

# SENIOR CAPSTONE/ SENIOR DESIGN EXPERIENCE

## 2025

# Synergize: Biodegradable Caffeine Pouch

Karla Dominguez<sup>1</sup>, Francesca Hamacher<sup>1</sup>, Siddharth Kumar<sup>1</sup>, Joel Kuriakose<sup>1</sup>

<sup>1</sup>Biological Engineering, Purdue University, West Lafayette, IN

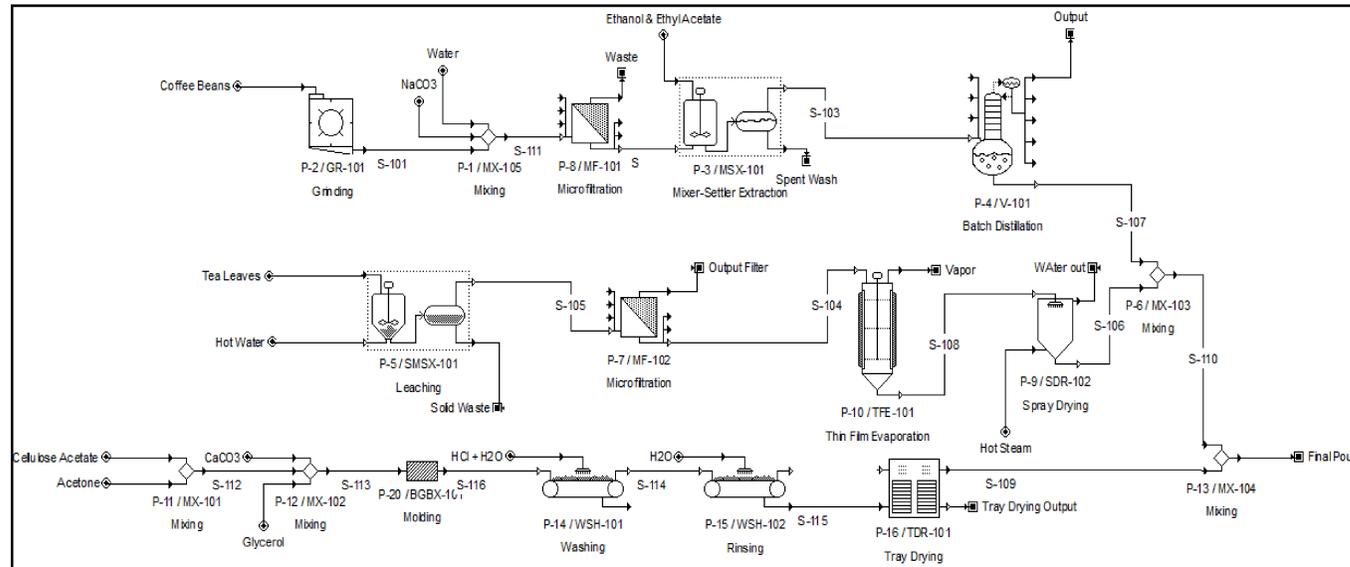


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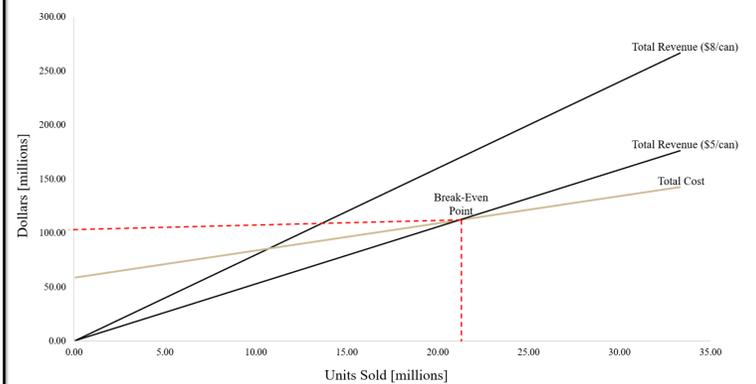
## Objective

To design a biodegradable, cognitive-enhancing oral cellulose pouch containing caffeine, L-theanine, and other natural ingredients while addressing associated economic, environmental, and ethical considerations.

## Process Flow Diagram



## Manufacturing & Plant Design



Cost	Value
Total Capital Investment	\$13,841,538.66
Product Cost & Manufacturing	\$27,697,082.35
Materials, Labor & Utilities	\$113,597,004.80
Total Can Cost	\$4.28
Selling Cost	\$5.29

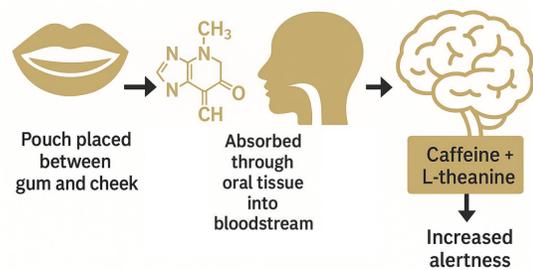
## Design Considerations

- Balanced Cognitive Enhancement with Caffeine and L-Theanine
- Biodegradable Packaging Using Cellulose
- Ethical and Environmentally Responsible Ingredient Sourcing

## Market Analysis

- Cellulose Packaging**
  - Projected to grow 5% over 10 Y (Future Market Insights)
- Nicotine Pouch Surge**
  - Sales rose 641% from 2019-2022 (CDC, 2024)
- Youth Usage**
  - 2.8M U.S. students use nicotine products
- Health-Conscious Alternative**
  - Meets demand for stimulants that offer alertness without nicotine or excessive caffeine side effects

## Mechanism of Action



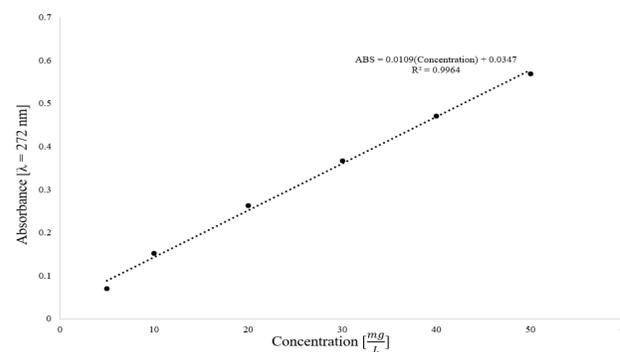
## Experimental Design

- L-theanine from Green Tea
- Caffeine from Coffee Beans
- Cellulose from Wood Pulp
- Pouch Construction

17% Caffeine  
33% L-theanine  
33% Excipients  
17% Theobromine

50 mg Caffeine  
100 mg L-theanine  
50 mg Excipients (Stabilizers, Glucose)  
50 mg Theobromine

## Caffeine Purity

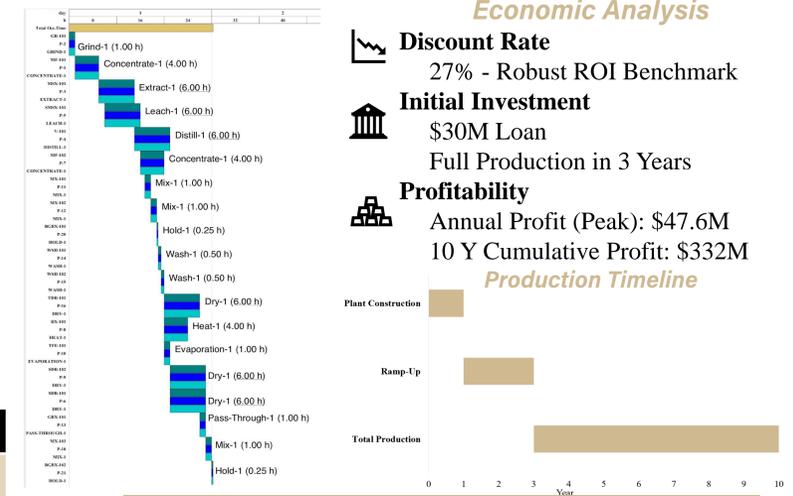


Extracted Caffeine Purity: 49.05%

Operations	Alternatives
Mixing: Mixer	Static Mixer, High Shear Mixer
Drying: Spray Drying, Tray Drying, Thin-Film Evaporation	Freeze Drying, Drum Drying
Distillation: Batch Distillation	Continuous Solvent-Recovery Distillation Column, Multi-Effect Evaporator
Separation: Microfiltration	Ultrafiltration, Centrifugation

## Economic Analysis

- Discount Rate: 27% - Robust ROI Benchmark
- Initial Investment: \$30M Loan
- Full Production in 3 Years
- Profitability: Annual Profit (Peak): \$47.6M, 10 Y Cumulative Profit: \$332M



## Future Work and Improvements

- Further Optimization**: Minimize raw material expenses through cheaper alternatives; Improve purity of caffeine and L-theanine extractions
- Additional Sustainability Measures**: Water and solvent purification, treatment, and reuse; Energy minimization through alternative energy sources

**Acknowledgments:** Thank you to Dr. Martin Okos, Daniel Hauersperger, and Mandy Limiac

### References:

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- Centers for Disease Control and Prevention. (2024, October 17). Tobacco product use among middle and high school students - national youth tobacco survey. United States, 2024. Centers for Disease Control and Prevention
- Temple, J. L., Bernard, C., Lipshultz, S. E., Czachor, J. D., Westphal, J. A., & Mestre, M. A. (2017). The Safety of Ingested Caffeine: A Comprehensive Review. *Frontiers in psychiatry*, 8, 80.