

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.
- 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.

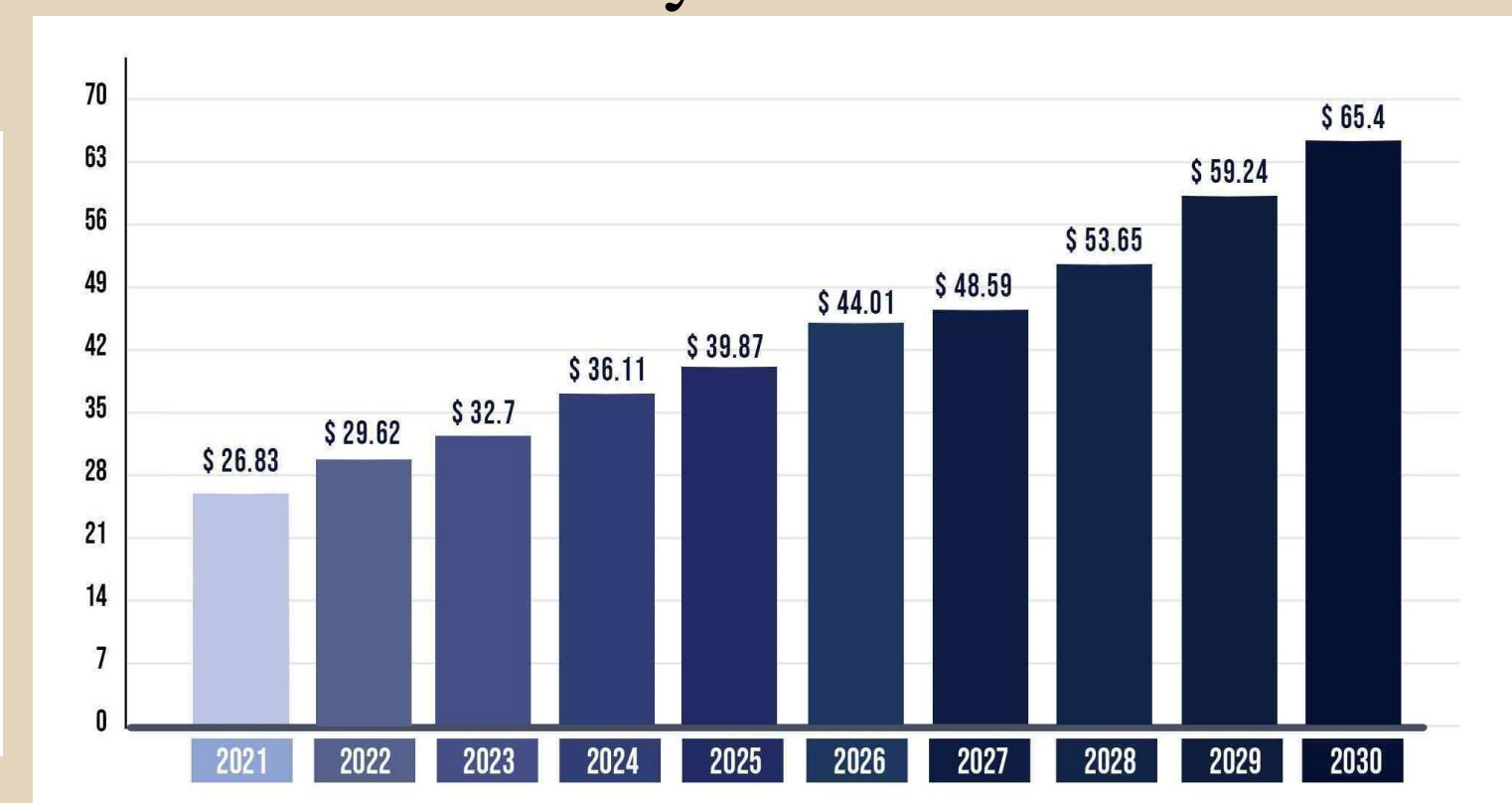


Figure 1. Vegan food market size, 2021 to 2030 (USD Billion)

Global factors

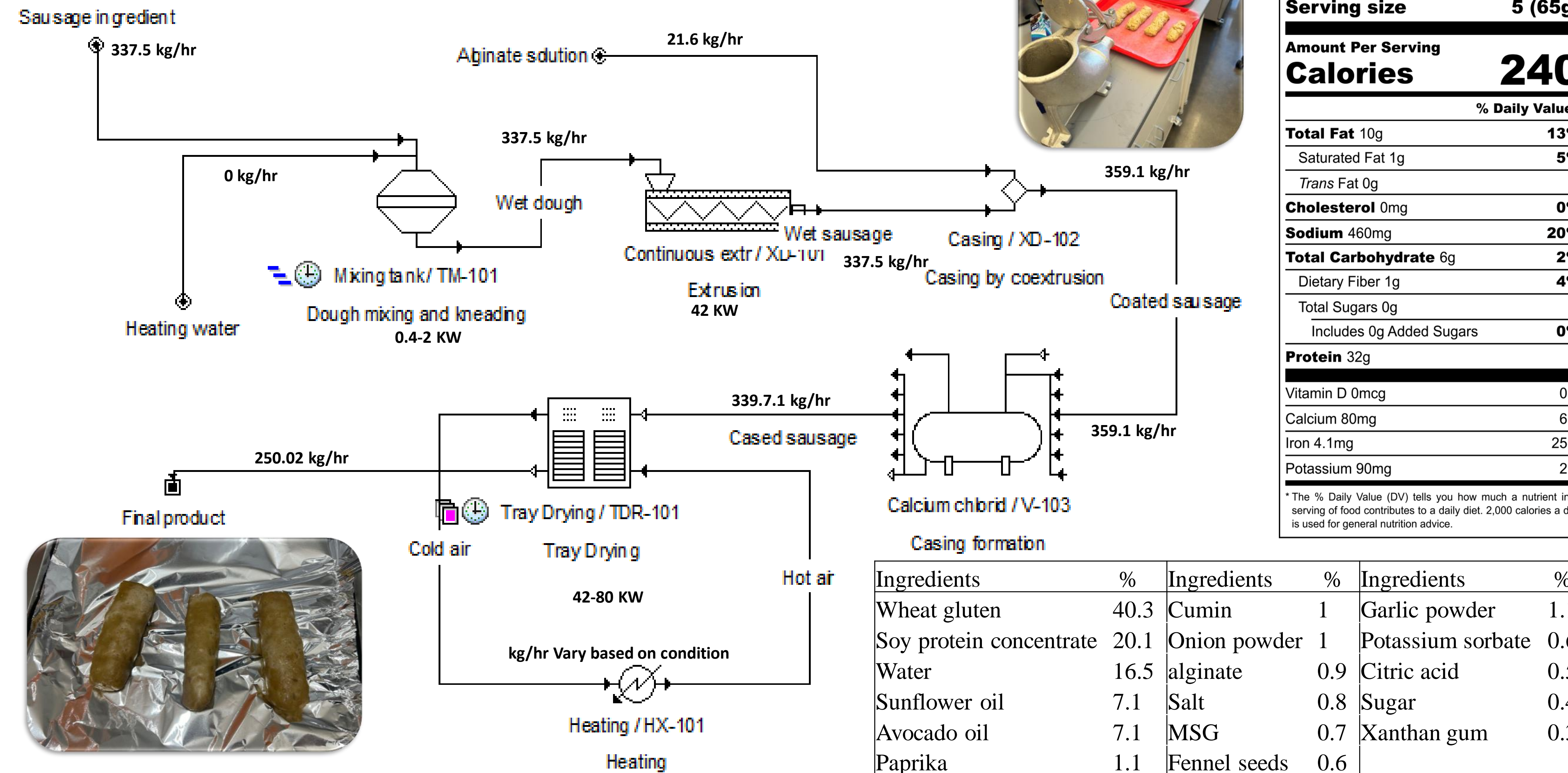
- Consumers are becoming more aware of the environmental impact that comes from meat production.
- Plant-based sausages have a **lower environmental footprint** compared to meat sausages, which aligns with the consumer sustainability values.



Unit Operations and Alternatives

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

Process Flow diagram



Unit Operation and Optimization

Mixing

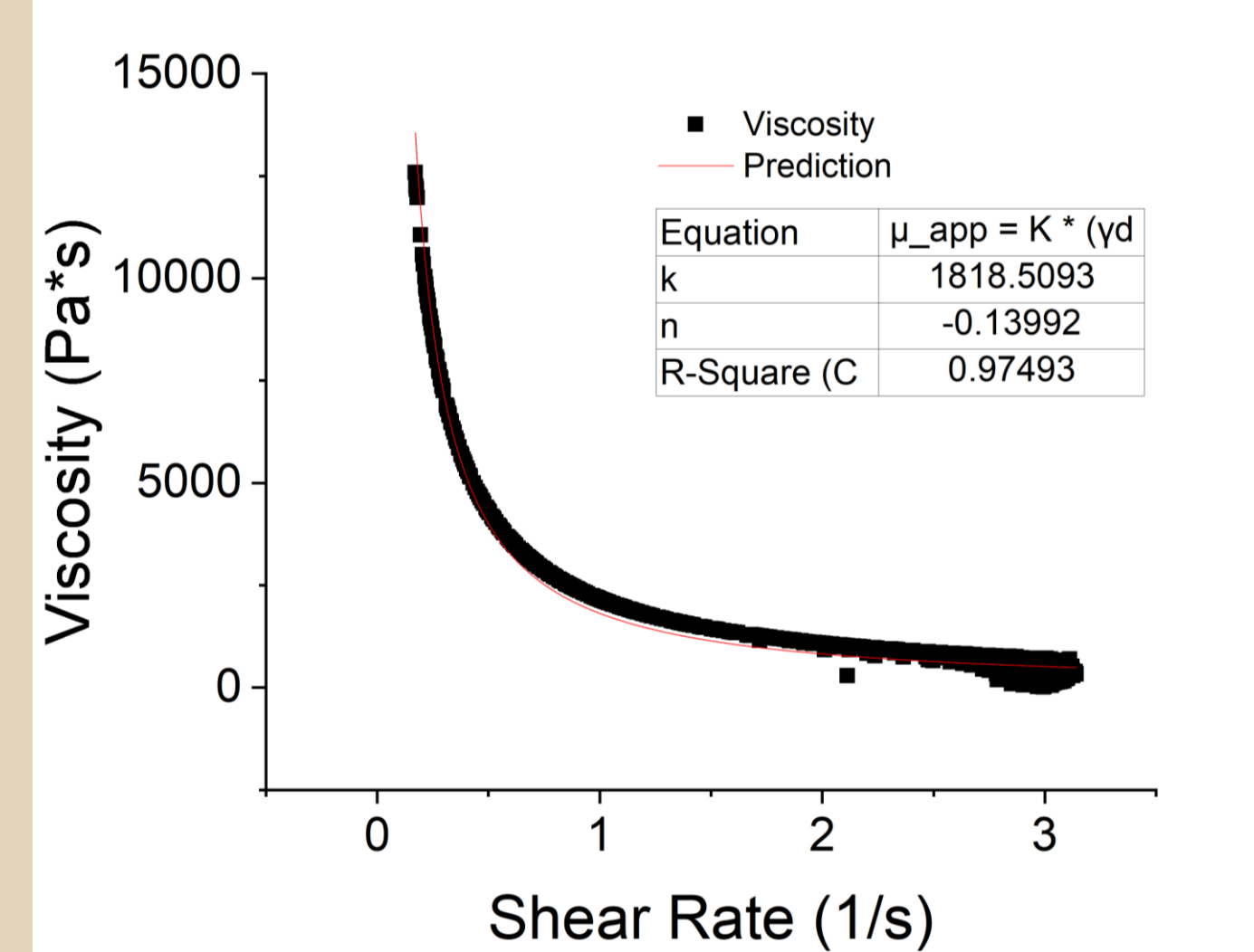


Figure 2. Viscosity of the dough.

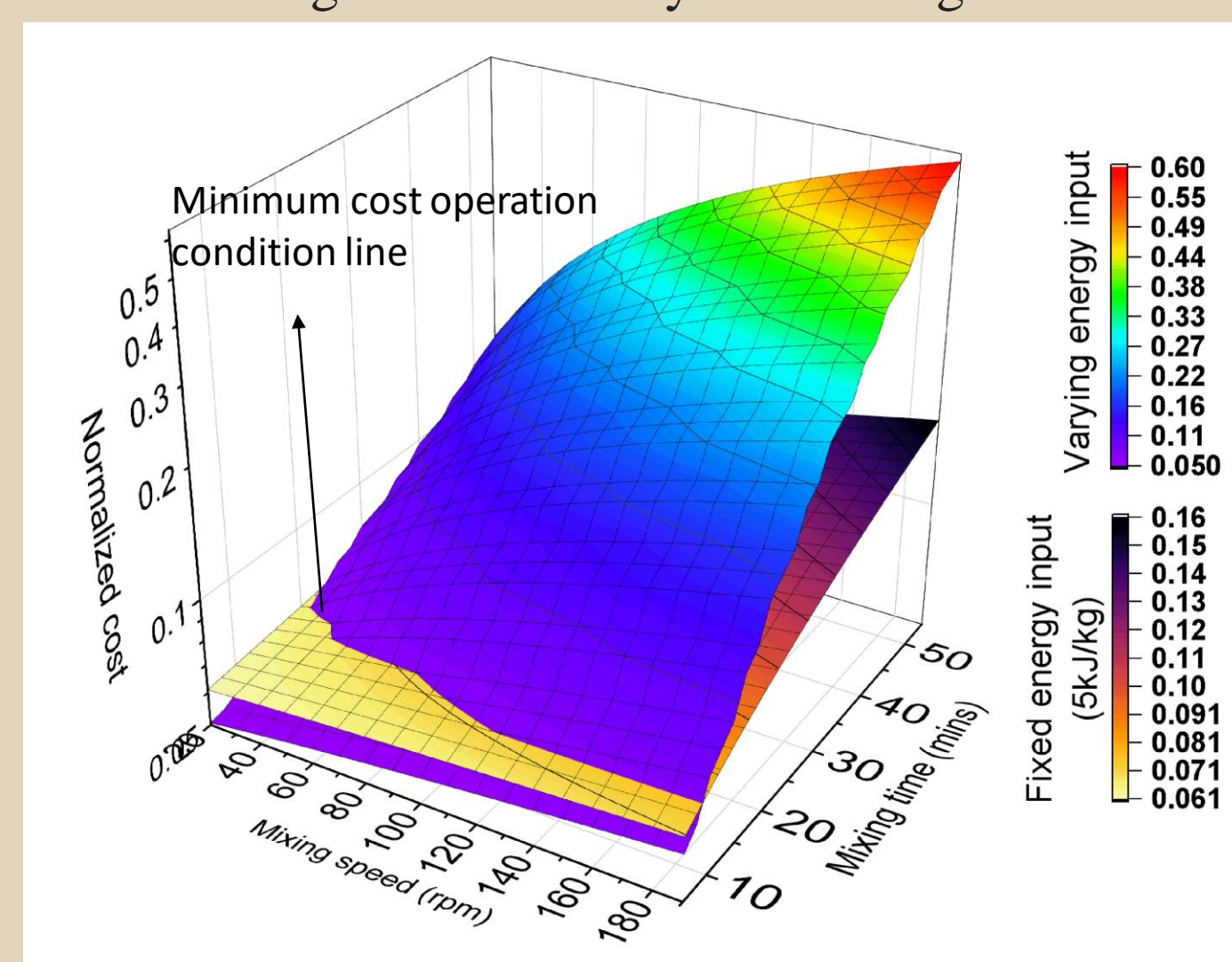


Figure 3. Cost optimization for mixing.

Extrusion

- Increasing screw diameter or channel width decreases rotational speed.
- These can be optimized to decrease power consumption if SME is known

Dex (m)	RPM
0.06	205
0.07	175
0.08	153
0.09	136
0.1	123

W (m)	RPM
0.01	205
0.011	169.5
0.012	142.43
0.013	121.36
0.014	104.64

Drying

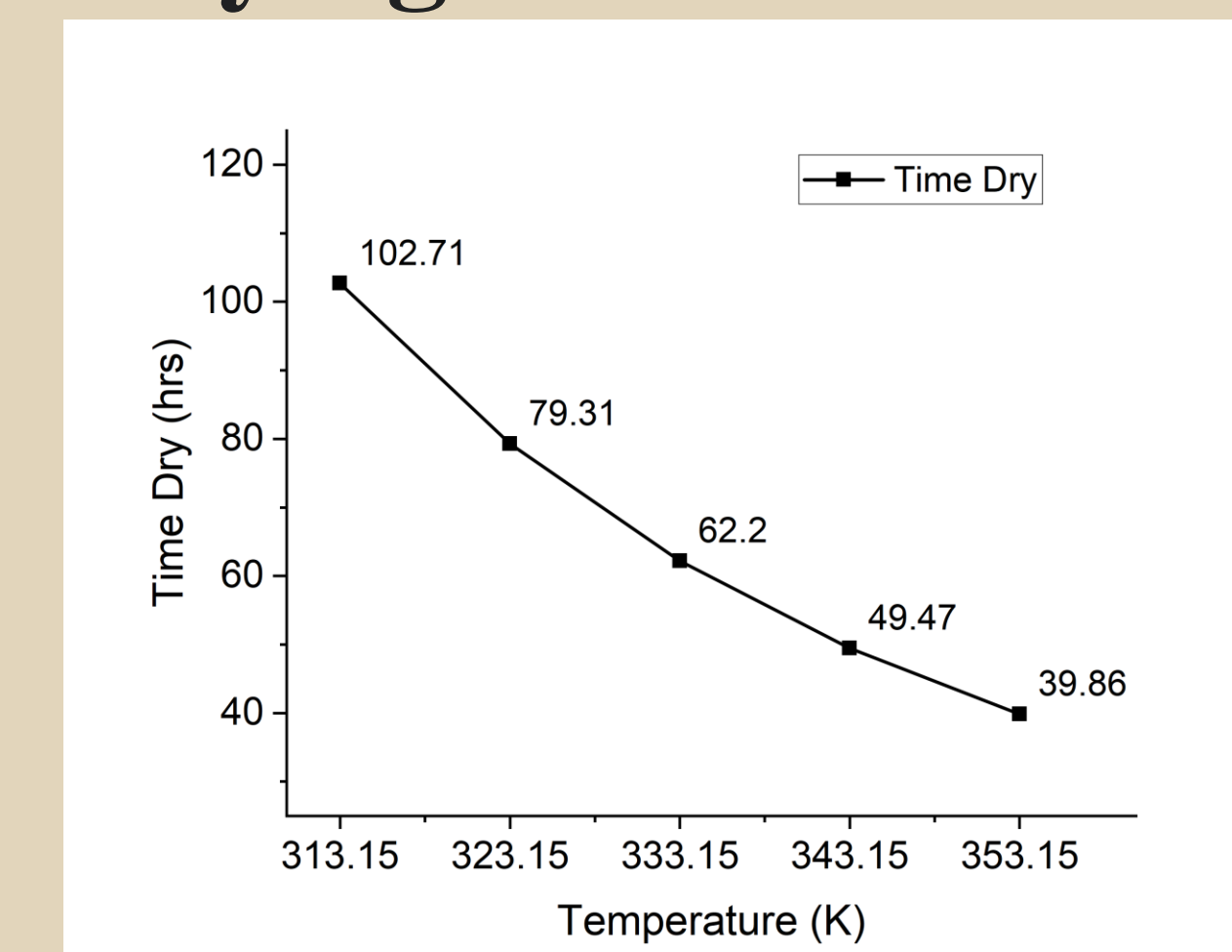


Figure 4. Drying time decreases as temperature increases.

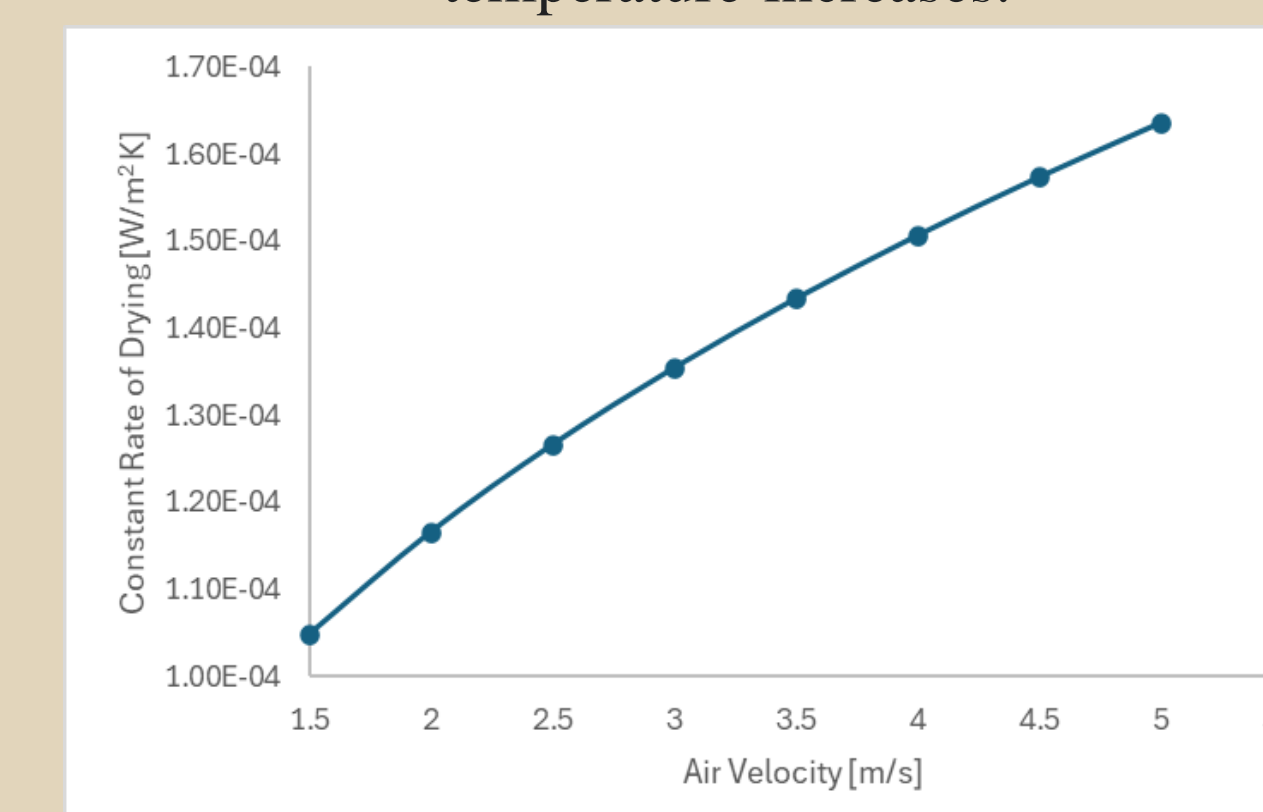


Figure 5. Increasing Air flow Velocity increase drying rate.

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

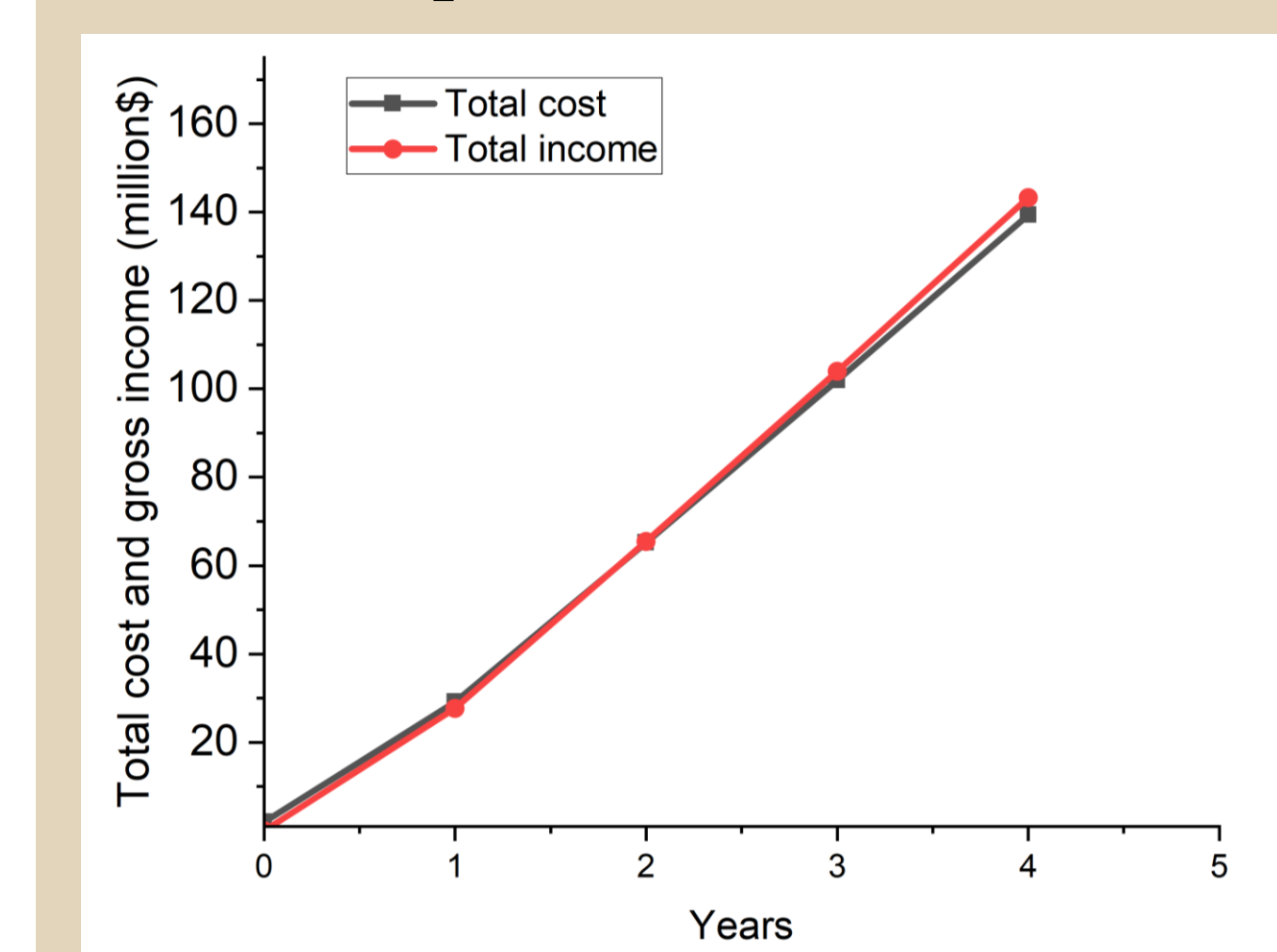


Figure 6. Total Cost and income over 5 years for 15 \$/kg sale price.

We make money at the 2nd year when sale price is 15 \$/kg.
Competitor sale price from online:

Impossible Plant Based Bratwurst	16.20 \$/kg
Field Roast Plant Based Sausages	16.34 \$/kg
Beyond Meat Beyond Breakfast Sausage	22.40 \$/kg
Simple Truth® Plant-Based Veggie Dogs	12.63 \$/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