PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2015

BoilerMilk: Purdue Ferm. Milk

Agricultural & Biological ENGINEERING

Team 6: Craig Meader (BE), Yuezhi Wu (BE), Jiayun Yu (BE), Tianqi Zhao (BE)

Problem Statement

Probiotic fermented milk with an adequate amount of live probiotic microorganisms is marketed for its intestinal benefits in humans. It has become enormously popular in Europe and Asia but still has a small market in the United States..

Overall Goal

Design a process to maximize the profit of probiotic fermented milk production while minimizing environmental impact.

Design Objectives

- Design a profitable manufacturing process producing a probiotic-rich fermented milk drink
- Improve the existing industrial process by reducing energy consumption
- Eliminate environmentally unsafe waste generated during production process

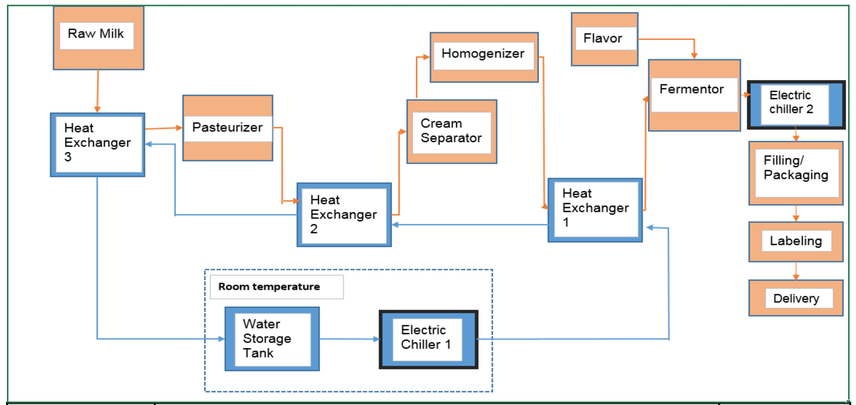
About Our System

- Pasteurize milk to kill pathogens and denature milk proteins
- Run raw milk through cream separator at 120oF to standardize it to 1% fat
- Ferment at 73oF to allow growth of probiotic bacteria
- Recycle starter culture after fermentation to save on costs
- Filling and packaging process after production continuously into 6 oz bottles

Background

- 432.67 metric tons of milk is produced worldwide per year while the US production is 85.89 metric tons.
- Of the world's major consumers of probiotic fermented drinks, 32% are in Europe, 25% are in Asia-Pacific, while only 7% are in the U.S.
- The total annual revenue of probiotic drinks is predicted to be 24 billion dollars in 2017, 80% of which belongs to probiotic dairy drinks.

Final Process Design



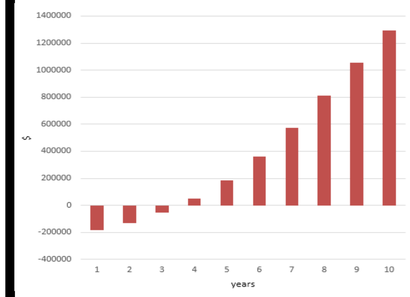
Equipment	Size	Price($)
Raw milk storage tank	Jacketed Lightly Stirred Vessel (1.38m Diam x 1.38m Height)	12,000
Other storage tanks	Water: 0.567m3 Sugar: 0.1870 m3 Vanilla: 9.9e-3 m3	W:700S:7500 V:3.70
Pasteurizer	Continuous single stream pasteurizer with regeneration section (1.5m3)	1500
Cream Separator	Centrifugal separator to reduce cream content in milk to 1%	1000
Homogenizer	Single-pass homoginizer with dP of 18.4MPa (1.34m3)	2450
Fermentor	Jacketed two-speed Stirred Vessel (0.96m Diam x 0.96m Height)	10,000
Electric chiller	Laboratory Process Chiller (0.73m x 0.57m x 0.85m)	3000 - 4500
Heat exchangers	Flate plate heat exchangers, 5"x12" ,different plates	400 - 1400
Filling/Packaging machine	Rotary Type Automatic Cup Filling Sealing Machine (1250*1250*1650mm, 800-1000 cups/hr, filling volume 50-300ml)	5000
Pumps	J.Flecher, Zowllwe company Regenerative pump	5400 for 6 pumps
Pipes	Stainless steel with 18% chromium and 8% nickel	1800

Economic Analysis

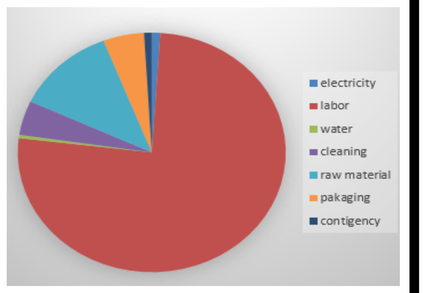
-After contacting the Purdue Housing and Food Services, we found the market for our product to be at 145,351.2kg/year. The chosen selling price is $1 per 6 oz. fermented milk drink cup. We assume the sales numbers of the first year will equal to 40% of our production rate with a 15% increase in sales each year after until our annual production is reached. This assumption was made with reference to the company Yakult, which produces a similar fermented milk drink product. Any unsold product each year will be donated to a local food bank in order to drum up more interest in our product.

-Capital investment was estimated at $215,683.80 with a fixed annual operating cost estimated to be $106,637.47. This cost includes labor, cleaning, electricity, waste, and water expenses. By year 10, we should have a cumulated revenue of $1,293,004.50 with a calculated payback period of 3 years. The net rate of return per year is 10.08%.

Cumulative Revenue in 10 years



Annual Cost Distribution

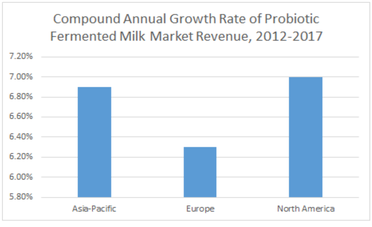


Experimental Design

- Able to perform multiple trials to determine optimal fermentation time of 16 hours for optimal thickness.
- Able to determine optimal flavoring using sucrose and vanilla extract.

Global/Societal Impact

According to global trends and the current market size on probiotic consumption, we are expecting an explosion of growth in the consumption of probiotic fermented milk products in the U.S.A.



Market Analysis

Purpose

To determine the promising prospect for probiotic fermented milk to open up the potential market demands.

Methods

Analysis of research materials including experimental records, investigative journalism, and news sources.

Findings

Increasing needs for probiotic beverages that can benefit human health for people at all economic levels. Particularly, a rapid worldwide growth in the demand for probiotic fermented dairy drinks that provide intestinal benefits.

Pros

1. Allows Purdue community to enjoy fresh, locally produced probiotic fermented milk.
2. Allows Purdue students to gain job experience in an active food processing plant while making money at the same time.
3. Design allows easy switch into other types of fermented milk by changing fermentation time and cream milkfat amount.

Cons

1. The equipment system has a small production level, so the system could not meet a large increase in demand.
2. Inefficiency due to the relatively small size of the equipment and number of processing days per year.
3. Expensive cost of starter culture and reliance on nothing to go wrong with the starter culture due to contamination.

Opportunities

1. Tap into a largely untapped market with the potential to expand greatly in the coming years.
2. Take advantage of the large numbers of international students at Purdue
3. Have access to some of the best and brightest minds in the field of Food Science and Food Process Engineering.

Threats

1. Big dairy manufacturing companies entering the market and taking away business.
2. Recent increase in the consumption of greek-style yogurt over traditional yogurt and fermented milk drinks.
3. Inability of fermented milkt drinks to become popular with domestic students at Purdue.

Alternative Solutions

Fermenter

- 2 Fermenters: $18,860
- 3 Fermenters: $27,748

Heat Exchanger

- Using heat exchanger to replace all chillers as well as preheating/cooling with milk itself.
  - Decrease operating cost but increase the equipment cost and control difficulty.
- Shell and Tube Heat Exchanger
  - Decrease efficiency of cooling; increase difficulty for cleaning.

Raw Materials

- Buying pre-processed 1% milk instead of raw milk
  - Will skip having to buy homogenizer and cream separator
  - Overall increases our payback period as well as decreases net revenue.

Nutrition Facts

Serving Size 3/4 cup
Servings Per Container 1

Amount Per Serving	
Calories 214	
	% Daily Values*
Total Fat 0.2g	**0%**
Saturated Fat 0.1g	**1%**
Trans Fat 0g	
Sodium 79mg	**3%**
Total Carbohydrate 47g	**16%**
Dietary Fiber 0g	**0%**
Sugars 47g	
Protein 44g	**88%**

*Percent Daily Values are based on a 2,000 calorie diet.

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