Low-cost, locally fortified porridge flour for improved maternal health in Kenya

PURDUE UNIVERSITY
College of Agriculture
AGRICULTURAL AND BIOLOGICAL ENGINEERING

Margaret Hegwood (Biological Engineering), Kristen Palmer (Biological Engineering), Sarah Reichstetter (Biological Engineering), & Kaitlin Wendel (Biological Engineering)

PROJECT BACKGROUND

Despite this century's advancements in maternal and infant care, women and children around the globe continue to suffer from poor health as a result of acute maternal malnutrition (USAID, 2018). For many women, particularly those living in developing countries, limited access to nutritious foods is a disadvantage caused by gender discrimination, lack of financial resources, and limited transportation (U.N. Women, n.d.). These hindrances lead to a depressed intake of essential vitamins and minerals, particularly those critical for infant development such as vitamin A, folic acid, and iron (U.N. Women, n.d.). As a result, children are frequently born with severe micronutrient deficiencies that hinder both physiological and psychological development (Attanasio *et al,* 2018).

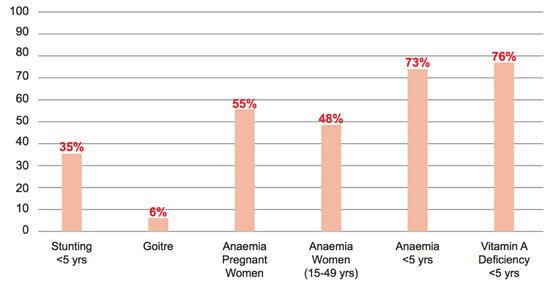
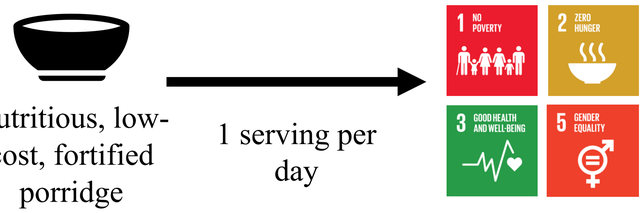


Figure 1: Micronutrient deficiencies in Kenya for women and children <5. Source: Kenya National Nutrition Action Plan

Current trends in global development, food science, and processing point towards the creation of supplemented and fortified food products as a way to address this issue (USAID, 2018). This project aims to address the need of improved maternal health in Kenya through the production of a low-cost, locally fortified porridge flour.

GLOBAL & SOCIETAL IMPACT

Addressing maternal malnutrition to ensure a more food secure planet and a healthier future generations., including Goals 1, 2, 3, and 5 of the UN Sustainable Development Goals.



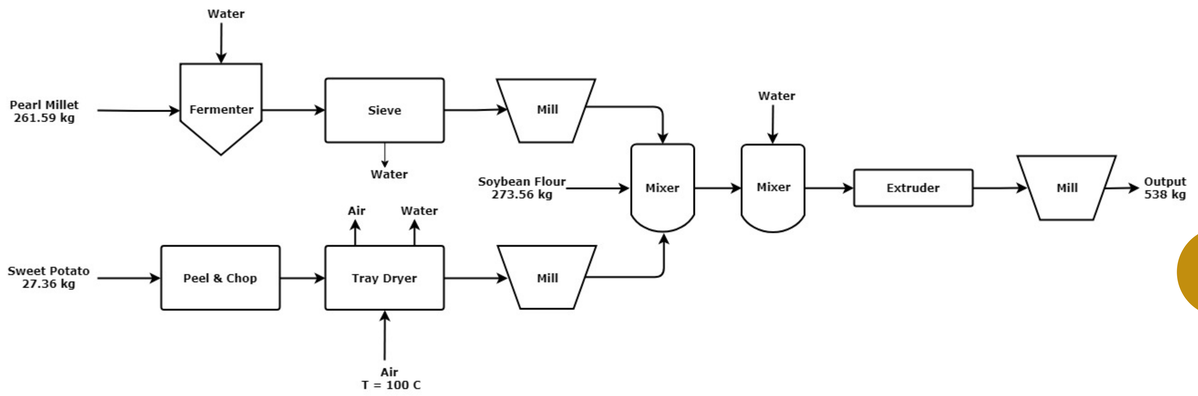
OBJECTIVES

Create a porridge flour product that is:

- low-cost and nutrient-dense for women of child-bearing age to address common macro/micronutrient deficiencies during pregnancy (targeting protein, iron, vitamin A)
- utilizes produce/crops that are locally available and/or in Kenya
- consumer acceptable and easily combined with a staple meal in Kenya
- lasts at least 6 months with little to no negative quality changes

Target Consumer — Women of childbearing age (between ages 15 and 49)

PROCESS FLOW



DESIGN CONSTRANTS & OPTIMIZATION

- low-resource (water, energy) and poor infrastructure
- Majority of women in Kenya do not have access to traditional grocery stores/supermarkets
- Need for low-cost and high nutrient
  - Local ingredients: sweet potato, soybean, millet
- Water recycle system

Unit Operation	Reasoning	Possible Alternatives
Continuous stirred-tank bioreactor	Increased protein digestibility; improved nutrient availability in final product	Tray Fermentor
Convection Oven Drying	Improved product shelf life and quality	Open Air Drying or Solar Dryer
Conical Mill	Appropriate particle size enhances final product rheological properties	Hammer Mill
Extrusion	Enhanced shelf life; improved nutrient availability	Oven drying

PROCESS EXPERIMENTATION & ANALYSIS

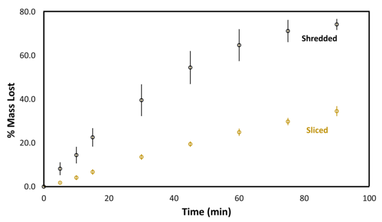


Figure 2: Percentage of mass lost during drying of sweet potatoes at 150 °F (65°C) for 90 minutes in an oven. Shredded samples exhibited a higher amount of mass lost during the drying period than those of sliced samples.

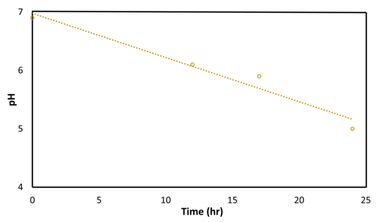


Figure 3: Change in pH with time during natural millet fermentation. A ratio of 3:1 millet flour to water was used to perform the fermentation.

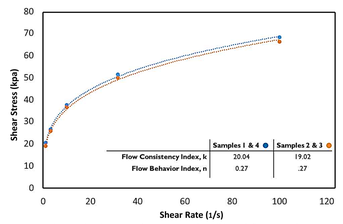


Figure 4: Flow consistency number (k) and flow consistency index (n) were determined for the 34% moisture dough using the capillary rheometer. A value of n < 1 indicates that the fluid is shear thinning.

ECONOMIC ANALYSIS

Annual Total Product Cost: : **$75,099.71**
Gross Annual Income: **$161,400**
Annual Cash Flow: **$40,216.99**

Product Sale Price: **$2.00 / kg**

Annual Internal Rate of Return: **19.8%**

Item	Cost (USD)
Equipment Cost	46,734.00
Equipment Installation	11,683.50
Instrumentation and Controls	3,738.72
Piping	9,346.80
Electrical Systems	9,346.80
Building (including services)	14,020.20
Land	1,869.36
Service Facilities	18,693.60
Total Direct Cost	115,432.98
Engineering and Supervision	11,543.30
Construction Expenses	15,116.22
Legal Expenses	1,511.62
Contingency	7,559.11
Total Indirect Cost	35,729.26
Working Capital	26,675.69
Fixed Capital Investment	151,162.24
Total Capital Investment	177,837.92

Aug/Sept 2018

- Product and industry trends
- Global , Ethical, and Societal Issues
- Literature review

Oct-Dec 2018

- Preliminary recipe and mass balances
- Preliminary energy balances
- Lab/kitchen experiments

Jan-April 2019

- Updated process flow, optimization, and controls
- Economic analysis and business plan
- Final project delivery

Future Work

- We have found that this work has potential applicability with a community partner, Ingabeyacu Enterprise LLC, in Rwanda.

INSTRUCTOR

Dr. Martin Okos

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150 YEARS OF GIANTLEAPS IN ENGINEERING