Feed the Future Innovation Lab for Food Processing and Post-Harvest Handling

Semi-Annual Report

Reporting Time Period: October 1, 2017 to March 31, 2018

I. Feed the Future Innovation Lab for Food Processing and Post-Harvest Handling

II. Research Progress Summary

A. Research progress made during the reporting period

The Food Processing Innovation Lab (FPL) continued to make progress in all key aspects of the program including drying, moisture detection, storage, processing and nutrition, with emphasis on gender and the environment. Under the drying and storage component, there was increased focus on training and dissemination of promising technologies. Over 2000 farmers, traders, and extension staff received training on best practices under drying and storage. Commercialization of the hygrometer and PICS bags was initiated, in collaboration with the local private sector. Strategies for cost-effectively reducing aflatoxin contamination in stored maize were identified. Under the processing and nutrition component, market drivers for commercial food products have been identified for use in optimizing blended product formulations. Commercially viable ingredients and formulations for instant cereal products blended with micronutrient-rich native fruits and vegetables have been developed. Additionally, extruded whole grain flours show reduced starch digestibility compared to decorticated flours, which give them added benefits of slow starch digestion and moderated glycemic response. The Government of Senegal's continued interest in the project was manifested through a high-level meeting to discuss increasing extrusion capacity and scaling-up of the "hub and spoke" incubation model to other regions in Senegal.

OBJECTIVE 1: Drying & Storage (Improve drying and storage of cereals and grain legumes in the humid tropics of Africa)

Activity 1

1) **Name and description: Commercializing the hygrometer and Purdue Improved Crop Storage (PICS) bags in Kenya.** Farmer training workshops were conducted in five major maize growing counties of Western Kenya: Nandi, Trans-Nzoia, Uasin Gishu, Bungoma, and Nakuru. Farmers, agricultural extension staff, grain traders, and other grain post-harvest management stakeholders were trained on moisture detection devices, solar drying, and hermetic storage technologies.
2) **Progress:** Workshops were used to sensitize farmers to adopt post-harvest technologies, which contribute to increased food security and household income. The workshops also engaged stakeholders in identifying potential challenges and opportunities in grain post-harvest management. Hygrometers and PICS bags were sold at the workshops to interested customers by a private sector partner, Bell Industries (*see table in section III for numbers trained*).

Activity 2

1) **Name and description: Commercializing the hygrometer and PICS bags in Senegal.** Train-the-trainer and farmer training workshops were conducted on drying and storing maize in Velingara and Kolda Counties of Senegal.
2) **Progress:** Drying and storage demonstrations were conducted jointly with private a sector partner COFISAC/FUMOA (PICS distributor) who is selling PICS bags and hygrometers. COFISAC/FUMOA is in the final stages of becoming licensed manufacturers of PICS bags. In the future, they will help coordinate and commercialize post-harvest technologies.

Activity 3

1) **Name and description: Identifying cost-effective strategies for reducing Aflatoxin contamination in stored maize.** Data analysis is on-going for a randomized control trial (RCT) of nearly 2,000 mostly smallholder households in southern Senegal to test how different interventions help reduce the

incidence and accumulation of aflatoxins in maize stored for 3-4 months. The interventions include: training on aflatoxin prevention by experienced extension officers, providing tarps to reduce maize drying on the ground, providing low cost moisture meters to accurately detect when maize is dry enough for safe storage, and providing a hermetic (air-tight) storage bags.

2) **Progress:** Preliminary results show that households used all inputs provided. Receiving information and receiving a hermetic bag significantly reduced aflatoxin levels in maize after 3-4 months of storage, compared to the control group (no intervention). This suggests that if smallholders receive training about best practices and a safe place to store maize, then they may make efforts to find a clean place to dry it before putting in a hermetic bag, leading to safer, higher quality maize for consumption.

Activity 4

1) **Name and description: Analyzing the cost-effectiveness of roadside drying.** CIMMYT conducted a survey on the cost of solar drying maize on the road in major production and marketing counties in Kenya in February 2018. A total of 125 respondents participated including maize farmers, traders, and transporters who engage in solar drying of maize in the course of their business. The goal of the study was to gather information on the maize drying practices and the associated costs.
2) **Progress:** Results suggest that the average total cost of drying a 90 kg bag of maize on the roadside is $1.60, revenue is $2.00, and thus profit is $0.40. It takes 2.7 days to dry a 90 kg bag of maize from 17.5% moisture content to 12.5% moisture content. Any commercial dryer would have to be more cost-effective and efficient than this method. These findings are an important benchmark for any solar drying innovation that enters the market.

Activity 5

1) **Name and description: Impact of pre-harvest biocontrol treatment on reducing post-harvest aflatoxin accumulation.** This study addresses the potential problem of aflatoxin accumulation in maize during the postharvest handling and drying period. Drying is often delayed due of rain and reduced solar conditions, which subjects the high moisture maize to conditions that favor the growth of Aspergillus flavus and aflatoxin accumulation. We hypothesize that the benefits of treatment of maize fields with biocontrol strains of A. flavus to reduce pre-harvest levels of aflatoxin will carry over into the postharvest handling and drying period.
2) **Progress:** The studies are being conducted in the U.S. using maize harvested from fields treated with commercial biocontrol products AF36 and Aflaguard. Maize was collected from both treated and untreated fields in Texas and North Carolina, dried, and sent to Purdue University. The moisture content of the grain was adjusted to 20% and three replicates of each grain source were incubated at 28C. Samples were collected after 0, 2, 4 and 6 days of incubation. We determined total fungal counts from kernel surface and the percent seed infection. Aflatoxin accumulation in the grain was also determined. A. flavus colonies were collected to determine genotype and their potential for producing aflatoxin. Preliminary results indicate that higher moisture result in rapid growth of fungi and an increase in kernel infection. The populations of A. flavus strains also increase at the higher moisture.

Activity 6

1) **Name and description: Evaluation of the performance of the Solar Pico Crop Dryer (POD) in Kenya**. In February of 2018 a recently modified version of the dryer was assembled in Kenya for testing at KALRO.
2) **Progress:** The new POD design will be tested in May 2018, with 10 prototypes fabricated for five local county governments and five farmers' groups, one in each county.

OBJECTIVE 2: Processing & Nutrition (Drive the value chain through processing to increase commercialization and improve nutrition)

Activity 1

1) **Name and description: Strengthening rural processing with fortified instant millet processing in Senegal.** Food processing incubation activities in Senegal led by Institut de Technologie Alimentaire (ITA) in partnership with a local processor, Mme. Astou Gaye Mbacke of Touba Darou Salam Processing Unit, focused on developing formulations and improving extrusion capability. The goal is to create a "hub-and-spoke" incubator model for adoption of new food and nutrition technologies for replication in Senegal and the region.
2) **Progress:** ITA and FPL worked with Mme. Mbacke to make over Touba Darou Salam's extrusion processing facility to help meet the standards for processing of safe and hygienic nutrient-fortified instant millet flours to supply food aid organizations. Dialogue progressed with government of Senegal officials through a solicited Concept Note to collaborate with certain departments and the World Food Programme to expand the extrusion processing capability of Touba Darou Salam Processing Unit to produce fortified instant flours and to scale-up the model to other regions of Senegal.

Activity 2

1) **Name and description: Optimization of fortified instant flour formulations for Kenyan market.** University of Eldoret and FPL, through their incubation center, developed new nutritionally enhanced products. In March 2018, the team conducted a product mapping and optimization exercise at Eldoret to understand desirable attributes for commercial products and to understand how products can be further differentiated in the Kenyan market. The exercise involved descriptive and cost analysis of existing maize, sorghum, and blended composite products with nutritional ingredients and claims.
2) **Progress:** Descriptive work on blended and acidified commercial products suggest that many of them fall within a narrow range of attributes that closely align with FPL formulations. Optimization for flavor and color parameters may offer opportunities to distinguish FPL products on the market along with quality nutritional instant products generated by FPL (which were generally lacking in the market). Preliminary cost analysis also suggests that natural fortification strategies will be cost-competitive in Kenya.

Activity 3

1) **Name and description: Identify and develop cost effective bioaccessible, and commercially relevant fortified millet and maize/sorghum instant products.** To optimize the instant cereal porridge products, a descriptive panel sensory evaluation was performed at Univ. of Pretoria to determine the difference between whole and decorticated pearl millet grain, and of extrusion cooking on the sensory attributes and shelf-life of instant flours and porridges. Efforts continue to develop a range of commercially viable ingredients and formulations for instant cereal products blended with micronutrient-rich native fruits and vegetables.
2) **Progress:** Extrusion of both whole grain and decorticated pearl millet flours extended their shelf life. Extrusion also provided for a more intense sweet aroma and canned sweetcorn-like aroma and wheaty flavor, presumably positive characteristics for millet porridges. Extrusion of decorticated grain flour, however led to lump formation and a sticky, cohesive porridge, which may be a negative characteristic. Texture related differences between extruded and unextruded samples were more evident in decorticated samples, while aroma and flavor differences were more prominent in whole grain porridges. The extrusion cooked flours in addition to being a convenient instant product, show promise of being more stable during storage.

Mineral bioavailability enhancers, such as moringa leaf powder (MLP), itself a rich source of iron, and baobab fruit powder (BFP), a rich source of organic acids, were further studied. Inclusion of BFP significantly ($p < 0.05$) increased the percentage bioaccessible iron to the same extent as the addition of citric acid alone. This shows that BFP because of it high content of organic acids could enhance iron bioavailability in the pearl millet based porridge. Neither inclusion of the organic acids alone or of BFP significantly enhanced the percentage bioaccessible zinc. The inclusion of MLP, however, did not improve iron bioaccessibility even with the additional inclusion of BFP, suggesting that there exists anti-nutrients in the MLP, which can inhibit iron accessibility.

Activity 4

1) **Name and description: Extrusion of millet and natural provitamin A carotenoid plant blends.** Translation of blends of millet with provitamin A carotenoid plant materials prototypes into fully cooked, marketable extruded products was implemented. This is a critical step to advance the findings of year 1-2 for viable commercial products.
2) **Progress:** Extruded blended products formulated by combining whole grain (WG) pearl millet (*Souna var.* from Senegal) with native African plant materials identified and studied in years 1-3, including dried carrot (15% for provitamin A carotenoids), *Adansiona digitata* (Baobab-5% for iron and vitamin C) and *Moringa oleifera* (Moringa - 5% for provitamin A carotenoid and iron). Formulations were designed to target 25-50% of the Dietary Value for iron and vitamin A. Results suggest that interactions through extrusion can be favorable to carotenoid recovery and bioaccessibility. Further, these results suggest that production of naturally fortified millet blends can be technically achieved without compromising the product quality, recovery or bioaccessibility of provitamin A carotenoids.

Activity 5

1) **Name and description: Provitamin A carotenoid (pVAC) stability during dry-milling, storage, and extrusion processing of biofortified maize genotypes (Purdue U/North Carolina State U; collaborator Prof. T. Rocheford).** Effects of milling and extrusion processing on biofortified orange were assessed on maize for potential application in Kenya.
2) **Progress:** Simulation of commercial dry-milling and extrusion processing on carotenoid stability in biofortified maize genotypes (Z. *mays*) were completed. Extrusion processing conditions were optimal at 35% extrusion moisture, producing fully-cooked instant maize flours with high pVAC retention (70-93%). These results support the notion that post-harvest losses in maize milled fractions may be dependent, in part, on genotype and extrusion processing and may provide an option for preserving biofortified maize consumer products.

Activity 6

1) **Name and description: Reduction of starch digestibility in extruded whole grain pearl millet.** A study was conducted to determine if extruded instant pearl millet products have an added benefit of slow starch digestibility and low glycemic response.
2) **Progress:** The study showed that extrusion of whole grain pearl millet causes a complexation of fatty acids and starch amylose that significantly reduces *in vitro* starch digestion rate, when the instant flour is reconstituted in a thin or thick porridge with hot water. The effect was more pronounced in whole grain than in decorticated flour extruded millet flour. This implies that whole grain instant flours may have an added benefit of slow starch digestion and moderated glycemic response, which is pertinent to the "feeling of fullness" that is applicable in urban markets where low glycemic products may be valued.

B. Issues or concerns encountered during the reporting period

There was a four and half months delay in the release of 2017/18 fiscal year funding from USAID, which affected many of project activities. All PIs were informed of the imminent delay, and requested to be prudent with the previous year's funding. However, the delay affected the commencement of some activities.

III. Human and Institutional Capacity Development

A. Short-term training

Country of Training	Brief Purpose of Training	Who was Trained[1]	Number Trained[2]		
			M	F	Total
Kenya	Training on drying, moisture sensing, and storage technologies	1,186 people including farmers, grain traders and county agricultural staff. Farmers make up 86% of attendance	669	517	1,186
Senegal	Training of trainers on drying and storage technologies, so they can go out and train farmers on hygrometers and PICS bags	Extension agents			12
Senegal	Training on drying and storage technologies	Farmers	762	411	1,173

B. Long-term training

Name (first, last)	Sex	University	Degree	Major	Program End Date[3] (month/year)	Degree Granted[4] (Y/N)	Home Country
Cheikh N'Diaye	Male	Purdue	PhD	Food Science	May 2018	Yes	Senegal

Cheikh N'Diaye returned to ITA in Senegal upon graduation and is now the lead PI on the project.

IV. Innovation Transfer and Scaling Partnerships[5]

- Global Good continues to work on refining and improving the hygrometer originally developed at Purdue. They hope to have a new version of the device ready for the market by the end of 2019.
- Bell Industries continues to sell hygrometers and PICS bags in Kenya. They join our team on all extension activities to give participants the opportunity to purchase hygrometers, tarps and PICS bags.
- COFISAC is now selling hygrometers and PICS bags in Southern Senegal. They join our team on all extension activities to give participants the opportunity to purchase hygrometers, tarps, and PICS bags.
- Touba Darou Salam extrusion processing facility was upgraded to meet the standards for processing of safe and hygienic nutrient-fortified instant millet flours to supply food aid organizations.
- A high-level meeting among, government of Senegal officials, FPL/ITA, and WFP was held in March 2018 to further discuss increasing extrusion capacity and scaling-up of the "hub and spoke" incubation model to other regions in Senegal.

V. Future Work

- FPL Annual meeting in Dakar, Senegal on June 18-20, 2018.
- Preparation for end line surveys for drying and storage work in year 5.

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[1] Such as farmers, government officials, women entrepreneurs
[2] Disaggregate by sex if known
[3] Anticipated graduation date or end of program support
[4] Indicate if program support resulted in a degree
[5] Includes transfer of technologies and knowledge as applicable to your programs; reference the impact pathway

- Additional extension and commercialization activities on drying, moisture sensing, and storage technologies and innovations in Senegal and Kenya. In Kenya, local county governments will be trained on the technologies developed on the project.
- Food formulation prototypes (regular/instant and nutritionally-enhanced/non nutritionally enhanced) will be translated into commercial food products and tested in the markets.
- Training of food processors to continue in both Kenya and Senegal.
- Initiate scale-up activities for the "hub and spoke" incubation model in Senegal, in partnership with government of Senegal and World Food Program.
- Nutrition (clinical) study using nutritionally-enhanced products will be conducted in Kenya in 2018/19 to assess method of increased bioavailability or iron and zinc

Note:

1. All reports must include the required Feed the Future branding. See page 24: http://feedthefuture.gov/sites/default/files/resource/files/Feed_the_Future_Graphic_and_Naming_Standards_Manual_june2015%281%29.pdf.

2. In accordance with 22 CFR 226.51(d), semi-annual reports shall be concise and present the following information:

    - A comparison of actual accomplishments with the goals and objectives established for the period, the findings of the investigator, or both. Whenever appropriate, and when the output of programs or projects can be readily quantified, such quantitative data should be related to cost data for computation of unit costs.
    - Progress made toward established benchmarks and result indicators of development impact, as discussed in the program description of this RFA and detailed in the Recipient's PMP.
    - Reasons why established goals were not met, if appropriate.
    - Other pertinent information including, when appropriate, analysis and explanation of cost overruns or high unit costs.
    - In addition, qualitative descriptions of success stories and achievements to illustrate impacts of the program must be included when possible.
    - Summary information on capacity training investments to include, but not limited to, number of Ph.D. candidates and M.Sc. candidates, candidates' countries of origin, and institutional affiliations during training (U.S. host institution and host country partner institution(s) involved in student training)