

Richard Chu (B.S. BE), Ashley Madrigal (B.S. BFPE), Jana Mudrock (B.S. BFPE), and Melissa Robins (B.S. BE)

**Goals and Objectives**

**Goal:** To create a nutritious mozzarella cheese snack from spray dried milk.

**Objectives:**

- Produce mozzarella cheese from spray dried milk
- Provide consumers in 18 - 24 age demographic a nutritious and portable cheese snack

**Background:**

- Traditionally, cheese is produced from liquid milk
- Seasonal shortages of liquid milk
- Refrigeration requirement of liquid milk

**Market and Market Size**

- Purdue students and West Lafayette (40,000)
- The target demographic is primarily millennials (18 – 24)
- Millennials - largest consumer group (26% population)<sup>1</sup>
- The 18 - 24 age demographic is an underdeveloped opportunity for snack sales growth<sup>1</sup>
- Demand for natural cheese products grew 19% between 2011 and 2016<sup>1</sup>

**Sustainability**

Ingredients	Life Cycle
Continuous supply of milk in Midwest	Proven demand for mozzarella cheese <sup>1</sup>

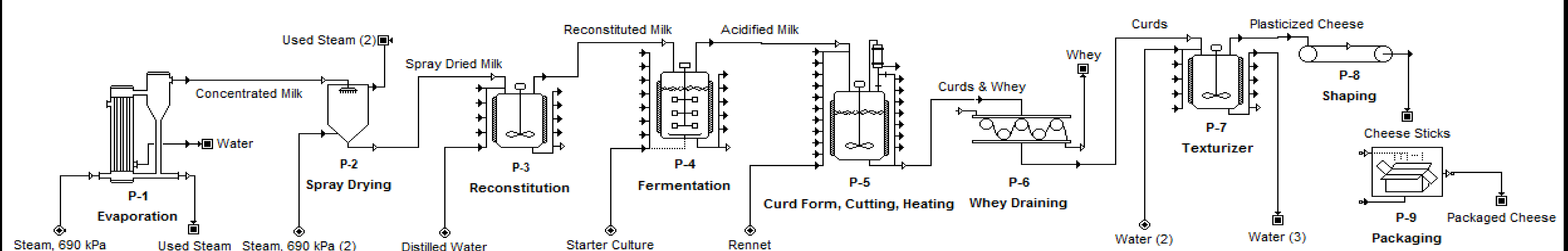
**Impact**

- Ability to produce cheese in areas with limited access to refrigeration<sup>2</sup>
- Less waste due to extended shelf life of dried milk<sup>2</sup>
- Average water consumption of 31.6 kg per kg of cheese
- Production of whey as a byproduct

**Optimization of Processes**

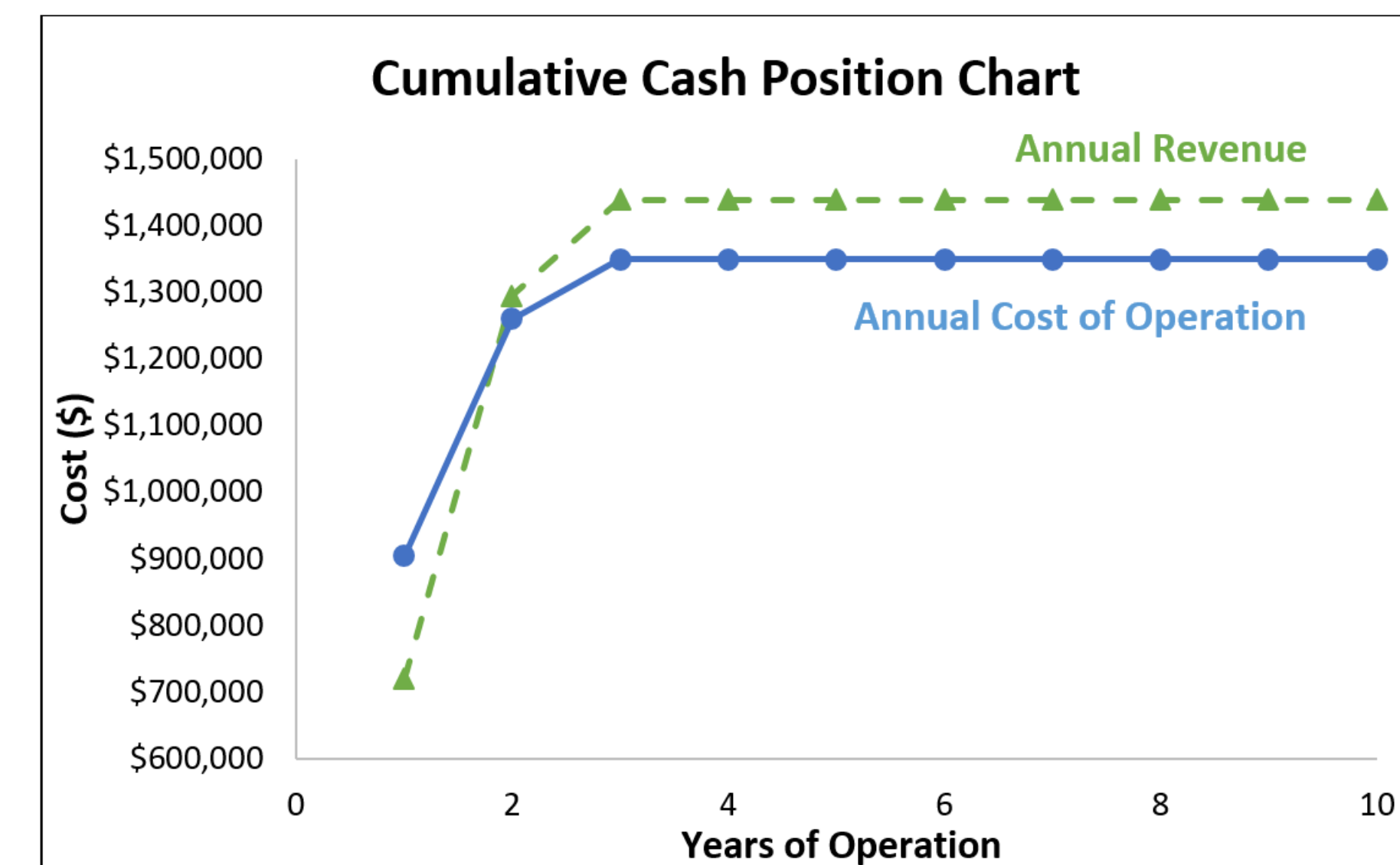
Unit Operation	Optimization Variable	Parameter Being Minimized
Spray Drying	Evaporative Capacity	Operating Cost
Reconstitute Milk	Impeller Speed	Power Requirement
Fermentation	Heat Exchanger Area	Operating Cost
Cut Curd and Heat	Heat Exchanger Area	Operating Cost

**Process Flow**



**Economic Analysis**

Costs	Dollars (\$)	Costs	Dollars (\$) / Units
<b>Manufacturing Costs</b>	<b>\$1,147,500.00</b>	Total Equipment Cost	\$384,862.82
A. Direct Production Costs	\$891,000.00	Fixed-Capital Investment	\$1,647,212.87
1. Raw Materials	\$331,259.36	Working Capital	\$288,647.12
2. Operating Labor	\$162,000.00	<b>Total Capital Investment</b>	<b>\$1,935,859.98</b>
3. Direct Supervisory and Clerical Labor	\$19,440.00	Fixed Costs (11% of TPC)	\$148,500.00
4. Utilities	\$175,500.00	Direct Production Costs	\$891,000.00
5. Maintenance and Repairs	\$115,304.90	Yearly Production	1,200,000 units (30 grams/unit)
6. Operating Supplies	\$17,295.74	<b>Variable Cost Per Unit of Sale</b>	<b>\$0.74/unit</b>
7. Laboratory Charges	\$16,200.00		
8. Patents and Royalties	\$54,000.00		
B. Fixed Charges	\$148,500.00		
1. Depreciation	\$38,486.28		
2. Local Taxes	\$49,416.39		
3. Insurance	\$9,883.28		
4. Rent	\$0.00		
5. Financing (Interest)	\$54,314.06		
C. Plant Overhead Cost	\$108,000.00		
<b>General Expenses</b>	<b>\$202,500.00</b>		
A. Administrative Costs	\$54,000.00		
B. Distribution and Marketing Costs	\$81,000.00		
C. Research and Development Costs	\$67,500.00		
<b>Total Product Cost</b>	<b>\$1,350,000.00</b>		
<b>Gross Earnings Cost</b>	<b>\$25,200.00</b>		



Years of Operation	Production Capacity	Annual Sales	Annual Cost of Operation	Depreciation	Annual Net Profit	Return on Investment
1	50%	\$720,000	\$904,500	\$38,486.28	-\$178,389.02	-9.21%
2	90%	\$1,296,000	\$1,260,900	\$38,486.28	-\$2,709.02	-0.14%
3	100%	\$1,440,000	\$1,350,000	\$38,486.28	\$41,210.98	2.13%
4	100%	\$1,440,000	\$1,350,000	\$38,486.28	\$41,210.98	2.13%
5	100%	\$1,440,000	\$1,350,000	\$38,486.28	\$41,210.98	2.13%

**Alternatives**

1. Cheese from 2% fat milk powder was tested, but resulted in an unappealing texture
2. Implement a two-stage spray drying process with temperature variations
3. A continuous process was evaluated, but was not cost effective for small scale operation
4. Reincorporate whey protein into the cheese to increase yield and protein content

**Prototype Analysis**

The bar chart shows Hedonic Rating (1-9) for Appearance, Taste, and Texture. For Appearance, 1% (green) is ~6.8, 2% (blue) is ~7.2, and Whole (yellow) is ~7.5. For Taste, 1% is ~2.8, 2% is ~4.2, and Whole is ~5.8. For Texture, 1% is ~2.5, 2% is ~5.2, and Whole is ~5.8.

**Parameters**

- Fat Content\*\*
- Curd Temperature
- Extent of Stretching

**Results**

3.25% (whole) milk resulted in product with highest yield and best sensory results

Powdered milk (left) creates cheese with dry, stringy texture and distinct milk powder taste when compared to fluid milk (right)

**Future Work**

- Invest in R&D to improve sensory qualities of product through addition of spices and/or texture modifiers
- Implement lean manufacturing principles to lower production costs
- Optimize plant layout and batch scheduling to improve production capacity and reduce downtime
- Outsource spray dried milk operations and expend majority of resources on cheese production
- Explore e-Commerce and other marketing strategies

**References:**

1. Mintel. (2016). Cheese-US-October 2016. Retrieved from <http://academic.mintel.com/display/748048/#>. (Last accessed 4/11/2018)
2. Pisecky, J. (2005). Spray drying in the cheese industry. *International Dairy Journal*, 15, 531-536.

**Technical Advisor and Instructor:**

Dr. Martin Okos

**Acknowledgements:** Special thanks to Troy Tonner, Alyssa Christoffer, Yvonne Hardebeck, and Carol Weaver