PURDUE UNIVERSITY

CAPSTONE/DESIGN EXPERIENCE 2017

Purdue Student-Run Microbrewery Research Lab

Agricultural & Biological

Michael Dexheimer (PHPE), Ivanna Gomez (FBPE), Sarah Greensfelder (PHPE), and Nick Palcheff (CBOE)

Problem Statement: With the development of the fermentation minor in the Agricultural and Biological Engineering College, the need for a new research lab has presented itself. Our group has set out to develop a Microbrewery to be housed in the new ABE building to serve the purpose of providing a research opportunity to undergraduate students as well as providing a highly demanded product to the Purdue community.

Market: According to brewersassociation.org, there were 4,225 craft breweries in the U.S. as of 2015, which was an 18.1% increase from 2014. As of 2015 the market is $22.3 billion (16% dollars sales growth). Since our beer is sold out of a campus building, that provides competitive advantage. We will need to show our unique, high-quality option is worth purchasing over other competitors.

Ethical Impact: Craft brewing turns beer drinking into more of a hobby. This may be misused by individuals who may be susceptible to abuse.

Global Impact: Major brewers have instituted programs to reuse materials used in the production process. There are many agricultural concerns associated with brewing.

Societal Impact: In an industry that must continuously respond to changes in consumer preferences, having such a large audience can be overwhelming for smaller breweries and cause them to not always meet their market's demands.

Alternative Solutions

Grains
- Crushed Grains
- Uncrushed Grains

Malt
- Dry Malt Extract
- Liquid Malt Extract

Filtration
- In-line ultrafiltration
- Mesh Screen

Packaging
- Bottles
- Cans
- Kegs

Pasteurization
- Flash pasteurization
  - In bottles
  - Before bottling

Overall Business Plan

1. Locate source of income to begin the project.
2. Locate a faculty member to start an undergraduate research program.
3. Select undergraduate research students to help run the production site.
4. Purchase equipment for entire process.
5. Implement/Install machines.
6. Trial-run process/Testing.
7. Validation of Procedure.
8. Sell/distribute product.
9. Expand based on demand.

Brewing Procedure

Mashing: Malted grains are steeped in hot water to provide fermentable sugars.

Sparging: Grain husks are rinsed and separated from the mixture that is now called wort.

Boiling the Wort: The wort is boiled for an hour and the hops are added. Hops will influence the aroma and taste profile of the beer.

Cooling the Wort: The wort is then rapidly cooled.

Fermentation: Yeast ferments the simple sugars from the malt and produces ethyl alcohol and carbon dioxide. This process takes 2-4 weeks.

Filtering: Removes bulk of the yeast.

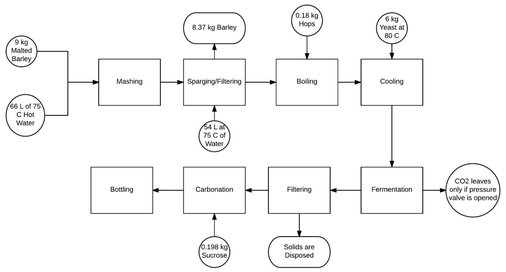
Carbonation: Fermentation tank is sealed once the beer has reached within 1% Plato of the final specific gravity.

Bottling: Carbonated beer is poured into glass bottles and cap-sealed.

Pasteurization: Bottles are heated to 180 degrees Celsius for several minutes.

Packaging: Beer is packaged into 4-bottle containers.

Process Flow Diagram



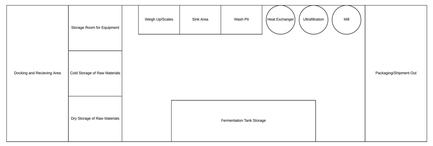
Mass Balance/Raw Materials

In Streams	Out Streams
1. 9 kg malted barley	7. 8.37 kg of barley
2. 66 L of 75°C H_2O	8. 4.50 kg of CO_2
3. 54 L of 75°C H_2O	9. 6 kg of filtered solids
4. 0.18 kg of hops	10. 116.48 kg of beer
5. 6 kg of 21°C yeast	
6. 0.198 kg of sucrose	

Energy Balance

• 66 L H_2O 25°C to 75°C:	13.8 kW
• 68 L H_2O + grains 75°C 1 hour:	0.380 kW
• 80 L H_2O + grains + malt 75 - 100°C:	8.042 kW
• 54 L H_2O 25°C to 100°C:	16.93 kW
• 130 L mash 100°C 1 hour:	0.571 kW
• 130 L wort 100°C to 38°C:	42.8 kW
• 130 L wort + yeast 21°C 2 weeks:	22.27 kW
• **Total energy needed:**	**104 kW-hr**

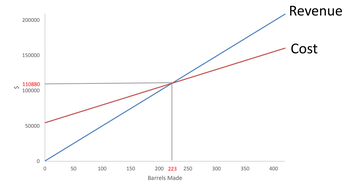
Plant Layout



Equipment

- Heat exchangers (4) $3288.00
- Fermenters (14) $17,752.00
- Ultrafiltration System $83.50
- Holding Tanks (4) $800.00
- Pasteurizer $1500.00
- Mill (optional) $240.00

Break-Even/Profit Loss



After 223 barrels and $110,880, the company breaks even. This is just a bit over 1.5 years, assuming a production of 140 barrels per year.

Experimental Analysis

Lab experiments were conducted in order to observe the effects of amount of yeast, priming sugar, and hops added to the beer. The variables were chosen as they would have the largest effect on alcohol percentage, flavor, and carbonation levels. Changes in these variables were determined via sensory tests and ABV testing. The sensory test showed that the sweetness was negatively correlated with the alcohol content and bitterness. This indicates that carbonation has a large effect on the perception of alcohol content and bitterness of a beer.

Sample	ABV (%)
Control	3.69
Yeast (+)	3.71
Yeast (-)	3.55
Sugar (+)	3.63
Sugar (-)	3.50
Hops (+)	2.85
Hops (-)	2.80

Design and Project Assessment & Recommendations

Sustainability/Emissions: This project provides a lab that operates using sustainable practices such as heat regeneration and recycling of spent material. Long term goals include production of raw materials in-house or from local growers. These raw materials will be used for our beer production and the resulting by-products will go back to local farmers, in an effort to develop a continuous self-sustaining process. Emissions such as CO_2 will be released into the atmosphere.

Assessment: We have discussed with ABE faculty about potential issues the lab would face. One issue is ensuring that we have the proper area in the lab to perform the brewing process, in addition to having the proper tools in place for the lab to operate smoothly. Year to year, we would like to preserve the operation of the lab. Looking ahead, the goal is to be able use student research to grow the lab. Additionally, our goal is to have the lab well known by students, faculty, and alumni.

Instructors:

Dr. Martin Okos

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