Semi-Annual Report: Feed the Future Innovation Lab for Food Processing and Post-Harvest Handling
Reporting Time Period: October 1, 2018 to March 31, 2019

I. Name: 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) progress in Kenya and Senegal in the drying and storage component of the project included the following: 1) Concluded studies to evaluate the effectiveness, consumer demand, and willingness to pay for the hygrometer and DryCard, 2) Working to commercialize an improved version of the hygrometer, 3) Field tested the Picosolar crOp Dryer (POD) solar dryer, 4) Trained and supported 3272 persons for drying and storage technologies, and 8 persons on aflatoxin analysis, and 5) Assessed the effects of pre-harvest biocontrol-treatment of maize on postharvest risk of aflatoxin accumulation. In the processing and nutrition component of the project, progress included: 1) A sensory study of thick and thin porridges was completed in Senegal on the final four formulated nutrient-fortified extruded instant flours, 2) Completed product development to generate 5-10 concepts with whole grain millet, sorghum, and maize, 3) Specification sheets have been completed for final formulations of nutrient-fortified instant flours, 4) Completed market study and sensory preference study in Kenya of developed whole grain and blended fortified products, 5) Worked with entrepreneurs to disseminate extrusion technology, and 6) Started clinical trial to test iron bioavailability in nutrient-fortified flours with natural plant fortificants.

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

Activity 1.2: Develop a low-cost moisture determination method

1) **Name and description:**
Activity 1.2.3: Compare the measurement of maize moisture using the hygrometer, the USDA-ARS probe, and the commercial John Deere Model SW5300
2) **Progress:**
Activity 1.2.3: The hygrometer and DryCard were evaluated for their effectiveness and consumer demand. We are working to commercialize the hygrometer in Kenya and Senegal and have improved the design of the hygrometer by adding a simple plastic jar for it (see Figure 1 in Attachment). We are branding the device as the Purdue Improved Moisture Assessment (PIMA).

Activity 1.3: Develop low-cost grain drying technologies for smallholders:

1) **Name and description:**
Activity 1.3.2: Implement field testing of POD solar dryer on research stations and with partner organizations including with farmers in Kenya.
Activity 1.3.3: Implement field testing of solar drying options with partner organizations including farmer associations and food processors in Kenya and Senegal.
Activity 1.3.4: Launch designed multipurpose drying dray (DEHYTRAY) to market.
Activity 1.3.5: Develop multipurpose dryer (the large unit) toward commercial manufacturing and pilot test for commercialization.
2) **Progress:**
Activity 1.3.2: KALRO tested the POD in five sites in Kenya: Nakuru, Uasin Gishu, Trans Nzoia, Nandi, and Bungoma. Results in Trans Nzia suggest that up to 12% moisture content was removed in 10

hours using the POD. In Uasin Gishu up to 10% moisture content was removed in 2 hours under favorable conditions.

Activity 1.3.3: This activity is ongoing in both Senegal and Kenya.

Activity 1.3.4: The technology has been launched by Klein Ileleji's company, JUA Technologies.

Activity 1.3.5: This is in process in both Kenya and Senegal. In Senegal, we training and supporting youth and women groups for drying and storage technology distribution and service providing, in cooperation with the ANCAR extension agents.

Activity 1.5: Assess potential for aflatoxin development in hermetic bags

1) **Name and description:**

Activity 1.5.2: Determine effect of Aflasafe treatment of maize on fungal populations and aflatoxin accumulation in hermetic storage.

2) **Progress**:

Activity 1.5.2: In process. Charles Woloshuk and Sharon Kinyungu at Purdue are assessing effects of pre-harvest biocontrol-treatment of maize on postharvest risk of aflatoxin accumulation (i.e., maize with and without Aflaguard biocontrol treatment). Results showed that for maize at 20% moisture content, fungi, including *A. flavus*, grew and spread rapidly. Both aflatoxigenic and non-aflatoxigenic strains of *A.flavus* increased during the incubation period. The presence of biocontrol strains did not appear to influence the growth or aflatoxin production by wild-type strains.

Activity 1.6: Socio-economic assessment of grain drying and storage alternatives for smallholder farmers, farmer associations, small-scale grain traders and food processors in Senegal and Kenya

1) **Name and description:**

Activity 1.6.1: Conduct endline survey on drying moisture determination and storage practices in Kolda and Velingara, Senegal.

Activity 1.6.2: Conduct endline survey on drying moisture determination and storage practices in Kakamega, Kenya.

Activity 1.6.3: Finish open-air drying study and compare open-air drying economics with other dryers on market in Kenya.

Activity 1.6.4: Work with existing and newly collected data to understand gender impacts of drying and storage in Kenya and Senegal.

2) **Progress:**

Activity 1.6.1: In process. 2,000 households in Velingara who were trained and received post-harvest inputs are being re-surveyed and aflatoxin samples are being taken. Goal is to see if benefits last longer and if there is spill-over information occurring to other households in these communities.

Activity 1.6.2: Completed. The main objective of the study in Kakamega was to assess the willingness to pay and the level of adoption for the hygrometer from Purdue Univ. and the DryCard™ from the Univ. California, Davis, two years after an initial willingness-to-pay auction was conducted in 2017 with the same respondents. On average, respondents were willing to pay 120 KSH ($1.20) for the hygrometer and 90 KSH ($.90) for the DryCard™. When asked which device the respondent would prefer to purchase at their own value of both devices, 73% said they would prefer the hygrometer, even at a higher price.

Activity 1.6.3: In process.

Activity 1.6.4: The FPL Gender Specialist is working with the drying and storage team: 1) to combine data collected in Vélingara, Senegal, from the initial gender study with that collected in January 2019 for a gender-based analysis, toward a peer-reviewed publication, and 2) to publish

drying and storage findings from focus group discussion data collected in Kenya and Senegal (manuscript being prepared for *World Development*).

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

Activity 2.1: Identify, develop, and test cost effective, bioaccessible, and commercially relevant fortified millet and maize/sorghum products

1) **Name and description:**
Activity 2.1.1: Complete consumer preference and market testing of fortified instant products.
Activity 2.1.2: Cost analysis of products and manufacturing to provide a range of costs to entrepreneurs.
Activity 2.1.3: Conduct shelf-life studies of millet-based ready-to-eat products through descriptive sensory evaluation and identification of factors responsible for product shelf-life
Activity 2.1.4: Complete product development work on whole grain, including their stability (shelf-life), and feasibility in the Senegal and Kenya markets.
Activity 2.1.5: Create specification sheets and manufacturing dossiers for each formulated product.
Activity 2.1.6: Conduct studies on use of extrusion processing to improve dietary fiber quality of instant products.

2) Progress:
Activity 2.1.1: In Senegal, a large sensory study was completed on the final four formulated nutrient-fortified extruded instant flours, and were tested in thin and thick porridges. Results are being analyzed. In Kenya, a point-of-sale market test (~240 participants) was conducted on the final two formulated fortified instant flours to understand consumer acceptability and interest. Results are being analyzed.
Activity 2.1.2: Progress has been made on cost analysis of food material ingredients for products developed for Senegal.
Activity 2.1.3: Not started yet.
Activity 2.1.4: Product development work has been completed generating 5-10 concepts leveraging whole grain millet, sorghum, and maize in Kenya and Senegal. Nutritional analyses have been completed for those leveraging food-to-food fortification in Senegal and are pending for Kenya.
Activity 2.1.5: Specification sheets have been completed for final formulations of nutrient-fortified instant flours in Kenya and Senegal.
Activity 2.1.6: Study on extrusion processing on whole grain dietary fibers has begun at Purdue.

Activity 2.2: Complete studies to understand drivers of consumer markets

1) **Name and description:**
Activity 2.2.1: Complete consumer preference and market studies on fortified instant products in Eldoret and Dakar.
Activity 2.2.2: Complete study to determine acceptability of whole grain and blended fortified products in Dakar.

2) **Progress:**
Activity 2.2.1: Market study was completed in Kenya and results are being analyzed. In Senegal, the market study is scheduled for summer 2019.
Activity 2.2.2: Sensory preference study was done on whole grain and blended fortified products in Dakar, Senegal; but a yet to be done market study is needed to complete the understanding of

acceptability of whole grain products in the Dakar market. Sensory preference data are being analyzed.

Activity 2.3: Further develop and disseminate processing and nutrition fortification technologies to entrepreneurs in the private sector

1) **Name and description:**
Activity 2.3.1: Work with entrepreneurs in Touba, Senegal as a model for disseminating extrusion technology; work toward scaling-up of millet processing to other regions.

2) **Progress:**
Activity 2.3.1: Meetings were held in March with Mme. Mbacke from Touba, C. N'Diaye, D. Traore, and B. Hamaker with Senegalese government officials regarding increasing processing capabilities. A meeting at ITA was also held with the director of Cellule de Lutte Contre la Malnutrition (CLM) regarding processing and increase of capacity for nutrient-fortified extruded instant flours.

Activity 2.4: Research and evaluate ways to increase micronutrient amount and bioaccessibility in nutrient-rich plant materials; consider value chains

1) **Name and description:**
Activity 2.4.1: Execute a clinical trial in Kenya to assess method of increasing bioavailability of iron.

2) **Progress:**
Activity 2.4.1: The clinical trial with ~20 participants started in late March at University of Eldoret, Kenya and at the University of Moi-AMPATH clinical unit to test iron bioavailability in nutrient-fortified flours with natural plant fortificants that are hypothesized to increase bioavailability.

B. Issues or concerns encountered during the reporting period

There was a four and half months delay in the release of 2018/19 fiscal year funding from USAID, which affected many project activities. All PIs were informed of the imminent delay, and were 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	Number Trained		
			M	F	Total
Kenya	Training and offer to purchase moisture detection service	Traders in Uasin Gishu	81	118	199
Kenya	Training on drying and storage technologies	Farmers – Field Day Exhibition, Jan. Extension training, Nandi County, Apr.	TBD 103	TBD 139	220 242
Senegal	Training on drying and storage technologies, and on aflatoxin analysis	Trainer – drying & storage Farmers – drying & storage Technicians – aflatoxin analysis	12 1714 6	2 883 2	14 2597 8
Kenya	Training on entrepreneurship and cereal processing	Students and youth	32	8	40

B. Long-term training

Name (first, last)	Sex	University	Degree	Major	Program End Date	Degree Granted	Home Country

Emmanuel Ayua	M	Purdue Univ.	PhD	Food Science	May 2020	No	Kenya
Pablo Torres Aguilar	M	Purdue Univ.	PhD	Food Science	Dec. 2019	No	Ecuador
Stacy Prieto	F	Purdue University	PhD	Agricultural Economics	Aug. 2018	Yes	USA; now employed by Catholic Relief Services
Hira Channa	F	Purdue Univ.	PhD	Agricultural Economics	May 2019	No; defense scheduled	Pakistan; has accepted job offer with World Bank
Amanda Fuller	F	Purdue Univ.	MS	Agricultural Economics	Aug. 2019	No; defense scheduled	USA
Laura Leavens	F	Purdue Univ.	MS	Agricultural Economics	Aug. 2020	No	USA
Sharon Wanjiru Kinyungu	F	Purdue Univ.	MS	Plant Pathology	Aug. 2019	No; defense scheduled	Kenya

IV. Innovation Transfer and Scaling Partnerships[5]

- See Activity 1.3.4. Dry Trays now available for sale under JUA Technologies (technologies developed under FPL). Women and Youth groups being trained in Velingara to provide drying and storage services to smallholder households.
- 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.
- A follow-up high-level meeting among, government of Senegal officials and FPL/ITA was held in March 2019 to further discuss increasing extrusion capacity and scaling-up of the "hub and spoke" incubation model to other regions in Senegal.

V. Future Work (for Year 6 in Phase II)

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

Activity 1.1: Train farmers and traders, on best practices for harvesting, drying and storage, using most cost-effective moisture testing, drying, and storage technologies.

Activity 1.2: Work with private-sector in Kenya and Senegal to scale up most cost-effective moisture testing, drying, and storage technologies.

Activity 1.3: Assess pre-harvest and post-harvest interventions to reduce aflatoxin in maize (in Kenya).

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

Activity 2.1: Develop and test cost effective, bioaccessible, and commercially relevant fortified millet and maize/sorghum products.

Activity 2.2: Understand drivers of consumer markets for fortified cereal grain products.

Activity 2.3: Develop and disseminate information on processing and nutrient-fortification technologies to entrepreneurs in private sector.

Activity 2.4: Evaluate ways to increase the micronutrient amount and bioaccessibility in nutrient-rich plant materials in formulated fortified foods, and assess their nutritional impact.

ATTACHMENT

Figure 1: Purdue Improved Moisture Assessment (PIMA)

Complete Description of Activity 1.6.2:

The main objective of the study in Kakamega was to assess the level of adoption interest for the hygrometer from Purdue University and DryCard™ from the University of California, Davis two years after an initial willingness to pay auction was conducted in 2017 with the same respondents. We conducted the same willingness to pay auction again to measure demand two years later for the devices. On average, respondents were willing to pay 120 KSH ($1.20) for the hygrometer and 90 KSH ($.90) for the DryCard™. When asked which device the respondent would prefer to purchase at their own value of both devices, 73% said they would prefer the hygrometer, even at a higher price.

Of our 300 respondents, 74 (50) had purchased a hygrometer (DryCard™) in 2017. Out of these respondents, 66% (62%) still use the device, 23% (24%) have used the device previously, but no longer use it, and 11% (13%) reported never using the device. Of the respondents who no longer use, or never used, their hygrometer, 46% indicated this was because the device was lost and 42% said the battery had died. For the DryCard™, 59% of respondents who do not use their device currently said the device had been lost.

To test if there is potential for hygrometers to be part of the third-party, service provider business model, we surveyed small- and medium-sized maize traders throughout Uasin Gishu county, a major maize producing region of Kenya. Despite the large maize production, very few traders of this size have access to moisture content testing devices. We surveyed 199 maize traders throughout the county and offered them a chance to purchase two moisture testing services – the first used a hygrometer to test relative humidity, and the second used a commercial moisture meter to test moisture content directly. The majority of traders (85%) in our sample buy from farmers and sell to consumers. Along this value chain, there is no reliable method of moisture testing, creating risk for the farmers, traders, and consumers. Targeting this point in the value chain can inform farmers and traders about their drying practices, and create trust with consumers that the maize they purchase is reliably safe from aflatoxins.

On average, traders were willing to pay 28 KSH ($.28) for the hygrometer moisture testing service, and 39 KSH ($.39) for the commercial moisture meter testing service. Anecdotal evidence suggests the demand would be even higher directly after harvest when most drying occurs, from September through December. Only 10% of respondents were still purchasing wet maize in March when surveys were conducted. Even so, there was general interest in such a service in the dry season as there is no accurate method for testing exact moisture content. Most respondents (83%) preferred the commercial moisture meter service to the hygrometer service, even at a slightly higher price. We attribute this strong preference to the time difference for the two services. While the hygrometer takes 15 minutes to calibrate, the commercial moisture meter provides instant readings.