Pollution Prevention Through the Food Product Development Lab

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Land Acknowledgement

We acknowledge that we are on the traditional territories of the Apsáalooke (Crow), Niimíipuu (Nez Perce), Očhéthi Šakówiŋ (Lakota), Piikáni (Blackfeet), Séliš (Salish), Shoshone-Bannock, and Tsétsêhéstâhese (Northern Cheyenne) Nations. We also recognize the ancestral lands of our Senegal partners in Kaolack. Please take a moment to acknowledge this land and its past, present, and future caretakers.

The project today was guided by the collaborating community in the Kaffrine region of Senegal.

Image credit: Food Product Development Lab

MTP2 & FFAR

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Company Background

Food Product Development Lab (FPDL) Research Facilities

Location: Hannon and Herrick Halls. MSU Bozeman, MT

- Employees: 16+ researchers and staff
- Size:
  - Hannon Hall: 8334 sf
  - Herrick Hall: 758 sf

Hannon Hall

Photo credit: Montana State University

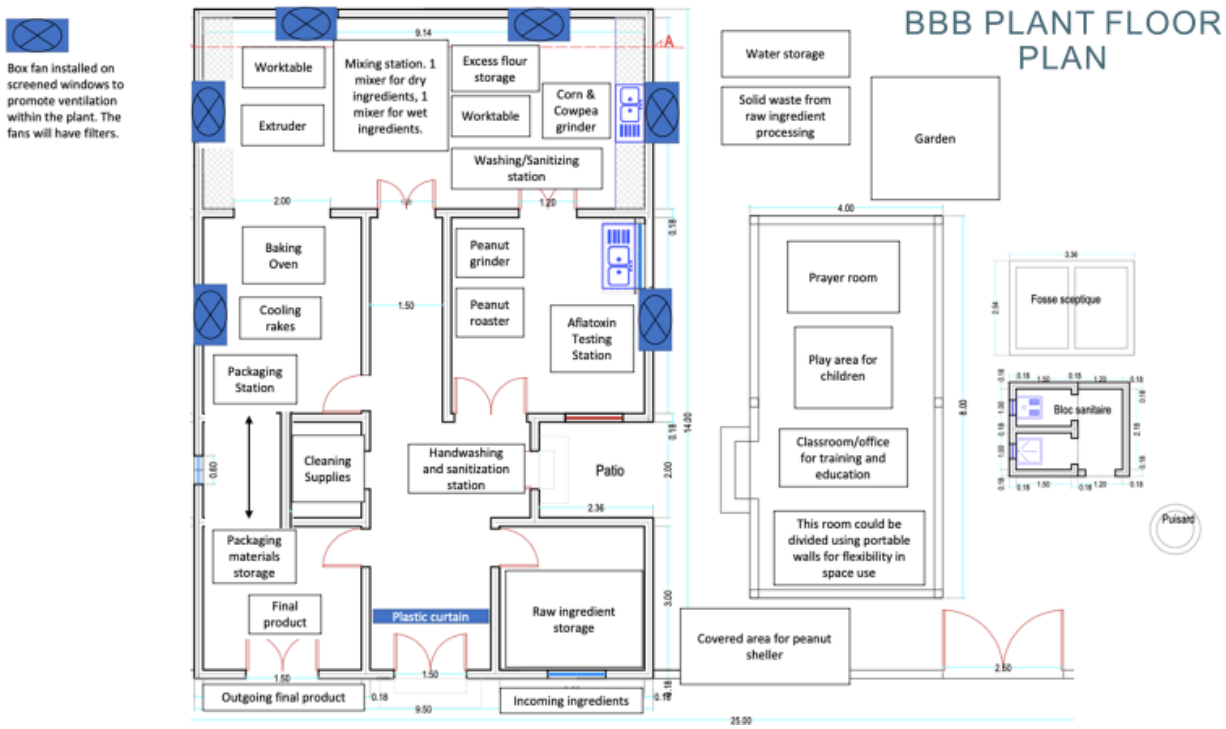
Herrick Hall

Photo credit: Montana State University

Company Background

Production Facilities in Senegal

- Product: Bonbon Bouye/Fermented Beverage
- Employees: 20+
- Size:
  - Manufacturing facility in Ndangane, Senegal: 1900+ sf
    - (Planned for construction)
  - Kaolack chamber of commerce



Production facility design by: Noah Adams, Abdullah Alsubaiei, Sage Kohr, and Dom Pisaneschi.

Image credit: MSU Food Product Development Lab

Collaborating Community

Background on Collaboration

Food scientist Edwin Allan conducted his graduate research thesis working with women's groups in the Kaffrine region of Senegal.

- Partnered with the FPDL and Bountifield in 2019-2020 to co-develop a nutrient rich snack Bonbon Bouye with Senegalese women farmers (1).
  - Utilizes local ingredients baobab and peanut flour.

Image credit: MSU Food Product Development Lab

*Image sourced from: http://exploringafrica.matrix.msu.edu/module-twenty-three-activity-one/

Photo credit: MSU Food Product Development Lab

Collaborating Community

Incentives for Collaboration

Collaborating women farmers wanted to improve their economic welfare and provide nutrition for their children.

- >30% of population lives below poverty line. 75% suffer from chronic poverty (2).
- High rates of malnutrition and anemia (2)
  - 71% of children 6-59 months of age
  - 56% of pregnant women

Photo credit: MSU Food Product Development Lab

Photo credit: MSU Food Product Development Lab

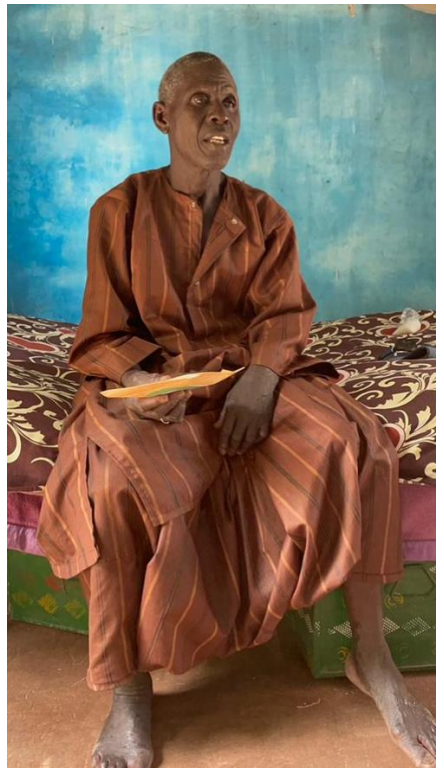


Photo credit: MSU Food Product Development Lab

Collaborating Community

Background on Beverage Project

The community wanted to continue collaborating.

- Focused on addressing the high rates of anemia, the FPDL co-developed a fermented beverage using indigenous baobab powder and sorghum flour.
  - Fermentation enhances bioavailability of iron (3) in sorghum, and increases antioxidant properties (4)
  - Baobab powder is high in Vit C. which raises rate of iron absorption (5)
  - Uses common ingredients and based upon indigenous recipes

*Baobab plant and powder. Images sourced from: https://divineharvestfoods.com/product/baobab-fruit-gambia-bread/; https://www.medicalnewstoday.com/articles/306445#benefits

*Sorghum plant and flour. Images sourced from: https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=17992; https://nuts.com/cookingbaking/flours/sprouted-sorghum-flour.html

Collaborating Community

Hann Bay Beach in Dakar.

Image sourced from: https://phys.org/news/2019-10-divers-senegal-plastic-tide.html

Challenges of Beverage Production

1) The community lacks refrigeration access to keep the beverage from expiring.

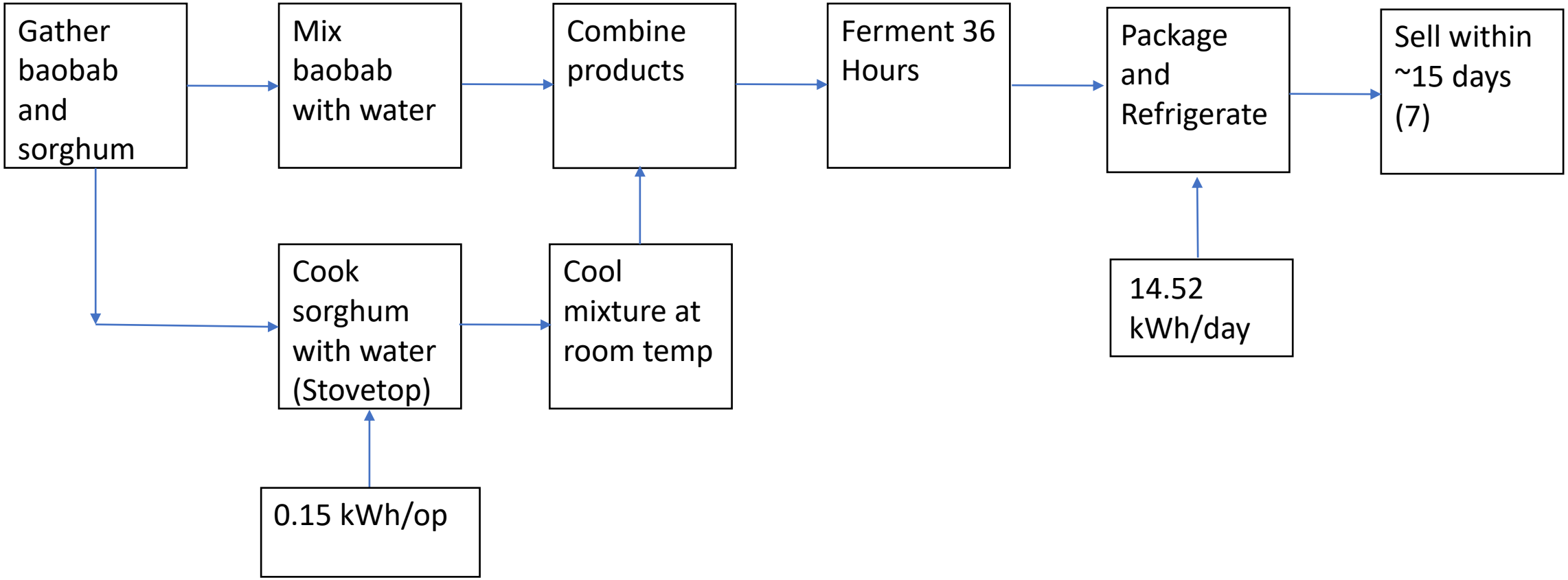
2) Plastic pollution rates are high in Senegal as a developing country (6), but importing sustainable packaging is expensive.

- 65,660 tons total mismanaged plastic waste (MPW) produced in 2021
- 169 tons MPW were released into the ocean

Country	Country Size (mi^2)	Tons MPW released into ocean 2021	Tons MPW created 2021
Senegal	75,955	169	65,660
Poland	124,547	29	14,124
Germany	138,065	134	50,676
France	210,016	235	27,780

*Senegal's mismanaged plastic waste (MPW) compared to larger developed countries (5)

Current Simplified Process Flow



Project 1: Extending the shelf life

Background

- Short product shelf-life.
- Lack of refrigeration.

*Image sourced from: https://unsplash.com/s/photos/rotten-apple

Approach

- Investigate possibility of a dried product.
  - Product marketing survey
  - Develop drying method
  - Food safety testing
  - Verify reconstitution of powder

Incentives to Change

Primary Incentives

1) Improve product shelf life and consumer convenience of keeping the product.

2) Package the product in an affordable and eco-conscious way.

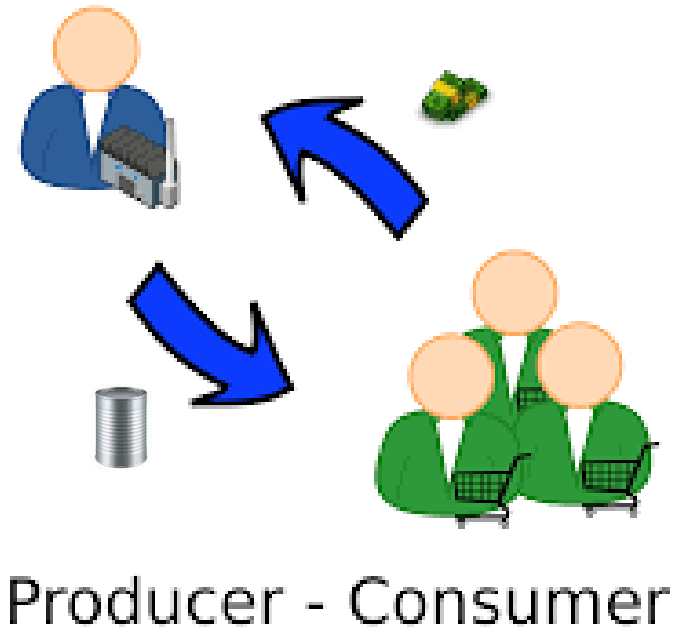
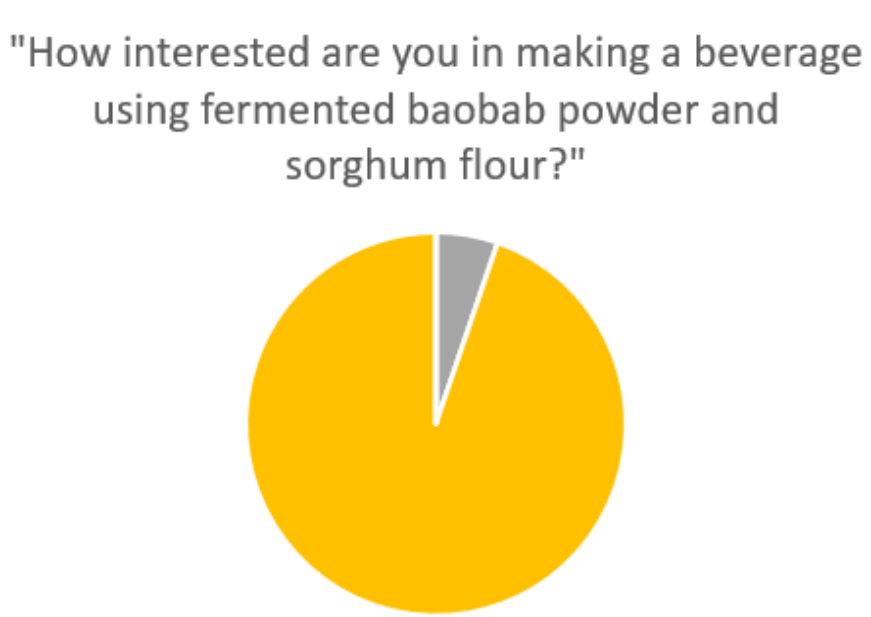


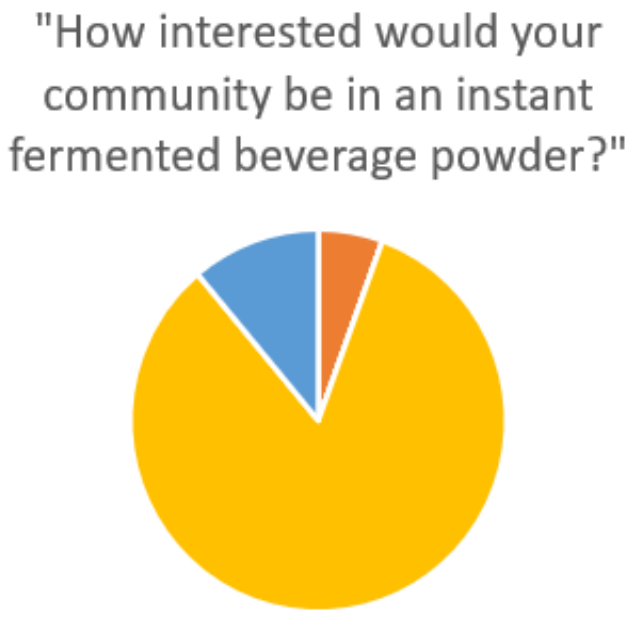
Image sourced from: https://www.iconspng.com/image/38000/producer-consumer

Image sourced from: https://www.dreamstime.com/fast-food-packaging-eco-friendly-paper-isolated-green-recycled-cardboard-background-containers-image165436269

Survey Results

- Survey of 19 members of the collaborating community shows interest both in creating the FPDL's beverage and in making an instant beverage powder.



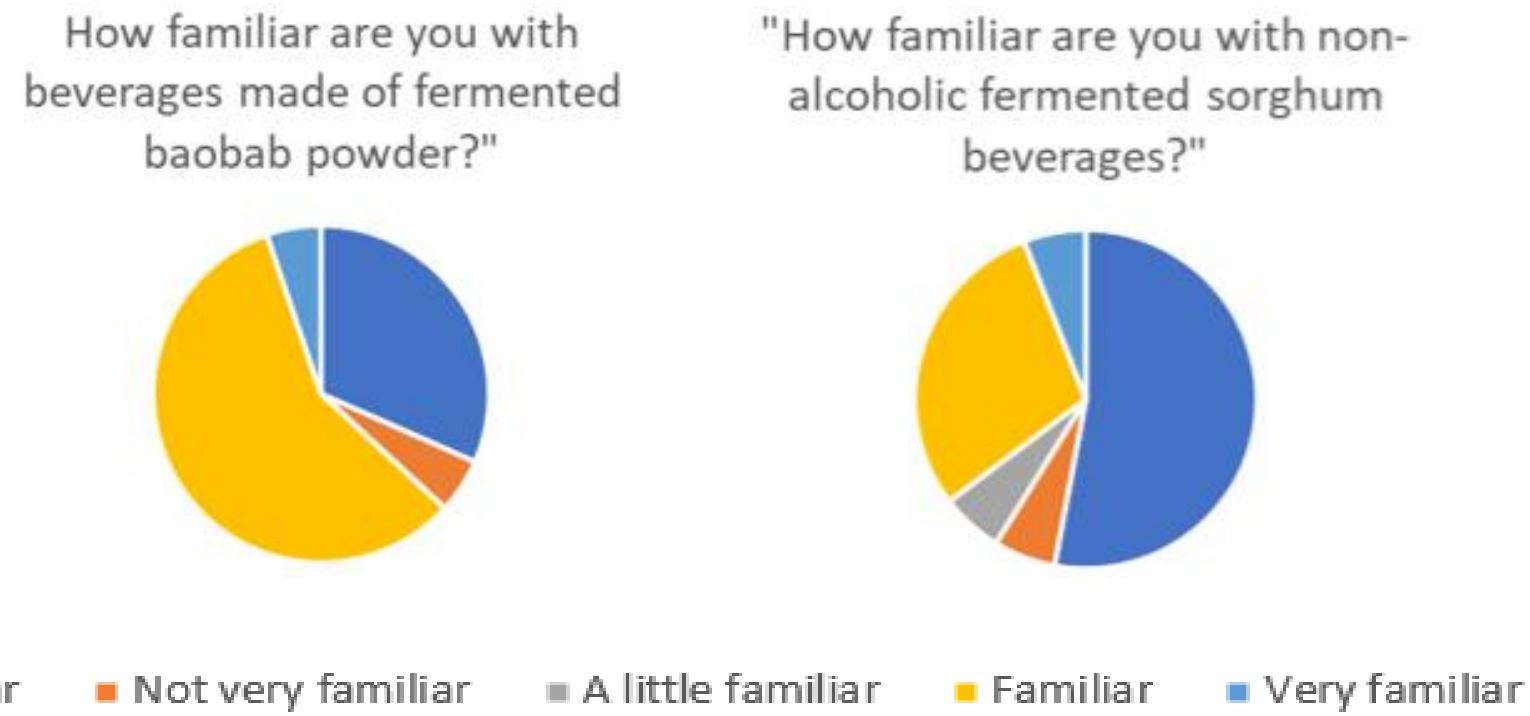


Not at all interested | Not very interested | A little interested | Interested | Very interested

Survey Results

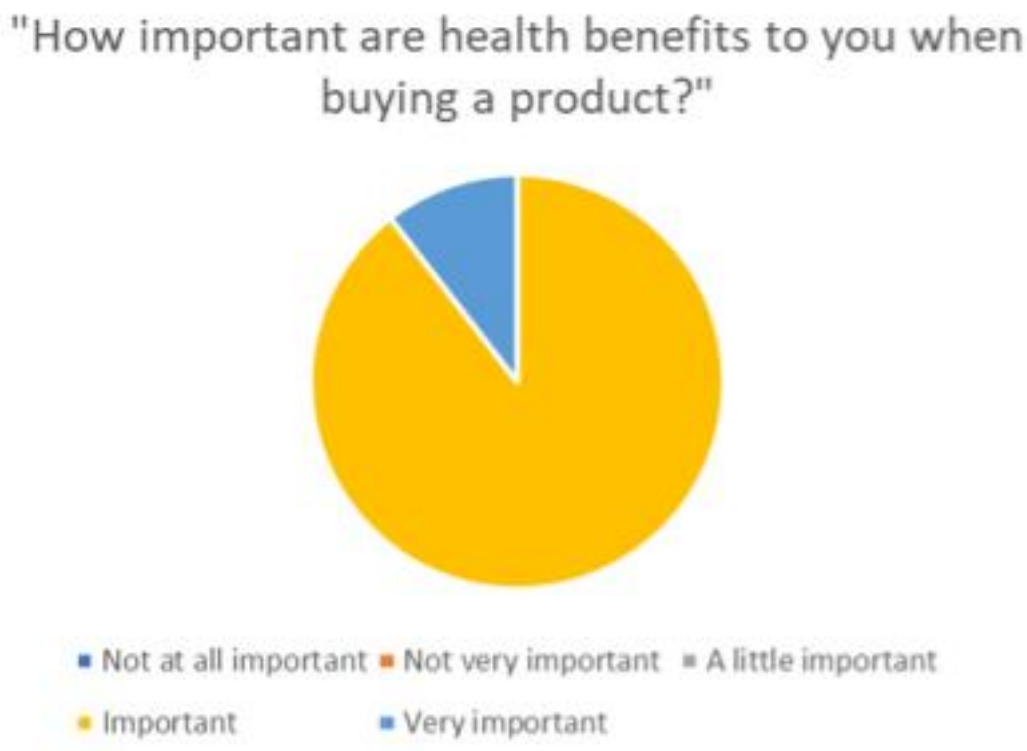
Data shows untapped market potential.

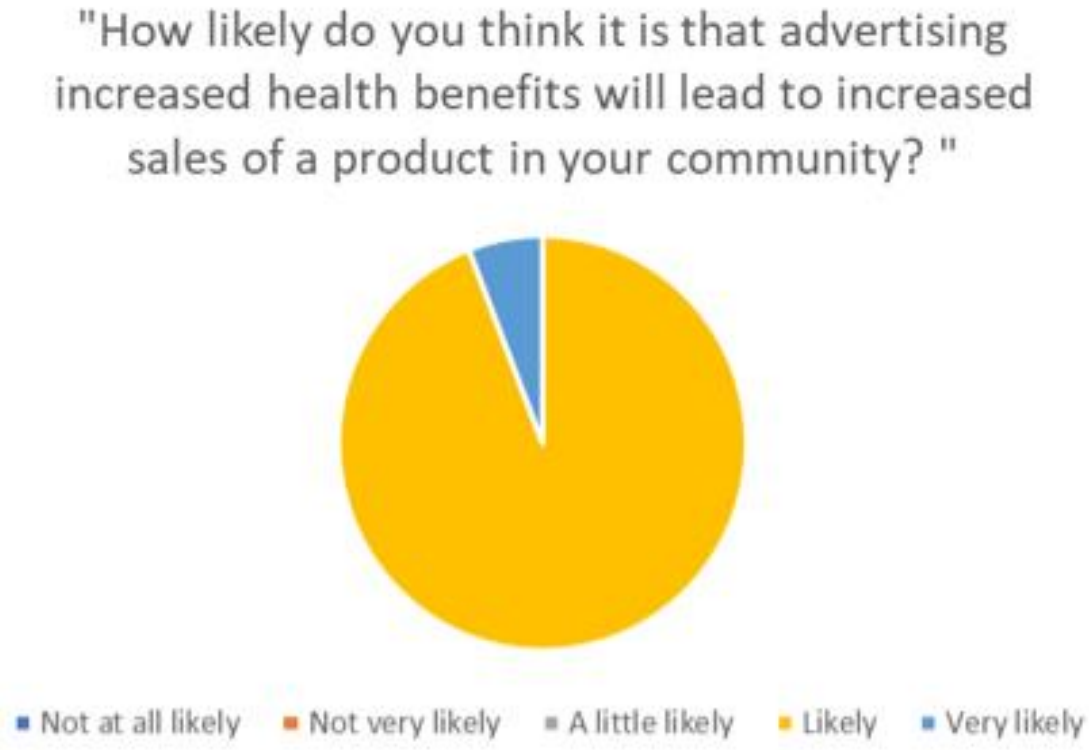
- Interest in making the beverage, but little familiarity with similar products in community.



Survey Results

- Data shows consumer value related to product nutrition.





Oven-drying Results

A method of oven-drying was researched and developed.

- Trials show ~9.2% mass yield of powder from drying beverage
  - Potential to reduce water used in beverage production should be examined

Verified the powder can be rehydrated into a beverage using hot water.

Microbial Results

- Samples were sent to NP Analytical (St. Louis, MO) and verified microbially safe (8)

Microbe	Food Safety Standards (GMP)	Oven Dried Product
Salmonella	None in 25 g	None in 25 g
Aerobic Plate Count	$<10^3$	$2.5x10^2$
E. Coli	<10	<10
Yeasts	$<10^2$	<10
Molds	$<10^2$	<10
Coliforms	<10	<10

*Results from microbial testing

Recommendations

Recommendation	Annual Reduction	Annual Savings	Barrier to Implement	Status
Drying the Beverage	2319 kWh	$359.47 + purchase of refrigerator	Electricity availability	Pending

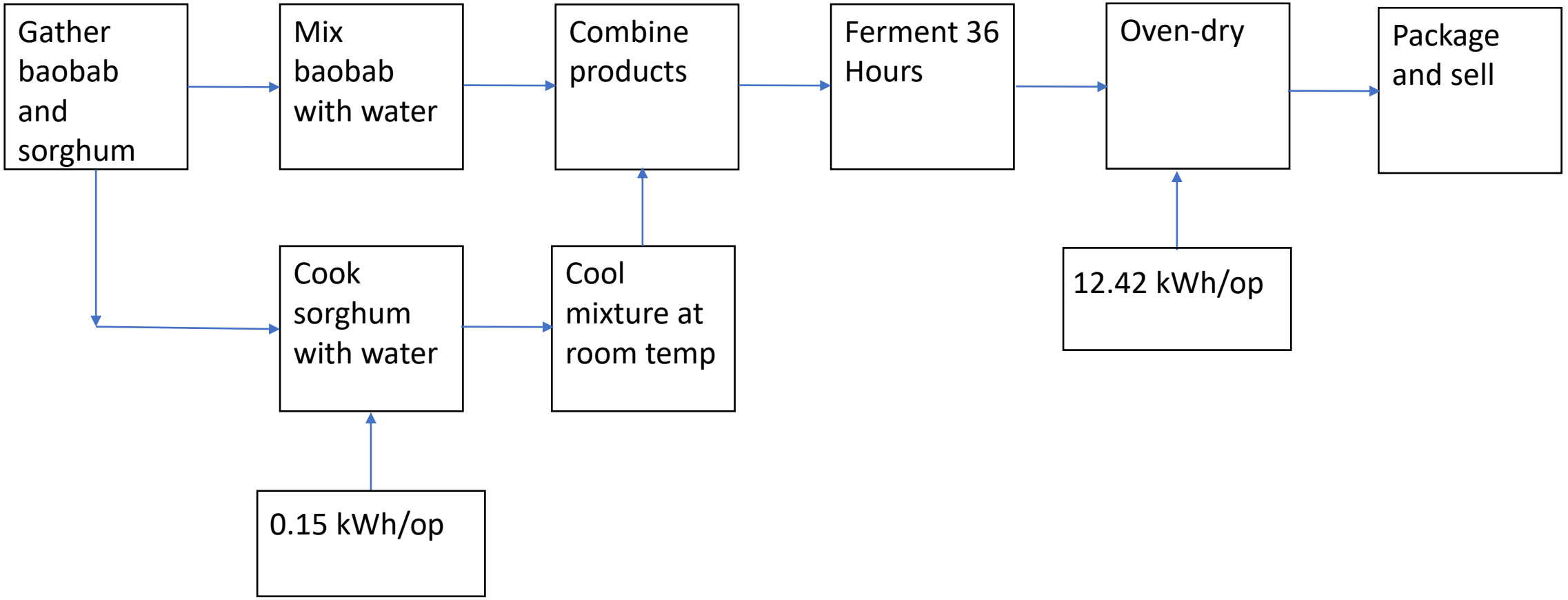
Cost of oven drying	$476.93/yr
Energy used by oven	2980.8 kWh/yr
Energy use of oven (11)	2.3 kWh/hr
Oven run time	5.4 hr/day, 20 day/month

*Drying cost and energy use considered

Cost of running fridge	$836.4/yr
Energy used by fridge	5299.8 kWh/yr
Cost of electricity in Senegal (9)	$0.16/kWh
Power of viable fridge option (10)	605 W
Fridge run time	Constant

*Data for calculating fridge operational cost

Recommended Simplified Process Flow



Project 2: Packaging

Background

- Importing packaging material is expensive.
- Senegal faces pollution control issues.

Approach

- Source packaging at the Kaolack chamber of commerce.
- Choose an affordable recyclable/reusable option.

Results

- There is a lack of community education and interest in a reusable package.
- From the CoC, a recyclable option can be sourced at $0.1/bag - $0.24/bag cheaper than importing the same bag.

Package Option	Size (cm)	Cost ($/bag)	Disposal Options	Components
Mylar Foil Aluminum Plastic Bag	18*26+4	0.1	Disposable	PET+AL+PE
Mylar Foil Zipper Bags	21*31	0.01-0.035	Disposable	PET+AL+PE
Kraft Paper Bag with Window	20*30+5	0.08	Disposable	MOPP/Kraft Paper/VMPET/cpc/PE
Matte Kraft Zipped Bag	20*30+5	0.1	Recyclable	BOPP/Kraft paper/CPP

Packaging options from the Kaolack chamber of commerce

Image sourced from: Fast Delivery Doypack Ziplock Brown White Kraft Handicraft Paper Standing Pockets Food Packaging Zipper Bags With Window - Buy Kraft Paper Bag With Window And Zipper,Stand Up Pouch,Food Packaging Bag Product on Alibaba.com

Recommendations

Recommendation	Annual Reduction	Annual Savings	Barrier to Implement	Status
Source Packaging from CoC	$0.24/bag	NA	Initializing production in Kaolack	Pending
Sourcing reusable packaging	NA	NA	Consumer education and interest	Pending

Summary of Recommendations

Recommended P2 Actions	If Implemented:								If Not Implemented:	
	$		Annual Reductions							
	One-time Cost to Implement ($)	Annual Savings from P2 Action ($)	Hazardous Material input (lbs)	Hazardous waste (lbs)	Air emissions (lbs)	Water pollution (lbs)	$MTCO_2e$ emissions (tons)	Water use (gal.)	Barrier to Implement	Plans to Implement within 5 years? (pick Y/N)
Drying the Beverage	-	359.47	-	-	-	-	-	-	Electricity availability	Y
Sourcing Packaging from CoC	-	0.24/bag	-	-	-	-	-	-	Initializing production in Kaolack	Y
Sourcing Reusable Packaging	-	-	-	NA	-	-	-	-	Consumer education and interest	N

Personal Benefits

- Communication/presenting skills
- Working/coordinating with several groups
- A better understanding of the research and production process
- Understanding of necessity of knowledge in each production step to create a Value Stream Map of production inputs, outputs, and wastes

*Image sourced from: https://www.deccanherald.com/national/now-450-hours-of-internship-must-for-4-year-ug-course-1108162.html

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  - Jennifer Grossenbacher
  - Barbara Watson
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