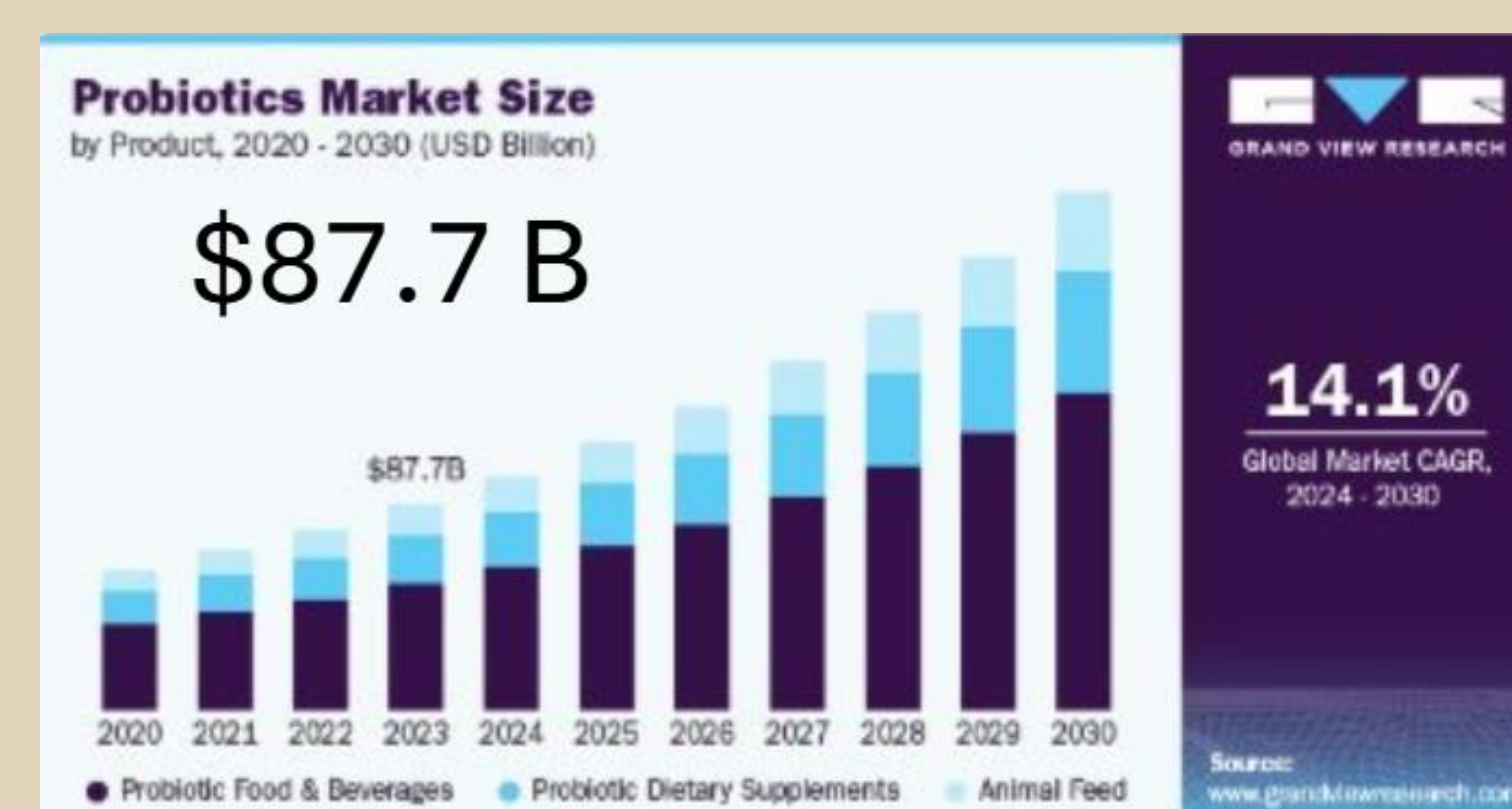


## Objective

Formulate a sustainable and cost-effective industrial scale probiotic gummy making process for digestive and immune support.

## Background

- Low barrier to market entry
- Increasing consumer focus on diet, nutrition, health and balanced immune systems
- Advantages of cold-set gelation
  - 300 times less CO<sub>2</sub>
  - 99 times less energy



## Global and Societal Considerations

- Sustainable manufacturing practices
  - Renewable energy
  - End-product recycle
- Lack of government regulations
- Educate consumers about benefits
  - Digestive health
  - Immune health

## Alternatives

### Fermentation:

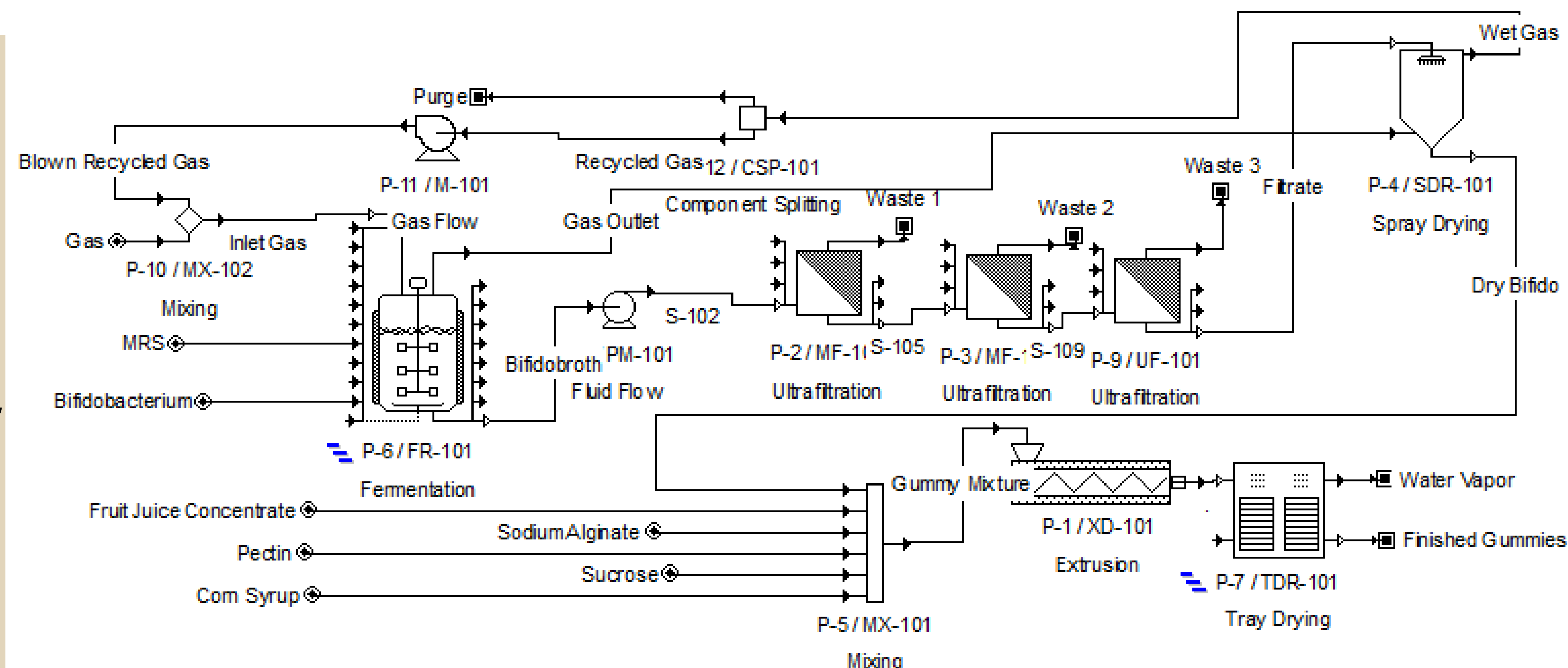
- Submerged membrane bioreactor
- Packed bed bioreactor

### Microbial Processing:

- Freeze drying
- Convective hot air drying
- Infrared and microwave

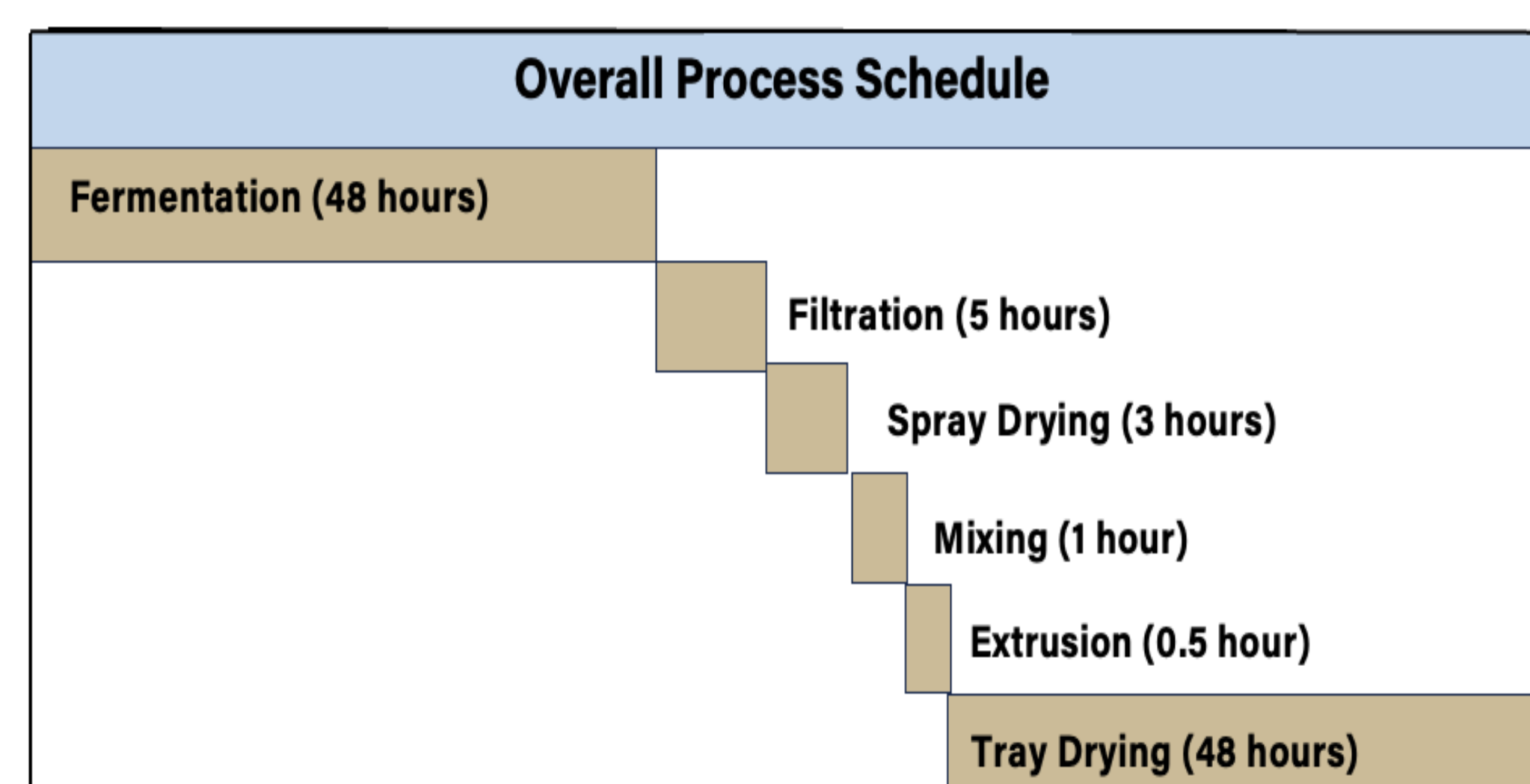
### Gummy dehydration:

- Freeze drying



## Process Operations

Fermentation, spray drying, and dehydration operations were modeled in the computer program SuperPro. Through optimizing the scheduling of the entire process, it was determined that for every one spray dryer, there should be eight fermenters and tray dryers each.



**Final Process Schedule:** Entire process takes 104.5 hours from inoculation to finished gummies.

## Final Design

Each gummy:

- Pectin cold-set gelation
- 2 billion CFU of Bifidobacterium
- 3 grams by mass
- Fruit flavor

## Economic Optimization

Each unit operation was optimized to minimize annual costs.

Unit Operation	Optimized Variable	Value
Fermentation	Substrate Concentration	25 g/L
Spray Drying	Inlet Air Temperature	130 °C
Dehydration	Air Temperature	40.42 °C

## Experimentation

### Fermentation

- MRS media
- Bifidobacterium Longum BB536
- Test and Experiments at 37 °C
  - Cell viability over time
  - Product production and pH
  - Substrate and sugar concentration

### Spray Drying

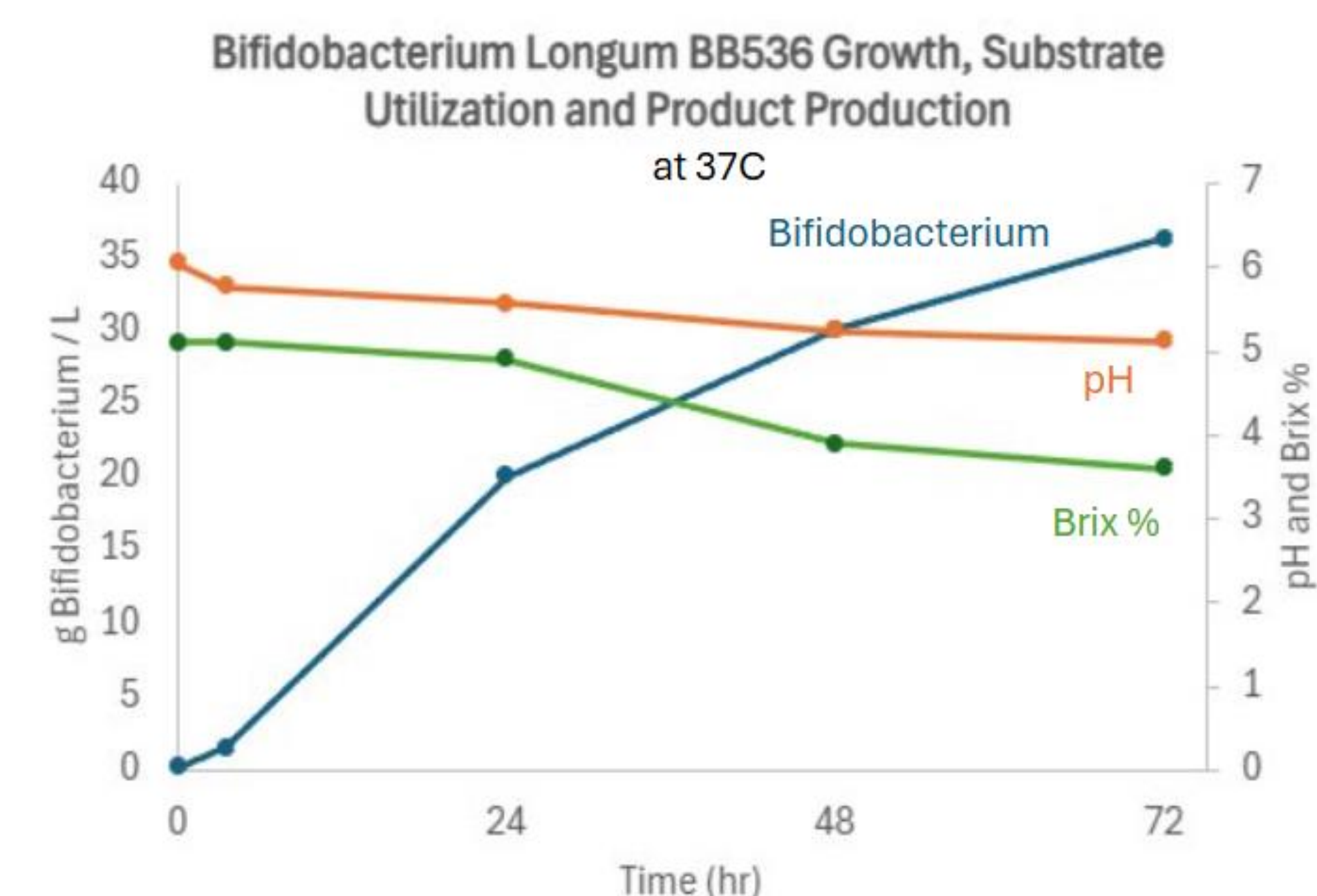
- Inlet temp 115 °C
- 8 mL/min liquid flow rate

### Final Recipe (18 gummies):

- 44 g sucrose
- 11 g corn syrup
- 30 g fruit juice concentrate
- 2 g sodium alginate
- 1.4 g pectin
- 450 mg dried Bifidobacterium

### Conditions:

- 35 °C
- 15% RH
- 48 hrs



## Future Work and Improvements

- Addition of other probiotics
- Improvement of organoleptic properties via taste testing
- Testing shelf life