology.

Conclusions for D4.1.
Cassava waste (peels and stems) can be a good ingredient for oyster mushroom substrate. Experiments showed that substrate based on pure cassava waste can be used. The advantages were a quick colonisation (more cycles thus increasing annual productivity) and no sterilisation needed (less energy thus reducing costs). The technology will be taken up by a Ghanaian company that produced now large amounts of cassava waste.

D4.2 Development and validation of methods for turning peels into animal feed.
The main objectives were:
• How can cassava waste be used as an ingredient in animal (goat) feed?
• Does cassava waste has a market potential as an ingredient for animal feed?

Work carried out:
At FUNAAB (Nigeria) cassava peels and cassava leaves were used as ingredient for goat feed in different ratio’s and supplemented with cowpea haulms and bone meal. Chemical analyses were done on all mixtures, nutrient intake was assessed for each diet and performance of goats was measured by measuring weight increase during the feeding period nitrogen utilisation and measuring the rumen environmental parameters. Market potentials of cassava waste as an animal feed ingredient was assessed by interviewing a variety of goat farmers.

Results:
• The chemical composition of diets containing cassava peels and leaves showed that they were rich in crude protein which is a major determinant of ruminant performance.
• The nutrient intake and weight changes of WAD goats fed the experimental diets revealed that cassava peels and leaves can be used as ruminants feed for optimal performance.
• The experiment showed improved digestibility and nitrogen retention of diets containing cassava peels and leaves.
• The experimental diets did not have deleterious effects on the haematological and serum biochemical parameters of WAD goats fed the experimental diets.
• Cassava leaves and cowpea haulms can serve as sustainable protein supplements to cassava peel based diets for WAD goats.

Conclusions for D4.2.
Cassava peels and leaves have potential as an ingredient for African dwarf goats. The best formulation is to sell it as a cassava fortified food and try to find a substitution for the expensive cowpea haulms. The willingness of farmers to pay for this type of feed correlates positively with the farm size (more intensive systems) and education of the farmer. An increase of education and awareness is needed.

D4.3 Development of methods for extracting starch and other nutrients from cassava peels
The main objectives were:
• What methods can be used to extract starch from especially pulp, a residue after industrial starch extraction from cassava?
• For what purposes (or what products) can be the extracted material be used?

At NSTDA (Thailand) cassava pulp was treated with in subsequent steps: cell wall lytic enzymes to reduce viscosity and improve release of starch, amylases for liquefaction and glucoamylase for saccharification. The filtrate was further processed to test suitability for syrup production. Residues were tested for production of microcrystalline cellulose.

Results:
A pre-treatment of cassava pulp with cell wall lytic enzymes increases starch hydrolysis and reduces starch residue to zero. Syrup produced from this material has similar quality as syrup produced from starch after refinery (the summary of the patents is attached).

Destarched pulp can be delignified and bleached to produce high quality microcrystalline cellulose. A recovery of 50% starch from pulp is possible. It can be done using most of the equipment used now in the industrial starch extraction from cassava roots. The economic feasibility depends on the costs of cell wall lytic enzymes.

Conclusions:
Pulp can be a good source to produce syrup when treated with cell wall lytic enzymes. The residue can be used to produce microcrystalline cellulose that can be used as a food ingredient. Interviews with companies that produce cell wall lytic enzymes indicate that scaling up the process will reduce the price of enzymes and makes it economical feasible. A pilot production facility will be built to extract starch from pulp.

D4.4 & D4.6 Development of methods for producing food ingredients from waste from brewing cassava beer.
Objectives:
• What is chemical composition and pasting characteristic of brewer spent cassava flour (BSCF)?
• How can BSCF be used as an ingredient to produce (extruded) snacks?

Work carried out:
At FUNAAB (Nigeria) proximate composition (moisture, protein, ash, carbohydrates, and fat), functional properties (bulk density, dispersibility, wettability, water and fat absorbing capacity) and pasting properties (temperature, viscosity etc.) were determined in different blends with wheat flour.

At SBTF (Vietnam) cassava spent brewers mash was used with different ingredients (wheat flour, cassava starch, corn starch, rice flour, refined sugar and baking powder). Here, also physicochemical properties were determined of fried and extruded snacks.

Results:
FUNAAB (Nigeria): BSCF addition increases the protein content of the blends probably due to the enzymes present in the spent brewers waste. Due to the higher density, higher water absorption density
and lower dispersibility in water of BSCF, the amount of BSCF that can be used in blends with wheat flour is restricted. Optimal mixtures were 70 : 30) (wheat flour : BSCF).

SBTF (Vietnam): Up to 5% addition of BSCF has no effect on quality of snacks. The best flavour that can be added to a snack generated with spend cassava beer mash was investigated in Vietnam. A consumer interview indicated that a shrimp-chilli flavour would be the best way to market such snacks.

Conclusions for D4.4 and D4.6: As a 30% substitution for wheat flour, BSCF can be an important ingredient to generate snacks. In addition, BSCF is high in nutritive substances and has thus positive effects on the nutritional quality of snacks. Up to 5% of BSCF can be added to usual ingredients without any detectable changes in quality of extruded snacks.

D4.5 Development of methods for scaling up mushroom production as a commercial enterprise

Objectives: What were the prerequisites to scale up mushroom production using cassava waste?

Work carried out & results:
Methods were used to transfer the knowledge generated to end users and intermediates:
• Training of researchers of both research institutes involved (FRI & FIIRO)
• Dissemination of the findings in Nigeria & Ghana by giving trainings to mushroom growers
• A final workshop for mushroom growers organised by partners within the project and an external expert.

In addition to workshops for growers, it has been a good investment to increase the general expertise on all aspects on mushroom cultivation of the researchers involved in the project since that has generated permanent support for the mushroom industry in Ghana and Nigeria.

Conclusion for D4.5: The possibilities of using cassava waste as (ingredient of) mushroom substrate has been well demonstrated. In addition to the potentials for the mushroom industry to grow in Africa, a business plan was generated. This plan evaluated the viability of mushroom production by one of the partners in the Gratitude project. This partner has now showed a commitment to invest in this activity on a short term.

WP5: FOOD SAFETY, QUALITY AND COMPLIANCE

Work package overall objective was to develop appropriate food safety and quality management systems for processing at household and SME level. Achievements were reported in each of the 3 deliverable as follow.

D5.1: Food safety baseline assessment

Objectives
• Food safety baseline assessment for selected households and SMEs from Vietnam, Thailand, Nigeria and Ghana involved in the processing of cassava and yam and in the production of derived products from them.
• Assessment of products by prerequisites and risk analysis tools.

Methodology
In the evaluation of the baseline assessment, the main areas considered were the following:

- Production of foodstuffs from cassava and yam
- Use of cassava and yam processing waste for mushroom farming
- Use of cassava and yam processing waste as animal feed
- Identification of potential products from spent cassava obtained from beer production.

The baseline assessment was organised in three key steps:

- Partners involved in WP5 have prepared a document compiling the basic fundamental information necessary to evaluate the level of safety implemented in all processes involving cassava and yam. They prepared a table which had to be filled for each company assessed and where the level of safety conditions at different levels of the process were rated. These documents were compiled considering European legislations in the field of food safety (i.e. HACCP).
- Partners of the project visited some selected households and SMEs in their countries to evaluate the safety procedures implemented. The evaluation was performed considering the guidelines provided by ESB and whenever possible filling the table previously prepared.
- Some ESB-UCP members visited some households and SMEs in Nigeria, Vietnam and Thailand (where larger enterprises were also included), to contact and realize the safety standards implemented and to propose possible improvements in the processing.
- The baseline assessment tried to consider whenever possible for each country the production and processing system for a selection of several households and SME’s for each products from WP2, WP3 and WP4 for cassava and yam (only in African countries). In the case of WP4 some products resulting from upgrading of cassava and yam by-products under development were only identified for further monitoring but were not explored from the safety point of view, since the entire processing and final product are not yet completely closed.

Results for D5.1.
The baseline assessment showed a quite complex and varied picture. Several differences could be observed between the different countries and, within the same country, between household and SMEs producers. Despite all these differences/variations, some highlights common to all situations could be drawn.

- Overall, there is a much higher level of awareness for food safety in SMEs producers than in households, although some safety practices were already identified at this level.
- In countries like Thailand, some of these producers have international quality and/or safety certifications; it is therefore expected a high level of food safety that could be used as example for other smaller companies.
- For production at household level, often there is no real implementation of food safety legislations / precautions; this is true for all countries surveyed. Indeed, in the majority of cases, personnel were not trained in food safety. Moreover, the production area is closed to the living area due to limited land and minimal investment capital; consequently the layout of the production line may not conform to appropriate prerequisite program for food safety.
- In all 4 surveyed countries, the cultivation of these tubers and the production of various food items represent an important contribution to the economy; this is true both at national level (i.e. contribute to GDP, etc.) and at a local level (important resource for local people, work opportunities, etc.). It is therefore important to improve the quality and the safety of the produced good.
A key step in this direction would be to give proper training in food safety to the people involved in the processing, especially the ones in households. Parallel to this, a “guide” to safe food production could be compiled; this would mean to decide a specific set of rules that should be followed in each production process.

This baseline also demonstrated the different levels of manufacturing among countries, mainly for Cassava between Asia and Africa, which can be a positive impulsion assuming the possible flow of knowledge between Asia into Africa (namely mushroom farming, animal feeding and cassava starch) and between Africa into Asia namely concerning the production of HQCF.

D5.2: Food safety management systems

Objectives
- Development of food safety management systems appropriated to the household level
- Development of food safety management systems appropriated to the SME level
- Develop food safety management systems appropriated to large scale enterprises

Methodology
Food safety management systems have been developed according to international and available local legislation. For each product have been identified the compositional requirements according to legislative guidelines and standards, the process flow chart, the food safety pre-requisites, the good practices and the hazard analysis and critical control points. The HACCP requirements have taken into account the principles contained in the Codex Alimentarius. They provide sufficient flexibility to be applicable in all situations, including in small businesses. In particular, it is necessary to recognise that in household and some SME it is not possible to identify critical control points and, in those cases, good hygienic practices can replace the monitoring of critical control points. Similarly, the requirement to establish “critical limits” does not imply the necessity to fix a numerical limit in each case. In addition, the requirement of retaining documents needs to be flexible in order to avoid undue burdens for very small businesses.

Results for D5.2
Food safety management systems have been developed for companies selected in the baseline assessment, depending on the foodstuff or commodities involved, and on the commercial and production dimension (household, SME, LE). Therefore, those systems have been developed for the following products:
- High Quality Cassava Flour (HQCF)
- High Quality Yam Flour (HQYF)
- Yam and Cassava fufu flour
- Cassava wet starch
- Bread produced with HQCF as derived cassava and yam foodstuffs, and
- Animal feed
- Dry starch
- Oyster mushrooms as added value commodities derived from cassava and yam processing waste.

For each country, the following stakeholders companies were identified:
- Ghana: SODIA (household – mushrooms, yam derived foodstuffs, animal feed), St. Baasa and Caltech Venture (SME – HQCF)
D5.3: Follow-up surveillance of the quality management systems (safety, quality and economic factors)

Objectives

- Develop methodologies to monitor safety and quality of products at the critical control points and at the prerequisites defined in D5.2 on the basis of information reported in D5.1.
- Follow-up surveillance of the quality management systems (safety, quality and economic factors)

Methodology

Training section on food safety and quality for food operators at the stakeholders companies have been organised in each partner country. Methodology used to perform those training sections and follow-up surveillance has been as follows:

Ghana: Using a survey questionnaire and on-spot observation methodologies, a quality survey was conducted on the products identified in a baseline study under objective 5.2. The follow-up surveillance of the quality management systems (safety, quality and economic factors) included discussions of operational procedures and quality checks. In addition production systems were monitored to measure improvements.

Four (4) Small and Medium Scale Enterprises (SMEs) made up of St. Bassa Ghana Ltd., Caltech Ventures Ltd., J.O. Co. Ltd. and Cassacoxa Ltd. and three Households: Christian Mothers Association, Northern Women Processors Association and Agyenka Agro Processing Ltd., and all processing cassava and one support service organization were involved in the initial baseline studies. As at the time of the follow-up surveillance of the quality management systems J.O. Co. Ltd. and Cassacoxa Ltd. and one Agyenka Agro Processing Ltd., had folded-up their operations. The quality survey therefore focused on St. Bassa Ghana Ltd., and Caltech Ventures Ltd., as the SME’s and the Households were Northern Women Association and Christian Mothers Association. On the issue of accreditation, only St. Bassa had Food and Drug Authority certification for their palm cream.

Nigeria: The survey was carried out involving trained processors (households) of the different cassava and yam-derived products on GHP and GMP. Designed questionnaires were used for the survey involving three SMEs and different households’ processors.

For “gbodo”, the household processors were scattered at different identified processing centres with different processors within the centres. The names of the processing centres surveyed were: Apata Oluwole, Apata Alaran, Apata Abayawo, Apata Aliu, Apata Sabiku, Apata Baba Ilua, Apata Yinusa Baale, Apata Oroki, Apata Jadesola and Apata Ogundoyin. For HQCF, the processors were SMEs and their...
names were: Thai Farm in Ogun State, Jonak Oshwa in Oyo State and Oamsal Nig. Ltd in Ekiti State.

Vietnam: The survey was carried out using visual mode of lecturing combined with interactive method between trainer and trainee. Teaching materials developed under D5.2 based on simplified procedure of GHP, GMP and HACCP principles that were applicable for cassava processing at household level were used. A number of 28 household processors participate in the survey. Products surveyed wet starch, dry starches of different qualities, candies and noodles from starch, or maltose dextrin, glucose. Place for training was the Duong Lieu People Committee’s Conference Hall. Training section had the duration of 10 days, from 5/12 to 25/12/2014.

Thailand: No survey was carried out since the company participating in the Gratitude project already had HACCP accreditation. In some extent their experience also contributed for HAACP definition in starch production.

Results for D5.3.
Results showed an increase in quality and safety for all the companies surveyed after training and implementation of some GHP and GMP. The training has updated common knowledge on food safety and quality for cassava processing including prerequisite programmes. Score increase in the parameters scrutinised was not the same across countries and improvement was different according to each parameter taken into account.

Ghana: Overall, results for survey showed a score increase for all the parameters scrutinised. Higher advance can be observed in training, HACCP implementation, dress code, cleaning systems and personnel facilities. Each of the companies surveyed showed some difficult in the production chain. Fresh cassava for processing is expensive and difficult to come by due to farmers refusing to sell at a reduced price to meet processors packets. Electricity cost is exorbitant as well as diesel cost. Disposal of cassava peels is a major challenge and peels were piling up at the processing centre. Constant supply of water for processing is a challenge affecting production quality. Pressing of cassava is done manually due to lack of hydraulic pressers that could facilitate quick drainage water from the cassava. Lack of a vehicle increases the cost of production. No assess to land to cultivate cassava. Pressing of cassava is done manually due to lack of hydraulic pressers.

Nigeria: Overall, results for survey show a score increase for all the parameters scrutinised. Higher advances could be observed in equipment maintenance, prerequisites, personnel facilities, training and quality of water. No implementation of HACCP was noticed, while improvements were done in GHP and GMP. There were big challenges to the quality of cassava and yam products in Nigeria. There is no water channelling in the production area and therefore stream water is used without control of quality and safety. Also, there is no electricity and no storage facilities. High cost of transportation must be faced as well. An important concern also is aging of existing processors due to urban migration.

Vietnam: Results for survey showed a score increase for many of the parameters considered. Higher advances could be observed in water quality, training, equipment maintenance, dress code, suppliers and pest control; nonetheless, average score after training and follow-up surveillance is near 3 based on a score scale 1-5. No increase in fabric, storage, HACCP implementation and prerequisites was noticed. At
household level, procedures in village were similar in all families with simple and partly mechanical equipment. There is no control of raw material in term of food safety because the procurement is based on the starch content of the cassava root. Water using for washing is from well with possibility of heavy metal contaminant or microorganism, however this can be treated in next steps of processing. Wet starch collection is done manually, using very simple tools: rake, trowel, brick and cloth.

Personnel were not trained in food safety. Production area is closed to the living area due to limited land, and minimal investment capital. The layout of the production line therefore doesn’t conform to appropriate prerequisite program for food safety. At household level, there is no implementation of HACCP. The application of food safety system is partially, but not documented. There is no significant problem concerning to food safety in the starch processing factory. Prerequisite programs have been successfully built for household level.

OVERALL CONCLUSION for WP5
The follow-up surveillance on the quality management system showed improvements in all the surveyed companies, either household or SME. The biggest amelioration has been accomplished in Nigeria where, however, no HACCP systems have been implemented. On the contrary, the system has been established in some companies in Ghana. For each country, advances in personnel training and water quality were the most important achievement. In Vietnam there was no implementation of HACCP too, however prerequisite programmes have been successfully built for household level and 25 household processors agreed to follow-up activities of GRATITUDE project on food safety programs. To guarantee the implementation of food safety systems companies need a long-term follow-up in term of communication and encouragement.

WP6: DEMONSTRATION OF TECHNOLOGIES WITH BENEFICIARIES

D6.1 Platform for South-South interaction and engagement
Objectives
The deliverable objective is to develop platform for South-South interactions and engagement by project partners as well as to select best-bet products from cassava and yam waste. A web-based platform for south-south interaction and engagement between the project partners and other potential parties will be developed. This platform will be led by UNAAB. To promote this dialogue and interaction, the project will set up a Moodle. Moodle (Modular Object-Oriented Dynamic Learning Environment) is a free source e-learning software platform. An advantage for this project is that Moodle is free to use and hence can be cost-effective as a business model and will be sustainable beyond the duration of this project. The Moodle will be set up in association with the planned GRATITUDE web site.

Methodology
Although Moodle was initially proposed as the platform for south-south interactions, when the project team revisited the approach it was considered that establishing a Facebook group had many advantages being:
a) Many people were familiar with Facebook
b) Facebook enables discussion between members
c) The wide membership of Facebook enables the group to encourage wider membership beyond the project base.
A web-based platform for S-S interaction and engagement between the project partners and other potential parties was developed by UoG-NRI (http://www.fp7-gratitude.eu/) in the GRATITUDE project Website (http://www.fp7-gratitude.eu/s-s-interaction). To foster quick responses, an S-S GRATITUDE platform was also created using Facebook (http://www.facebook.com/groups/unaabaas/permalink/505458612843660/#!/groups/524883700865294/) by FUNAAB in collaboration with UoG-NRI. To promote free release of information and further interactions concerning intellectual property rights, all partners signed the Consortium Agreement with NRI by September 2012. The team commenced interactions through a S-S platform through project website, Facebook and blog interaction, on root crop based technology development, product innovations, storage practices, waste to wealth information using yam and cassava as case studies.

Results for D6.1.
As of August 2013, 137 members from the Africa, Asia and EU have joined the group. A use of the group was to gather responses from the Facebook group and followers of the International Society of Tropical Root Crops (ISTRC) to invite them to share their value-addition practices to wastes from cassava and yam.

A South-South (S-S) platform was created through the project website, as well as a EU FP7 GRATITUDE project Facebook group and a blog for countries in the ‘south’ to interact and engage with each other on issues covered by the Gratitude project, in particular adding value to waste materials of cassava and yam. The GRATITUDE Facebook group (linked to the ISTRC Facebook group) contributed to the valuable activity of sharing information and experiences in value addition to waste from cassava and yam. This interaction will help enhance the role that cassava and yam play in food and income security. Linkages to professional body (ISTRC) and frequent posting of issues enticed participants and created dynamism throughout the project period.

D6.2 Report on the selection of products and enterprises chosen for the study
Objectives
The deliverable objective for this paper is to select the best bet products from the activities within WP 3 and 4 that can be implemented by SMEs. In addition, the paper discusses the some of the research work and attempts to identify the next steps required before the private sector can invest in the concepts.

Methodology
Following project agreed criteria that best product must include at least one product from each category and at least two higher value products derived from WP 4; product must be safe, acceptable to the consumers and economically viable, WP project teams ensured private sector inclusiveness in the selection of the best bet product. At the end of various workshops held in Ghana, Nigeria, Vietnam and Thailand coupled with laboratory and market value chain results; the GRATITUDE came up with a selection of products.

Results for D6.2.
Following various workshops held in Ghana, Nigeria, Vietnam and Thailand coupled with laboratory and market value chain results, the GRATITUDE team was able to identify a range of “best bet” products that
have the potential to become commercial opportunities for Small and Medium Size Businesses (SMEs). Some of these best bets need more research or further development, others were a bit closer to commercial reality and the next step will be to prepare business plans with private sector partners with the aim of creating market opportunities for the new products. A total of seven best products or processes were identified:

1. High Quality Cassava Flour (HQCF)
2. Industrial Grade Cassava Flour (IGCF)
3. High Quality Yam Flour (HQYF),
4. Cassava and yam peels as substrate for mushroom cultivation,
5. Cassava peels for animal feed,
6. Bakery and confectionary products from Spent Cassava Brewing Waste (SCBW), and
7. Recovery of starch from cassava pulp, a by-product of the cassava starch industry.

The WP recommended the following:

• HQCF: Develop products that glorify HQCF’s lack of gluten. Currently few commercial opportunities.
• Nigeria and Ghana: Considerable lessons already learnt which need to be transferred to other countries. BMGF C: AVA is promoting investment in the value chain.
• Thailand: Identifying products & markets that want gluten-free flour. Possible investment identified.
• Vietnam: Identifying products & markets that want gluten-free flour. Possible investment identified.
• IGCF: Research only taking place in Ghana and in Ghana Need to expand and confirm market opportunities.
• HQYF: Possible opportunity to use waste yams – but needs further research. In Nigeria and Ghana: Need to develop cheaper HQYF by using a cheaper source of yams to improve market opportunities.
• Mushroom substrate: Market & spawn problems slowing down investment. Further research into profitability needed. In Nigeria and Ghana Confirm it is more profitable to use cassava waste as a substrate rather than sawdust. Interest from commercial partners in Ghana - but constrained by limited market opportunities.
• Animal feed. In Nigeria and Ghana Need to focus efforts on goat feedlots – its use needs to be promoted through extension services.
• SCBW: Develop products that glorify SCBW rather than use it for low level substitution. In Vietnam Commercial opportunities limited by lack of SCBW.
• Recovery of starch: Excellent progress in Thailand, initial trials demonstrate viability and potential commercial investor identified. If can be proven commercially in Thailand, technology can be transferred to other countries.

High Quality Cassava Flour (HQCF) uptake is the gluten market in Thailand. There is interest in manufacturing beer from cassava in some countries; this generates Spent Cassava Brewing Waste (SCBW), which could be used in snack food manufacture. Cassava beer has recently been introduced in Ghana, which might generate commercial quantities of SCBW for further research and pilot-scale evaluation. Recovery of starch from cassava pulp shows the potential for the greatest economic impact. The very significant cassava industries in Thailand and Vietnam, and the smaller ones in Nigeria and Ghana all produce the by-product, cassava pulp, which contains 55% starch (by dry weight), which is not currently extracted. However, research undertaken by one of the Thai partners in Gratitude has demonstrated that about half of the starch in the pulp can be recovered if it is mixed with certain enzymes.
The researchers have undertaken some economic analysis that shows that the cost of recovery will be less than the value of the recovered starch. One of the major starch factories in Vietnam is interested in developing a business plan and then investing in the implementation of this new technology.

D6.3 Demonstration of high value products from high quality cassava flour and cassava wastes

The specific objectives of the report were to demonstrate and validate the technology developed in project locations by small producer and SMEs. Lessons learn from these demonstration activities will serve to validate, adjust then support to wider dissemination of the technologies developed.

Methodology

Bread from High Quality Cassava Flour (HQCF) and snack food with cassava beer spent were chosen for pilot scale production and demonstrations in Vietnam. Two HQCF processes were tried at the pilot scale in 2013 and 2014 in household producer, Ha Tay district, Hanoi, Vietnam. The results and products including HQCF, bread products and snack foods were presented and demonstrated at a number of events organized in Vietnam, Indonesia, Laos, Portugal and New Zealand. The demonstrations of gluten-free bakery products made from HQCF were conducted in different occasions having different target groups in Thailand.

Demonstration of small ruminants feed from cassava waste (peels) under work package 4 were carried out in three states of southwest, Nigeria to cassava processors, feed millers, feed sellers, goat farmers and cassava farmers, etc.

Demonstration of the findings under work package 2 & 3 in Nigeria was carried out in 10 locations in 4 States with Southwest Nigeria with 294 participants (male and female) to farmers, processors, entrepreneurs, etc. Strategies for yam curing and storage to prevent post harvest loss of yam tubers during storage and production of snacks from high quality cassava flour.

Yam Stakeholders’ Training Workshops on how to effectively cure wounded yams, delay sprouting of stored yams and store yams in improved yam barn, which has been developed under the GRATITUDE Project by the CSIR-Food Research Institute was organized in conjunction with Social Development and Improvement Agency (SODIA), Ghana. Key participants were farmers, AEAs’, yam wholesalers, retailers, transporters and other stakeholders. Also hands-on training workshops were held for mushroom growers especially on the use of cassava peels to grow mushrooms.

Results for D6.3

Transfer of African HQCF process and products to Vietnam was established. The process was adapted and capacity to produce HQCF by the Vietnamese partners at pilot levels was also successful. Demonstrations of HQCF for Bread were successful in Vietnam. Optimal conditions Cassava bear spent supplemented snack production was established to be temperature 121.3oC main screw speed 30Hz, BSC powder:4% and Water content: 1.88%. Spent based snack then was produced at pilot scale in 2014 at Trang An bakery, Hanoi and successfully demonstrated in various locations in Vietnam. The Production of cassava beer spent snacks was well received by stakeholders in South West Nigeria. A private meeting to demonstrate gluten-free products made from HQCF was conducted with one of the largest Thai food processing companies. Participants in Thailand suggest that cassava flour-based gluten-free products are
acceptable by most consumers. Demonstration strategies for yam curing and storage to prevent post harvest loses of yam tubers during storage were successful in Nigeria and Ghana. Also, mushroom production was well demonstration by FIIRO team, Nigeria and FRI, Ghana while commercial small ruminants feed (being a new product) was demonstrated through agricultural based institutions (using them as a change agent) in three states of southwest, Nigeria. In general, South-South Interaction with mentoring from the Northern partners aided major success storied achieved in WP 6. The cooperation received from our primary beneficiaries in sparing time, resources and temperament for the demonstration exercises were part of the success factors.

WP7: Dissemination and Support to Replication
This is discussed under the ‘Description of the potential impact and the main dissemination activities and the exploitation of results’

Potential Impact:
The main issue in bringing out these impacts was in terms of scaling up and scaling out of the research activities. Partnerships were key to bringing about impacts from this research and the project’s dissemination activities were really important for making the outcomes visible. This project strongly focussed on SMEs as deliverers of impact. In this respect, a value chain approach that involved the majority of GRATITUDE partners enabled a holistic understanding of the focus commodities, where losses can be reduced and was the first time such a comparative study between Africa and Asia had been undertaken. While physical losses were less than previously reported (12% instead of 30% for cassava), economic losses were larger (ca EURO 0.5 billion per annum in Ghana). This is having an impact on research partners outside of GRATITUDE such as the Bill and Melinda Gates Foundation Cassava: Adding Value for Africa Phase II and the CGIAR Root, Tubers and Bananas Program. The SME Nobex in Nigeria was particularly active regarding adopting drying technologies for cassava flour in collaboration with FUNAAB and UoG-NRI and in collaboration with the Bill and Melinda Gates Foundation Cassava: Adding Value for Africa project, flash dryer retrofits in Nigeria resulted in a 43% energy reduction leading to a potential saving of Euro2.7 Million /annum with a very high potential for commercial adoption. In Ghana, St Baasa in collaboration with CSIR-FRI, AA and PRI-Wageningen promoted and adopted cassava waste for mushroom cultivation; technologies which had improved environmental advantages with a planned output of 650 tonnes / annum in five years.

There is also recognition that larger scale enterprises can play a major role in creating demand for tropical root and tuber crops. NorthEastern Starch in collaboration with NSTDA, UoG-NRI and AA explored the recovery of starch from pulp which is now currently being patented in Thailand. Enzyme methods were developed and could lead to a 6.25% additional starch recovery in Thailand alone with estimated future annual benefits of Euro 173 Million /annum. Additionally, commercial partners are exploring with the GRATITUDE partnership, the use of HQCF for gluten free products. Cassava is gluten free and in Thailand products testing by GRATITUDE were acceptable and could access 5% of current gluten free starch market. This would have an estimated future annual benefit of Euro 99 Million /annum with a high potential for commercial adoption. SABMiller collaborated on a proof of concept with SBFT in Vietnam and FUNAAB in Nigeria but have yet to go into commercial beer production using cassava in these countries for operational and logistical reasons. However, the snack products produced from cassava spent brewers waste had high acceptance in Vietnam and hence potential.
Not all impact can however be achieved with commercial SMEs and for that reason two of our demonstration partners work more directly with farmers. One is the extension arm of the UNAAB and the other is an NGO in Ghana (SODIA).

GRATITUDE also had impacts at the European and international levels. This was the first time the EU and international research and implementation partners with complementary skills were able come together to address post-harvest loss issues in the food chain in a comprehensive way that would not have been possible without access to such funding. Such funding facilitated south-south learning between Asia and Africa which was an essential component of the project.

Dissemination and education
Dissemination and education are important aspects of the project to ensure increased awareness of the issues and also to facilitate wider uptake of the project findings leading to a tangible contribution to achieving the Millennium Development Goals. The project team have placed great emphasis on the socio-economic dimension to our research. The main dissemination activities were undertaken by WP7 (Dissemination and support to replication). In this workpackage it was found that the dissemination of knowledge gained and lessons learned under ‘Gratitude’ has been substantial. Guided by the project’s Communications Strategy, different stakeholder groups have been reached via the website, publications, conference presentations, training materials, press and media releases, video, and dissemination workshops. Awareness of waste reduction and utilisation in root and tuber crops has increased among farmers, processors, researchers, the private sector and policy makers.

The overall objective of WP7 was to disseminate knowledge gained and lessons learned from the validation of the technologies, to enable replication elsewhere and hence wider scale impact. The specific objectives were:

1. To develop a strategic approach to information dissemination which will inform major stakeholders about the project objectives, approaches, partnerships and outcomes.
2. To package and share information on options and techniques for reducing post-harvest losses of yam, for monitoring losses in the fresh product value chain, and for adding value through processing higher value products and new products from waste.
3. To consolidate experience and develop training packages on the reduction of post-harvest losses of yam; on adding value through processing and on new products which utilise cassava processing wastes, such as mushrooms, animal feeds, snack foods, starch and sugars.
4. To support training in business skill development, marketing of new products, food safety and quality assurance.
5. To promote lesson learning and information exchange among all partners and with a wider group of international stakeholders involved in food research, product marketing and policy making in developing countries and Europe.

To address the above objectives, WP7’s approach for demonstration and education was to fast track initial project communications through development of the project website and to develop a communication, dissemination and training strategy to guide subsequent communication activities. An important part of the communications strategy was the identification and prioritisation of target audiences
Results of dissemination activities.

Task 7.1 - Development of a communication, dissemination and training strategy

The objective of the communications strategy was “to facilitate effective internal communication of the project partners to reach external audiences and engage with public and media”. The specific objectives were to increase awareness of how to reduce and utilise waste from root and tuber crops among farmers, processors and policy makers, on a country regional and global scale; to improve and maintain communication between project consortium members, and the flow and sharing of information; to produce and circulate dissemination material and plan dissemination events. The influence of the communications strategy was monitored by collecting feedback on website features and monitoring website hits, the distribution of publications and feedback etc. This task had three deliverables, the first reporting on the initial development of the Communication, dissemination and training strategy and the second and third providing an update and final consolidation.

An important initial task in the development of the communications strategy was the identification of target audiences and their information needs. A stakeholder mapping exercise was conducted through a ‘communications survey’ asking partners for information on their intended communication products and audiences for the different work packages. This information was used to compile a project stakeholder map and to inform the content of the communications strategy. Thought was given to what messages, products and channels would be most appropriate for different stakeholders. A Communications Strategy document containing guidelines and tools for partners was produced with guidance on promoting the project identity, (including appropriate recognition of the EU) and project branding. A number of tips were given to encourage good communications between partners and for production of materials. Completion of this deliverable constituted milestone 2, ‘Communication, dissemination and training strategy defined’.

Policy makers were identified as an important audience and partners made efforts to include the relevant actors in their countries in stakeholder briefing meetings at the start of the project, and in presenting results.

The communication strategy was updated mid-term (D7.4). A dissemination list was sent to all partners for them to fill in their past and future activities, specifying type of activity, description, timing, location, audience, means of distribution, countries reached and feedback if any. This was consolidated to assist planning. A group discussion held at the mid-term review planning meeting made suggestions for the improvement of the website which were incorporated in a revised structure and layout. Communication linkages with partner countries were strengthened through interaction among staff with responsibility for communications in the different partner institutions.

A consolidated final report on the progress and outputs of the communications strategy was produced (D7.6). It provided the final overall picture of Gratitude dissemination activities undertaken, the communication materials and resources produced and accessed via the web site, the lessons learned and future steps.
Gratitude project partners made at least 17 presentations at conferences and meetings, both international and national. 15 posters presentations were prepared. The presentations and posters given at conferences were a major way of informing the scientific community and agricultural development and education professionals of the findings of the project. The poster presentations at workshops were more practically oriented for potential users of the technologies. Training workshops and demonstrations were mechanisms for reaching farmers, village enterprises, local extension workers, NGOs and small and medium enterprises and private sector companies. Training materials produced by the project include those written in English and available on the project website and those produced in local languages for specific in-country training.

The project has documented and consolidated many of the Gratitude activities and country visits in video and photographs and interviews with members of the Gratitude team, which are accessible on the Gratitude website (www.fp7-gratitude.eu). The thirteen photo galleries on the web site capture some of the significant events in the project as well as technical aspects of the research. Other products were web site articles, Gratitude newsletters (general and Ghana and Nigeria specific), radio and TV broadcasts, and use of social media. The dissemination output from Gratitude has been substantial, including published papers, but importantly it has embraced a range of channels and modes of communication and has targeted different stakeholder groups.

Task 7.2 – Design and preparation of training materials and guidelines
Deliverable D7.5 (Training materials and guidelines designed and produced) reported on the training materials and guidelines designed and produced for different stakeholders on the major areas of the project’s research. The technical content of the training materials and guidelines was developed by the relevant work package participants, while WP7 added value in the production and promotion of the materials. The production of written training materials was particularly important for WP2 and WP5, although all work packages have undertaken training. The main task was the editing and formatting of the nine food safety training guides produced by ESB Portugal, under WP5. These targeted particular stakeholder and country audiences and covered the main products on which Gratitude conducted research. Each guide also covered hazards analysis and critical control points (HACCP) for SME with the aim of ensuring food safety and guaranteeing consumers’ health, as well as minimizing weight and quality losses. Two manuals were produced in 2014 by WP2 in Ghana on the post harvest work with yams, in addition to a technical leaflet/manual. Other local materials were produced in Vietnam, Thailand, Ghana, Nigeria, and at Wageningen.

Task 7.3 – Raise awareness of the project and its achievements through outreach using a range of media
Achievements relating to this task include the development and population of the project website and the publicity output for public awareness. The website was designed to promote sharing and learning based on project achievements and results. It has made information accessible on the different research areas and specific country activities and events, and provided opportunities for interactive web-based discussions.

Design of the website was one of the first activities under WP7 (D7.1 Website, video, interactive media on
project achievements and results) and the first milestone of the project. It was due to be completed in month 5, but the website was online in month 3 (http://www.fp7-gratitude.eu). It was planned with several groups in mind; all potential Gratitude participants, the funders, the public and the wider research and development community. Efforts were made to ensure the website was easily navigable and the content clear for the reader to understand. Country pages were added as a result of suggestions from partners in 2013 and additional information was placed on the home page to improve site navigation. From the start of the project until May 2015, there were 3,791 visitors to the web site (5,819 sessions and 18,649 page views). 65.15% were new visitors. Other than the home page, the top five visited sections of the web site were ‘partners’, ‘research areas’, ’ about the project’, ‘Reports/publications’ and ‘media coverage’. Linkages to the website were created from partners own institutions’ sites.

All country partners publicised the project at the outset in 2012, briefing the press and national news agencies and creating news items on their organisations’ web pages or posting information about the project on research web sites and this contributed to D 7.2 (Initial project publicity information produced – press releases, briefs and handouts). The press release on new Gratitude project Feb 2012 prepared by WP7 was adapted and translated for use by country teams. Further press releases on the development of the project were produced at midterm review and for the dissemination activities at the end of the project. The project leader was interviewed for an article on youris.com and the Gratitude web site in July 2013.

In addition to general project information, by 2013 a number of press briefings were produced on technical developments and the opportunities for creating value from waste products, for example, on ‘best bet products’, mushroom production using cassava waste and post harvest losses.

The strength of the international partnerships in the Gratitude project were communicated through news items on the Gratitude web site and FUNAAB Nigeria web site, on the south- south exchanges between Africa and Asia. Other news briefings covered participation of partners in national and international meetings

Items for public outreach were produced, including the Gratitude brochure, poster, newsletters, news articles, case studies etc. and for more specialised professional audiences – technical publications, workshop reports etc. Publicity was an on-going task within work package 7, with a regular flow of news items reflecting partner activities.

Task 7.4 – Host a dissemination workshop with major stakeholders
The aim of the dissemination workshop at the end of the project was to enhance cross country learning among project partners and provide an important vehicle for sharing the project outputs more widely among major national and international stakeholders.

D7.7 Dissemination workshop
Initially the end of project workshop was planned to be held in Ghana, but because of restrictions on international workshops related to the Ebola outbreak in West Africa, the workshop was held in Porto, Portugal in November 2014. However, a three month project extension allowed a second dissemination workshop in Accra to take place in March 2015. Both workshops included sessions focused on presentation and discussion of the research results and a practically oriented, demonstration/exhibition
session, showing samples of new products and explaining new technologies and issues through poster presentations.

The workshop in Portugal was held at the Catholic University and was attended by project partners from UK, Thailand, Vietnam, Ghana, Nigeria, Netherlands and private sector invitees from Portugal. The first afternoon of the workshop was allocated to a ‘Demonstration market place’. There were a number of short presentations designed for a general and industry audience on key achievements from the project, covering post harvest loss reduction, mushroom technology and technology for producing snacks from spent cassava from the brewing industry. Further presentations were made on high quality yam flour and high quality cassava flour, recovering starch from cassava pulp, food safety and the business case for different products. Then participants visiting different ‘stalls’ set up round the room, covering the different technologies and products produced. The second and third day presentations were based on the work packages.

In the final sessions, the project coordinator referred back to questions he had posed at the beginning of the meeting and these were discussed. Regarding losses, the learning point was that the picture on losses is nuanced and complex. Different target groups have different experiences and perceptions. The project compared losses at different parts of the value chain – from farmer to consumer - across the four participating countries. It contributed towards understanding of the contexts in which losses are high, drawing a distinction between physical and economic losses. More effort is needed to reach a deeper understanding of the losses, who incurs them and what the implications are. The scale of losses is important – if there are large amounts of waste then its transformation through processing becomes a more viable proposition. For small producers or processors, there would be a need for a mechanism of coordination and collection of waste for joint processing. This introduces further complexities of group organisation and management. Small household producers may not feel the loss of small quantities, but it is nevertheless a loss of value.

Gender
The issue of women and children working in cassava peeling is nuanced. Project efforts to reduce drudgery should not disempower women. Cassava processing offers women flexible wage labour opportunities which are compatible with child care. Processing also provides opportunities for older children to earn money for their school expenses. Project partners found the comparison of gender relations among the four countries a very valuable experience. The business case is likely to be strong for cassava beer, HQCF, starch recovery from pulp and mushrooms growing on cassava substrate. One of the premises for making a business success out of these technologies is that there should be an entity ready to take it up. Producing safe products depends on the quality of the raw material. Traceability is important and checking for contamination and identifying the sources. Reflecting on whether objectives had been achieved, it was concluded that some solution had been found, but further time for implementation is needed. The project was a good example of a focus on problems of partners in south which were addressed by mobilising cooperation and expertise from research communities in the north and south, encouraging north- south and south- south cooperation. The south- south component has been strong and shows ownership. Partnerships and private sector partners have been important in helping to realise project results.
The workshop in Accra, hosted by the Council for Scientific and Industrial Research (CSIR), Food Research Institute, was attended by Gratitude project partners from Ghana, Nigeria and UK, growers and exporters associations, NGOs, farmer groups, extension officers, scientists, cassava enterprise owners /entrepreneurs from Ghana and Nigeria and investors. The workshop highlighted the achievements and show-cased some of the technologies developed under Gratitude. Presentations were made by project partners, followed by discussions and an exhibition of different products, posters and brochures. There were also demonstrations of the procedures for yam curing and control of sprouting and for composting cassava waste for growing mushrooms and other mushroom production technologies. The third day of the Workshop was a training and mentoring day dedicated to technologies for mushroom production.

The dissemination events successfully promoted cross country learning and communicated the potential benefits of the new technologies to a wider group of agricultural actors and small and medium enterprises which could ultimately transform the livelihoods of smallholder farmers and retailers of cassava and yams.

Conclusion and success factors
Dissemination of knowledge gained and lessons learned under ‘Gratitude’ has been substantial. Awareness of waste reduction and utilisation in root and tuber crops has increased among farmers, processors, researchers, the private sector and policy makers. Factors assisting the success of the communications component were identified. Firstly, communications and dissemination were integrated as a work package and an essential part of the project design. Every meeting and project discussion included a reflection on dissemination and communication. The communications strategy sensitised partners to different stakeholder groups and types of communication channels. Different stakeholder groups have been reached via the website, publications, conference presentations, training materials, press and media releases, video, and dissemination workshops. In combination with the South –South component of WP6, the communications work under WP7 helped to enhance communications and cross learning among project partners from different parts of the world coming together for the first time and developing a team spirit; “It was tough at the beginning, but we developed friendship and partnership”.

List of Websites:
The public website of the GRATITUDE project is www.fp7-gratitude.eu

The relevant contact details regarding the website is Ms Gillian Summer/ Communications Specialist, Natural Resources Institute, University of Greenwich, Email: G.E.Summers@greenwich.ac.uk; tel +44 1634 883949