Cassava Flour Production

ME 491 – International Development

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Motivation

“The service we render to others is really the rent we pay for our room on this earth.” — Wilfred Grenfell

• Develop a mechanical device that produces flour from cassava root
• Targeted for use by small farmers in Kenya
• Will help to increase annual income
• Will provide a safe and reliable way to store harvested cassava root for future consumption
• Device will empower women in Kenya who are often the ones performing this labor intensive task
• The project is generously sponsored by a Kenyan NGO called the Macheo Children’s Centre
Macheo Children’s Centre

- Established in 2005
- Located in Thika, Kenya (East-Africa)
- Mission – “To offer the children of today a better and brighter future.”
- Macheo means ‘sunrise’ in Swahili
- Macheo Children’s Centre is home to 56 children
- Thousands of other children in surrounding slums benefit from the education program
- Education program consists of a daily meal, uniforms, and psychosocial support.
Kenya

- Population: ~ 41 million
- Life Expectancy: 57.1 Years
- Education Index: 0.582
- Human Development Index: 143 out of 187
- GNI per capita in PPP: $1,492
- Gender Inequality Index: 0.627
- 80% of Kenya’s population live below the international poverty line of $2 per day. (2000)
- 75% of Kenya’s population lives in rural areas

U.S.A.

- Population: ~ 313 Million
- Life Expectancy: 78.5 Years
- Education Index: 0.939
- Human Development Index: 4 out of 187
- GNI per capita in PPP: $43,017
- Gender Inequality Index: 0.299
- 16% of the U.S.A.’s population lives in rural areas
Food Security and Health

- Kenya relies heavily on food imports
- According to the Global Hunger Index (GHI) 18.6% of the population of Kenya is undernourished experiencing chronic hunger.
- Under-five mortality rate was 8.4% in 2009
- 16.4% of children under the age of 5 in Kenya are underweight
  - In the US 3.8% of children under 5 are considered underweight while 10.4% of the same age group is overweight.
- In the summer of 2011 intensely volatile food prices worldwide led to the first famine of the 21st century in the horn of Africa, including Kenya.
  - Political instability in 2007, and droughts in 2008 and 2011 also contributed.
Nutrition in Kenya

• Typical Kenyan consumes 2200kcal/day with just 17g of animal protein.
• Typical North American consumes 3800kcal/day with 74g of animal protein.
• Starches such as corn, potatoes, sweet potatoes, beans, and cassava are the staple foods of a Kenyan diet.
• As of 2006 75% of Kenyans made their living through agriculture.
  • About half of what they farm is used strictly for subsistence purposes.
Cassava Root

- Long, tapered, firm, tuberous root
- Also called tapioca, yuca, mogo, manioc, mandioca
- Very hardy, will grow where other crops can’t and still produce high yields
- Staple food for nearly one billion people, most of these being among the world’s poor
- Very rich in starch, poor source of protein
- Can be classified as either sweet or bitter
- Contains potentially harmful levels of cyanide
- Once harvested and separated from the rest of the plant, the root will rot within two to three days

**Nutrition Facts**

<table>
<thead>
<tr>
<th>Amount Per Serving</th>
<th>% Daily Value*</th>
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<tbody>
<tr>
<td>Calories 160</td>
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<tr>
<td>Calories from Fat 2</td>
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<tr>
<td>Total Fat 0g</td>
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<tr>
<td>Saturated Fat 0g</td>
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<tr>
<td>Trans Fat</td>
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<tr>
<td>Cholesterol 0mg</td>
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<tr>
<td>Sodium 14mg</td>
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<td>Total Carbohydrate 38g</td>
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<tr>
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<tr>
<td>Sugars 2g</td>
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<tr>
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<td>Vitamin C 34%</td>
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<tr>
<td>Calcium 2%</td>
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<tr>
<td>Iron 1%</td>
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*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.
Culinary Uses of Cassava

• Boiled roots may be fried and make a good chip
• Fufu, a starchy cooked dough, is made from boiling cassava flour
• Tapioca balls are made from cassava
• Gari is a fried-course flour that is often eaten cold in the form of gari soakings
• Cassava flour is mixed with wheat flour to make bread
• Fresh roots are used in soups and stews like potatoes
• There is even one company in Mozambique that makes cassava beer!
Cassava Flour Production

- First, the peel must be removed from the harvested root
- This eliminates most of the cyanide
- Next, the root is laid out to dry
- It is often cut into smaller pieces before the drying process
- Once dried, the root is then ground into flour
- This grinding process is typically done by hand
- Shelf life of approximately two years
Difficulties in Processing

• Avoiding spoilage
• Cyanide removal
• Peeling
• Drying
• Fungal growth and mycotoxins
• Grinding flour
• Involved multi-step process
Cyanogen Removal

- Cyanogenic glucosides, primarily linamarin, are the cyanide containing compounds in cassava.
- Stored in the vacuoles of cassava cells.
- Linamarase stored in cell wall, separate from linamarin.
- With breakdown of cell structure the two are able to mix.
Enzymatic Breakdown of Linamarin

**Step-by-step**

- Linamarin (I) is reduced to glucose (II) and acetone cyanohydrin (III) upon mixing with linamarase (β-glucosidase).
- Acetone cyanohydrin is then reduced to hydrogen cyanide (HCN) and acetone (IV)
  - Reduce by enzyme hydroxynitrilelyase (HNL)
  - Or spontaneously depending on temperature and pH
- Free HCN is volatile at 25.7°C while acetone cyanohydrin is volatile at 82°C.
Important Design Parameters

- Function
- Cost
- Manufacturability
- Ease of Operation
- Quantity
- Health
- Operating Conditions
- Maintenance
Design Concepts

Methods:
• Abrasion Grinding
• Compression-Based Crushing
• Rack Drying
• Sunlight Concentration

Geometries:
• Cylindrical
• Rectangular
• Vertical Feed/Collection
• Horizontal Feed/Collection

Driving Mechanisms:
• Crank
• Bicycle
• Screw
• Gravity

Materials:
• Metal
• Wood
• PVC
• Stone
Concept Designs
### Objective Analysis

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<td><strong>6.32</strong></td>
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</table>

The table above shows the analysis of various parameters with their respective weights and concept numbers.
Subjective Analysis

- 9 designs in total
- Several factors considered
- Each design mixed-and-matched various design concepts
- Allowed for thorough exploration of several options/geometries
- Immeasurable properties – aesthetics, fatigue from extended use, removal of toxins – considered and discussed by group
- Upon evaluation of objective analysis and further subjective analysis, final design decided
First Prototype

Materials:
- Plywood
- 2x4 lumber
- PVC pipe
- Sheet metal

• Quick/simple way to test our final prototype idea
• Various hole sizes/shapes were explored
Second Prototype

Dryer and Grinder

- Human powered grinder
  - Hand crank
  - Cheese grader concept
    - Sharp edges on the metal drum

- Solar powered vertical dryer
  - Same concept found in PhD dissertation, “Natural drying of Cassava”, by Gonzalo Roa
Second Prototype
Manufacturing Process

Materials:
- 2x4 lumber
- 2x6 lumber
- Plywood
- Laundry dryer drum
- Fence post
- Fence post elbows
- Angle iron
- Galvanized hardware cloth
- Screws, Nails, Nuts, Bolts, Staples, etc.

Tools:
- Hand drill
- Drill bits
- Screwdriver
- Hammer
- Circular saw
- Wrenches
- Staple gun
- Tin snips
Second Prototype

Preliminary Testing

Procedures:
- Peel cassava with fruit peeler
- Cut cassava into 1”x2” pieces
- Put cassava into vertical drier with device outdoors until dry
- Crank handle to grind cassava

Data:
- 3 days for cassava to dry
- After grinding, particles ranged from .1 mm – 10 mm in size
- Cassava was ground at a rate of 18.14 kg/hour
Second Prototype
Future Recommendations

“Success is not final, failure is not fatal; it is the courage to continue that counts.” – Sir Winston Churchill

• Add weight on top of cassava to increase production speed
• Make device adaptable for any size cylindrical drum or barrel.
• Add additional shields to protect the operator and aid in the collection of the flour
• Add an option to make the device bicycle driven
• Secure the device to the ground
Diffusion of Ideas

• We plan to create assembly instructions to be sent to our contact in Thika, Kenya
• These instructions will be mostly pictorial to allow for ease of understanding
• We plan to check in with our contact every two weeks for the first two months to assist with any challenges that arise.
• After the initial period we plan to be in contact every three months to receive updates on how our device is performing
Thank you!

- MSU College of Engineering
- Dr. Brian Thompson
- Simon Wachieni
- Dr. Irvin Widders
- Dr. Dale Romsos
- Dr. Maurice Bennink
Questions?