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Year 6 Accomplishments for Drying and Storage

and plans for future work

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Co-PIs: Ibrahima Sarr (ISRA); Patrick Ketiem (KALRO); Hugo De Groote (CIMMYT)
Jonathan Bauchet, Richard Stroshine (Purdue);
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Students: Laura Leavens, Nina Jovanovic, Yurani Arias-Granada (Purdue)

FPIL Annual Meeting, 19 May 2020. via Zoom

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UNITED STATES AFRICAN DEVELOPMENT FOUNDATION

OBJECTIVE: HELP SMALLHOLDER FARMERS AND SMALLSCALE TRADERS DRY, STORE, SELL, AND CONSUME BETTER QUALITY MAIZE

- With lower levels of aflatoxin
- Improve food security
- Over time help increase income and make market recognize and value quality maize.

FPIL HAS MULTI-DISCIPLINARY STRENGTH IN DRYING AND STORAGE

- Committed to drying and storage innovations for the smallholder farmer and small-scale trader in SSA.
  - These people are the majority of the population
  - Improving their income and resiliency drives rural development.
- Our technologies and innovations reflect this focus.
- We take extension and scale-up/commercialization of innovations seriously.

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PHASE I (2014-2019) FOCUS ON DEVELOPING & EXTENDING TECHNOLOGIES

- Combination of PH practices to improve food safety and food security
  - Training on best practices
  - Drying technologies (POD, DEHYTRAYS, tarps)
  - Moisture assessment (hygrometer, drycard)
  - Storage (hermetic bags)
- Conducted Extension around these technologies
  - 9,657 trained in Senegal + 3,383 trained in Kenya = **13,040 total trained**
- Began to develop supply chain
  - Distributors and retailers in both Senegal and Kenya.

PHASE II (2019-2022) FOCUS ON ECONOMIC VIABILITY AND SCALING-UP TECHNOLOGIES

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OUTLINE

I. Research (applied for development and maximum impact)
   - Kenya
   - Senegal

II. Extension (training stakeholders)
   - Kenya
   - Senegal

III. Scale-up (commercializing technologies)
   - Kenya
   - Senegal

IV. Links to Processing and Nutrition

V. Future Plans

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I.1.A) IN KENYA, IMPORTANT RESEARCH ON THE ECONOMIC VIABILITY OF PH TECHNOLOGIES

Economics of Open-air maize drying (De Groote et al. 2020)

Introduction

- Drying of maize is a challenge for farmers and commercial actors in humid tropics due to quality loss and health problems from storing wet grain
- There have been no economic analysis of dryers in the region

Objective

- Calculate the cost of open air maize drying, per bag, and per % point of moisture reduced
- Use this cost as a baseline against which to compare economic performance of solar and other dryers

Data

- Survey 125 commercial maize actors interviewed in the major maize growing areas of Kenya

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Results

- Drying is an integral part of the maize value chain
- Respondents reduced maize moisture content by 5.8 % (from 17.8% to 12%) on avg
- Average Cost = US$ 1.13 / 90 kg bag or US$ 0.22 / 90 kg bag / % moisture = **US$ 2.46 / tonne / % moisture**.
- Rate of Return (RoR) for transporting maize form purchase point to drying point + drying **= 11%**
- RoR for transporting maize from drying point to point of sale **= 24%**

Conclusions

- maize drying profits are small and profits from trading are derived in large part from spatial arbitrage.
- Alternative drying technologies therefore need to ensure they are more economical than open-air drying, by comparing their performance to open air drying using the parameters presented here.
- More advanced dryers may be better for food safety but may require gov't intervention to be viable for drying maize.

I.I.B) IN KENYA, THE CASE FOR THIRD PARTY MOISTURE TESTING

Fuller and Ricker-Gilbert (2020)

Purpose was to assess demand for a third-party moisture reading service.

Question: Is there a business case for people to sell this service vs. buying individual devices?

- Cheaper, removes bias from mistrust of trading partners
- Elicited traders' willingness to pay (WTP) for a hygrometer service and a commercial-grade moisture meter service
- Site: Uasin Gishu County – major maize producing area and maize trading hub (Eldoret)
- Focus: small- and medium-scale maize traders
- 199 traders surveyed across 6 sub-counties

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Devices

Hygrometer
$2.50 (250 KSH)

10 – 15% of small-scale farmer and trader population willing to buy at this price (Channa et al. 2020)

Agra-Tronix MT-16
$170 (17,000 KSH)

Only large-scale commercial actors buy at this price

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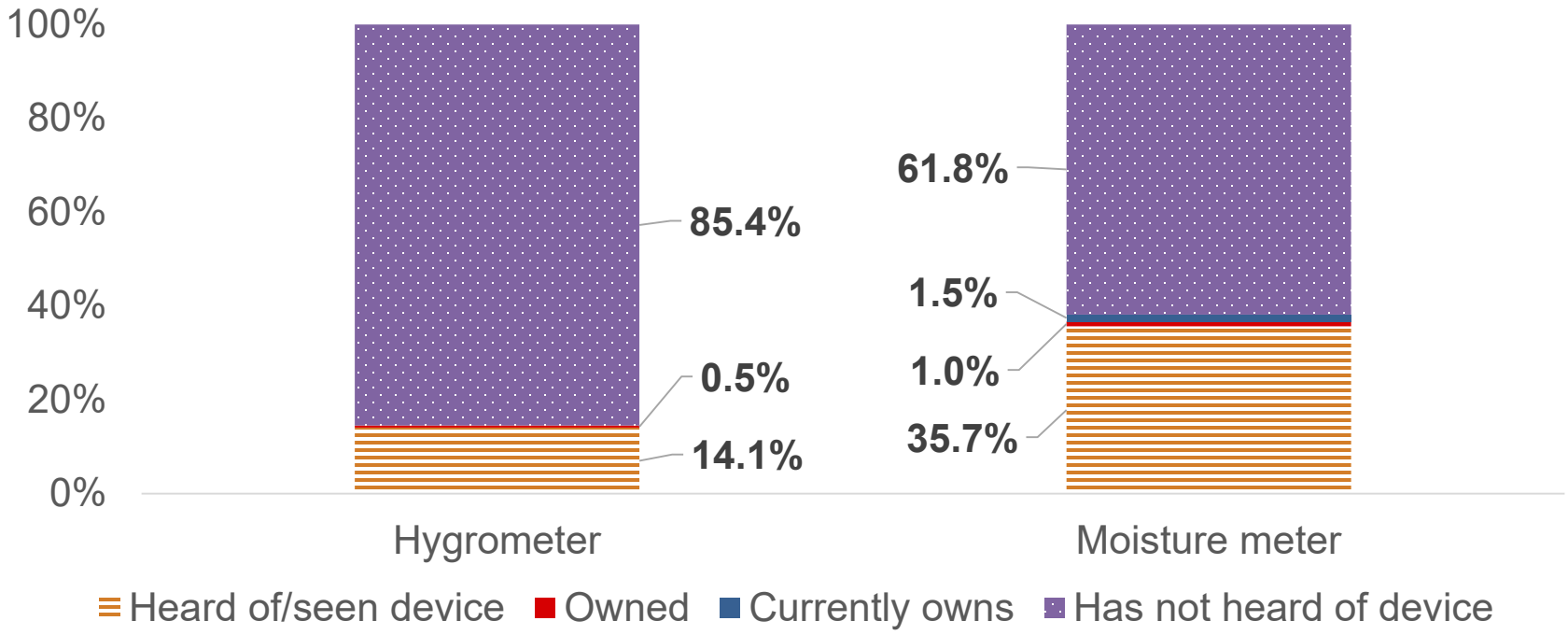
Prior Exposure to Hygrometer and Moisture Meters



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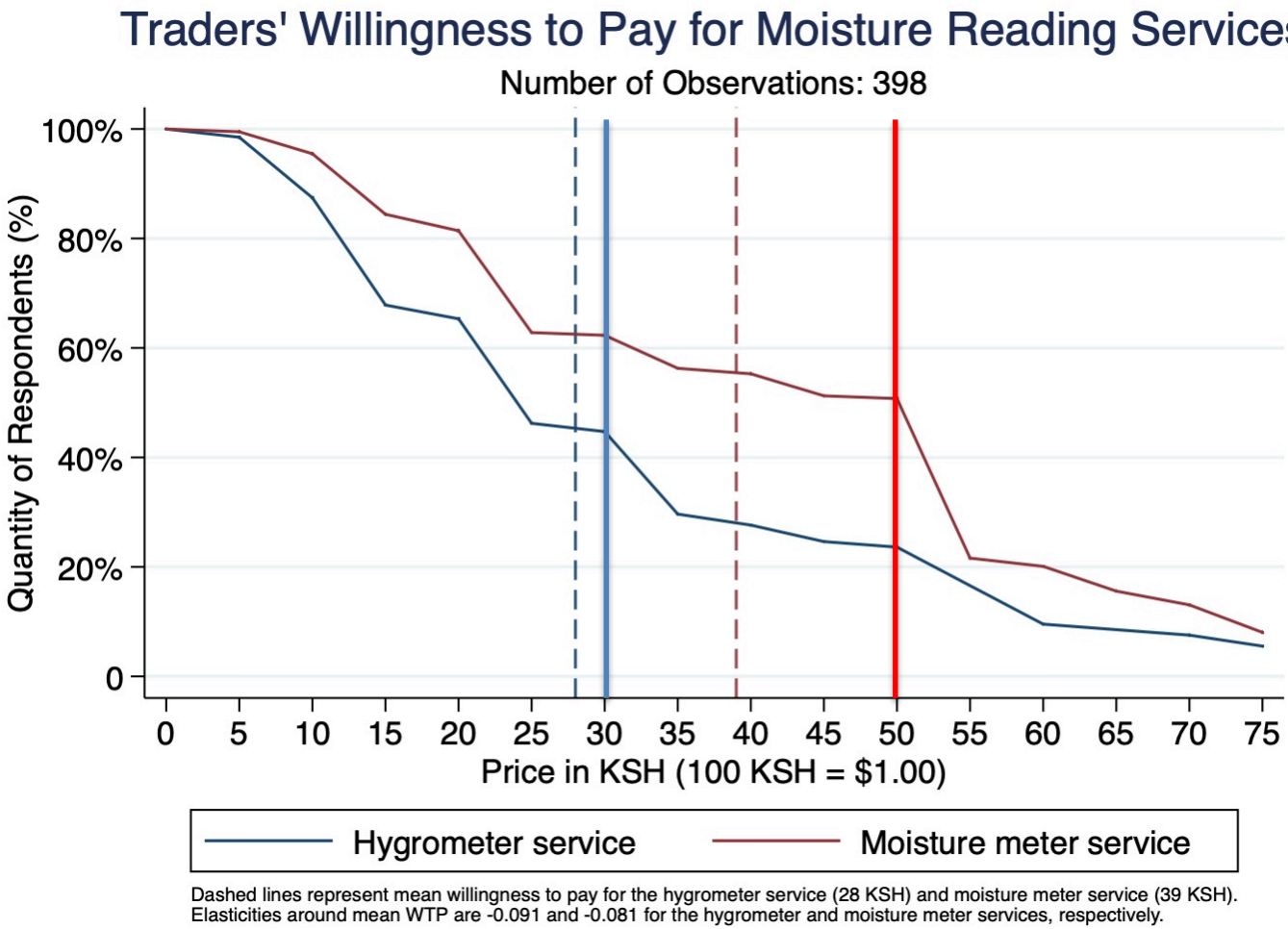

Hygrometer reading
Mean WTP = 28 KSH
Profit max price = 30 KSH

MM reading
Mean WTP = 29 KSH
Profit max price = 50 KSH

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Calculating break-even point

at revenue-maximizing price level

Hygrometer

- Cost (5 hygrometers) = **1,250 KSH**
  - Allows service provider to take 5 samples of maize at one time
- Revenue-maximizing price = **30 KSH**
- Break-even point = **42 readings**

- At a 45% success rate at this price, service provider would need to find only **95 potential customers to break-even**

Moisture meter

- Cost (1 MM) = **20,000 KSH**
  - Assuming some import taxes, this cost is likely a low estimate
- Revenue-maximizing price = **50 KSH**
- Break-even point = **400 readings**

- At a 51% success rate at this price, service provider would need to find **785 potential customers to break-even**

Conclusions

- Third-party service provider model:
  - Removes potential mistrust of devices owned by trading partners.
  - Traders are more receptive to the moisture meter service, but hygrometer service is more profitable based on cost ($2.50 vs. >$170)
  - Hygrometer service offered at a lower price ($0.30) is more profitable than moisture meter service ($0.50)
  - Seems to be a viable way to get moisture tested for more people, compared to them buying at US $2.50

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I.2) IN KENYA, PRE-HARVEST & POST-HARVEST INTERVENTIONS FOR REDUCING AFLATOXIN

(JOVANOVIC ET AL 2020)

Two main ways aflatoxin contaminates maize

- Pre-harvest in the field
- Post-harvest during drying and storage

Design an intervention to test most cost-effective intervention point and complementarity between pre-harvest and post-harvest interventions among farmers in eastern Kenya

- Pre-harvest treatment (Aflasafe)
- Post-harvest treatment (plastic tarps)
  (choices based on Hoffmann et al. 2019)

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1.3) IN SENEGAL, MEASURING LONGER-TERM IMPACTS OF PH TECHNOLOGIES AT REDUCING AFLATOXIN

- Leavens (2020)
- Follow up to earlier study from 2016/17 by Prieto, Bauchet and RG (2020)
- RCT in Velingara, farmers given training and PH inputs in attempt to reduce aflatoxin in stored maize.
- Training and PICS found to have biggest impact in 2017
- Leavens followed up in 2019

What should farmers do to prevent aflatoxin contamination In post-harvest?

Our intervention: set of training and package of technologies. Enough to store roughly one acre harvest ≈ 500 kilograms (total cost of technologies ≈ $15)

1) 

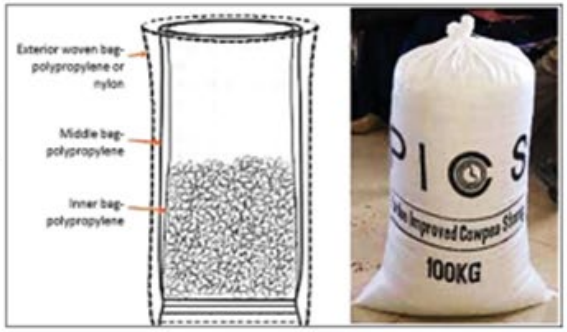
Training on good post-harvest practices

2) 

$3.00 per 5 x 2 m

3) 

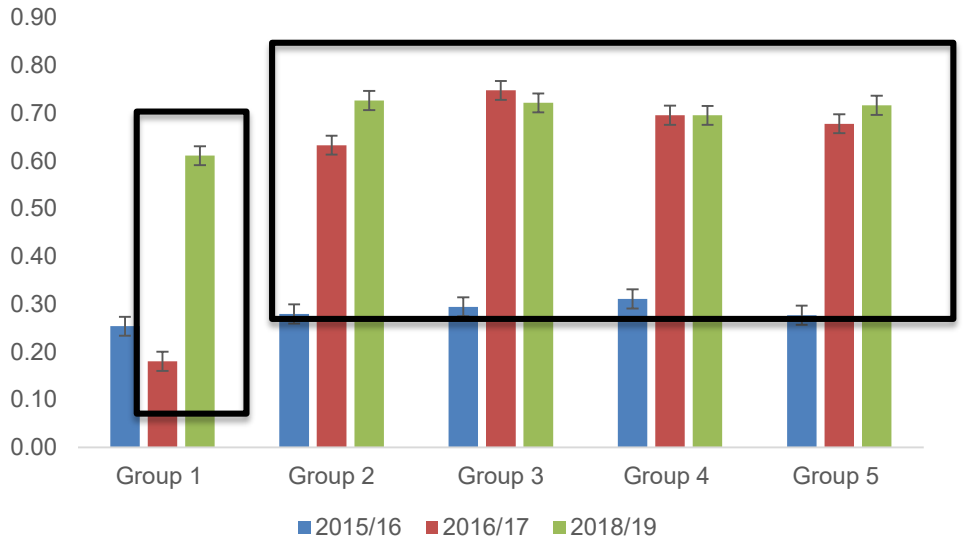
$2.50 per device

4) 

$2.00 per 100 kg bag

RESULTS: AFLATOXIN AWARENESS

Aware that aflatoxins are toxic by year and treatment group



Group 1 = control; Group 2 = training; Group 3 = 2) + hygrometer; Group 4 = 3) + tarp; Group 5 = 4) + PICS

- Training increased awareness in groups besides the control in 2016/17
- Informal information sharing increased awareness for the control group in 2018/19

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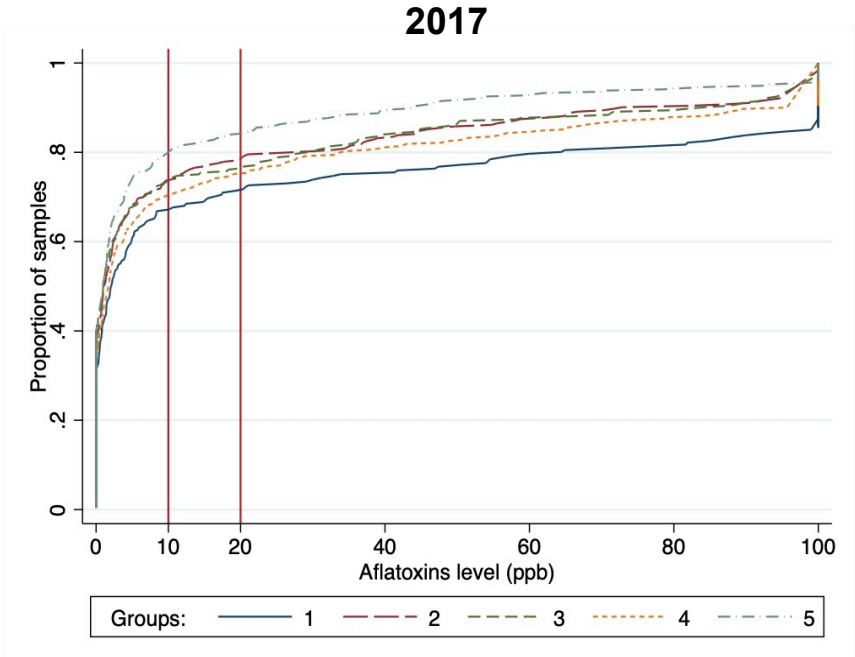
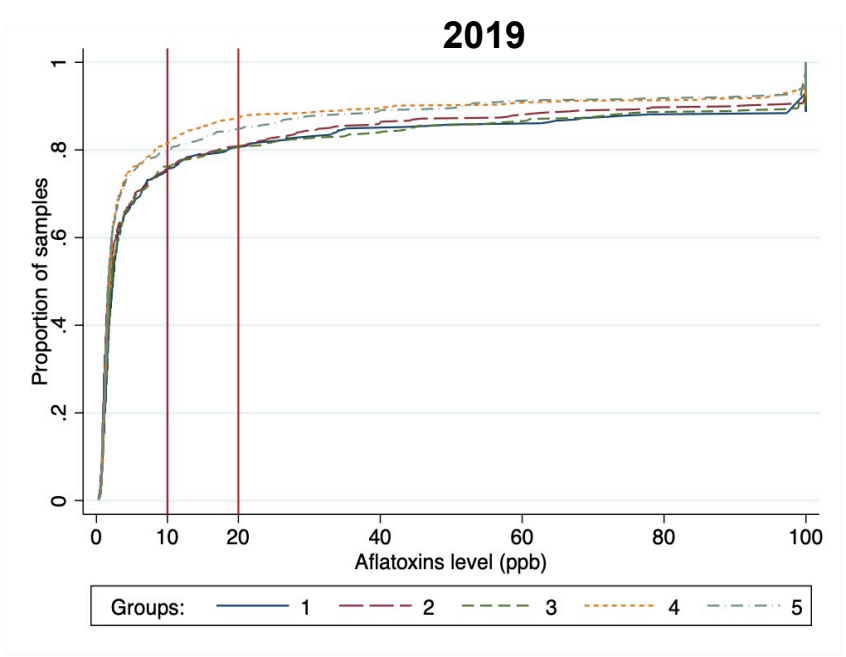
DISTRIBUTION OF AFLATOXIN LEVELS BY GROUPS OVER TIME





Group 1 = control; Group 2 = training, Group 3 = 2) + hygrometer, Group 4 = 3) + tarp; Group 5 = 4) + PICS

- In 2017, all groups lower than control, group 5 lower than others (training and PICS have impact)
- In 2019, groups 4 and 5 lower than others (tarp and PICS have longer term impact)
- **Gender finding: Households where women went to training had lower aflatoxin levels!**

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1.4) IN SENEGAL, MEASURING FACTORS ASSOCIATED WITH MICRO-BIOLOGICAL CONTAMINATION & AFLATOXINS IN PEANUTS (COLLABORATION WITH FSIL)

(Arias-Granda, Bauchet, and Sarr)

- Surveyed 250 smallholder groundnut producers from groundnut basin of Senegal
- Tested sampled for aflatoxin and bacterial contamination
- Goal to link this contamination to PH practices. Design intervention points.
- Survey halted in March due to Coronavirus

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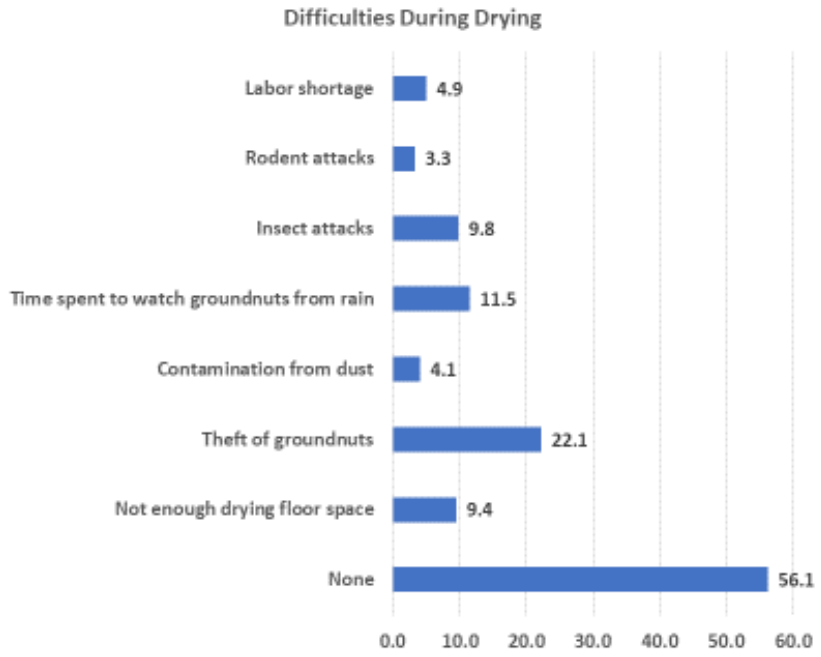
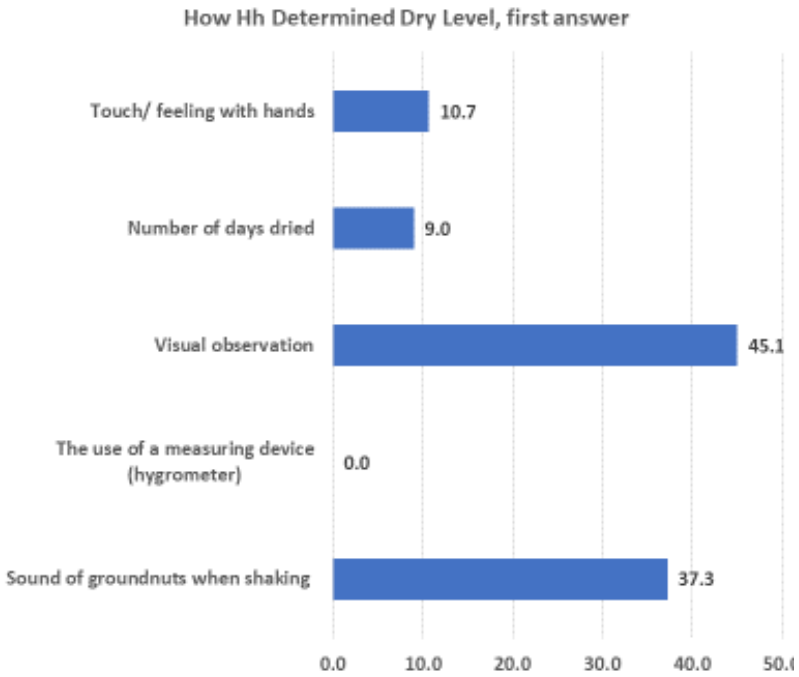
GROUNDNUT DRYING RESULTS

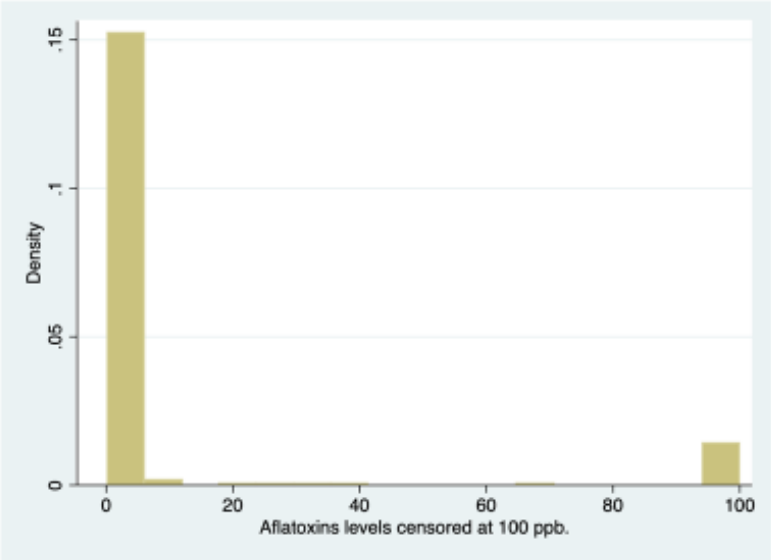
- All the households dried the groundnuts on the bare ground. They never used tarps, plastic sheets or elevated platforms.





AFLATOXIN RESULTS

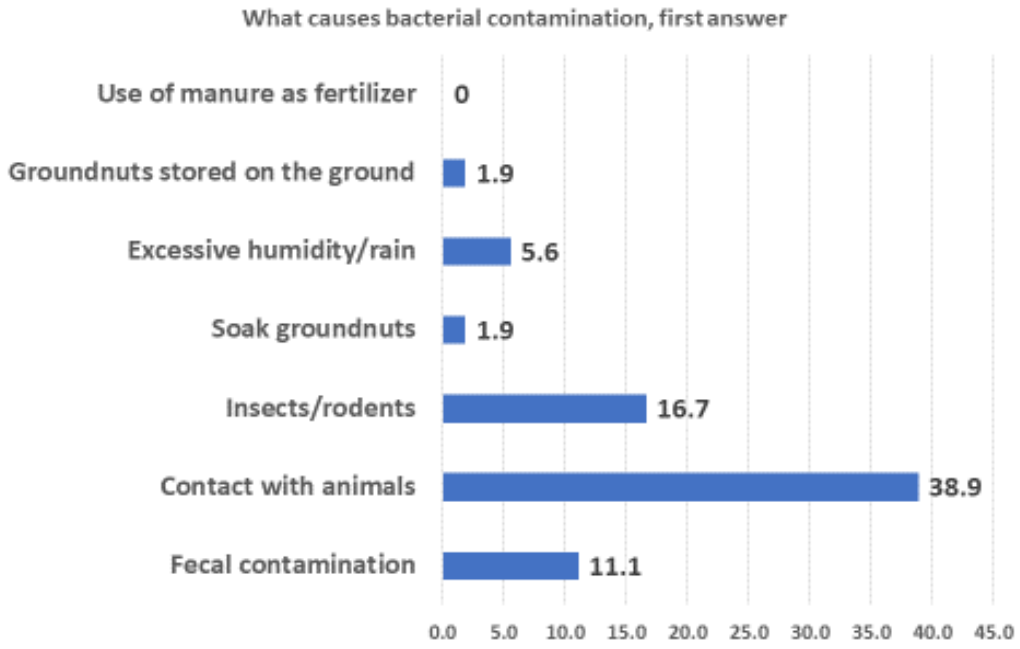
Aflatoxins levels: Households



- Aflatoxins levels were very high or very low.
- All values in 100 were "over range" (above 100 ppb.)

BACTERIAL CONTAMINATION RESULTS

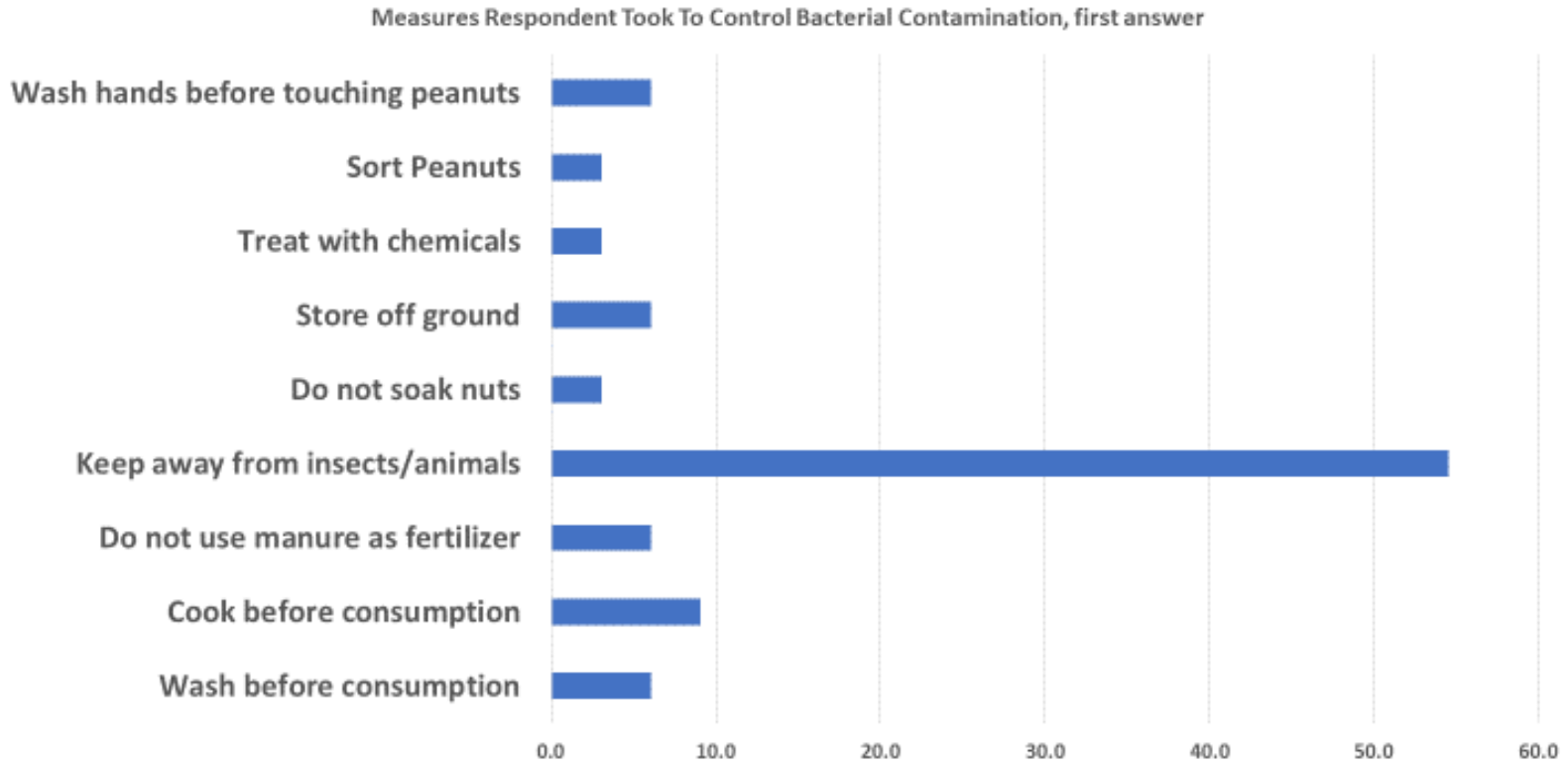
- 22% of respondents heard about bacterial contamination before this survey.
- Of those who heard about bacterial contamination, 89% indicated bacteria is harmful to human health.



Producers think contact with animals is a cause of bacterial contamination.

CONTROL OF BACTERIAL CONTAMINATION

- Of those who knew about bacterial contamination, 61% took measures to prevent bacterial contamination from affecting their groundnuts.



OUTLINE

I. Research (applied for development and maximum impact)
- Kenya
- Senegal

II. Extension (training stakeholders)
- **Kenya**
- **Senegal**

III. Scale-up (commercializing technologies)
- Kenya
- Senegal

IV. Links to Processing and Nutrition

V. Future Work

II.1 EXTENSION: IN KENYA

Year 6 Goal: Conduct at least 40 demonstrations with farmer and trader groups at local level in Kenya to train at least 2,000 farmers, traders, extension agents, and venders.

Goal Exceeded: 2,456 stakeholders have been trained on improved post-harvest practices including drying, moisture measurement and storage in Uasin Gishu, TransNzoia, and Nakuru counties.

- Plan to train more when Coronavirus restrictions lifts (Year 7).
- 11 county and national government officials have been sensitized to the FPIL technologies and trained on good post-harvest practices
- Dr. Patrick Ketiem leveraging work under FPIL to work with One Acre Fund to test different tarp specifications for food safety.
  - Goal is to change tarp standards so cheaper tarps available to farmers = increased use of tarps for drying.

II.2 EXTENSION: IN SENEGAL

Year 6 Goal: Conduct demonstrations with farmer and trader groups at local level in Kolda region of Senegal. Target 2,000 participants.

Goal in progress: 1,506 farmers were trained on drying and storage of maize in the Kolda region. Additional planned trainings had to be stopped/suspended due to COVID-19.

Plan to train more when Coronavirus restrictions lifts (Year 7).

250 groundnut farmers surveyed and trained under FSIL collaboration.

- 350 more planned post Coronavirus.

Dr. Ibrahima Sarr will return to villages in Velingara that were part of post-harvest aflatoxin intervention to disseminate results.

III.1 SCALE-UP: IN KENYA

- **Working with Bell Industries in Kenya to Scale-up hygrometer and make them available for sale in rural areas.**
  - Sold >2,000 hygrometers since 2017.
- Product bundled with tarps and PICS bags
- Conversations with other hermetic bag manufacturers to bundle

- **Exploring role for third party testing & land mile of supply chain**
- Received leveraged funds to train 300 youth to sell PH inputs in Eastern Kenya
- Funding from LASER/PUSLE ($200,000), 2020-2022
- 150 youth trained and receive access to input in each of two years.
- Go out and sell PH inputs
  - hygrometers, moisture testing, PICS bags, labor to fill and tie bags
  - potentially expand to other products. Make them agricultural service providers in rural areas.

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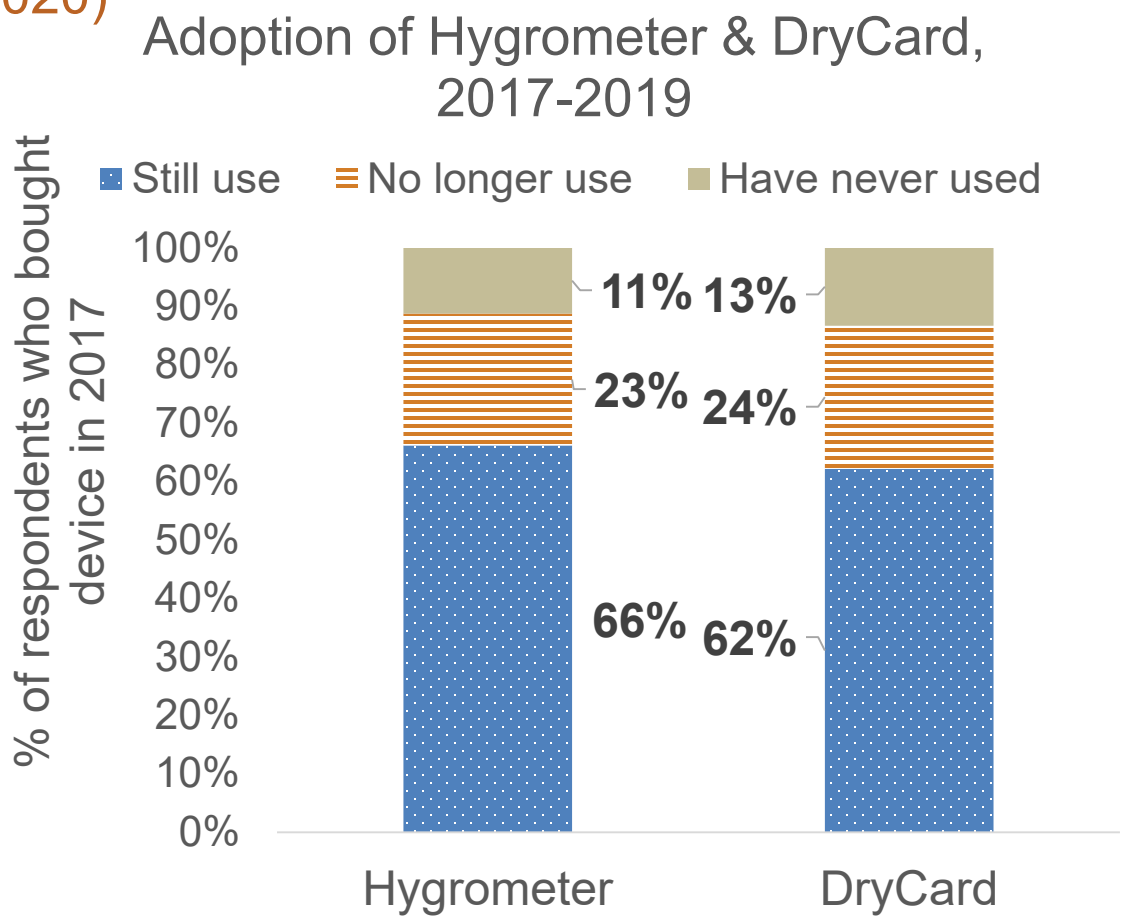
Assessing longer-term demand for Hygrometers and DryCards in Kakamega, Kenya (Fuller 2020)

Out of 300 respondents:

- 74 purchased **hygrometer*** in 2017
- 50 purchased **DryCard**** in 2017

*71 farmers responded to question
**45 farmers responded to question



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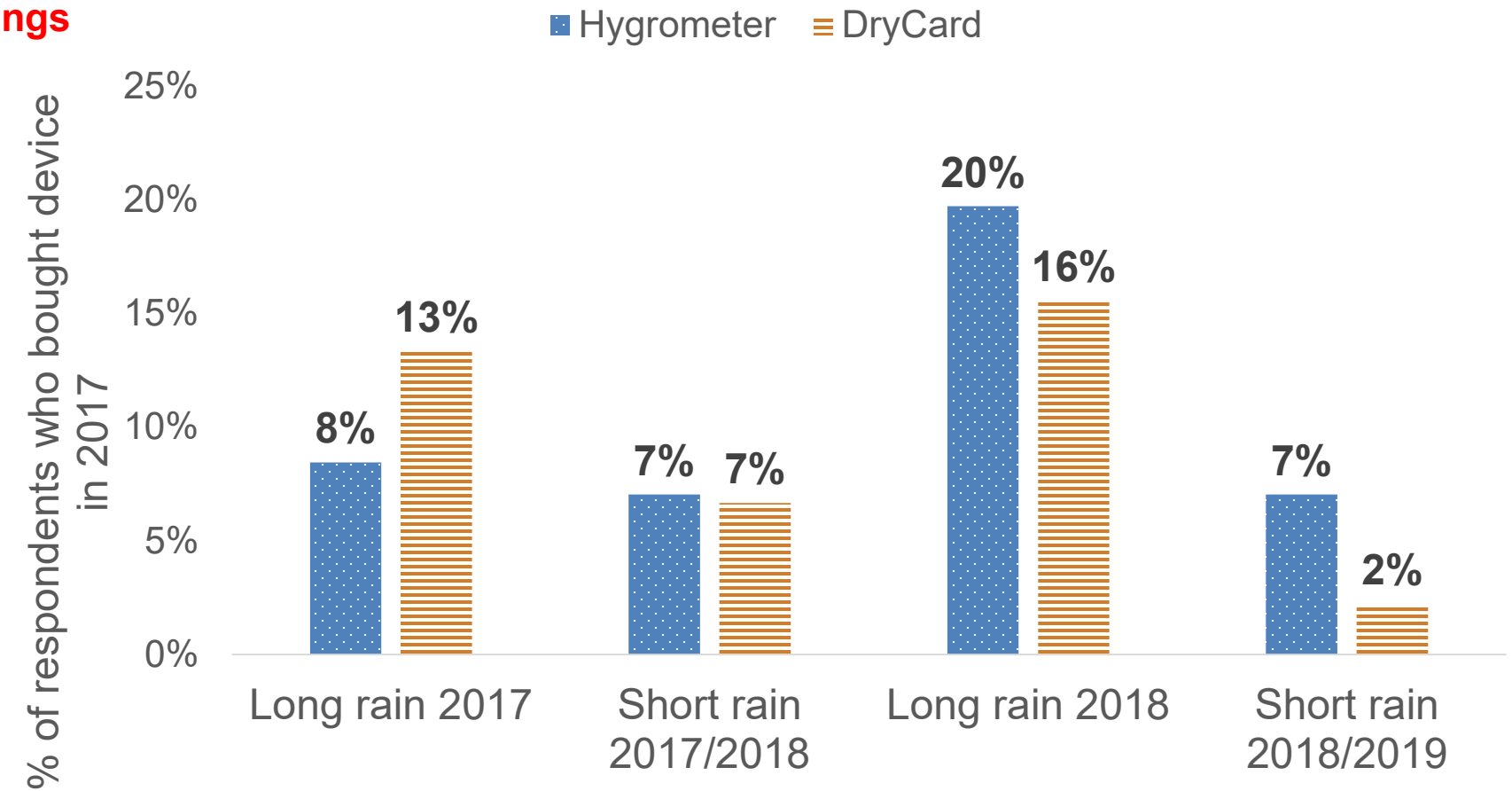
Preliminary findings

Shared device, 2017-2019



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III.2 SCALE-UP: IN SENEGAL

- **Working with SEDAB to identify venders for hygrometers in Senegal.**
- Product bundled with tarps and PICS bags
- Ordering for themselves now.

- Dr Sarr and ISRA has trained women and youth groups to offer drying and moisture testing services for farmers in Southern Senegal.

Evidence of adoption/scale up of PH technologies in Velingara in 2019

Purchased tarp	Discussed tarp	Purchased Hygrometer	Discussed hygrometer	Purchased PICS bag	Discussed PICS bag	Discussed aflatoxin
12%	36%	7%	38%	6%	39%	39%

- Based on Leavens (2020).
- PICS bags and hygrometers not available prior to 2016/2017 intervention.
- Consistent with research findings on lower aflatoxin levels and higher awareness (seen earlier).

IV. LINKS TO PROCESSING AND NUTRITION

- **Potential opportunity to increase quality and food safety in the post-harvest value chain by training farmers who supply processors on PH practices and introducing them to PH technologies.**

- Could provide processors with opportunities to access price premiums in specialty markets
  - like schools, hospitals and WFP.

- For example: In Senegal, ISRA trains Madam Mbake's farmers on recommended drying and storage of millet for better quality grain going into extruder.
- For example: In Kenya, KALRO trains farmers who supply large-scale milling companies with training on recommended drying and storage practices.

- **Has to be a market incentive (price premium) or government intervention (subsidy or regulation) for this to be sustainable.**

V. FUTURE PLANS (YEAR 7 & 8)

- **FPIL has demonstrated impact (Research, Extension and Scale-up)**
- Many papers published and in pipeline. Applied research leading to actionable decisions and recommendations.
- >13,000 trained in phase I (Years 1-5); >4,000 additional trained in year 6.
- Technologies being scaled up and plan for further scale up in future.

- **Year 7**
- Finish publications, and complete studies in progress (pre-harvest/post-harvest in Kenya, groundnuts in Senegal).
- Continue training stakeholders: 4,000 more to be trained (2,000 in each country)
- Continue scaling up and work on interventions for last mile of supply chain.
  - Youth reseller project

- Look for new opportunities to leverage FPIL knowledge to maximize impacts

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THANK YOU FOR YOUR TIME!

Questions?

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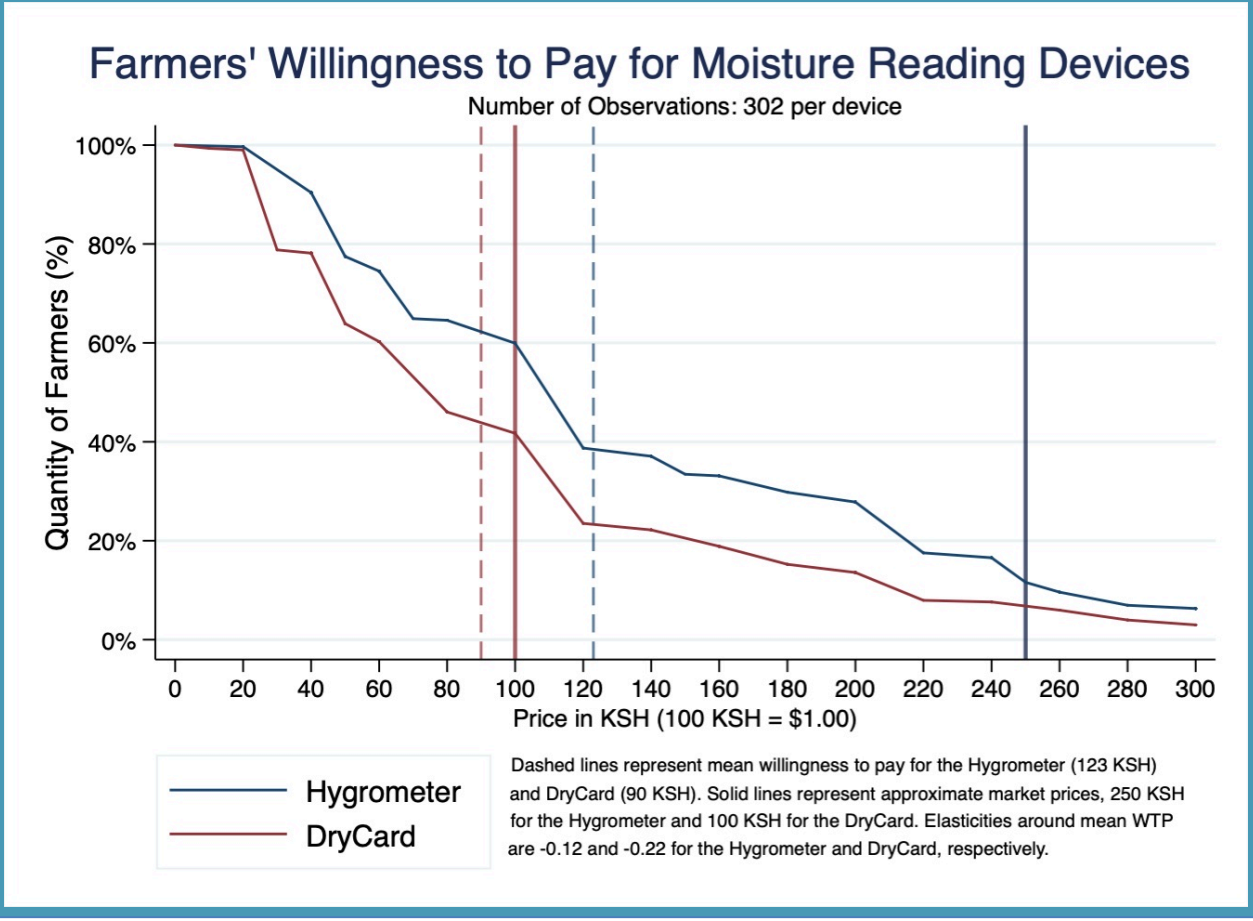
Assessing longer-term demand for Hygrometers and DryCards in Kakamega, Kenya (Fuller 2020)



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FPIL Processing-Nutrition Annual Meeting Report

May 19, 2020

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PROCESSING-NUTRITION TEAM

- Kenya – University of Eldoret
  - Violet Mugalavai, Augustino Ongware
- Senegal – Institut de Technologie Alimentaire (ITA)
  - Cheikh N'Diaye, Djibril Traore, Fallou Sarr
- University of Pretoria
  - Gyebi Duodu, John Taylor, Johanita Kruger, Riette de Kock
- CIMMYT
  - Hugo DeGroote
- Purdue University
  - Bruce Hamaker (PI), Regan Bailey
- North Carolina State University
  - Mario Ferruzzi (co-PI)

STATUS END OF PHASE 1 – KENYA & SENEGAL

- Hub-and-Spoke incubators functioning well in Senegal and Kenya
  - ITA ↔ Mme. Mbacke's unit in Touba, Senegal
    - Extruder processing of fortified instant flours for 2 years with production and sales data
    - Scaling-up planned to increase capacity and locations
  - U Eldoret ↔ local entrepreneurs
    - Training and use of processing facility, establishing markets
    - Gaining visibility
- Fortified instant flours
  - Formulations w/ natural fortificants determined – Kenya and Senegal
    - 25% of shortfall micronutrients (iron, pro-vitamin A, zinc per serving)
    - Sourcing, cost, hybrid with synthetics
    - Whole grain products emphasized
  - Sensory evaluations completed in both; market and willingness-to-pay studies done in Kenya (April 2019)
  - Bioaccessibility studies completed
- Nutrition studies
  - Clinical study on increased iron bioavailability – delayed

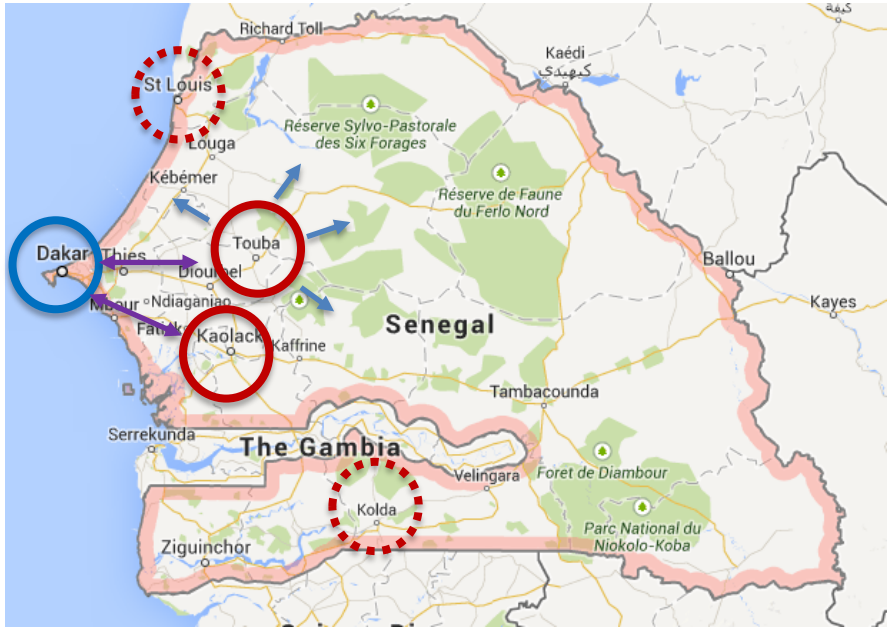
FOOD PROCESSING-NUTRITION PHASE 2 APPROACH

- Goals
  - Expand translational efforts
  - Continue research for technology-related incubation of rural and urban women and youth entrepreneur processors, and for
  - Market-led nutritional approaches

- Approaches
  - Increased emphasis on scaling up of processing of nutrient-fortified instant cereal-based porridge flours
  - Market-tracking and nutritional impact studies that will allow us to measure the impact of products in target populations
    - Market Penetration Study – Senegal
    - Nutritional Intervention Study - Kenya

HUB-AND-SPOKE INCUBATOR - SENEGAL

- Touba
  - Sells instant fortified flours to government (CLM, local), clinics, pharmacies, stores
  - 3 years of processing and sales data
    - 2019 – Jan-Sept, 140 MT, ~$330,000
  - Sells through women's "GIE" group, also some process and sell
- February 2020 – Scaling Ceremonies
  - 2nd extruder in Touba
  - New extruder and training in Kaolack
- Dialogue with Senegalese gov't (Prime Minister's office, CLM), WFP, ADB, NGOs on scale-up/expansion of incubation activities
- COVID-19 Period – Processors still processing and selling fortified instant flours



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HUB-AND-SPOKE INCUBATOR - KENYA

- University of Eldoret
  - Train and establish local entrepreneur processors
  - Part of student curriculum
  - Visibility on television and radio
  - Characterization of compositions of naturally fortified instant whole grain flour blends completed
  - Composite instant and regular flours developed, millet instead of sorghum
- Sensory and market study
  - Two fortified instant maize and sorghum-mixed porridge flours found acceptable to Eldoret consumers
  - When nutritional information was supplied with further demonstration of the instant property of the flours, participants showed an increased willingness-to-pay

Ferruzzi, Taylor, N'Diaye, DeGroote

TRANSLATION OF FOOD-TO-FOOD FORTIFICATION AND EXTRUSION TECHNOLOGY REQUIRES DETAILED GUIDANCE

- Provides a clear product description, technical specification and production plan to enable entrepreneurial adoption of FPIL technology
- Intention is for this "product manual" to be utilized by in-country partners for implementation of new product development and production as well as for education of entrepreneurs in food science, manufacturing and safety
- Will help ensure product quality, consistency and safety
- Serves as a starting point for new product development

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TRANSLATION OF FOOD-TO-FOOD FORTIFICATION AND EXTRUSION TECHNOLOGY REQUIRES DETAILED GUIDANCE

Technical Specification and Production Plan for Food-to-Food Fortified Instant Porridge Flours (Senegal)

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

Prepared by:

Cheikh N'Diaye, Institut de Technologie Alimentaire
Hawi Debelo, North Carolina State University
Mario G. Ferruzzi, North Carolina State University
John R.N. Taylor, University of Pretoria

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Ingredient	Product 1: Whole grain pearl millet, Carrot, Baobab, Mango, Moringa		Product 2: Whole grain pearl millet, Carrot, Baobab, Papaya		Product 3: Whole grain pearl millet, Carrot, Baobab, Papaya, Vitamin Mineral Premix	
	%	per 100 kg batch	%	per 100 kg batch	%	per 100 kg batch
Cereal Base						
Whole Grain Pearl Millet	72.4	72.4 kg	69.9	69.9 kg	75.4	75.4 kg
Provitamin A source						
Carrot Root Powder	14.9	14.9 kg	14.9	14.9 kg	11.9	11.9 kg
Papaya Fruit Powder			5.0	5.0 kg	7.5	7.5 kg
Mango Fruit Powder	5.0	5 kg				
Iron/Zinc source						
Moringa Leaf Powder	2.5	2.5 kg				
Baobab Fruit Pulp Powder	5.0	5.0 kg	10.0	10.0 kg	5.0	5.0 kg
Hibiscus Calyx Powder						
Vitamin Mineral Premix (mg)					0.0625	62.5 g
Minor ingredients						
Salt	0.1	100 g	0.1	100 g	0.1	100 g
Citric acid	0.1	100 g	0.1	100 g	0.1	100 g
TOTAL	100%	100 kg	100%	100 kg	100%	100 kg
Micronutrient Targets per 50 g serving of flour	mg	%NRV	mg	%NRV	mg	%NRV
Iron	3.5	25.2	3.02	21.5	3.8	27.3
Zinc	1.5	14.5	1.4	14.4	2.2	22.3
Vitamin A	276.5	34.6	284.3	35.5	295.8	37.0
Vitamin C	17.0	21.2	24.8	31.0	26.1	32.6
Calcium	36.4	4.5	47.3	5.9	39.5	4.9
Macronutrient Targets per 50 g serving of flour						
Total Energy (kJ)	829.9	9.9	819.4	9.8	834.7	9.9
Protein	6.6	13.2	6.0	12.0	12.4	24.9
Carbohydrate	38.1	14.7	38.8	14.9	38.5	14.8
Fat	2.1	3.0	2.0	2.8	2.1	3.0
Dietary fibre	6.5	26.1	7.8	31.3	6.6	26.6

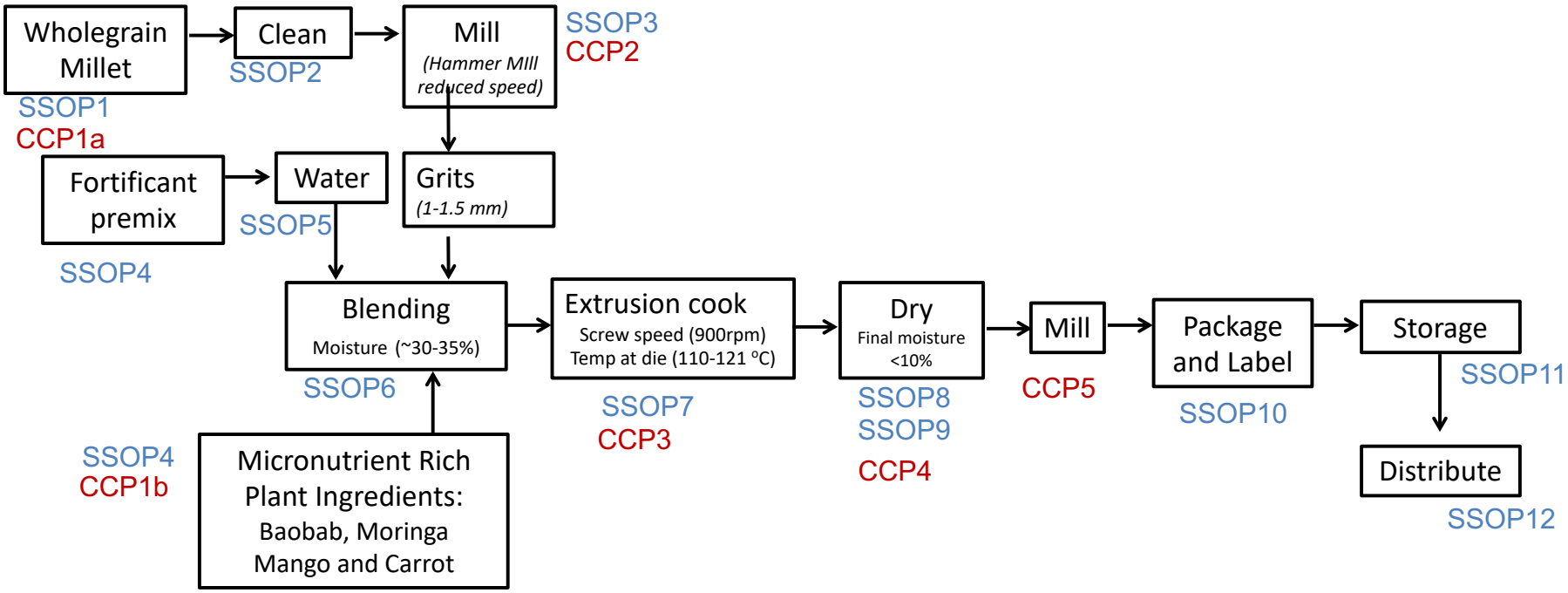
Provides guidance on:

- Raw Material Quality Specifications
- Model Formulations
- Micronutrient targets Per 50g serving of flour
- Macronutrient targets Per 50g serving of flour

PROVIDES DETAILED PROCESS DESIGN AND FLOW

Safety Standard Operation Procedures (sSOP) included for workers and product safety/quality

Preliminary Hazard Analysis and Critical Control Points for product safety



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PROVIDES GUIDANCE ON:

Instant whole grain and refined grain millet with added micronutrient premix

Instant naturally fortified product examples produced by ITA Dakar

Product Quality Control and Nutritional Labeling

	Product 1	Product 2	Product 3
Colour	Olive green	Yellow/Orange	Yellow/Orange
Aroma	Typical of cooked millet porridge Vegetative Earthy moringa aroma	Typical of cooked millet porridge Vegetative/Fruit Slight fruit aroma	Typical of cooked millet porridge Vegetative/Fruit Slight fruit aroma
Taste	Typical of cooked millet porridge Mild sweetness Characteristic moringa taste	Typical of cooked millet porridge Mild sweetness Characteristic papaya taste	Typical of cooked millet porridge Mild sweetness Characteristic papaya taste
Texture Mouthfeel	Pourable Mouth coating Fully cooked texture but with some subtle rough texture	Pourable Mouth coating Fully cooked texture but with some subtle rough texture	Pourable Mouth coating Fully cooked texture but with some subtle rough texture

Product Packaging Material and Form

Product 1 Product 3

Product Preparation Instructions

NUTRIENT	Per 100 g flour	%NRV*	Per single serving (50g four) of thin (350 g) or thick (200 g) porridge as prepared	%NRV*
Energy (kJ)	1659.9	19.7	830	
Protein (g)	13.1	26	7	
Glycaemic Carbohydrates (g)	76.2	29	38	
of which Total Sugars (g)	12.9		6	
Total Fat (g)	4.2	6.0	2	
of which Saturated (g)				
Dietary Fibre (g)	13.1	51	7	26
Vitamin A (µg)	553	70	277	35
Sodium (mg)	57.4	2.9	29	
Iron (mg)	5.4	40	3	20
Zinc (mg)	2.9	30	2	15

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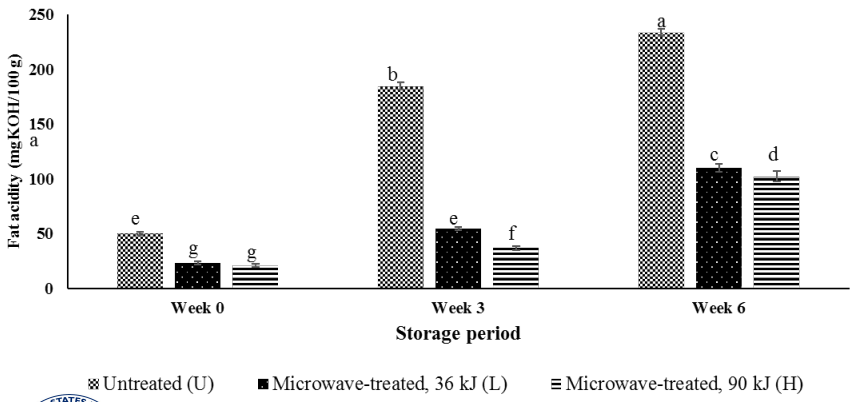
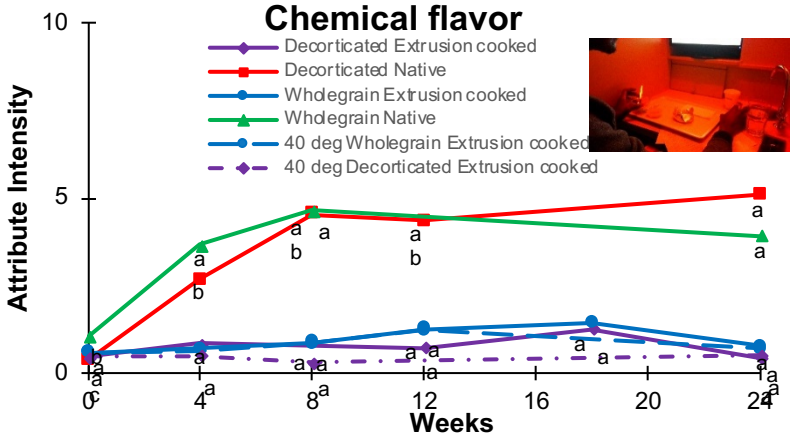
Olalekan Adebowale, Isiguzoro Onyeoziri,
John RN Taylor and Riette de Kock
University of Pretoria

- PhD student Olalekan Jimi Adebowale
- Paper submitted to intl. journal. *Stabilization of wholegrain sorghum flour and consequent potential improvement of food product sensory quality by microwave treatment of the kernels.*
  - Wholegrain sorghum kernels (WGK) were microwave heated (36 & 90kJ/100g) before milling to flour. The flour was accelerated stored at 50 °C.
  - Fat acidity of flour from microwave treated WGK reduced by 50 %.
  - An effective and practical way to stabilize WGF and thereby enhance the shelf life.



- PhD student Isiguzoro Onyeoziri
- Paper submitted to intl. journal. *Effects of extrusion cooking on the sensory profiles of pearl millet porridges prepared from stored whole grain and decorticated grain flours*
  - Extrusion cooking of pearl millet flours stabilizes the sensory profile of pearl millet porridges.
  - Extrusion cooking intensifies cereal-like flavors of pearl millet porridges.
  - Extrusion cooked pearl millet flours remain stable for 6 months at ambient and elevated temperatures.



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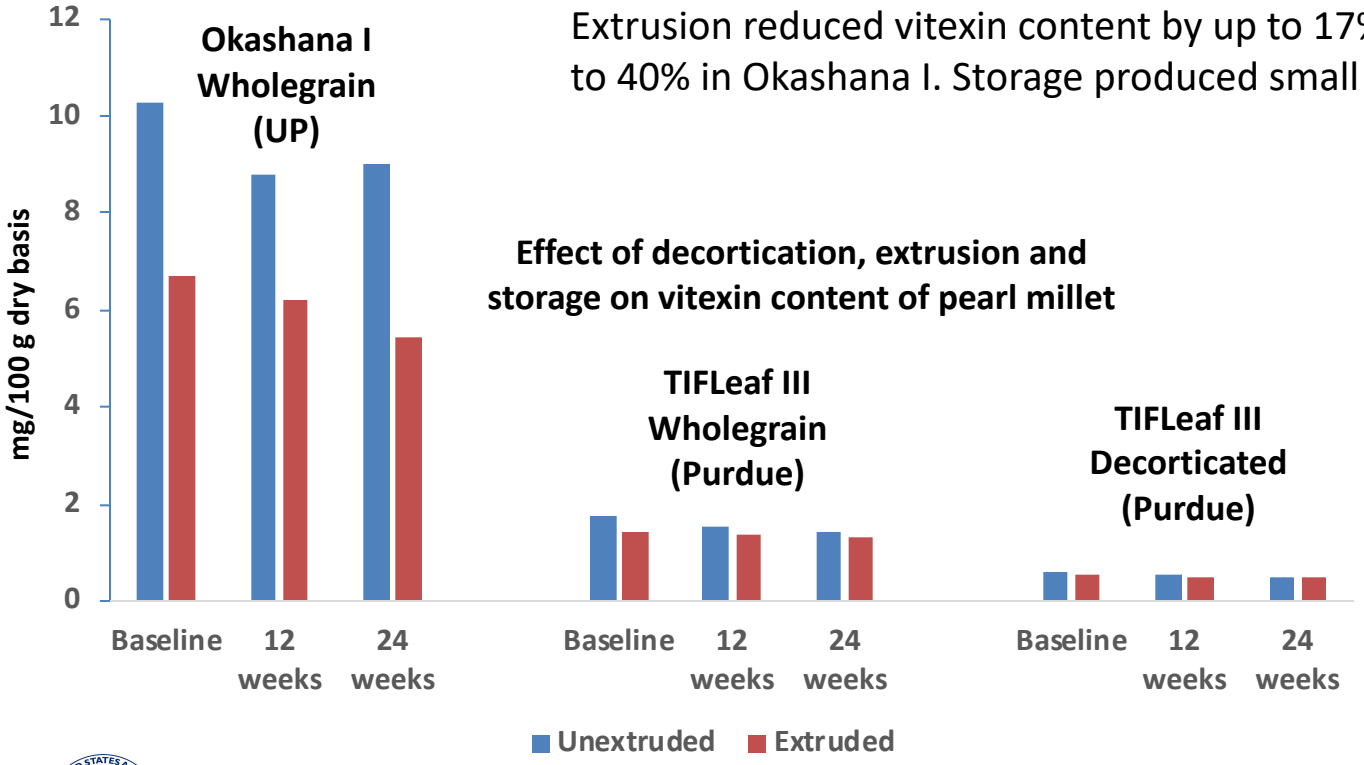
Isiguzoro Onyeoziri, Riette de Kock,
John RN Taylor and Gyebi Duodu
University of Pretoria

Effect of decortication, extrusion and storage on C-glycosyl flavones in pearl millet

Vitexin and vitexin rhamnoside were detected in Okashana I. Only vitexin was detected in TIFLeaf III
Okashana I had higher levels of vitexin than TIFLeaf III

Decortication reduced vitexin content of TIFLeaf III by up to 65%

Extrusion reduced vitexin content by up to 17% in TIFLeaf III and by up to 40% in Okashana I. Storage produced small decreases in vitexin



Levels of C-glycosyl flavones in the pearl millet samples are significantly lower than reported effective dose for goitrogenic effects

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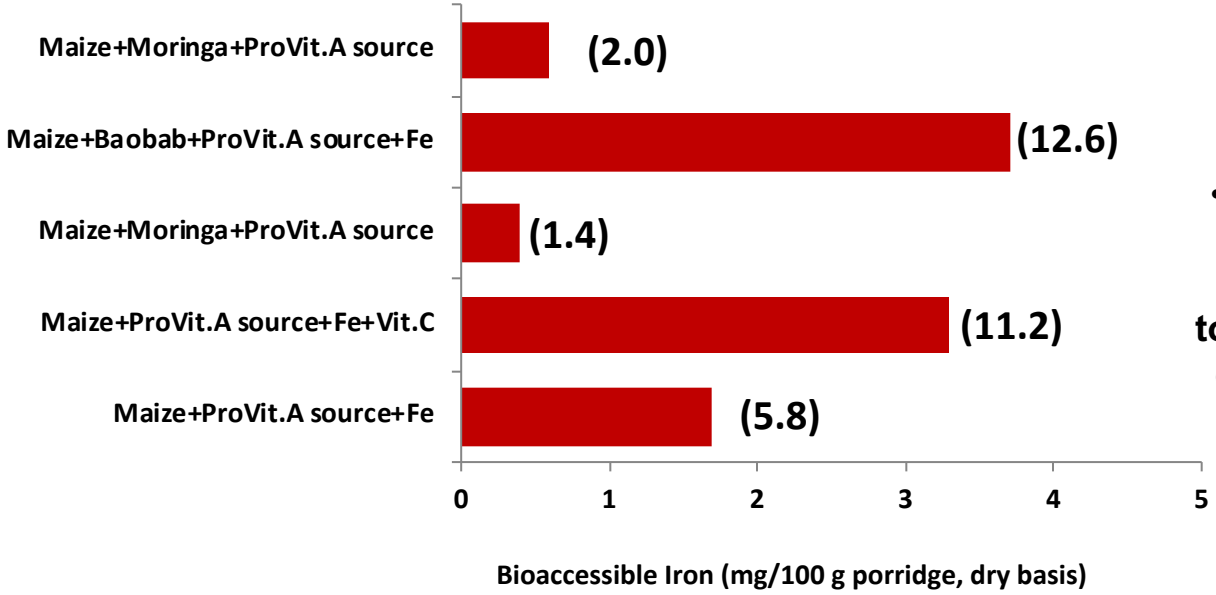
Oluyimika Y Adetola and John RN Taylor
(University of Pretoria)

Comparison of Iron Bioaccessibility of Whole Maize Porridge fortified with Moringa leaf and/or Baobab fruit versus Conventional Fortification with Fe and Ascorbic acid (Vitamin C)



- All porridges had the same iron content
- Figures in brackets are the estimated percentage contribution of one meal to the iron NRV of adult females consuming a plant-based diet of very low mineral bioavailability

- **Moringa negatively affects iron bioaccessibility, despite its high iron content**

Probably because of its high content of phenolics and calcium

- **Baobab is as effective as Vitamin C in improving iron bioaccessibility**

This is because of its high content of organic acids (citric, ascorbic and malic)

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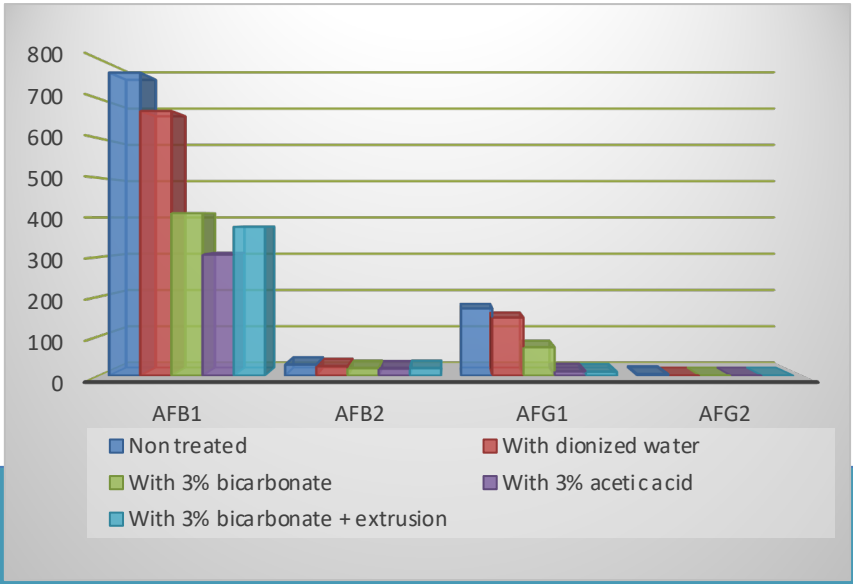
SENSORY TEST OF INSTANT WHOLE MILLET FLOUR

Panelists were not having difficulties to differentiate porridges from extruded whole millet flour and the traditional. While for extruded refined millet flour the difference was obvious. Possibility to promote whole grain flour by extrusion.

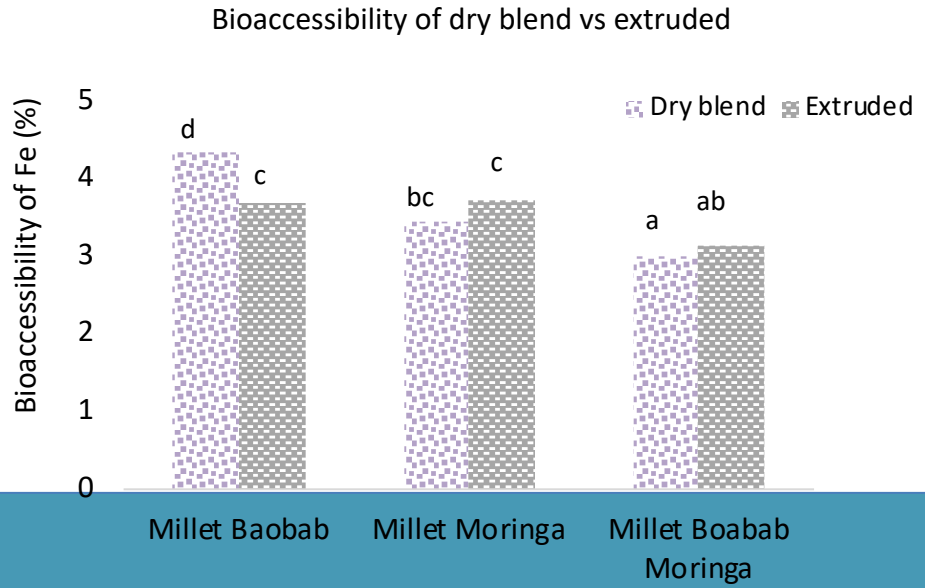
	N	Correct responses	Incorrect responses	p-Value	
Porridge of extruded refined millet flour vs. Porridge of traditional refined flour	36	29	7	<0.001	Significant difference
Porridge of traditional refined flour vs. Porridge of extruded whole millet flour	32	16	16	0.04	Significant difference

FINALIZING OF 2 PHD WORKS

Eliasse showed that the treatment using chemical (soaking in acid acetic or in bicarbonate) alone or with extrusion have a great impact on aflatoxins

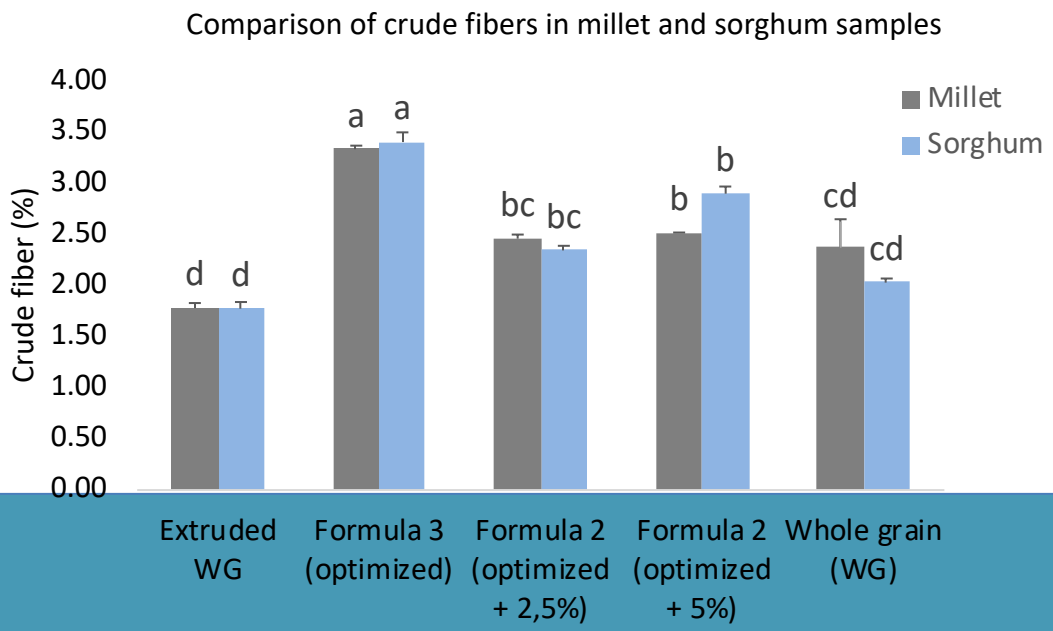


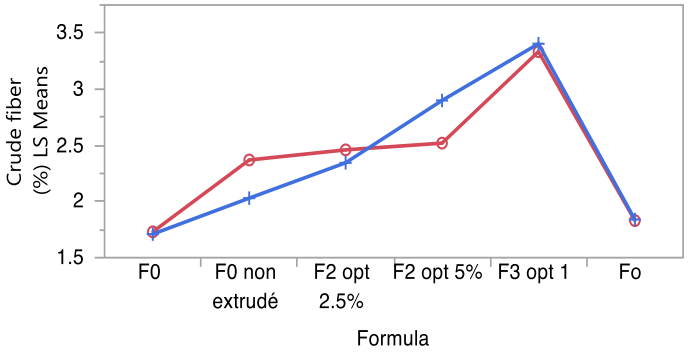
Maty showed that co-extruded millet and Moringa enhanced iron content more than with Baobab. But still no difference was found with the dry blend.

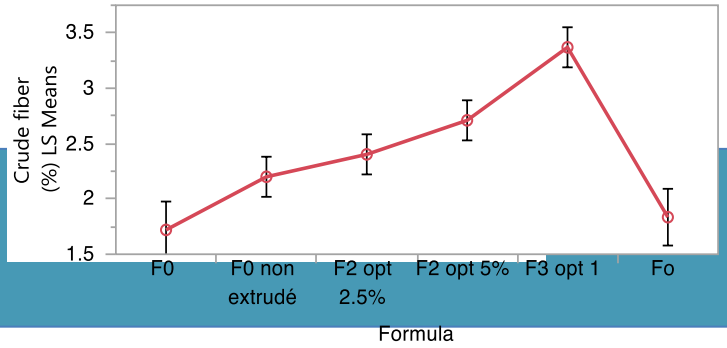


NEW PHD WORKING ON WHOLE GRAIN

In millet and sorghum, the formulation has significant impact on the crude fibers. The two-way ANOVA did not show significant difference on the interaction.







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ITA - Senegal

CEREMONY OF OPENING : NEW PROCESSING FACILITIES FOR MADAME NDAO (KAOLACK)

- This facility will help to expand the extrusion processing in another influential zone where millet is mostly produced
- The facility will be important to develop strong ties between university and the private sector (said the representative of the President of Kaolack University)
- The facility will help instantized a well commercialized infant flour (Name Yaye Aby) sold in many places of Kaolack and other places (supermarkets and pharmacies).

Inauguration of the millet fortified instant flour processing unit: Bruce Hamaker, Madame Ndao (the rural entrepreneur), Cheikh Ndiaye, and Baba Ndiaye (the President of the Economic Advisory of Kaolack, representing the local and national Government)

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SECOND EXTRUDER INAUGURATION: MADAME MBACKE INCREASE CAPACITY

- This second extruder will help increase Madam Mbacke's capacity of production
- Centralized system for instant flour production to be distributed with a brand name YAMA.
- Prefect of Touba mentioned that this second extruder will be very helpful for increasing woman entrepreneurship, which is the only solution to really fight against malnutrition and increase resilience.

Inauguration of the second extruder to Madame Mbacke: Bruce Hamaker (on the right), Madame Mbacke and Djibril Traore (co-PI of FPIL at ITA), Cheikh Ndiaye (PI of FPIL and representing the General Manger of ITA), and Mansour Diallo (the Prefect of Touba, representing the local and national Government) in the left.

PAPERS PUBLISHED/SUBMITTED

Published

De Groote, H., V. Mugalavai, M. Ferruzzi, A. Onkware, E. Ayua, K. G. Duodu, M. Ndegwa, and B. R. Hamaker. 2020. Consumer acceptance and willingness to pay for instant fortified cereal products in Eldoret, Kenya. *Food and Nutrition Bulletin.* https://doi.org/10.1177/0379572119876848

Ndiaye C, Martinez MM, Hamaker BR, Campanella OH, Ferruzzi MG. Effect of edible plant materials on provitamin A stability and bioaccessibility from extruded whole pearl millet (*P. typhoides*) composite blends. *LWT – Food Science and Technology*. 2020 Apr 1;123:109109.

Debelo H, Ndiaye C, Kruger J, Hamaker BR, Ferruzzi MG. African *Adansonia digitata* fruit pulp (baobab) modifies provitamin A carotenoid bioaccessibility from composite pearl millet porridges. *Journal of Food Science and Technology*. 2020 Apr;57(4):1382-92.

Submitted

Munyua B.,H. De Groote, D. Traore, J. R.N. Taylor, M. Ferruzzi, B. R. Hamaker. 2019. Measuring consumers' acceptance and willingness to pay for instant fortified pearl millet products, Dakar Senegal. Paper submitted to *International Food and Agribusiness Management Review (May 2020)*

Kruger, J. Taylor, J.R.N., Ferruzzi, M.G., Debelo, H. What is food-to-food fortification? A working definition and framework for evaluation of efficiency and implementation of best practices. *Comprehensive Reviews in Food Science and Food Safety*.

Adebowale, O. Onyeoziri, I., de Kock, R., Taylor, J.R.N. Stabilization of wholegrain sorghum flour and consequent potential improvement of food product sensory quality by microwave treatment of the kernels.

Onyeoziri, I., Adebowale, O., Taylor, J.R.N., de Kock, R. Effects of extrusion cooking on the sensory profiles of pearl millet porridges prepared from stored whole grain and decorticated grain flours.

YEAR 7 PLANS - SENEGAL

(Activities to be completed or initiated)

- ITA-FPIL co-organization of a workshop with the Department of Malnutrition in Senegal and other partners interested in malnutrition (WFP, FAO, UNICEF and others) on F2F Fortification and Market-led Nutrition
- Market penetration study of instant fortified millet flour in different socio-economic targeting populations include middle low incomes and middle high incomes
- Strengthen Madame Ndao (Kaolack region) to get Instantized her nutritional flours already sold in pharmacies, supermarkets and other places
- Working with Madame Mbacke on well designed packaging of new validate formulations ready for the supermarkets.

SENEGAL MARKET PENETRATION & NUTRITIONAL MODELING STUDY

- Dakar (Fall 2020)
- The study will test the *overall hypotheses* that an instant product designed with optimized nutritional characteristics, based on consumer preferences and leveraging local nutrient dense ingredients can successfully deliver nutrition through sustainable market-driven approaches.

    1) *Assess the financial and market feasibility of F2F instant porridge flours designed by FPIL targeting middle upper and lower income consumers.*
    2) *Define the level of market penetration for F2F products as defined by percentage of households and market share within the 6-7 locations in Dakar.*
    3) *Determine if adoption of F2F products can have meaningful nutritional impact with particular focus on shortfall micronutrient intake for vulnerable populations.*

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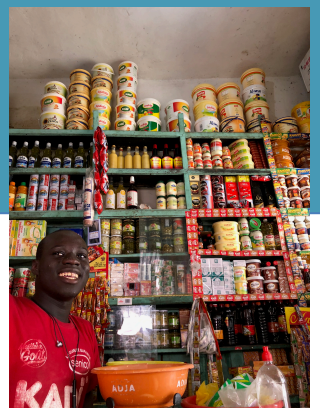
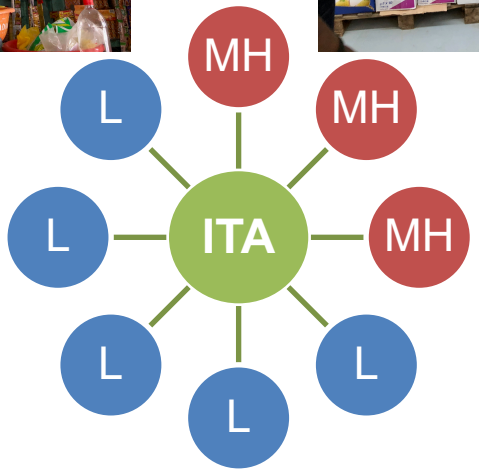


GENERAL STUDY DESIGN

- 10 week market study with single F2F fortified instant product selected with ITA
- 6-8 market sites in Dakar region
  - Target middle/high and low income consumer



Week 1-2: Demonstration/Promotion

Week 3-5: Promotion/Discounted Sales

Week 6-10: Comparative Sales

- Price at parity w/ millet products
- Price at premium to millet products

Collect market data
+
1200 consumer
600/600
purchasers/non-purchasers
Follow-Up Interviews

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DATA COLLECTION & TIMELINE

- Key Market Data
  1. Total volume/units of F2F product sold
  2. Total volume/units millet products sold
  3. Total value of F2F product sold
  4. Total value of millet product sold
  5. Product comments from consumers
  6. Number of repeat purchasers

TIMELINE

IRB Submission/Review: June/July 2020
Product Production: Aug Sep 2020
Study Phase: Oct – Dec 2020

COVID 19 Dependent

- Consumer Interview/Questionnaire
  1. Consumer socioeconomics (all)
  2. Food Frequency (all)
  3. Diet Diversity (all)
  4. F2F Product specific questions (purchasers)

YEAR 7 PLANS - KENYA

- Continued expansion of the University of Eldoret food processing incubation activities with emphasis on partnering with a SME processor (*Dola*) on fortification and instant flour technologies
- Nutritional intervention study planning and IRB submission; implementation will begin in Year 7
- The technical specification and product production plan for Kenya

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Key Findings from an Evaluation of FPIL's Activities in Touba, Senegal

Laura Leavens - Purdue University
Dr. Cheryl O'Brien - San Diego State University

FPIL Annual Meeting May 19th, 2020

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FPIL'S WORK IN TOUBA

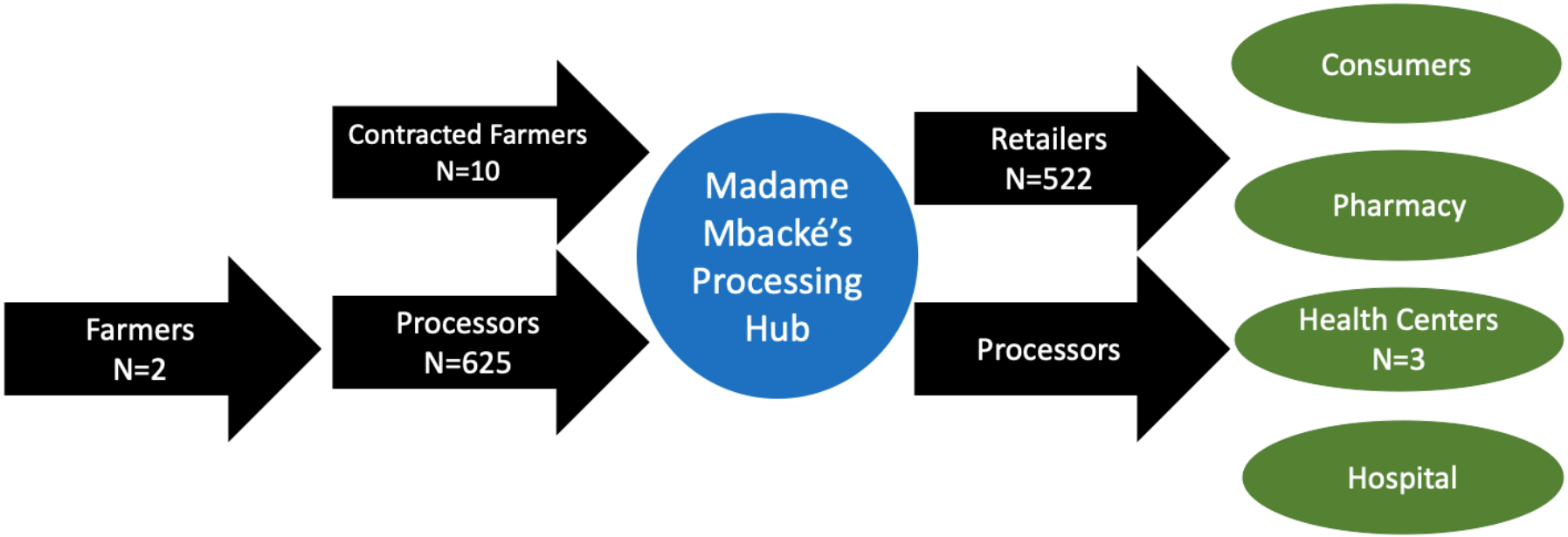
- Support women's food processing business run by Madame Mbacké
  - Work with Dr. Bruce Hamaker (Purdue Food Science) and ITA Dakar (Institute of Food Technology)
- FPIL provided business with extruder
  - Just received a second one in 2020
- Produce instant, fortified flours that consumers eat in the form of porridge
  - Make other products but FPIL's involvement is only with the flour

FPIL'S WORK IN TOUBA

- Product addresses several issues
  - Malnutrition and micronutrient deficiencies (extremely common in area)
  - Lack of economic opportunities for women
  - Constraints on women's time due to burden of house and care work

- Made with locally available millet and fortificants (moringa and baobab)

VALUE CHAIN


Farmers
N=2
Contracted Farmers
N=10
Processors
N=625
Madame
Mbacké's
Processing
Hub
Retailers
N=522
Processors
Consumers
Pharmacy
Health Centers
N=3
Hospital

EVALUATION STRUCTURE

- Interviewed all (10) farmers contracted with Mme Mbacké
  - Additionally interviewed (2) farmers who sold directly to processors

- Interviewed heads of health clinics, a pharmacy, and hospital who use flours
  - And heads of a few clinics/health mutuals who do not currently purchase or sell flours but are either interested or reimburse clients who purchase the flours

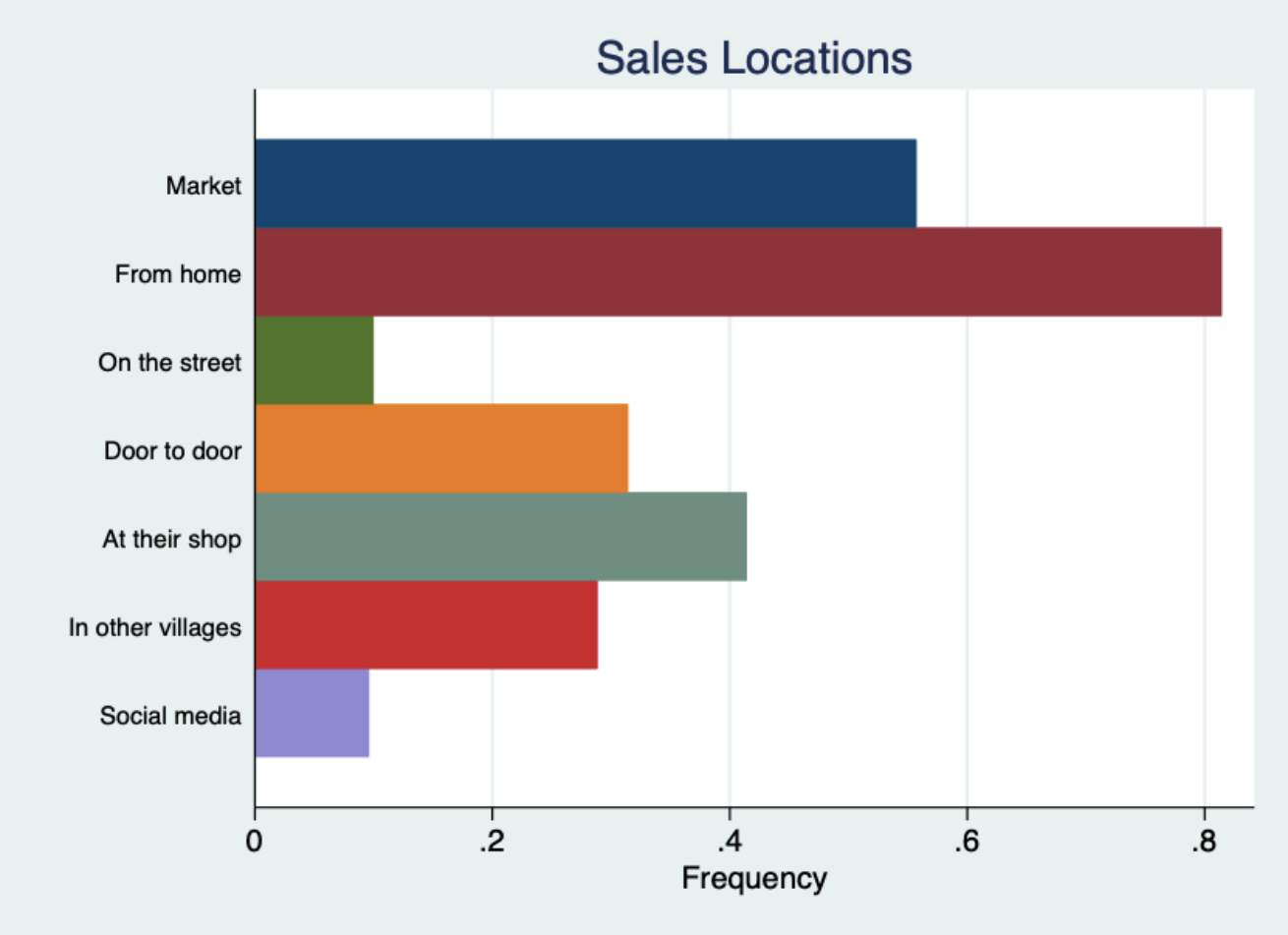
- Interviewed and held participatory activities with processors and retailers:
  - Separately interviewed all 23 processing and 20 retailing group leaders
  - Selected 14 groups of processors and 14 groups of retailers
  - Selected 4 women from each of these groups for activities: 112
  - Interviewed half of these women prior to the activities: 56

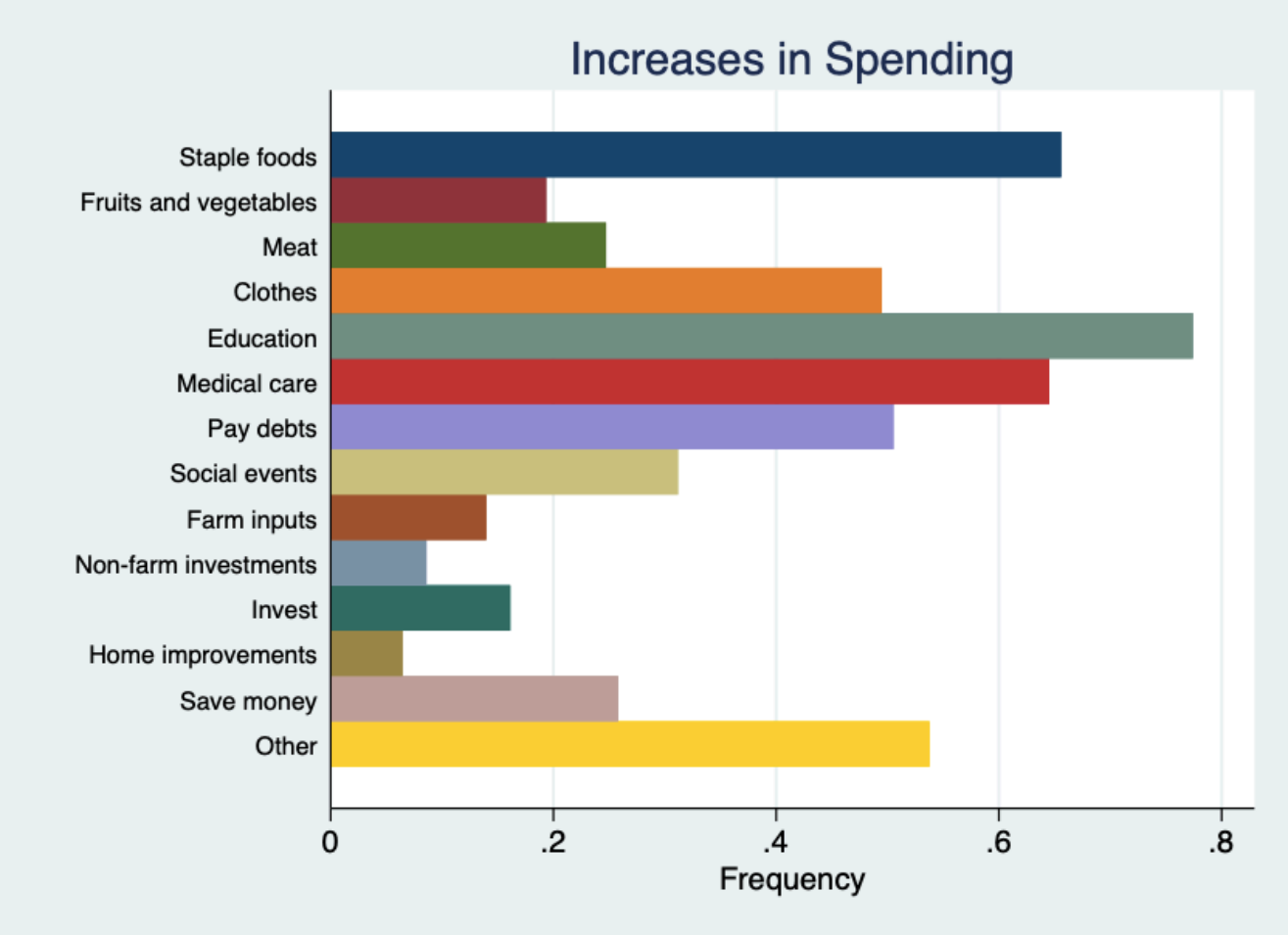
MBACKÉ'S BUSINESS BY THE NUMBERS

- Total kg instant flour produced by Mme Mbacké in 2019: 139,900 kg
- Total value of instant flour produced by Mme Mbacké in 2019: $287,190
    - One kg of instant flour is worth $2.06 (1,250 CFA)
- Women directly employed by this business: 1,147
    - 625 Processors
    - 522 Retailers

WOMEN'S INTERVIEWS: SALES AND REVENUE

- Median instant flour sales during a typical month:
  - Processors: 40 kg
  - Retailers: 50 kg
- Revenue (median sales x average sale price) generated during a typical month for each:
  - Processor: $122.19
  - Retailer: $126.12
- Net revenue [(sale price- purchase price) x median sales] generated for a retailer
  - $43.48 (average Senegalese monthly household income is ~ 80 USD)


Sales Locations
Market
From home
On the street
Door to door
At their shop
In other villages
Social media
0
.2
.4
.6
.8
Frequency


Increases in Spending
Staple foods
Fruits and vegetables
Meat
Clothes
Education
Medical care
Pay debts
Social events
Farm inputs
Non-farm investments
Invest
Home improvements
Save money
Other
0
.2
.4
.6
.8
Frequency

PARTICIPATORY ACTIVITIES

- Wanted to understand how the women perceive any impacts of the project in their lives and give them a chance to openly share their experiences with each other (generate community discussion)
- Non-threatening way to discuss sensitive topics (gender roles, domestic conflict, etc)
- Does not require literacy skills (effective for diverse groups of people)
- Getting at values is hard in a survey

THREE ACTIVITIES

- "Before and Now" Diagrams: Understand how FPIL's involvement has affected their lives

- Resource Mapping: See what resources the women use, could use, need (improve project moving forward), and barriers to their success

- Pie Charts: Learn what the women value most about their involvement with selling instant flours

KEY FINDINGS FROM ACTIVITIES

Female processors and distributors said that after joining their respective women's groups, the following **positive changes** occurred in their lives, their households, and communities:

- **Gender Equality and Women's Empowerment**
- **Improved Infrastructure and Overall Security**
  - electricity; "ability to go everywhere in their neighborhood due to improved security"; roads; transportation; police station; market created; etc.
- **Improved Household Finances, Health, and Living Conditions**
  - access to water; own a home; "ability to pay for medical needs, electricity, and more food"; etc.
- **Education of Children of all ages – Education, Knowledge, Schools**

(CONT.) KEY FINDINGS FROM ACTIVITIES

Barriers to being more successful included:

- Major barrier = **husband's lack of understanding/support**, his jealousy/accusations, domestic violence, husband won't let her leave the house, some husbands are (im)migrants and fear wife working, etc. And Rigid gender roles/norms surrounding travel outside of home and need for husband's consent

- 2nd most cited: **time constraints w/ children**, and lack of child care. And "Many women do not have family planning and give successive births; many women give birth repeatedly."
- Next most cited: Other time constraints (cooking; fetching fuelwood). No transportation/car. Jealousy of other wives in polygamous HHs.

(CONT.) KEY FINDINGS FROM ACTIVITIES

Things that help them be successful:

- Social Fund / ”Solidarity Box” to help each other (women’s groups)
- Good salary
- Relationships with each other

Major things they need to be more successful:

- Training / Schooling (computers (i.e MS Excel); agriculture; marketing)
- Child Care Center – affordable and safe child care
- Cell phones for each woman (overlaps with husband barrier)
- Understanding / Support of the Husband
- Partnerships (with govt, NGOs, and banks, Agricultural Bank)
- “Freedom to work”

PRODUCER INTERVIEWS

Descriptive Statistics	Obs	Mean	Std Dev	Min	Max
Education	12	3	4.2	0	10
Experience (years)	12	33.2	15.2	10	60
Hectares Farmed	11	39.1	56.52	2	200
Amount harvested (tons)	12	28.1	55.5	3	200
Amount sold (tons)	9	125.6	180.1	3	500
Revenue USD (605 CFA/$)	9	50,722	71,030	1,240	194,215

- All 10 contracted farmers reported their income has increased, as well as become more consistent and predictable due to the contract
- Some indicated they:
  - receive a better price than at the market
  - Increased ability to save/handle unexpected expenses

(CONT.) PRODUCER INTERVIEWS

Postharvest Practices (Millet	Percent of Respondents
Heard of aflatoxin	42
Know aflatoxin is harmful (conditional above)	100
Dry on ground	17
Dry on sheet	33
Know dry visual inspection	83
Know dry sound	75
Store single layer plastic bag	50
Store traditional granary	40
Heard of PICS bags	50
Bought PICS bags (conditional above)	17

Another farmer commented on the lack of supply of PICS bags. He said he tried some and they were “perfect”. He could use thousands of bags but he couldn’t get enough. Noted the price of 1000 CFA/bag is good because it’s less costly than using lots of insecticide.

HEALTH CARE PROVIDER INTERVIEWS

- Overall finding: growing demand for instant flours from medical professionals

- Hospital/Pharmacy: currently purchases 800 kg every month but wants to buy 1 ton
  - Started purchasing instant flours in 2017
  - 500 kg goes to hospital, 300 kg to hospital pharmacy
  - Hospital buys flour to give to children
  - Pharmacy gives flour to women, elderly, and children
  - Hospital does not sell or feed flour to inpatients

(CONT.) HEALTH CARE INTERVIEWS

- Clinics
  - Buy instant flour to resell to patients
  - Average monthly purchases: 390 kg but can double in lean (hungry) season
  - In exceptional cases, give flour away for free as “children cannot wait”
  - Nutrition outreach: trained teams of women who go door-to-door and document progress and people come in for testing
  - Feed flour to patients who must stay overnight

(CONT.) HEALTH CARE INTERVIEWS

- Female nurse who also runs two clinics in the poorest areas of Touba
- Newly elected head of Touba's public health clinics: **wants all clinics to use flours**
- Showed us a device that goes around the arm of a child in order to assess their nutritional status
- She told us that children "sometimes go right from the red to the green [in a couple of months] **because of the flours**"

(CONT.) HEALTH CARE INTERVIEWS

- Health mutual
  - Do not sell, give away, or feed to patients
  - Reimburse 80% of purchase price for its members

- Private clinic
  - Spoke with head doctor who is interested in using flours in clinic
  - He, the head of the medical district of Touba, and the association of medical doctors want to use this product for the malnourished
  - Wants more information/proof of product quality, safety, and availability
  - More interested in whether it could be used with children under 5

CLM INVOLVEMENT

- CLM (Cellule de Lutte Contre la Malnutrition) is the Senegalese government's anti-malnutrition agency
  - Subsidize purchase of 40 tons of instant flours
- Interviewed CLM representative and Mme Bousso Mbacké
  - CLM works with Madame Bousso Mbacké, another influential woman in Touba, to distribute flours across 100 sites
- Forthcoming pilot project to see if this is a model that can be adopted nationwide
  - Draws upon the women's processing and distributing network, which the FPIL project has been supporting through Mme Mbacke's business.

IN SUMMARY

- FPIL's support of Madame Mbacké's processing business has generated positive impacts on many stakeholders
  - Provided empowerment and employment for 1,147 women who otherwise have very few opportunities
  - Increasing farmers' financial wellbeing
  - Health professionals are increasingly adopting the instant flours to improve nutritional outcomes in their communities

- More attention needs to be paid to the quality of the grain being used in order to ensure the product is safe, especially with increasing demand

- Future research should also assess the true impact of the flours on nutritional status

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