# SENIOR CAPSTONE/ SENIOR DESIGN EXPERIENCE

Alginate Vegan Sausage

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**Agricultural and Biological Engineering** 

## **Objective**

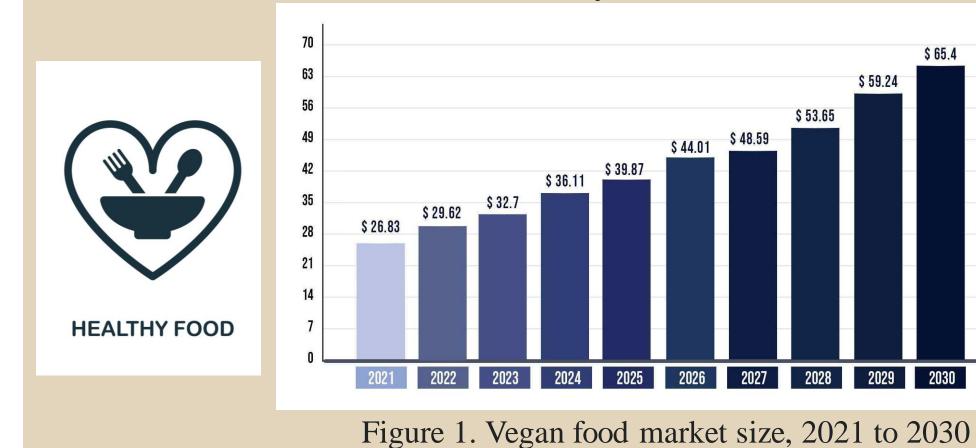
• To design a novel food product for the increasing vegan market by utilizing a sodium alginate casing and a wheat gluten/soy protein concentrate formulation.

2024

• To develop a large-scale production, 33 million sausage/year, and create a profitable business focused on minimal energy use and minimal waste.

## Market analysis

- The market for plant-based sausages is valued at **955** millions in 2022.
- There is a growing health consciousness amongst consumers and the demand for healthier food choices has almost **doubled** in last 4 years.



(USD Billion)

### Global factors

- Consumers are becoming more aware of the environmental impact that comes from meat production.
- Plant-based sausages have a **lower**environmental footprint compared
  to meat sausages, which aligns with
  the consumer sustainability values.

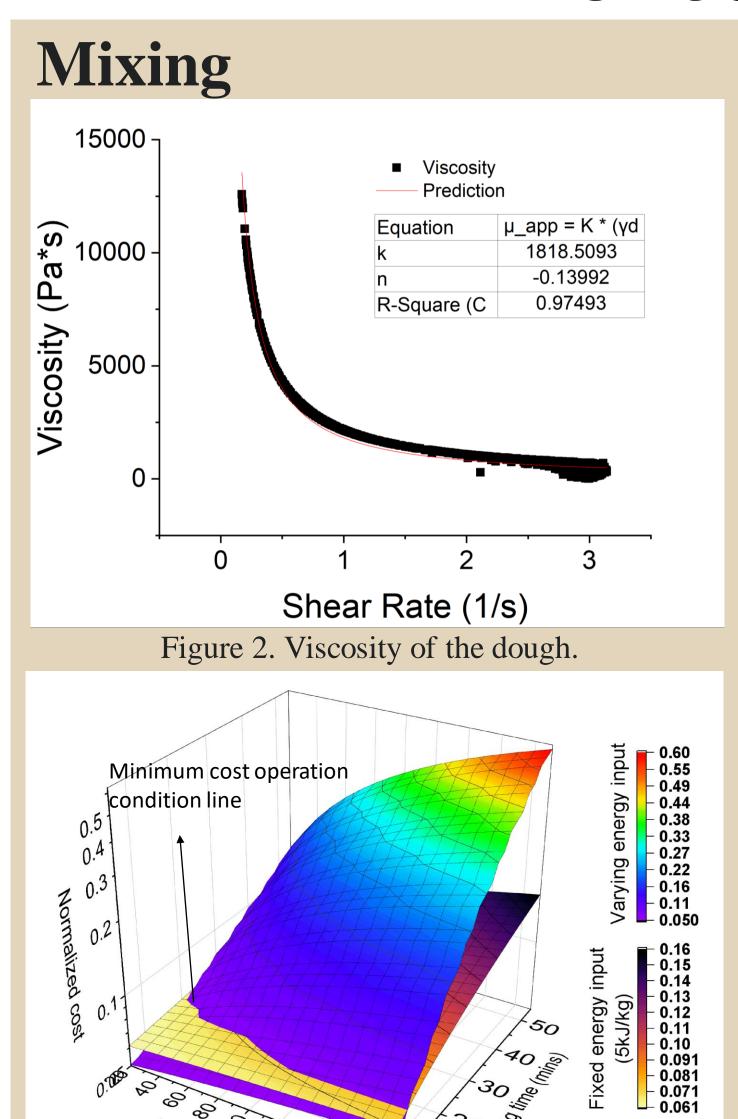


## Unit Operations and Alternatives

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<b>Unit Operation</b>	Alternative Solutions
Mixing	Spiral mixer, Chorleywood bread process (CBP), Continuous mixer
Extruding	Co-extrusion, extrusion, and vacuum filling
Preparation & Preservation	Curing, Fermentation, and <b>Drying</b>

#### Process Flow diagram **Nutrition Facts** Serving size Sau sage in gredient 21.6 kg/hr Amount Per Serving **337.5** kg/hr **240 Calories** % Daily Value Total Fat 10g 337.5 kg/hr Saturated Fat 1g 359.1 kg/hr 0 kg/hr Trans Fat 0g Wet dough Cholesterol 0mg Continuous extr / XLJ-101 337.5 kg/hr Casing by coextrusion Sodium 460mg **Total Carbohydrate** 6g Mixing tank/TM-101 Dietary Fiber 1g Coated sau sage Total Sugars 0g Dough mixing and kneading Includes 0g Added Sugars Protein 32g Vitamin D 0mcg 339.7.1 kg/hr Calcium 80mg 359.1 kg/hr Cased sausage Iron 4.1mg 250.02 kg/hr otassium 90mg \* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day Calcium chlorid / V-103 Tray Drying / TDR-101 Final product Casing formation Cold air Tray Drying Hot air % Ingredients Ingredients Ingredients 42-80 KW 40.3 Cumin Garlic powder Wheat gluten 20.1 Onion powder Soy protein concentrate Potassium sorbate 0.6 kg/hr Vary based on condition 0.9 Citric acid 16.5 alginate Sunflower oil 0.8 |Sugar Salt Heating / HX-101 0.7 |Xanthan gum Avocado oil 1.1 Fennel seeds

### Unit Operation and Optimization



#### Extrusion Increasing screw diameter

• Increasing screw diameter or channel width decreases rotational speed.

**RPM** 

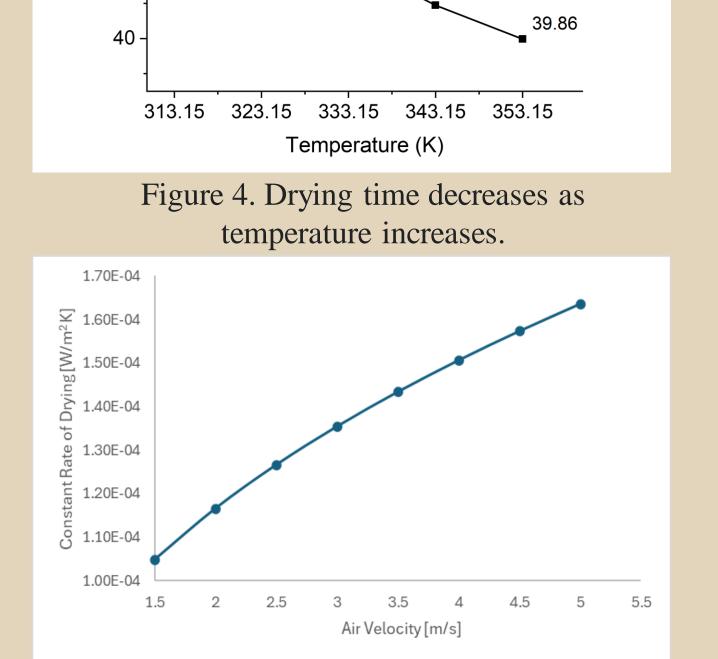
 These can be optimized to decrease power consumption if SME is known

Dex (m)

0.06	205
0.07	175
0.08	153
0.09	136
0.1	123
<b>NAL</b> (1000)	DDN 4
W (m)	RPM
<b>w (m)</b> 0.01	<b>RPIVI</b> 205
•	
0.01	205
0.01	205 169.5
0.01 0.011 0.012	205 169.5 142.43

#### Drying

60 -



—<del>■</del> Time Dry

Figure 5. Increasing Air flow Velocity increase drying rate.

### Plant systems

#### Mixing

- CIP and QA to ensure the safety of food.
- Sustainable energy source.

#### Extrusion

- HAACP and QA
- Their implementation can minimize waste by reducing the likelihood of defects, rework or disposal of non-conforming material.
- Feedback loops to maintain pressure and flowrate can aid in critical control points

#### Drying

- Utilize air-to-air heat exchanger to improve energetic performance of tray dryer.
- Solar energy can be used to minimize carbon footprint

## Economic analysis

- Total equipment cost: 464,410\$
- Total capital investment: 2,275,609 \$
- Total product cost: 13.78 \$/kg
- Break-even cost in 10 years: 14.61 \$/kg
- Annual production: 8093 batches, 2,023,250kg

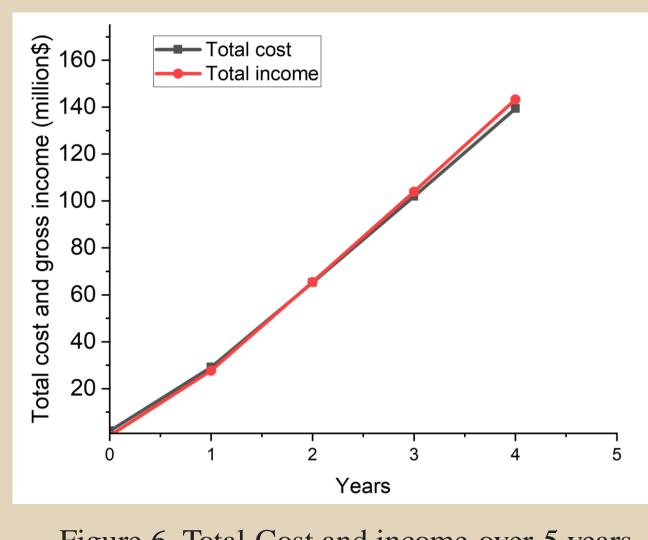


Figure 6. Total Cost and income over 5 years for 15 \$/kg sale price.

Simple Truth® Plant- 12.63

Based Veggie Dogs \$/kg

#### Future work

#### **Unit operations**

- Using solar energy to power tray drying
- Finding the SME for different RPM to further optimize the extruder

#### Final product

• Adding more nutritional value by adding vegetables into the formulation

Technical Advisor: Daniel Hauersperger

**Instructor**: Dr. Martin Okos

Figure 3. Cost optimization for mixing.

References: https://www.precedenceresearch.com/vegan-food-market

https://www.peta.org/about-peta/faq/how-does-eating-meat-harm-the-environment/

https://www.gminsights.com/industry-analysis/plant-based-sausages-

market#:~:text=Plant%2Dbased%20Sausages%20Industry%20Analysis,CAGR%20from%202023%20to%202032