

Use of Biosciences for Value Addition and Diversification to Enhance Commercialization of Sorghum and Millet Products

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November 2011

International Livestock Research Institute (ILRI)






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Citation: Mugula, J., Byaruhanga Y., Abegaz K., 2011. Use of Biosciences for Value Addition and Diversification to Enhance Commercialization of Sorghum and Millet Products. Nairobi, Kenya, ILRI.

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Consortium Project Document-06/2011

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Duration: **Three Years**

Amount: **US \$ 697,773**

2. Executive Summary

Poverty is the major development challenge in East Africa. Over 80% of the population depends on subsistence agriculture for livelihood. Product value addition may contribute towards alleviation of poverty, malnutrition and economic stagnation. Sorghum and millet are among of the major cereals grown in Tanzania, Ethiopia and Uganda. Being drought resistant they are best suited for exploitation to mitigate the adverse impacts of food insecurity, poverty and climate change. Their processing to add value has not been fully exploited to realize optimal economic potential.

Traditional processing of sorghum and millet to produce various products is one of the sources of household income. Commercialization of traditional products has been limited due to poor quality, safety and short shelf-life. This may be improved by up-scaling and using appropriate bio-enrichment technologies. Optimised malting and extrusion technologies will lead to diversification of products such as quality malt, clear-malt drink and malted extruded snacks. Previous investigations have produced prototypes based on sorghums and millets that have potential to increase demand for these crops, create new opportunities for enterprise development and improve livelihoods of key players. This project strives to improve utilization of sorghum and millet (finger millet in this project) through product value addition, diversification, commercialization, and industrialization.

The use of quality malt, clear malt beverage and malted extruded snacks will be promoted to increase sorghum and millet utilization and income generation. Marketing research, business technology incubation centres and public-private partnership approaches will be used as main pathways to diffuse the technology and products to the marketplace. The project outcomes include creation of new enterprises and employment, improved competitiveness of sorghum and millet products, increased incomes to smallholder farmers and consequently, improved livelihoods of the rural poor. This is in line with millennium development goals (MDGs), especially MDG1 which aims to eradicate extreme hunger and poverty. The indicative project budget is USD 699,072 .

3. Background and rationale for the proposed project

Sorghum and millets are among major cereals grown and consumed in East Africa, supporting livelihoods of millions of people (Mugula & Lyimo, 2000; Pereira-Neto et al., 1995). Ethiopia is the top producer, Tanzania the second, and Uganda the third producer of sorghum in East Africa. In the year 2010 Ethiopia, Tanzania, Uganda, Rwanda and Kenya produced 2,600,000; 850, 000; 490,000; 163,000; and 130,000 MT of sorghum, respectively. Uganda is among the top ten global producers of millets. In the year 2010, Uganda, Ethiopia, Tanzania, Kenya and Rwanda produced 710,000; 525,000; 220,000; 70,000 and 40,000 MT of millets, respectively (Tanzania Agribusiness Report Q2, 2011). Forecast continued growth in sorghum production e.g. in Tanzania, predicted that sorghum production growth by 7%, reaching 908,000 MT in 2010/11 agricultural year (Index Mundi, 2011; FAOSTAT, 2011; Business Monitor International, 2011) long-term forecast envisages sorghum production growth of 40% by 2014/15 (Business Monitor International, 2011). The two cereals can withstand semi-arid conditions and require relatively low production inputs, which partly makes their production more profitable. In addition, sorghum and millet are widely accepted and deeply rooted in the agricultural and food systems of the people in East Africa. If promoted and processed, they can increase farmers' incomes and improve livelihoods. Such advantages of sorghum and millet make them potential vehicles for economic growth, wealth creation and improving the livelihoods of smallholder farmers.

Industrialization and commercialization of traditional food crops has been shown to contribute to economic growth and poverty reduction with direct benefits to smallholder farmers in East Africa. This project proposes to facilitate commercial production of clear malt drink, quality malt flour and malted extruded snacks. The science and technology for the production of these products have been extensively studied. In this project, the established science and technology of malted sorghum and millets will be used to develop value added competitive products and diffuse the technology and products to the market place. The project's rationale is that creating linkages between key sorghum value chain players coupled with industrialization and

commercialization of indigenous products will add value, improve their competitiveness, and increase the demand for sorghum, thus, benefiting the key players in the value chain for sorghum and millet.

In Kenya, the production of malted products is getting commercialized though it is not fully industrialized (Wambugu et al., 2003). In Nigeria, a number of clear malt drinks are industrially produced from sorghum and millet. In addition, some beer brands are produced from 100% sorghum. The use of sorghum in the production of malt drinks and beer increased the sorghum requirements from the 67,000 tons/annum in 1989 to an estimated 1,500,000 tons/annum in 2005. By 2003, successful use of sorghum and sorghum malt was saving Nigeria more than US\$ 100 million annually (ICRISAT, 2003). This is evidence that industrializing traditional foods can improve farmer livelihoods and economic development through value addition and increased grain production.

Like other cereals, sorghum and millet have a high starch content and relatively low protein content of about 7-13%. They also contain substantial amounts of iron, calcium and zinc. However, these cereals also contain anti-nutrients including phytates and tannins that have been implicated in reducing the bioavailability of proteins, starch and minerals (Mugula & Lyimo, 1999, 2000). In addition, the high starch content of cereals, though advantageous due to its energy content, increases the bulk of millet and sorghum porridges with concomitant reduction of nutrient density— a phenomenon that is undesirable in infant feeding.

Malting degrades starch leading to reduction in gruel thickness and increases bio-availability of nutrients in cereal-based foods (Onyango et al., 2003). Various laboratory studies have demonstrated that malting process which involves, soaking, germination and drying increase enzymes and vitamins contents in the grains. The enzymes produced during germination lead to hydrolysis of starch and protein with release of direct available sugar and amino acids. Proteolytic enzymes improve protein digestibility and amino acid availability especially lysine, methionine and tryptophan that are lacking in cereals. Malting improves phytase activity and contributes to the reduction of phytic acid and improves bioavailability of minerals such as iron and zinc and reduces level of tannins and total phenols contents. It also increases significantly the contents of vitamins A, B, C and E. By the activity of galactosidase in the grain, malting contributes to reduction of flatulent oligosaccharides that causes flatulence (Mbithi-Mwikya et al., 2000). The hydrolysis of starch contributes to the reduction of the bulk density and increases nutrient density of cereal based gruels. This is important in improving nutrition security.

Malting of sorghum or millet is a traditional process used in East Africa to prepare traditional gruels and non-alcoholic beverages such as *togwa* (Mugula et al., 2002), *obushera* (Muyanja et al., 2003), *borde* (Abegaz, et al (2002a, Abegaz, 2002). Malting process is weakly used at high production levels because it is hardly feasible by family and small scale enterprises and is time consuming. Variability of malt process causes variability of enzymatic power and technological properties, and conditions in which traditional malt is processed allow development of toxic cyanogenic compounds, mycotoxins and enterobacteria (Hounhouigan et al., 2007) which needs to be avoided to ensure food safety. Therefore, industrial production of malted products requires optimization of the malting process.

Industrialization of the indigenous malted cereal products requires consistent supply of grain that meets the required grain quality standards or specifications in order to ensure production of consistent quality products. The previous BIOEARN Project 7 developed the sorghum grain quality specifications for indigenous malted and fermented products. However, the consistent and sufficient supply of quality grain to SMEs still remains a challenge. This project therefore, seeks to address the challenge of quality grain supply to SMEs through creation of linkages between farmers (as suppliers of grain sorghum and millets) and SMEs (as the users of sorghum and millet grains). The rationale is that coupling of grain suppliers (farmers) and grain users (SMEs) will provide an opportunity of mutual direct communication of the grain quality and quantity required on one hand and trade negotiations on the other. It is envisaged that such linkage will also foster improved performance and productivity in the SMEs, enterprise growth among farmers, and the attendant income benefits to small holder farmers.

Production of non-alcoholic clear malt beverages has been reported in a number of countries including Kenya, Nigeria, South Africa, Australia and USA. These relatively higher nutrient dense products have many nutritional benefits than conventional commercial non-alcoholic beverages such as soft drinks.

Commercialization of such drinks has been reported in very few African countries. In East Africa malted barley based non-alcoholic beverages like *Malta* and *Alvaro* are popular. However, such clear malt drinks are made from barley that is mostly imported. Thus the products are quite expensive, viewed as exotic and not very accepted by some consumers. Besides, barley based drinks have been associated with gluten intolerance and caeliac diseases in some individuals (Ciacci, et al., 2007). Since, sorghum grains do not contain gluten, malted sorghum based beverages may serve as an alternative to people sensitive to gluten. This indicates that well processed, packaged and shelf stable sorghum based “clear malt drink” with characteristics such as being non-alcoholic, sweet, flavourful, nutritious, and safe can have a wider market potential in Tanzania, Ethiopia, Uganda and the rest of East Africa.

The BIOEARN Project 7 developed a clear malt drink and a protocol for its production from one sorghum variety. However, BIOEARN Project 7 did not succeed in addressing the technical challenges in operations such as filtration and others, presented by up scaling of the production protocol. In the proposed work, the research team will work in partnership with SMEs to build on the success and lessons of the BIOEARN Project 7 to apply the developed clear malt drink technology to other sorghum varieties, address the identified technical challenges, upscale the technology for production of clear malt and roll it out for uptake.

Snacks are very popular worldwide because of their convenience, availability, shelf stability, nutrient density and organoleptic characteristics (Gonzales, 2005). Extrusion is reported to cause substantial reduction in the viscosity of cereal gruels, thus enhancing their nutrient densities, and also increasing microbiological safety and shelf life (Wambugu et al., 2003). Maize, wheat and rice are the most common cereals used in the production of extruded snacks. There are reports indicating that sorghum can be extruded to produce snacks, breakfast cereals and porridges (Wambugu et al., 2003; Acosta, 2003; Acosta et al., 2004). Whole sorghum kernels have been extruded into healthy snacks with excellent taste, texture and acceptability (Acosta et al., 2004). In addition, decorticated white sorghum has been extruded to obtain snacks comparable in bulky density to those made from yellow cornmeal. Extrusion of whole sorghum kernels has significant advantage of energy saving because there are no decortications, milling and no dry matter losses (Acosta et al., 2004). The high fibre content of whole sorghum and its antioxidant property suggest a health, and nutraceutical rationale for its human consumption in controlling sugar (Farrar et al., 2008) and cholesterol levels (Carr et al., 2005), therefore, can be used in dietetic management of diabetes and heart conditions (Gonzales, 2005). There is epidemiological evidence suggesting that sorghum, consumption reduces the risks of certain types of cancers in humans (Awika & Rooney, 2004; Yang et al., 2009). Extrusion has been applied in preparation of sorghum-and millet-based high nutrient density complementary foods and instant porridges. Instant thin porridge powder has been prepared and commercialized in South Africa. It is a dry powder to which one simply adds either hot or cold water/milk to make instant breakfast porridge or complementary food.

Despite their potential, sorghum and millet remain the most under-utilized and under-developed cereal grains compared to wheat, rice and maize. Traditional processing of sorghum and millets has been observed to offer products with limited value. Currently, they are used at household and cottage levels to make stiff, soft porridges and alcoholic beverages with perceived low quality. Improvement of quality and product diversification will increase utilization, demand and appreciation of the cereals besides income generation. Extrusion and bio-enrichment technologies such as malting could be used to enhance quality and for new product development.

Commercialization of sorghum-and millet-based products has been limited by poor quality, safety and short shelf life of traditional products made from them. This may be improved by up-scaling and out-scaling appropriate technologies, and applying modern scientific principles and technologies such as good manufacturing practices. This project will build onto the experience and lessons from BIOEARN Project 7 to

address the limitations to technology transfer, commercialization and industrialization with the view to create more opportunities for sorghum and millet-based enterprises through which livelihoods of stakeholders along the entire commodity value chain will be improved.

4. Adding value to existing efforts (relevance and quality of content of the proposal):

Use of malting technology to produce value added products has been reported with success in several countries including South Africa, Nigeria, Kenya and Uganda (Hounhouigan et al., 2007; Mugula et al., 2002). This technology has wide potential for value addition to underutilized cereals such as sorghum and millets. Malting is used to reduce viscosity and increase nutrient density in the production of complimentary foods such as cereal-based gruels. It is also used in conjunction with fermentation to produce alcoholic beverages such as beer, and non-alcoholic beverages like *togwa* in Tanzania, *obushera* in Uganda, *borde* in Ethiopia, *kamata* in Rwanda, and *uji* in Kenya. These non alcoholic beverages products are widely consumed and are sources of income generation to alleviated poverty and improve livelihoods of all stakeholders along the commodity value chain.

Efforts have been made to improve the quality, shelf life and acceptability of traditional sorghum and millets based-products in East Africa. These include improved and safe non alcoholic beverages such as *togwa* and *obushera*, and development of a new product, clear malt drink, notably, through the BIOEARN Project 7. Clear malt drink has been developed in Uganda using local sorghum and millet varieties. However, production of clear malt drink was done on sorghum variety. This project will apply the developed production technology on other farmer preferred sorghum varieties in the region to determine their performance in production of clear malt drink. In addition, the proposed project will address the technical challenges identified in the BIOEARN project 7, upscale the process for production of clear sorghum based malt drink developed in Uganda and avail it for further industrialization and commercialization. Wide consumption of improved malt-based products will create increased demand by small and medium scale processors for use of quality malt as an ingredient used for their manufacture. This will in turn result in increased demand for sorghum and the attendant benefits to sorghum farmers.

Despite the knowledge on malting process and importance of sprouted sorghum and millets consumption, the process remains largely a traditional process in Africa (Hounhouigan et al., 2007). Malting process needs to be further exploited to develop other value-added products e.g. high quality malt flour, extruded instant malted flour and snacks. Snacks are very popular worldwide because of their convenience, availability, shelf stability, nutrient density and organoleptic characteristics (Gonzales, 2005). In East Africa traditional processing of sorghum and millet has been hindered by poor handling and processing conditions which result in products with poor safety and quality to meet consumers' demands (Mugula et al., 2003). This project strives to improve quality and safety of sorghum and millet-based products and their diversification for commercialization and large scale utilisation and promote industrialisation

Extrusion is a technique used to form desired shapes by forcing a material in a sealed chamber through a region of high-temperature and pressure, and then through a die towards a small opening. Cooking extruders convey a homogenized, heated and pressurized food mass through a barrel, using a screw fitted inside towards a relatively small opening at the end. The material expands when exiting through a die, as there is a sudden release of pressure. It is a low cost, energy efficient, versatile process which produces a high quality product continuously without effluents (Gonzalez, 2005). Extrusion causes substantial reduction in the viscosity of cereal gruels, thus enhancing their nutrient densities, and increase microbiological safety and shelf life (Wambugu et al., 2003). Maize, wheat and rice are common cereals used in the production of extruded snacks. Sorghum can be extruded to produce snacks, breakfast cereals and porridges (Wambugu et al., 2003; Acosta, 2003; Acosta et al., 2004). Extrusion technology provides enormous opportunities for development and production of a wide range of nutritive snack and convenience foods such as instant flours that are crucial in addressing challenges of malnutrition, and nutrient availability from plant foods. This project will use extrusion

technology to develop and manufacture convenience and ready to eat food products from sorghum. Such products will include nutrient enriched snacks, instant sorghum flours for complementary food products.

Whole sorghum kernels have been extruded into healthy snacks with excellent taste, texture and acceptability (Acosta, 2003). In addition, decorticated white sorghum has been extruded to obtain snacks comparable in bulky density to those made from yellow cornmeal. Extrusion of whole sorghum kernels has significant advantage of energy saving because there are no decortications, milling and no dry matter losses (Acosta, 2003). In addition, the mineral and vitamin content of the sorghum, such as calcium, iron, phosphorus, and vitamin B, is reduced by removal of the outer pericarp. The consumption of sorghum has health benefits in controlling sugar and cholesterol levels, and can be used in dietetic management of diabetes, heart conditions and certain types of cancers in humans. Extrusion has been applied in preparation of sorghum-and millet-based high nutrient density weaning foods and instant porridges. Instant thin porridge powder has been prepared and commercialized in South Africa. It is a dry powder to which one simply adds either hot or cold water/milk to make instant breakfast porridge. This proposed project will promote the use of extrusion to manufacture instant flour and sorghum flakes for consumption in East Africa.

The African vision to achieve food security through an agricultural led strategy is clearly articulated in the New Partnership for Africa's Development (NEPAD) through Comprehensive African Agricultural Development Programme (CAADP). Successful implementation of CAADP requires two reinforcing capacities; (1) capacity to drive the policy, planning and resource mobilization processes; (2) capacity for public and private investment and enterprise. The latter is needed to create the entrepreneurship that will achieve CAADP's goal of 6% annually growth in agricultural production. In addressing CAADP goal this project combines knowledge and technology from Universities and Research institutions to increase the capacities of entrepreneurs in the private sector.

The proposed project is also in line with the partner countries' policy frame for transforming agriculture and economies. In Tanzanian government program, "KILIMO KWANZA" is aimed at making a revolution in agriculture by enhancing increased sorghum and millet production through increased demand by value added processing to increase access to new and wider markets. The proposed project addresses itself to 2 of KILIMO KWANZA 10 pillars. Pillars number 4 (Paradigm shift to strategic framework of Kilimo Kwanza) specifies putting in place arrangement for production of strategic commodities such as sorghum and millets) while pillar number 7 (Industrialization for Kilimo Kwanza) specifies expansion of agro-processing industries. Regarding Uganda, the National Development Plan 2010-2015 and the Ministry of Agriculture Development Strategy and Investment Plan for 2010-2015 identify sorghum as a priority crop to accelerate national development programs in employment creation and socio-economic transformation. During this period, the government of Uganda intends to support the sorghum subsector through establishing (i) a sorghum commodity platform to discuss issues pertaining to the crop (ii) public-private partnerships in the areas that need public support for private investment (National Development Plan 2010/11-2014/15, Government of Uganda). Ethiopia is implementing agriculture-led industrialization policy where agro-processing and SMEs are priority sectors in its national development and transformation program. In the present state of climate change sorghum and the millets are preferred crops for promotion because of the drought tolerance.

5. Potential for economic and social impact

Socio-economic development of stakeholders along the sorghum and millet value chain will be realized through capacity building, enhanced public-private partnerships, and increased throughput, sales and consumption of safe and nutritious clear malt drink, quality malt flour and malted extruded snacks. Capacity building in infrastructure and human resource will avail malting and extrusion technologies for the manufacture of a wide range of value-added products. This will increase income generation and improve the livelihoods of stakeholders.

A recently concluded project (BIOEARN Project 7) that promoted technologies for increased utilization of sorghum and millet trained over fifty micro and small scale entrepreneurs engaged in non-alcoholic lactic acid fermented beverages based on cereals. The project was successful in imparting knowledge and skills as well as stimulating new small and medium enterprises in commercial production of obushera in Uganda and togwa in Tanzania. The demand for the beverages is extremely high to an extent that the five leading entrepreneurs who are producing the beverage are overwhelmed by the demand. A photo of the packaged product is shown below.



Fig.1. Value added Bushera and Togwa in modern packaging to access new and wider markets

A substantial proportion of enterprises initiated and trained under the BIOEARN Project 7 cite lack of a consistent supply of good quality sorghum grain and or malt flour as a major challenge to their business produce *obushera* and *togwa* of consistent quality and quantity. This is in spite of the BIOEARN project 7 developing clear sorghum grain quality specifications. This project will initiate partnerships between small holder farmer groups and SMEs that will foster direct communication of the specifications and how they can be achieved by the farmers. Such partnerships will empower farmers to engage in direct trade negotiations and also nurture enterprise development among farmer groups. Business Incubation Centres will mediate the partnership and also nurture enterprise development among farmer groups. It is envisaged that this approach will enhance the economic benefits from sorghum and millet accruing to small holder farmers.

This project will encourage and nurture off-the-farm startup enterprises among the different players in the sorghum value chain. This is envisioned to contribute to job and wealth creation and ultimately improvement of rural livelihoods and poverty reduction

6. Regional and international collaboration

The collaborators include Department of Food Science and Technology, Sokoine University of Agriculture (SUA), Morogoro Ben's Winery (MBW) in Tanzania; Department of Food Technology and Nutrition and The Food Technology & Business Incubation Center, Makerere University (MU) and Lisha Products Ltd. (LPL) in Uganda; Institute of Nutrition, Food Science and Technology, Hawassa University (HU) and Addilo Complementary Food Production Unit (ACFPU) in Ethiopia. This project consortium is composed partners from countries leading in sorghum and millet production and consumption in East Africa. The partners and institutions in the consortium were chosen to address the key strategic success components for a technology transfer and commercialization process namely, research in product and process development and up scaling; technology packaging and transfer; enterprise development; private sector. All institutions have the requisite expertise, well established departments in food science and technology, agricultural economics and agri-business. The private partners have expertise in food manufacture including cereal processing and entrepreneurship.

7. Project goal and purpose

The **project goal** is to improve livelihoods of stakeholders along the sorghum and finger millet value chain through commercialization of sorghum and millet based products

The **purpose** of the project is to use biosciences for value addition and diversification to enhance commercialization and industrialization of malted and extruded sorghum and finger millet products to improve livelihoods of key players along commodity value chain

Objectives

- a) Up-scale technologies for commercial production of high quality sorghum malt flour (HQMF), clear malt drink (CMD), malted extruded instant flour (MEIF), sorghum flakes (SF) and sorghum snacks (SS)
- b) Promote best practices along the sorghum and finger millet value chain for production of high quality and safer products
- c) Enhance capacity of SMEs in supply of quality sorghum and millet grain, malting processes, extrusion technology, waste management, and entrepreneurship.
- d) Dissemination of technology for commercial production of high quality sorghum malt flour (HQMF), clear malt drink (CMD), malted extruded instant flour (MEIF), and sorghum flakes (SF) and sorghum snacks (SS).

Outputs

- a) Industrial utilization of sorghum and finger millet increased
- b) Variety of value added sorghum and millet products (HQMF, CMD, MEIF, SF and SS) on the market increased
- c) Best practices along the sorghum and finger millet value chain applied
- d) Value added sorghum and finger millet based products developed
- e) Publications, technical reports, policy briefs, patents applications and manuals prepared
- f) Number of enterprises in sorghum and millet value chain increased

Outcomes

- a) Improved capacity to meet livelihood needs such as paying for school fees and health by sorghum producers
- b) Increased utilization of sorghum and finger millet by industry
- c) Improved availability of quality sorghum and finger millet grain for industrial use
- d) Increased number of SMEs using the up-scaled technologies
- e) Increased availability of diversified safer and quality sorghum and millet based products
- f) Increased employment opportunities along the sorghum and finger millet value chain
- g) Increased government revenue through taxation of enterprises along the value chain.
- h) Increased income of stakeholders along the sorghum and finger millet value chain

8. Methodology and description of project activities

This project builds onto the experiences and lessons learnt from the previous BIOEARN project 7 that used modern principles of science and technology to produce value added indigenous fermented cereal products at industrial commercial level. This project will focus on the up-scaling and transfer of technologies for the production of high quality sorghum malt flour (HQMF), clear non-alcoholic malt drinks (CMD), malted extruded instant flour (MEIF), and sorghum flakes (SF), and sorghum snacks (SS). The project will use an approach where farmers, processing SMEs, consumers, technology transfer agents, and researchers actively participate and engage in a successful process of technology up scaling and transfer. An inbuilt technology-business incubation approach will be used to nurture SMEs along the sorghum value chain. This approach will use the forward and backward linkages between the different value chain players to inform each step of the technology up scaling and transfer process. Each partner country team will be composed of a university and a private sector SME. Each of the country teams will identify and co-opt a farmer group(s) and consumers as associate partners in project implementation. Business technology incubation within the wall activities will be done at one centre in each partner country, where the incubatees will be hosted until graduation.

Each of the partner countries will focus on one of the three product streams. The selection of the country's focus is based on the partner strength and prior experience. Thus the partner country focus will be as follows:

- a) Tanzania will focus on malted extruded instant flour (MEIF) and sorghum flakes (SF)
- b) Uganda will focus on the clear malt drink (CMD)
- c) Ethiopia will focus on the high quality sorghum malt flour (HQMF) and sorghum snacks (SS)

The project team recognizes that increased industrial utilization of sorghum and millet will lead to generation of wastes that may impact on the environment. Subsequently the project will use a value added waste management approach where, (i) cleaner production technology approaches will be adopted to minimize waste production and (ii) the minimal produced waste will be developed into other value added uses including animal feed, mulching and soil fertility enhancement.

Partner countries will implement project activities along work package approach. A work package will be composed of generally similar activities in the technology up scaling and transfer process. The specific partner country work packages may however slightly differ due to country specific peculiarities and product stream focus. Nonetheless, each country's work package will be made up of the following general similar activities. The project implementation will be done in phases as follows:

Objective I: Up-scale technologies for commercial production of high quality sorghum malt flour (HQMF), clear malt drink (CMD), malted extruded instant flour (MEIF), sorghum flakes (SF) and sorghum snacks (SS)

Activity 1.1 Baseline study: This entails market survey to get information on traditional and competitive products, processing methods and technology level, product quality, consumption patterns and marketing, and SMEs involved in cereal processing

Activity 1.2. Procurement of equipment: This will involve purchase, clearance, transportation and installation processes.

Activity 1.3. Formal recruitment of incubatees

Activity 1.4. Adaptation of technologies at semi-commercial levels

Activity 1.5. Testing of up scaled technologies on different farmer preferred sorghum varieties and product formulations

Activity 1.6. Training of incubatees in malting processes and extrusion technology for commercial production of HQMF, CMD, MEIF, SF and SS

Activity 1.7. Training on product quality analyses including chemical, microbiological, physical and organoleptic attributes of the products from up scaled processes for compliance with national and regional standards

Activity 1.8. Education tour of incubators: A tour outside East Africa to learn from successful incubators

Objective II: Promote best practices along the sorghum and finger millet value chain for production of quality and safer products

Activity 2.1. Coupling of farmer group to SMEs in order to share information on industry desired grain quality specifications, how to achieve the desired specification to meet industry demand, traceability, and good postharvest practices for sorghum and finger millet grain to successfully manage grain storage and supply as a business

Activity 2.2. Training of incubatees in good agricultural practices (GAPs), Good manufacturing practices (GMP), good hygienic practices (GHP) and Hazard analysis and critical control point (HACCP)

Objective III: Enhance capacity of SMEs and other entrepreneurs in supply of quality sorghum and millet grain, malting processes, extrusion technology, waste management and entrepreneurship.

Activity 3.1. Assist incubatees to develop raw material and product specifications, implement quality and safety management systems and to manage wastes from different product streams

Activity 3.2. Support incubatees in application of malting processes, extrusion technology, food business management and marketing

Activity 3.3. Development, evaluation and perfection of business plans and linking incubatees to financial institutions

Activity 3.4. Consumer studies, commercial production and marketing by SMEs

Activity 3.5. Monitoring and evaluation of incubatee enterprises

Objective IV: Dissemination of technology for commercial production of high quality sorghum malt flour (HQMF), clear malt drink (CMD), malted extruded instant flour (MEIF), and sorghum flakes (SF) and sorghum snacks (SS).

Activity 4.1. Consultative and dissemination workshops engaging all key stakeholders including policy makers

Activity 4.2. Bi annual regional meetings to plan, review project activities, foster knowledge and experience sharing as well as cross country promotion of technologies

Activity 4.3. Technical reports, manuals, leaflets, policy briefs, patent application and publications

Activity 4.4. Participation in annual national and regional trade fairs, exhibitions, promotions, electronic and print media appearances

Activity 4.5. Participation in international conferences

9. Pathway to impact (commercialization and or use)

Creation of partnerships between the different sorghum and millet value chain players will foster sharing of experiences and knowledge; better understanding and articulation of problems; and challenges along value chain. The partnership approach will enable generation of suitable solutions to the identified problems and unlock the potential of sorghum in the partner countries. This project will use the business incubation approach as a pathway to up-scale technologies and subsequent transformation into viable enterprises. Use of business technology incubation centre (BTIC) has shown high success rates in translating science and technology into viable enterprises (Doherty, 2007; Phipps, 2007) and this approach is advocated by various states in the region. For example, in Tanzania, this concept has been promoted under Ministry of Industry in Trade through SME Development Policy whereby, priority programs and projects identified for implementation of this policy identifies SUA as among the key actors (URT, 2003). Other institutions including Small Industry Development Organisation, Tanzania Private Sector Foundation Competitive Cluster Program consider BTIC as an effective pathway for technology transfer in Tanzania. Similar scenario is observed in Uganda and Ethiopia. Business incubation and public-private partnership approaches will reinforce one another with forward and backward linkages thus promoting diffusion of technologies to key sectors of the sorghum value chain. It is anticipated that such a two pronged approach will stimulate enterprise growth and foster business competitiveness with the attendant increased employment and business opportunities in the sorghum value chain as well as increased incomes to farmers.

The project outcomes include creation of new enterprises and employment, improved competitiveness of sorghum and millet products, increased incomes to smallholder farmers and improved livelihoods of the rural poor. In order to ensure that the above outcomes are realized the project, through business incubation will address the temporal lack of processing premises challenge faced by SMEs as they build capacity. After graduation, the enterprises will be linked to financial institutions to access credit facilities and funds required for expanding their businesses and developing their premises to a level that is acceptable to regulatory agencies in respective countries. The project will provide limited startup package upon graduation. This will include packaging materials. During incubation entrepreneurs will acquire and master the knowledge, technologies and business skills. In addition, the incubatees will produce, promote and market their products to a level that they can replicate the business in their location upon graduation. Continuous backstopping through technical support, mentoring, monitoring and evaluation of incubatees during and after incubation period will be provided.

Apart from the incubatees who will use the technologies, farmers and traders will become knowledgeable of good postharvest handling practices that will ensure safe and high quality raw materials supplied to small scale processors. Farmers will also benefit from the created market for their sorghum and millet. Sustainability in quantity and quality of raw materials supplied will be ensured through contracts between farmers and processors or agents/stakeholders. In addition consumers of all age groups will be assured of a diversity of safe and high quality products. Food Science and Nutrition students in participating countries will be introduced to the technologies; this will subsequently have multiplier effects in respective countries

10. Team Leadership, Composition and Roles of Partners

Team leadership: See CVs in Annex.

Team composition and roles of various partners:

Sokoine University of Agriculture (SUA)-Lead institution, in charge of overall coordinating and managing of project activities; also directly in charge of up scaling and transfer of technologies for the production of MEISF and SF, dissemination and coordination of foreign travel. *Department of Food Science and Technology:* Prof. J.K. Mugula, Cereal Science and Technology, Biotechnology, and Team leader; Prof. B.P.M Tiisekwa(PhD) Malting and Fermentation, up-scaling and business technology incubation; Mr. J.B. Kussaga (M.Sc. Food Quality Management), Process and Product Design and Quality Management; and Mr. R. Suleiman (M.Sc. Food Safety), Food safety and Quality Assurance. *Department of Agricultural Economics and Agribusiness;* Mr. J.C. Masimba (M.Sc. Business Administration). Advice on marketing and social-economic aspects, coordinate business entrepreneurship training and development in Tanzania.

Makerere University, Department of Food Technology and Nutrition, Co-Principal Investigator: Dr. Yusuf B Byaruhanga. Up-scaling and transfer of CMD, technology sourcing and adaptation, and business incubation and dissemination in Uganda.

Hawassa University, Ethiopia: Co-Principal Investigator: Prof. Kebede Abegaz: Up-scaling and transfer of HQMF and sorghum snacks, technology sourcing and adaptation, and coordination of business incubation and dissemination in Ethiopia.

Morogoro Ben's Winery- (SME, Tanzania): To provide technological and business advice on extruded snacks and instant flours processing business, participate in process up scaling and transfer, advice on equipment procurement, provide supplier and market information, test marketing of products, consumer studies, and nurturing farmer groups into grain supply enterprises in Tanzania.

Lisha Products Ltd - (SME, Uganda): Is an SME in Uganda that is producing and marketing cereal beverages. LPL will provide technological and business advice on Uganda's malt flour, and CMD processing business, participate in process up-scaling and transfer, advice on equipment procurement, provide supplier and market information, branding and test marketing of products consumer studies, and nurturing farmer groups into sorghum grain supply enterprises.

Addilo Complementary Foods Process Unit (SME, Ethiopia): Women group SME (Durame district, Kembata-Tembaro Zone, SNNP) that process complementary foods (CF) from cereals, legumes, oil seeds, roots/tubers and other crops with the support of FAO/UNICEF and Hawassa university. It also distributes the CF products to other communities/districts. It will participate in product development, processing and distribution of malt flour and snacks to other districts and communities. It will provide technological and business advice on Ethiopia's HQMF and snacks, participate in process up-scaling and transfer, advice on equipment procurement, provide supplier and market information, branding and test marketing of products consumer studies, and nurturing farmer groups into grain supply enterprises.

Management of project funds: Funds will be disbursed to each project partner in accordance with financial regulations and budget approved by BIOINNOVATE Program Manager

11. Competence and skill track record of the principal investigator

PI: Prof. J.K. Mugula Sokoine University of Agriculture, holds a PhD in Food Science - Agricultural University of Norway (now known as Norwegian University of Life Sciences), Norway; M.Sc. (Food Technology)-University of Reading, Britain; B.Sc. Agriculture (specialization in Food Science and Technology)

- University of Dar es Salaam. He has wide experience in the application of food science, technology and biotechnology for sorghum and millet-based complementary foods process development and technology transfer. He has been a PI of the following projects (1) Transfer of bioenrichment technologies for preparation of low-cost complementary foods and protection of resultant intellectual property. The Innovation Fund project under the Programme for Agricultural and Natural Resources Transformation for Improved Livelihoods (PANTIL) supported by the Norwegian Government; (2) Intervention to assist Manyara sunflower seed oil processors to improve quality, marketing and access to credit under the Future Opportunities and Challenges in Agricultural Learning (FOCAL) programme supported by Norwegian Government; (3) “Development and promotion of inexpensive weaning/supplementary foods by bioenrichment techniques using local under-utilized legumes and cereals” supported by SUA-NORAD Frame Agreement Programme TAN 091 supported by Norwegian Government, and International Foundation for Science (Sweden); and as Co-PI of (1) BIOEARN Programme Project 7: “Harnessing the Commercial Potential of Indigenous Malted and Fermented Cereal Products (in Tanzania and Uganda), supported by SIDA, (2) Promotion of the utilization of sorghum and millets under the European Union supported international project (involving institutions and stakeholders from Britain, France, Portugal, Botswana and Tanzania) entitled "Consumer preferences for selected sorghum and millet products in SADC region of Africa” and (3) Fish farming, processing, preservation and entrepreneurship in selected villages in Morogoro region, SUA-Tuskegee University Linkage Project supported by USAID. Referee: Prof. B.E.Chove, Head of Department of Food Science and Technology, SUA, P.O. Box, 3006, Morogoro, Tanzania. Tel. +255 23 2603511-4 Email: bchove@yahoo.com

Co-PI: Dr. Yusuf B. Byaruhanga, Makerere University, Department of Food Technology and Nutrition, PI of BIOEARN programme project 7: “Harnessing the Commercial Potential of Indigenous Malted and Fermented Cereal Products (in Tanzania and Uganda), supported by SIDA. Yusuf holds a PhD, M.Sc. (with Distinction) - University of Pretoria and B.Sc. Food Science and Technology - Makerere University. He has wide experience in the areas of food product and process development, food quality assurance and technology transfer. On secondment, Yusuf also works with the Food Technology & Business Incubation Center at Makerere University in coordinating research for development and technology transfer activities. He is currently involved in the improvement of quality and value addition to fermented cereal and dairy products. Yusuf has been principal investigator (team leader) on various multidisciplinary research and consultancy teams involving private and public sector players to develop food products and technologies for improved nutrition and livelihoods of the poor. Yusuf is a result oriented team player, committed and eager to learn new approaches to research for development and technology transfer. Yusuf is currently Senior Lecturer at the Department of Food Technology and Nutrition, School of Food Technology, Nutrition and Bioengineering Makerere University. He enjoys athletics and cycling. Yusuf is fluent in English, Swahili, Luganda, and Runyakitara.

Co-PI: Prof. Kebede Abegaz, Hawassa University, Institute of Nutrition, Food Science & Technology, and holds Ph.D. (Food Science)- Agricultural University of Norway. He has wide research experience in food production hygiene, food biotechnology and microbiology (fermentation technology), food quality assurance and traceability, food product and process development, food value chain development, business incubation center establishment and food technology transfer. He has been PI for (1) development of appropriate post-harvest handling technology of pepper & Food product development, SOS-Sahel; (2) Fermentation of Tef Injera batter & starter culture development; Kotcho Fermentation, EIAR; (3) establishment of Fruits & Vegetables canning industry, GTZ; (4) appropriate food technology transfer & ginger post-harvest handling in southern Ethiopia; GTZ (5) value chain development, food processing & market linkage, ECBP; (6) establishment of Small & Medium Enterprises of mango & tomato processing units, SNV; (7) formulation and standardization of high quality pepper powder on the basis of indigenous knowledge as part of the “Smallholder Livelihood Improvement Project (SLIP)”; (8) establishment of food processing business incubation centre (BIC), ECBP; (9) New Product Development: Nutritional Quality Improvement on Cereal-based complementary Foods. Co-PI in the following projects: (1) Improving Food Security in the Highlands of Ethiopia through Improved & Sustainable Agricultural Productivity and Human Nutrition, CIFSRRF; (2) Food Product Development: Orange-flesh sweet potato based vitamin A enriched complementary foods, USAID-Ethiopia; (3) Neglected Crops,

Women, Food Science and Technology, NUFU (4) Complementary food development from locally available germinated grains (cereals & legumes) and feeding for infants & young children. Team leader on various action research and consultancy teams in private-public partnership projects, appropriate postharvest handling and value addition on fruits & vegetables, food product & technology developments, food recipe standardization and sensory analysis for acceptability of the products, establishment of business incubation centers at various provinces and cities, value addition on farm produces of smallholder farmers' cooperatives/unions & their market linkage, smallholder livelihood improvement project: pro-poor, development of complementary foods from locally available produces for young children.

12. Matching funds

The leading institution, SUA is currently implementing business technology incubation in collaboration with Small Industries Development Organisation (SIDO), World Bank and Korea International Co-operation Agency (KOICA). The incubator currently has space and equipment for certain processing operations including filling and packaging lines whose value is about USD 2 million. The SME partner in Tanzania, Morogoro Ben's Winery (MBW) through its incubation program with support from Cluster Competitive Program (CPP) of Tanzania Private Sector Foundation (TPSF) is embarking on construction of food processing facility with a value of USD 350,000. The majority of the incubatees are engaged in sorghum and millet processing to producer complimentary and fermented foods including improved togwa. In Uganda, Makerere University has incubation facility and supports food processing SMEs and will contribute resources in kind equivalent to USD 34,500. In Ethiopia, Hawassa University also has incubation facility to support food processing SMEs.

13. Institutional support

The host institution (SUA) will provide staff time and expertise in the areas of food product and process development, food analysis and quality and safety management systems, and social and marketing research. The institution will host BTIC that will support activities of the technology transfer office; and provision of space for the project office, laboratory and pilot plant; utilities (water, electricity and internet); management of project funds and procurement of equipment and other items.

Department of Food Technology and Nutrition, Makerere University will provide expertise in the areas of food product and process development, food analysis and quality management systems; office, laboratory and pilot plant space and facilities; the Food Technology and Business Incubation Center facilities including staff, a business incubation program framework and procedures; with the attendant network and linkages to financial institution, business development services as well as professional and peer learning association.

Morogoro Ben's Winery (MBW) - (SME, Tanzania): provide technological and business advice on Tanzania's beverage processing business, participate in product development, advice on equipment procurement, provide supplier and market information, mentor other SMEs, test marketing of products, and housing project incubation.

Lisha Products Ltd (LPL) - (SME, Uganda): provide technological and business advice on Uganda's malt flour, snacks and beverage processing business, participate in product development, advice on equipment procurement, provide supplier and market information, mentor other SMEs, product branding and market testing

Addilo Complementary Foods Process Unit (ACFPU) - (SME, Ethiopia): It is owned by women group SME (Durame district, Kembata-Tembaro Zone, SNNP) that process complementary foods from locally available agricultural products (cereals, legumes, oil seeds, roots/tubers, crops) with the support of FAO/UNICEF and Hawassa university. It also distribute the CF products to other communities/districts. It will participate in product development, processing and distribution of malt flour and snacks to other districts and communities.

14. Monitoring and evaluation, dissemination and communication plans

The progress of project activities will be monitored and evaluated continuously based on the various indicators as shown in Table 1 and 2. The communication plan will include dissemination and promotion activities involving private sector, public sector and the university in a continuous dialogue through the established incubation centre. Promotion and dissemination activities will include: a) publications, project technical reports, policy briefs, brochures, leaflets and manuals; b) consultative and dissemination workshops, c) print and electronic media releases which will engage all key stakeholders including, but not limited to, policy makers, researchers, investors, professional practitioners, farmers, suppliers of industrial inputs, distributors and marketers; and d) marketing promotion including exhibitions and trade fairs.

15. Intellectual Property and Other Policy Issues

It is expected that the proposed project may generate patentable information. SUA, MU and HU intellectual property management policies, which prescribe the procedures for disclosure, registration, transfer of intellectual assets and distribution of proceeds will be followed in management of any intellectual assets generated. Proceeds will be shared appropriately among the partners.

16. Milestones and time frame

Milestones and time line of the project are as shown in the Project activity plan (Table 2)

17. Indicators of progress towards results

The project duration is three years as indicated in Table 1.

Table 1. Project Progress Indicators

Activity	Year 1		Year 2		Year 3		
	H1	H2	H1	H2	H1	H2	
1.1. Baseline study							Information on traditional and competitive products, processing methods and technology level, product quality, consumption patterns and marketing, and SMEs involved in cereal processing. <i>Indicator:</i> Baseline report
1.2. Equipment procurement							Information on prices and export expenses. <i>Indicator:</i> Equipment procurement record
1.3. Formal recruitment of incubatees							At least three incubatee enterprises for each product in each country recruited. <i>Indicator:</i> List of recruited incubatees. <i>Indicator:</i> Incubatee recruitment records
1.4. Adaptation of technologies at semi-commercial levels							Processing parameters critical at up scaled semi-commercial level determined. <i>Indicator:</i> Pilot plant reports & records
1.5. Testing of up scaled technologies on different farmer preferred sorghum varieties and product formulations							Technology performance with different varieties established Product formulation for different varieties established <i>Indicator:</i> Pilot plant reports & records
1.6. Training of incubatees in malting processes and							At least three incubatee enterprises for each product in each country trained.

extrusion technology for commercial production of SS HQMF, CMD, MEIF and SF							<i>Indicator:</i> List of recruited incubatees. <i>Indicator:</i> Incubatee training records
1.7. Training on product quality analyses including chemical, microbiological, physical and organoleptic attributes of the products from up scaled processes for compliance with national and regional standards							Compliance with national standards established, products certified. <i>Indicator:</i> Product certification report
2.1. Coupling of farmer group to SMEs							SMEs coupled to sorghum and millet farmer groups. <i>Indicator:</i> List of farmer groups and training records
2.2. Training of incubatees on raw material specification, GAPS, GMPs, GHPs, HACCP and traceability							At least three incubatee enterprises for each product in each country trained. <i>Indicator:</i> List of recruited incubatees. <i>Indicator:</i> Incubatee training records
2.3. Formation of network of professionals							Network of processing, business management and marketing experts and business mentors to support incubatees established. <i>Indicator:</i> List of network members
3.1. Assist incubatees to develop raw material and product specifications, implement quality and safety management system and to manage wastes from different product streams							Grain standards for manufacture of products established <i>Indicator:</i> Raw material specification document At least three incubatees apply good practices and implement quality systems <i>Indicator:</i> Quality manuals
3.2. Support incubatees in application of malting processes, extrusion technology, food business management and marketing							At least three incubatee enterprises for each product in each country supported. <i>Indicator:</i> List of recruited incubatees
3.3. Development, evaluation and perfection of business plans and linking incubatees to financial institutions							Promising business plans evaluated and perfected and linkage to financial institutions <i>Indicator:</i> Concluded business plans and accessed to credit
3.4. Consumer studies, commercial production and marketing by SMEs							Product positioning in the market. <i>Indicator:</i> marketing reports Incubatee(s) initiate production and marketing of the products. <i>Indicator:</i> Production and sales reports
4.1. Consultative and dissemination workshops							At least two dissemination workshops held to inform stakeholders of project

engaging all key stakeholders including policy makers							activities. <i>Indicator:</i> List of participants, number of workshops and reports
4.2. Bi annual regional meetings to plan, review project activities, foster knowledge and experience sharing as well as cross country promotion of technologies							Bi- annual regional meetings for planning, knowledge and experience sharing as well as cross country promotion of technologies <i>Indicator:</i> List of participants, number of products introduced in each country, number of meetings and reports
4.3. Technical reports, manuals, leaflets, policy briefs, patent application and publications							At least one refereed journal publications, technical reports, policy briefs and manuals <i>Indicator:</i> Manuals and reports
4.4. Participation in annual national and regional trade fairs, exhibitions, promotions, electronic and print media appearances							Press releases on project developments and potential benefits/achieved benefits for clients. <i>Indicator:</i> Newspaper, radio, TV magazine and newspaper articles and exhibition reports
4.5. Participation in international conferences							At least two conferences attended. <i>Indicator:</i> poster, paper, presentation
4.6. Monitoring and evaluation of incubatee enterprises							Reports delivered on schedule. <i>Indicator:</i> Monitoring and evaluation report

18. Project activity plans

The project activities will be carried out as indicated in Table 2.

Table 2. Project activity plan

Activity	Involved Partner Scientists and Institutions.	Year 1		Year 2		Year 3	
		H1	H2	H1	H2	H1	H2
1.2. Baseline study	All						
1.2. Equipment procurement	All						
1.3. Formal recruitment of incubatees	All						
1.4. Adaptation of technologies at semi-commercial levels	All						
1.5. Testing of up scaled technologies on different farmer preferred sorghum varieties and product formulations	All						
1.6. Training of incubatees in malting processes and extrusion technology for commercial production of HQMF, CMD, MEIF, SF and SS	MEIF and SF (SUA), CMD (MU), HQMF and SS (HU)						

1.7. Training on product quality analyses including chemical, microbiological, physical and organoleptic attributes of the products from up scaled processes for compliance with national and regional standards	All						
2.1. Coupling of farmer group to SMEs	All						
2.2. Training of incubatees on raw material specification, GAPS, GMPs, GHPs, HACCP and traceability	All						
2.3. Formation of network of professionals	All						
3.1. Assist incubatees to develop raw material and product specifications, implement quality and safety management systems and to manage wastes from different product streams	All						
3.2. Support incubatees in application of malting processes, extrusion technology, food business management and marketing	All						
3.3. Development, evaluation and perfection of business plans and linking incubatees to financial institutions	All						
3.4. Consumer studies, commercial production and marketing by SMEs	All						
4.1. Consultative and dissemination workshops engaging all key stakeholders including policy makers	All						
4.2. Bi annual regional meetings to plan, review project activities, foster knowledge and experience sharing as well as cross country promotion of technologies	All						
4.3. Technical reports, manuals, leaflets, policy briefs, patent application and publications	All						
4.4. Participation in annual national and regional trade fairs, exhibitions, promotions, electronic and print media appearances	All						
4.5. Participation in international conferences	All						
4.6. Monitoring and evaluation of incubatee enterprises	All						

19. Detailed and summary project budget (USD)

a) Materials and supplies USD 261,805; b) Travel USD 48,300; c) Field work costs USD 281,430; d) General expenses USD 57,240; e) Other expenses USD 48,998 TOTAL BUDGET (USD) – 697,773 . Detailed budget as indicated in Table 4.

20. Log frame for the project

The project log frame is as indicated in Table 3.

Table 3. Project Log Frame

Outputs	Outcome	Performance indicator of outcome	Data source	Collection	Assumptions
Specific Objective # 1: Up-scale technologies for commercial production of HQMF, CMD, MEIF, SF and SS					
Industrial utilization of sorghum and finger millet increased	1.1.Increased production of sorghum and finger millets by farmers to meet industrial demand	About 10% increase in production of sorghum and millet by 2014	<ul style="list-style-type: none"> • Project technical reports • Project monitoring and evaluation reports • Project partnership agreements • Observations 	<ul style="list-style-type: none"> • Content analysis • Project reviews • Interviews • Observations 	Governments of the region continue to develop and pursue policies that favor science, technology and industrialization use in development
	1.2. Improved capacity to meet livelihood needs such as paying for school fees, food and health by sorghum and finger millet producers	Stakeholders in sorghum and millet value chain improve their livelihoods by 2014	<ul style="list-style-type: none"> • Sales and purchasing records • Observations • Technical reports • Marketing reports 	<ul style="list-style-type: none"> • Content analysis • Market surveys • Interviews • Observations 	<p>The prevailing socio-economic and political stability in the partner countries will continue unperturbed</p> <p>The environment and weather changes will not adversely affect the production of sorghum and millets</p>
	1.3. Increased number of SMEs using the technologies	At least two incubatee SMEs in each country use the technologies by 2014	<ul style="list-style-type: none"> • Project technical reports • Project monitoring and evaluation reports • Observations 	<ul style="list-style-type: none"> • Content analysis • Market surveys • Interviews • Observations 	<p>The partner institutions will continue to pursue policies and strategies aimed at using biosciences in increasing their direct contribution to socio-economic</p>
Variety of value added sorghum and millet products on the market increased	1.4 Increased availability of diversified sorghum and millet based products HQMF, CMD, MEIF, , SF and (SS)	At least two products available on the market by 2014	<ul style="list-style-type: none"> • Market research reports • Technical reports • Observations • Publications • Product prototypes 	<ul style="list-style-type: none"> • Content analysis • Market surveys • Interviews • Observations 	
Specific Objective # 2: Promote best practices along the sorghum and finger millet value chain for manufacture of quality and safer products:					

Best practices along the sorghum and finger millet value chain applied	2.1. Improved health of consumers of sorghum and finger millet based products	Reduction by 70% of foodborne diseases related to the products manufactured	<ul style="list-style-type: none"> • Market research reports • Technical reports • Observations • Publications • Product prototypes 	<ul style="list-style-type: none"> • Content analysis • Market surveys • Interviews • Observations 	development Funds will be availed for the implementation of this project
	2.2 Safe products with consistent quality	Absence of pathogenic microorganisms. Uniform product quality at all times.	<ul style="list-style-type: none"> • Laboratory records and technical reports • Product prototypes 	Content analysis Sensory analysis	
Specific Objective # 3: Enhance capacity of SMEs in malting and extrusion technologies, waste management and entrepreneurial skills through TBIC					
Value added diversified sorghum and finger millet based products available	3.1 Increased availability of quality and safer diversified products (i.e. HQMF, CMD, MEIF, SF and sorghum snacks (SS))	Quantity of improved and diversified products on the market increased by end of 2014 Approximately CMD 5000 litres/day, HQMF 2000kg/day, MEIF 1000kg/day, SF 500kg/day and SS 500/day by each respective entrepreneur by year 2014	Production and marketing reports	Content analysis Interviews Observations Sensory panel tests Market survey Product promotion information	
Value added approaches to waste management	3.2. Mitigation of environmental impact of the developed technologies	Value added product prototypes from wastes of the developed technologies	<ul style="list-style-type: none"> • Laboratory records and technical reports • Publications 	Experiments and pilot trials	
Specific objective #4: Dissemination of technology for commercial production and market of HQMF, CMD, MEIF, SF and SS					
Number of enterprises in sorghum and millet value chain increased	4.1 Increased availability of quality and safer diversified products	Quantity of improved and diversified products on the market increased by end of 2014	Production and marketing reports	Content analysis Interviews Observations	

	4.2. Increased employment opportunities along the value chain	Number of people engaged in the industry increased by 20% by 2014.	Employment reports	Content analysis Interviews Observations	
	4.3 Increased government revenue through taxation of enterprises, and products	Number of registered enterprises and products increased by 20% by 2014	Registration records observations		
Increased number of consumers	4.4. Increased income of stakeholders along the sorghum and millet value chain	Purchasing power and expenditure of enterprises increased by 20% by 2014	Expenditure reports	Content analysis Interviews Observations	
Publications, technical reports, policy briefs, patents, applications and manuals prepared	4.5. Increased use of the technologies, best practices and products	Number of enterprises using the technologies and best practices Number of consumers			

Table 4: APPROVED PROJECT SUMMARY BUDGET

Year 1								
Activity	Budget Categories	SUA	MAK	HU	ACF	MBW	LPL	Total
A	Equipment and Consumables	70,344	63,161	42,550	-	-	-	176,055
B	Travel	4,200	4,200	4,200	-	-	-	12,600
C	Field work, training and dissemination	20,600	16,300	17,745	6,050	6,050	6,050	72,795
D	General project expenses	8,360	7,020	6,920	-	-	-	22,300
E	Overheads	7,245	9,068	4,999	182	182	182	21,857
	Total Year 1	110,749	99,749	76,414	6,232	6,232	6,232	305,607

Year 2								
Activity	Budget Categories	SUA	MAK	HU	ACF	MBW	LPL	Total
A	Equipment and Consumables	38,200	34,067	10,050	-	-	-	82,317
B	Travel	7,700	7,700	7,700	-	-	-	23,100
C	Field work, training and dissemination	40,500	30,305	39,245	11,450	11,450	11,450	144,400
D	General project expenses	6,550	5,210	5,520	-	-	-	17,280
E	Overheads	6,507	7,728	4,376	344	344	344	19,641
	Total Year 2	99,457	85,010	66,891	11,794	11,794	11,794	286,738

Year 3								
Activity	Budget Categories	SUA	MAK	HU	ACF	MBW	LPL	Total
A	Equipment and Consumables	1,500	833	1,100	-	-	-	3,433
B	Travel	4,200	4,200	4,200	-	-	-	12,600
C	Field work, training and dissemination	22,250	19,050	16,935	2,000	2,000	2,000	64,235
D	General project expenses	7,550	5,410	4,700	-	-	-	17,660
E	Overheads	2,485	2,949	1,885	60	60	60	7,500
	Total Year 3	37,985	32,442	28,820	2,060	2,060	2,060	105,428

	Total Year 1 - Year 3	248,191	217,202	172,126	20,085	20,085	20,085	697,773
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Collaborative Project to Investigate Consumer Preferences for Selected Sorghum and Millet products in SADC Region of Africa. European Union Report CEC STD 3 *, Contract TS3 CT94-0267, 110 pages

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Yang, L., Browning J.D., Awika J.M. (2009). Sorghum 3-deoxyanthocyanins possess strong phase II enzyme inducer activity and cancer cell growth inhibition properties. *J Agric. Food Chem.* 57(5):1797-804.

PI CURRICULUM VITAE

Name: Jovin, K. Mugula, **Nationality:** Tanzanian, **Sex:** Male, Contact Address: Department of Food Science & Technology, Sokoine University of Agriculture, P.O. Box 3006, Morogoro, Tanzania; jmugula@yahoo.com, jkmugula@suanet.ac.tz

ACADEMIC QUALIFICATIONS: Ph.D. (Food Science) Agricultural University of Norway, Norway; M.Sc. (Food Technology), University of Reading, U.K.; B.Sc. (Agriculture), University of Dar es Salaam.

Work experience

Currently Associate Professor, Department of Food Science & Technology, Sokoine University of Agriculture. Involved in) Teaching, coordination and supervision of the field practical training and research to food science and technology undergraduate and post-graduate students; (b) Consultancy and outreach activities in food and allied industry (c) External Examiner for Post graduate candidates at Makerere University, Jomo Kenyatta University of Agriculture and Technology and, Viva Voce Examination Panelist for PhD candidates at SUA; (d) Peer reviewer of manuscripts submitted to more than ten international journals.

Membership in the following committees: (a) Tanzania Bureau of Standards Microbiological Specifications of Foods Technical Committee; (b) Tanzania Food and Drugs Authority- Food Technical Committee; (c) National Food Safety Coordinating Committee.

Key publications related to utilization of sorghum and millets

Mugula, J.K., Lyimo, M., 1999. Evaluation of the nutritional quality and acceptability of finger millet-based tempe as potential weaning foods in Tanzania. *International Journal of Food Sciences and Nutrition* 50, 275-282.

Mugula, J.K., Lyimo, M., 2000. Evaluation of the nutritional quality and acceptability of sorghum-based tempe as potential weaning foods in Tanzania. *International Journal of Food Sciences and Nutrition* 51, 269-277.

Mugula, J.K., Nnko, S.A.M., Narvhus, J.A., Sørhaug, T., 2002. Microbiological and fermentation characteristics of *togwa*, a Tanzanian fermented food. *International Journal of Food Microbiology* 80, 187-199.

Pereira Neto, J.B., de Faria, M.L., Domingues, M.M., Saraiva, C. Santo, P.E., Laswai, H.S., Shayo, N.B., Mugula, J.K., Ndabikunze, B., Kundi, S.T.P., 1995. *Consumer preferences for selected sorghum and millet products in SADC region of Africa*. Collaborative Project (partner institutions from Tanzania, Botswana, France, Portugal and Britain). European Union Report CEC STD 3 *, Contract TS3 CT94-0267, 110 pp.

Project Management Competence (sorghum and millet products)

(a) Co-Principal Investigator BIOEARN-IF Program Project 7 "Harnessing the Commercial Potential of Indigenous Malted and Fermented Cereal Products (in Tanzania and Uganda) financially supported by SIDA.

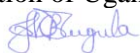
(b) Principal Investigator of project "Development and promotion of inexpensive weaning/supplementary foods by bio-enrichment techniques using local under-utilized legumes and cereals" in Morogoro urban and rural districts, Tanzania, financially supported under SUA-NORAD Frame Agreement Programme TAN 091 and International Foundation for Science (Sweden).

(c) Principal Investigator of project *Transfer of bio-enrichment technologies for preparation of low-cost complementary foods and protection of resultant intellectual property*. The Innovation Fund project under the Programme for Agricultural and Natural Resources Transformation for Improved Livelihoods (PANTIL) supported by the Norwegian Government.

Training

Attended training workshop on *Strategies for strengthening small-scale food enterprises in Eastern and Southern Africa*. Workshop jointly offered by The Technical Centre for Agricultural and Rural Cooperation (CTA, Germany) and The Germany Foundation for International Development (DSE), FAKT (Germany) and the National Agriculture Research Organization of Uganda, Entebbe, Uganda, 2-6 November 1998.

SIGNATURE:



DATE: 16 May 2011

CURRICULUM VITAE

Name: Yusuf B. Byaruhanga; **Nationality:** Ugandan; **Sex:** Male

Contact address: Department of Food Technology and Nutrition, Makerere University, P O Box 7062 Kampala.
ybbyaru@yahoo.com; ybbyaruhanga@agric.mak.ac.ug

Education:

PhD. Food Science, University of Pretoria; MSc. Food Science (with Distinction), University of Pretoria;
BSc. Food Science and Technology, Makerere University.

Employment Record:

Currently Senior Lecturer: Dept. of Food Technology and Nutrition, School of Food Technology, Nutrition and Bioengineering, Makerere University. I am involved in teaching graduate and undergraduate courses namely; food chemistry, food quality assurance and product & process development. On secondment, I also work with the Food Technology & Business Incubation Center at Makerere University in coordinating research for development and technology transfer activities. In addition, I am Coordinator: Skills Training Program for Small & Medium Enterprises- a program for short training courses. Am also involved in various research, development and technology transfer projects aimed at developing and improving traditional food processing technologies.

Research management experience:

Principal Investigator: Harnessing the commercial potential of indigenous fermented cereal beverages; BIOEARN-IF Grant (2008-2010; Project Total Value: USD 494,863)

Principal investigator: Development of value added products from passion fruit; GoU Grant (2010-2011; USD 25,000)

Principal investigator: Value addition to traditional Ugandan foods for improved health and nutrition; NUFU Grant (2007-2011; Project Total Value: USD 500,000)

Principal Investigator: Production of cereal based high-energy nutrient-dense food products from indigenous foods; NORAD Grant (2006-2008; Project Total Value: USD 34,000)

Principal Investigator: Assessment of policy impediments on the implementation of national school feeding program; I@MAK Grant (2007; Project Total Value: USD 10,000)

Co-PI: Improving small-scale production practices and quality of bushera a traditional non-alcoholic fermented beverage, AICAD/RD-02/FPP/03-032 (2002-2003; Project Total Value: USD 50,000)

Co-PI: Enhancing use of science & technology for enterprise development through increased interaction with high education institutions and research organisations; AAU (2009-2010; Project Total Value: USD 50,000)

Co-PI: Unlocking the potential of sorghum and maize as new food, feeds and industrial raw materials; MSI (2009-to date; Project Total Value: USD 980,000)

Consultancy:

Increasing business competitiveness through improved process efficiency and new products for Craft Bazaar Ltd, a fruit juice processing company. Craft Bazaar Ltd/BUDS, 2000

Description of service: SWOT analysis of Craft Bazaar Ltd production and business operations. Reviewed production process efficiency and weakness. Proposed and tested improved in-house processes, quality management systems and production and sanitation systems and schedules. Developed new and improved fruit juice products

Feasibility study for the production of ready-to-eat therapeutic foods; Nulife Project, 2008

Description of service: Developed ready to eat therapeutic foods with attendant processes. Assessed and evaluated the technical feasibility for the production of ready to eat therapeutic foods.

Selected publications:

I.M. Mukisa, D.G. Nsiimire, **Y.B. Byaruhanga**, C.M.B.K. Muyanja, T. Langsrud & J.A. Narvhus. Obushera: Descriptive Sensory Profiling and Consumer Acceptability. *Journal of Sensory Studies* 25 (2010) 190–214.

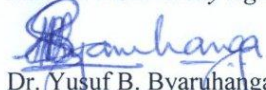
Y. B. Byaruhanga & P. M. Opedun. Impact of culture on food security in Uganda *Global Knowledge* 2008, 1:52-59

Y. B. Byaruhanga, C. Erasmus, M. N. Emmambux and J. R. N. Taylor. Effect of heating cast kafirin films on their functional properties *Journal of the Science of Food and Agriculture* 2007, 87:167–175

Y. B. Byaruhanga, M. N. Emmambux, P. S. Belton, N. Wellner, K. G. Ng, and J. R. N. Taylor. Alteration of kafirin and kafirin film structure by heating with microwave energy and tannin complexation *Journal of Agricultural and Food Chemistry* 2006, 54:4198-4207.

C. Gao, J. Taylor, N. Wellner, **Y. B. Byaruhanga**, M. L. Parker, E. N. Clare Mills, and P. S. Belton. Effect of preparation condition on protein secondary structure and biofilm formation of kafirin, *Journal of Agricultural and Food Chemistry* 2005, 53:306-312.

Y. B. Byaruhanga and M. Ndifuna. Effect of selected preservation methods on the shelf life and sensory quality of obushera. *Makerere University Agricultural Research Institute Bulletin* 2002, 5:92-100.


Dr. Yusuf B. Byaruhanga

17th May 2011

CURRICULUM VITAE

Name: Kebede Abegaz, **Nationality:** Ethiopian, **Sex:** Male, **Contact Address:** Institute of Nutrition, Food Science & Technology, Hawassa University, P.O.Box 5, Hawassa, Ethiopia; abegaz2005@yahoo.co.uk .

Academic Qualifications: **Ph.D.** (Food Science & Technology) Agricultural University of Norway; Norway; **M.Sc.** (Biotechnology), Sofia University, Bulgaria; **Diploma** (Biology), Addis Abeba University, Ethiopia.

Currently Asst. Professor, Institute of Nutrition, Food Science & Technology, Hawassa University. Involved in (a) Teaching various courses for Food Science and Postharvest Technology undergraduate and post-graduate students including: senior project works, industry attachments & laboratory/practical activities, advising M.Sc. Thesis and co-advising PhD research projects; lecturing as guest professor at different Ethiopian universities; (b) serving as director for the Institute of Nutrition, Food Science & Technology and member of university management council; (c) Consultancy and outreach activities in food industries, MSEs, Value chain analysis and development, establishment of agro-processing units at farmers' cooperatives/unions/urban SMEs, food product development and market linkages, (c) External Examiner for Postgraduate candidates at different Ethiopian universities; (d) Peer reviewer of manuscripts submitted for publication to many international journals; (e) Member of editorial boards for few international journals.

Membership in the following committees: (a) Quality and Standard Authority of Ethiopia Technical Committee for Microbiological Specifications of Foods; (b) Food Safety and Codex Activities in Ethiopia; (c) President of National Monitoring Committee (NMC) for Engineering Educators in Higher Institutions in Ethiopia, IGIP; (d) Member of the Editorial Board of the International Journal on Food Science, Technology & Nutrition (e) Secretary of Alumni Association of Ethiopians Educated in Norwegian Universities; (f) Ethiopian Apiculture Board (EAB) & Chair person of EAB branch for the southern Ethiopia.

Project Management Competence

- a) Co-Principal Investigator: Neglected Crops, Women, Food Science and Technology, NUFU.
- b) Co-Principal Investigator: Improving Food Security in the Highlands of Ethiopia through Improved & Sustainable Agricultural Productivity and Human Nutrition, CIFSRF.

Training:

Attended short term trainings on Agro-processing Value Chain development, SNNP Regional State, GTZ and SNV, Awassa, Ethiopia, Dec, 2007 to May, 2008.

Applied Food Analysis and Post-harvest Technology, *JICA*, Thika, Nairobi, Kenya, Feb.- March, 1996.

Post-harvest Practice, MASHAV, Volcanic centre, Israel, February - March, 2009.

Didactics Training: New Teaching and Learning Methods in Higher Education, ECBP, University reform unit, Aug, 2008 to Feb 20, 2010.

Diploma Training on Capable Manager (ongoing), DIF Project, Hawassa University.

Key publications related to cereals and food fermentation

Kebede Abegaz (2006). Isolation, characterization and identification of lactic acid bacteria involved in traditional fermentation of *borde*, an Ethiopian cereal beverage. *The African J. Biotechnol.*

Kebede Abegaz, Thor Langsrud, Fekadu Beyene and Judith A. Narvhus (2004). The Effects of Technological Modifications on the Fermentation of *Borde*, an Ethiopian Traditional Fermented Cereal Beverage. *The Journal of Food Technology in Africa*, Vol. 9, pp. 3-12.

Kebede Abegaz, Fekadu Beyene, Thor Langsrud and Judith A. Narvhus (2002b). Parameters of processing and microbial changes during fermentation of *borde*, a traditional Ethiopian beverage. *The Journal of Food Technology in Africa*, Vol. 7, pp. 85-92.

Kebede Abegaz, Fekadu Beyene, Thor Langsrud and Judith A. Narvhus (2002a). Indigenous processing methods and raw materials of *borde*, an Ethiopian traditional fermented beverage. *The Journal of Food Technology in Africa*, Vol. 7, pp. 59-64

Kebede Abegaz (2002). Traditional and improved fermentation technology of *borde*, a cereal-based Ethiopian beverage. Ph.D. Thesis. Department of Food Science, Agricultural University of Norway, Ås, Norway.

Gulelat Dessie, Kebede Abegaz and Mogessie Ashenafi (1997). Effect of “Siljo” fermentation on the growth of *Staphylococcus aureus*, *Bacillus cereus* and *Listeria monocytogenes*. *Ethiopian Medical Journal*, 35: 215-223.

Gulelat Dessie, Kebede Abegaz and Mogessie Ashenafi (1996). Fate of *Salmonella Enteritidis* and *Salmonella typhimurium* during the fermentation of “Siljo”. *East African Medical Journal*, 73: 432-434.

SIGNATURE:



DATE: 20 July 2011

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ግብርና ኮሌጅ
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Hawassa University
College of Agriculture
College Head Office

ቁጥር/ Ref. No AcA/02/46/11
ቀን /Date 28/07/2011

To: BIOINNOVATE AFRICA, C/O ILRI, P.O. BOX 30709, NAIROBI 00100, KENYA.

Subject: Letter of Intent for the research proposal entitled "Use of biosciences for value addition and diversification to enhance commercialization of sorghum and millet products"

The College of Agriculture, Hawassa University, is pleased to collaborate and write this letter of intent for collaborative research under the project that uses biosciences for value addition and diversification to enhance commercialization and industrialization of malted and extruded sorghum and finger millet products and technology transfer to improve livelihoods of key players along commodity value chain and enrich bioavailability of sorghum and millet based foods that may pave the way for development of complementary foods in the region. The college is one of the few oldest agricultural institutions in Ethiopia. It has made significant scientific contribution in pioneering teaching, research and public services in areas where it has sound expertise; and has taken initiatives to serve the community where its mandate allowed doing so. Hence its involvement in practice oriented teaching and development oriented research has brought it significant reputation both at national and international levels. The purpose of this project is thus inline with the mandates of the college. The College of agriculture comprises of two departments and two institutes that comprise different undergraduate and graduate programs and the Institute of Nutrition, Food Science and Technology is one of them. Thus, the college can collaborate to provide expertise in any of the respective field of studies.

The College, with the direct involvement of the Institute of Nutrition, Food Science and Technology is committed to provide expertise in the areas of food product and process development, food safety, food analysis and quality management systems; laboratory and pilot plant space and facilities; utilities (water, electricity and internet), the Food Technology and Business Incubation facilities including staff, a university technology village/business incubation program framework and procedures; business development services as well as professional and peer learning association including operational research with SMEs in Ethiopia.



Sincerely,


Yibrah Beyene (Ph.D)
College Head



**SOKOINE UNIVERSITY OF AGRICULTURE
FACULTY OF AGRICULTURE
OFFICE OF THE DEAN**

P.O. Box 3001 MOROGORO – TANZANIA

TEL: +255 23 2 604649; FAX: 23 2 604649, 23 2 604562 OR 23 2 603259; E-MAIL: foa@suanet.ac.tz

Our Ref: SUA/FoA/A.1/14

Your Ref:

Date: 31/1/2011

BioInnovate Africa
c/o ILRI
P.O. BOX 30709
Nairobi 00100
Kenya

Dear Sir/Madam,

RE: COMMITMENT TO PARTICIPATE IN THE BIOINNOVATE PROJECT

Kindly refer to the above-mentioned subject. This is to inform you that we have been consulted on the proposed project titled “**Use of Biosciences for value addition and diversification to enhance commercialization of sorghum and millet products**” and do hereby confirm that we will participate fully in the execution of planned project activities of the project.

Looking forward to your approval,

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'A.K. Kaaya'.

Dr. A.K. Kaaya

DEAN
FACULTY OF AGRICULTURE

MAKERERE

P.O. Box 7062,
Kampala-UGANDA

E-mail: foodtech@agric.mak.ac.ug



UNIVERSITY

Phone: 256-414-533865

Fax: 256-414-533676

**COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
SCHOOL FOOD TECHNOLOGY, NUTRITION & BIO-ENGINEERING**

16th May 2011

The Program Manager
BioInnovate Africa
C/O ILRI
P O Box 30709
Nairobi 00100
Kenya

Dear Dr. Seyoum Leta,

RE: COMMITMENT TO PROPOSED PROJECT

The School of Food Technology, Nutrition and Bioengineering, Makerere University is committed to fully support and participate in the execution of the regional project "Use of Biosciences for value addition and diversification to enhance commercialization of sorghum and millet products" as proposed for funding under the Bioinnovate Program. To that end, the School of Food Technology, Nutrition and Bioengineering will contribute resources in-kind equivalent to US\$ 34,500. These contributions will include catering for utilities, office, laboratory and pilot plant space and equipment.

The technology transfer and business incubation concepts that the proposal plans to promote is a priority area for Makerere University and Uganda at large.

In light of the above, the School pledges, once the objectives of the project have been accomplished, to continue promoting and supporting the development and transfer of technologies through the two units namely: Department of Food Technology and Nutrition, as well as the Food Technology and Business Incubation Center at Makerere University.

Yours sincerely,

Prof. John H. Muyonga
Dean



31st January 2011.

BiInnovate Africa
c/o ILRI
P.O. BOX 30709
Nairobi 00100
Kenya

Dear Sir/Madam,

**RE: COMMITMENT TO PARTICIPATE IN THE BIOINNOVATE PROJECT WITH SOKOINE
UNIVERSITY OF AGRICULTURE, MOROGORO TANZANIA**

Kindly refer to the above-mentioned subject. This is to inform you that we have been consulted on the proposed project titled **“Use of Biosciences for value addition and diversification to enhance commercialization of sorghum and millet products”** and do hereby confirm that we will participate fully in the execution of planned project activities of the project.

Looking forward to your approval,

Yours sincerely,


Director



Lisha Products Ltd

P O Box 16052
Kampala
Uganda

Tel: +256 704028700
+256 784306707
Email: lishaproducts@gmail.com

27th July 2011

The Program Manager
BIOINNOVATE Africa
C/O ILRI, P.O. BOX 30709
Nairobi 00100
Kenya

Dear Sir,

RE: COMMITMENT TO PARTICIPATE IN BIOINNOVATE PROJECT: "USE OF BIOSCIENCES FOR VALUE ADDITION AND DIVERSIFICATION TO ENHANCE COMMERCIALIZATION OF SORGHUM PRODUCTS"

I write to confirm Lisha Products Ltd's participation in the development of the proposal on "Use of biosciences for value addition and diversification to enhance commercialization of sorghum products", a project that will increase competitiveness of SMEs in the sorghum value chain.

Lisha Products will actively participate in the successful implementation of the project activities such as consumer studies on clear malt drinks, supporting farmer groups in grain supply enterprise development and other activities as stipulated in the proposal. We will also support, advise and inform the broader technology transfer and adoption processes in the project as per the proposal.

Yours faithfully,

Barbara B. Bombom
Director

Handwritten: HOC TO DR. KEBREABE 0462206711

TO: BIOINNOVATE AFRICA, C/OILRI, PO BOX 30709, NAIROBI 00100, KENYA.

Subject: Letter of commitment for the research proposal entitled "Use of biosciences for value addition and diversification to enhance commercialization of sorghum and millet products"

Addilo Complementary Food Production Unit (ACFPU) is located in Kedida Gamella district at semi-urban Kebele of Addilo town (350 Km south of Addis Ababa) is one of the four SMEs in Ethiopia that are involved in complementary foods (CF) Production and distribution. It is initiated with the support of FAO and UNICEF. This SME is the first of its kind in the southern Ethiopia and owned by an organized group of women cooperative. It produces CF from locally available agricultural products (cereals and pulses) and distributes the products. The CF production at ACFPU is always based on germination of grains and drying before milling and packaging.

The ACFPU is pleased to collaborate and write this letter of commitment for collaborative research on product development and market promotion under the project of biosciences for value addition and diversification to enhance commercialization and industrialization of malted and extruded sorghum and finger millet products and technology transfer to improve livelihoods for key players along the value chain and enrich bioavailability of sorghum and millet based foods. We believe that the project is inline with the major business activity of ACFPU and its capacity building to strengthen the production and distribution of nutritionally enriched CF from locally available cereals (where sorghum & millets are of interest in the southern sub-region) and legumes.

Thus, the ACFPU is highly interested to collaborate with your project in product and technology development, pilot processing for the developed products, distribution of malt flour and snacks, technology transfer and market promotion that pave the way for commercialization and industrialization of malted and extruded sorghum and finger millet products. We hope this collaboration will help the ACFPU in capacity building, technical experience sharing on entrepreneurship skills through business/technology incubation and potential market linkage.



Sincerely,

Signature: **AMIRU ZEKARIAS WORK**
Education office head

Handwritten: የወንጌል ግብርና ምርት ማሻሻያ ስራ

