CAPSTONE/DESIGN EXPERIENCE 2016
D.I.Y Acetaminophen Tablets

Kinsey Kauffman (Biological Engineering/Pharmaceutical Sciences), Michael Mavity (Biological Engineering/Pharmaceutical Sciences), Jordyn McCord (Biological Engineering/Pharmaceutical Sciences) & Katie Simons (Biological Engineering/Pharmaceutical Sciences)

Purpose:

To provide a comprehensive business plan and technical operating procedure for quality manufactured acetaminophen tablets by students at the Kilimanjaro School of Pharmacy (KSP) in Moshi, Tanzania

Objectives:

- Model the production of acetaminophen tables by students at KSP
  - Determine an appropriate recipe and process design
- Clearly define applicable quality analysis checks both in process and post production for the drug product
- Develop an appropriate business plan for the production facility

Background

Product Consumption

- Acetaminophen is used as a pain reliever and fever reducer
- 27 billion doses sold in 2009 (*IMS National Sales Perspectives)*

Partner Constraints

- KSP hosts 50-80 students a year in their pharmacy programs
- Material for producing tablets is bulk purchases with donated money
- The tables are not intended to be sold; but to be used by the hospital at the Kilimanjaro Christian Medical Center

Product Quality Analysis

- Weight - uniform weight variation ensures correct API per tablet
- Crushing strength/breaking force - quantify tablet strength
- Friability - tests for product loss due to surface abrasion
- Disintegration/Dissolution - availability of API for absorption

Economics

Profit - Loss Forecast

This forecast is expected to come up in the negatives. The product is intended for use as a teaching technique and not for sale.

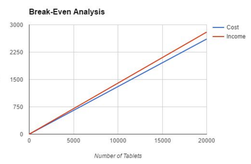
Category	Cost (USD)/Month	
Sales Revenue	0.00	*product not for sale
Variable Costs	1468.00	materials needed/month
Gross Profit	-1468.00	
Fixed Costs		
electricity	817.03	
rent	0.00	*school utilizes lab for a teaching facility, no rent needed
labor	0.00	*student run
Total Fixed Costs	817.03	
Net Profit (Loss)	-2285.03	*meant to be negative, non-profit run process

Total Product Cost

	Direct Production Cost		
	Raw Materials	0.1-0.8 of TPC	17616
	Operating Labor	0.1-0.2 of TPC	0
	Direct Supervisory and Clerical Labor	0.1-0.2 of operating labor	0
	Utilities	0.1-0.2 of TPC	41690.11
	Maintenance and Repair	0.02-0.1 of fixed capital investment	0
	Operating Supplies	0.005-0.01 of fixed capital investment	0
	Laboratory Charges	0.1-0.2 of operating labor	0
	Patents and Royalties	0-0.06 of TPC	0
	Fixed Charges		
	Depreciation		
	Local Taxes	0.01-0.04 of fixed capital investment	0
	Insurance	0.004-0.01 of fixed capital investment	0
	Rent	0.08-0.12 of value of rented land and buildings	0
Manufacturing Cost	Financing	0-0.1 of total capital investment	0
	Administrative Costs	0.2 of costs of operating labor	0
	Distribution and Marketing Costs	0.02-0.2 of TPC	0
	Research and Development Costs	0.05 of TPC	0
General Expenses			
Total Product Cost	manufacturing cost+general expenses	.59306.11	
Gross Earnings Cost	total income-total product cost	-59306.11	

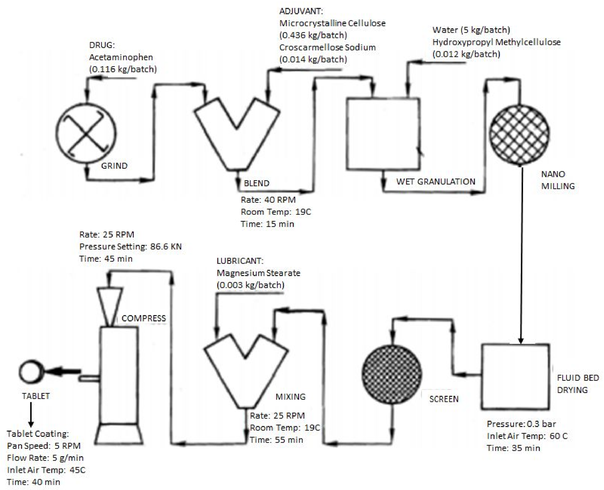
Financial Plan:

- Break-Even Analysis Assumptions:
  - Product is to be sold at minimal cost simply to break even so as to minimize loss at KSP
  - Tablets are sold for $0.13 ($285TSH)
  - 11,250 tablets are produced monthly (75% yield post quality processing)
- Discounted Cash Flow (DCF) Analysis: 10 year cash flow potential of $146,035
- 100% Return on Investment (ROI) for capital and -36% ROI after one year of production at a breakeven charge of $0.13 per tablet



Process Unit Operation & Flow Diagram

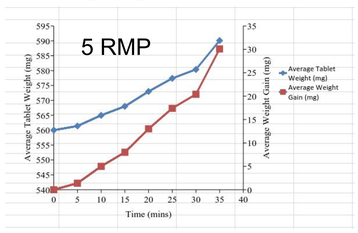
Unit Operation	Function
Grind API	API grinding is a process utilized in the tablet manufacturing process in order to reduce the size of the pharmaceutical ingredients to increase uniformity.
Dry Blend Mixing	Precise mixing of ingredients is desired in order to achieve product consistency and ensure product safety by promoting homogeneity in the final product.
Wet Granulation	Wet granulation is important in forming particles that are able to mechanically endure the manufacturing process, prevent the segregation of API and excipients, improve flowability and compressibility, reduce toxic dust, better tolerate environmental stresses (e.g. moisture), and increase bulk density.
Nano Milling	Milling is the process of reducing the size of the granules.
Fluid Bed Drying	The drying step of the wet granulation production process involves removing the solvent/liquid solution added during the wet granulation step.
Screening	The screening step occurs directly after fluid bed drying. Once the particles are dry, they are run through a sieve to ensure appropriate diameters.
Mixing	Mixing ensures the uniformity of product composition and removes any lumping or aggregations that may have occurred during another operation.
Tablet Press	Tablet compression is the process of producing tablets from the mixture formed during the milling and final blending steps. The correct amount of granules are weighed and compressed into tablets via a rotating tablet press. This rotating press utilizes a setup of two punches and a die to form a tablet of the desired shape.
Tablet Coating	Film coating is the process by which the surfaces of uncoated tablets produced during tablet compression are coated with a specific material.

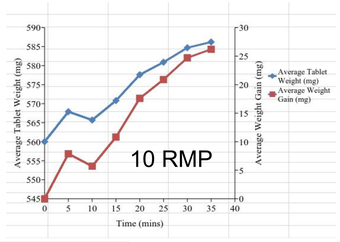


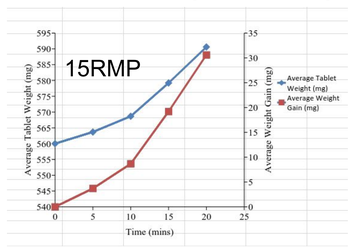
Tablet Coating: Experimentation

Varying Pan Speed: affects tumbling and therefore uniform coating of tablets

- Monitoring weight increases (and their standard deviation) in samples of tablets being coated allowed for analysis of uniformity







		5 min	10 min	15 min	20 min	25 min	30 min	35 min
5	Average	0.5614	0.5650	0.5680	0.5730	0.5774	0.5804	0.5901
RPM	Standard Deviation	0.0089	0.0102	0.0079	0.0075	0.0060	0.0103	0.0114
10	Average	0.5679	0.5657	0.5708	0.5776	0.5809	0.5847	0.5862
RPM	Standard Deviation	0.0078	0.0095	0.0106	0.0053	0.0077	0.0076	0.0054
15	Average	0.5637	0.5687	0.5792	0.5906	0.0306		
RPM	Standard Deviation	0.0111	0.0070	0.0052	0.0045	0.0045		

Average weight increase and the standard deviation of ten tablets weighed at each time interval for the differing RPMs

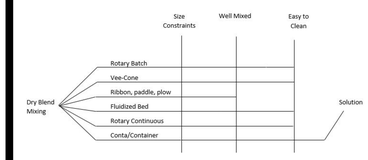
Results

- There appeared to be no significant variation in weight studies
  - suggested by standard deviation values and acceptance values
- There is an insignificant change due to pan speed at the levels tested

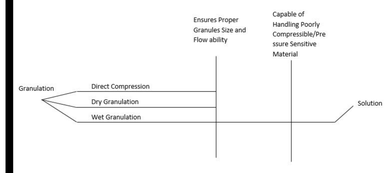
Product Recipe and Ingredient Functionality

Ingredient [functionality]	Percent by Weight	Weight per batch
Microcrystalline Cellulose [Diluent]	71.4	436 g
Acetaminophen [API]	19	115.9 g
Hydroxypropyl Methylcellulose [Binder]	1.9	11.6 g
Croscarmellose Sodium [Disintegrant]	2.38	14.6 g
Magnesium Stearate [Lubricant]	0.476	2.9 g
Coating	4.76	29 g
Final Product	100	610 g

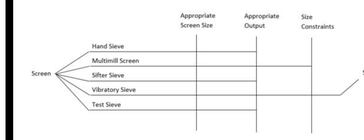
Unit Operation Determination



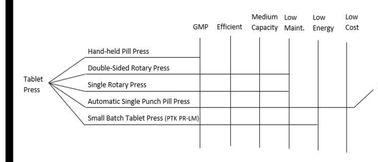
Morphological Analysis for Dry Blend Mixing



Morphological Analysis for Granulation



Morphological Analysis for Screening



Morphological Analysis for Tablet Press

Ethical, Global & Societal Considerations

Partnering with a school in Tanzania allowed for a greater understanding to be attained of the Pharmaceutical Industry in a less developed country. A student run business such as this, would allow for a greater opportunity for learning and utilization of pharmaceutical manufacturing in a situation where equipment and availability to learn such skills are limited. While the purpose of this business would not be to attain wealth (since tablets are not sold) this business fosters an increase in the knowledge of a practical skill set that can be used to facilitate growth and development in the country.

Partner:
Kilimanjaro School of Pharmacy
Moshi, Tanzania
St. Luke's Foundation

Technical Advisor:
The Chao Center

Instructors:
Dr. Martin Okos

Acknowledgements:
ABE Department
College of Pharmacy
IPPH 562 Labs & Teaching Assistants
Dr. Stephen Byrn, IPPH