PURDUE UNIVERSITY

CAPSTONE/DESIGN EXPERIENCE 2016

Non-alcoholic Freeze-dried Beer

Agricultural & Biological ENGINEERING

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Problem Statement

The freeze-dried product industry has a niche market, but it has been slowly and steadily on the rise in recent years. They are often preferred over typical dehydrated products because of their high quality as well as their ability to be easily rehydrated. We generated an idea for a novel product within this industry: freeze-dried non-alcoholic beer powder.

Objective

To develop a profitable student run business that provides industrial experience for Biological Engineer and Food Science students

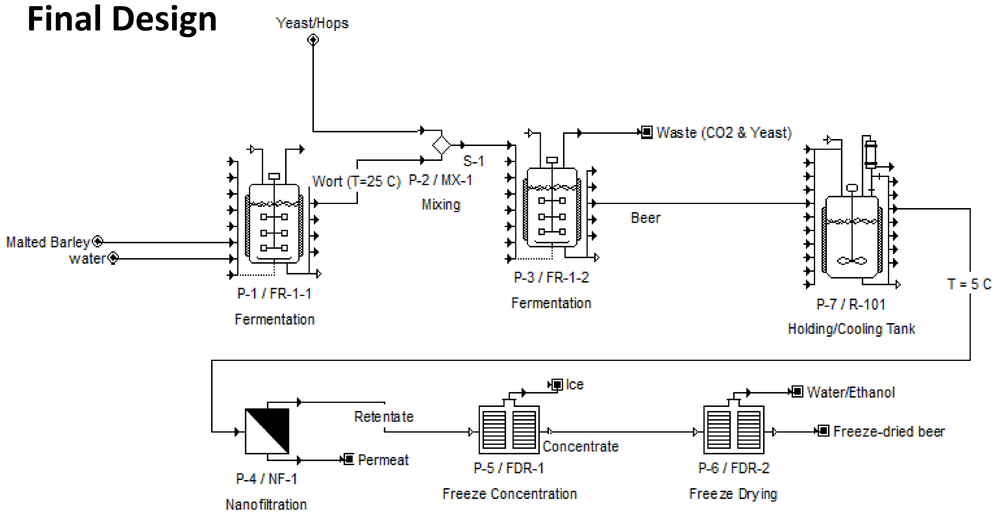
Background

Common products currently in the powdered drink market consist of tea, sport drink, and fruit flavored mixes. The market has seen slight, but steady growth, and has a projected annualized revenue growth rate of 1% over the next five years (IBISWorld 2015). Alcoholic related products are not currently common in the powdered drink market. However, the recent approval granted by the Alcohol and Tobacco Tax and Trade Bureau for a product called Palcohol, which is essentially powdered vodka, has opened the doors for similar products to enter the market, including ours.

Sustainability

- Waste water from freeze concentration can be recycled for use in fermentation.
- Waste fluid from membrane filtration and freeze concentration could be sent to a company that separates mixtures so that the water and ethanol could be re-used

Final Design

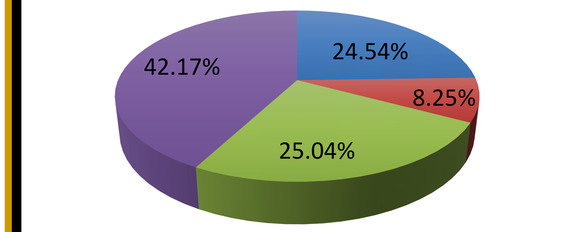


Note: There will only be one fermenter used. However, two are shown in the process flow diagram so that the SuperPro Designer program could be utilized for calculation purposes.

Economic Analysis

Annual Profit Analysis (First 5 Years)	
Product per year	207,529.6 4oz
Selling Price	$2.00/oz
Revenue	$415,059
Profit	$61,724
Payback	5 years
Return on Investment	17.47%

Equipment Cost Breakdown



The annual profit analysis pertains only to the first 5 years of operation. A 5 year 3.85% fixed interest loan will be used to pay for capital costs, giving an annual payback on capital of $34,640. After loan repayment, profit and ROI will both increase.

Annual Profit After 5 Years	
Profit	$96,364
Return on Investment	30.24%

Fixed Capital	Cost
Equipment	$38,715.28
Plant	$92,916.67
Total	$131,632

Annual Costs	Cost/year
Ingredients	$21,382
Labor	$158,994
Utilities	$20,880
Miscellaneous	$117,439
Total	$318,695

Societal/Global Impacts

- Provides hands-on industrial experience for students
- Allows international students to gain work experience
- Culinary product with an increased shelf-life
- Easily transportable during activities such as camping and hiking
- Beer alternative for those who refrain from drinking due to pregnancy or religious/cultural reasons

Alternative Solutions

Fermentation: Purchasing beer from a vendor rather than fermenting could potentially reduce cost.

Nanofiltration: Membrane filtration was chosen over alternative separation processes such as dialysis, evaporation, and vacuum distillation because it requires lower energy costs and does not require harsh operating conditions, thus ensuring high product quality.

Freeze Concentration: Block freeze concentration was chosen over suspension and film freeze concentration methods due to ease of operation and lower costs.

Freeze-drying: Freeze-drying was chosen rather than spray-drying in order to maintain product integrity by operating at lower temperatures.

Application of Engineering:

Freeze Concentration Experiment

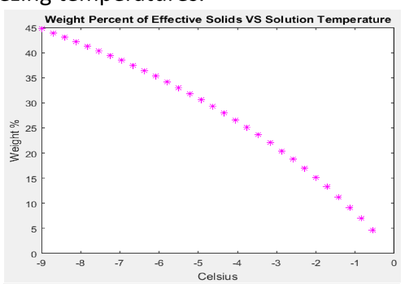
	Sample 1 (-1°C)	Sample 2 (-1°C)
% Water	90.76	91.32
% Ethanol	0.68	0.64
% Effective Solids	8.56	8.04
	Sample 1 (-2.4°C)	**Sample 2 (-2.6°C)**
% Water	84.10	79.15
% Ethanol	1.18	1.54
% Effective Solids	14.72	19.31

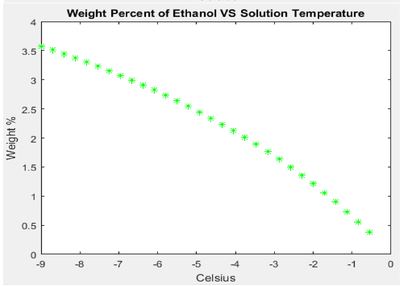
Based on the data above, the molecular weight of the effective solid/ethanol mixture was calculated using the following equations.

$$\ln(X_w) = \frac{\lambda'}{R}\left[\frac{1}{T_{wo}} - \frac{1}{T}\right]$$

$$X_w = \frac{x_w/18.02}{x_w/18.02 + x_m/MW_m}$$

An algorithm was then developed to determine theoretical yields at various freezing temperatures.





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