Design of a Low Calorie Canned Cocktail Production Plant

Analysis of Prohibition Era Appalachian Moonshine Development

A Thesis Prospectus[1]
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Ethanol, a volatile organic compound produced by the fermentation of sugars, is the specific type of alcohol that is the intoxicating component in alcoholic beverages consumed by humans. Alcohol is deeply embedded in many aspects of society including religion, healthcare, economics, government regulations, and traditional cuisine(Vaillant & Keller). The intrinsic presence of alcohol in human lives is unfailingly accompanied by the significant negative impacts of the drug's usage. According to the World Health Organization along with the significant mental, economic and infrastructural problems caused by alcohol abuse, 3 million deaths worldwide are attributed to dangerous alcohol consumption each year(World Health Organization, 2022). Attempts to regulate alcohol consumption to mitigate its hindrance on society date back to the Babylonian Code of Hammurabi, the oldest code of laws (Vaillant & Keller).

In 2022 the market size value for canned cocktails was estimated to be valued at USD 853.2 million, with an expected expansion of 13.4% compound annual growth rate, CAGR, from 2022 to 2030 (Grand View Research, 2022). Significant research and development efforts have been used to produce new product lines corresponding to the growing seltzer and canned cocktail markets by many of the largest alcoholic beverage producers including Diageo plc, Anheuser-Busch InBev, and Brown-Forman. Presently there is a large variety of malt based canned alcoholic products available that provide lower proof drinking options. However, as the seltzer and canned cocktail market has grown and aged so has the drive for more sophisticated flavor profiles. Malt based products have an inherent lingering aftertaste that is unfavorable for a cocktail style drink. I will propose the development of a sugar based vodka distillery and canned cocktail production facility to address the flaws in current canned cocktail products.

The extensive role of alcohol in different cultures coincides with the influence of culture on alcohol production. The technical aspects of alcohol production are only one of the many factors that influence the development and usage of alcohol technologies and products. Religion, economics, geographical location, societal stigmas, and government regulations are additional factors that influence alcohol consumption and development. Attempts to make systematic changes in alcohol consumption have often failed due to the failure to cohesively account for these factors. I will propose to analyze the ratification of the 18th amendment of the United States Constitution as an example of a failed attempt to eliminate drinking culture through primarily regulatory means.

Addressing both the technological and societal aspects of alcohol production and consumption is necessary to impart lasting changes. The covid 19 pandemic is a recent event that highlights the importance of understanding this dynamic. Alterations in regulations like ABC shift in the allowable scopes of liquor licenses, social encouragement to avoid public gatherings, and the technical aspects of alcohol product production were key in shifting the culture of alcohol consumption to deter the spread of the virus and save lives (Thornburg, 2020). Using software to model the chemical processes I will address the technical issue by determining the operating conditions and design specifications of a plant producing canned liquor based alcoholic beverages. Then, I will apply Hughes' theory of Technological Momentum to the case study of the technological system of alcohol production and distribution in the Virginia Appalachian mountains during the prohibition era, to observe the effect and limitations of regulatory based changes on the technological system of alcohol production.

Technical Project Proposal

The growing cultural trends surrounding seltzers, ices and canned mixed drinks amongst millennials in correlation with the onset of the pandemic has skyrocketed sales.(Goldfine & Grey, 2021) Thus, canned cocktails have high market potential and potential for growth due to its convenience and reminiscence of buying drinks at a bar. Furthermore, canned cocktails have largely marketed themselves to health-conscious populations and the gluten-free community who are shifting towards drinking low-alcohol fruit-flavored beverages (Grand View Research, 2022).

Most common seltzers have a lingering aftertaste from the malt-base that many consumers find unsettling. Our product aims to improve the taste by using a distilled liquor base instead. Additionally, in developing a liquor base beverage there is broad versatility and a wide range of products that can be marketed from a more streamlined process. We envision this product being consumed both at home and at formal events, where a more polished, mobile drink can replace live mixing of cocktails that may cause anxiety about the transmission of covid.

Process Overview

This Capstone project will design a unit-operations process to ferment and distill cane sugar-based liquor for implementation in low-calorie carbonated canned cocktails. Our initial step is to produce a high concentration of ethanol within our mash. Sugar will be added with Safspirit C-70 yeast in a fermenter to produce ethanol and carbon dioxide (Smith, 2020). The fermenter would be connected to a heat exchanger, keeping the fermentation temperature around 25℃-33℃, the ideal range for the yeast strain used. The yield of ethanol produced will be kept around 10-15% purity, as too much ethanol would kill the yeast and inhibit further fermentation. The ethanol mash will then be transported to scrubbing and filtering units to remove any impurities and eventually sent through a continuous feed distillation process (Holl, 2022). This process consists of a distillation column, reboiler, condenser, and reflux drum. Steam will be

used in conjunction with the heat exchange units to control the temperature of the columns. The ethanol mash will be injected into the column and vaporize on the trays traveling up the column where it will recondense and vaporize into a more pure product. The bottoms product will consist almost entirely of water and other byproducts due to their higher boiling points (News BTS, 2020).

As ethanol is continuously distilled, the alcohol percentage/purity will increase to reach a goal of 90% purity. Fruit flavorings will be purchased and combined with the purified ethanol, water, stevia, and preservatives (sodium citrate) to create a product of 4-7% ABV (alcohol by volume) (Patel, 2022). Once thoroughly combined, the drink will then be carbonated with food-grade carbon dioxide and sent to canning. We intend to sell 3-4 flavors in a mixed pack of 12 canned cocktails. The general outline of the block flow diagram is seen below.

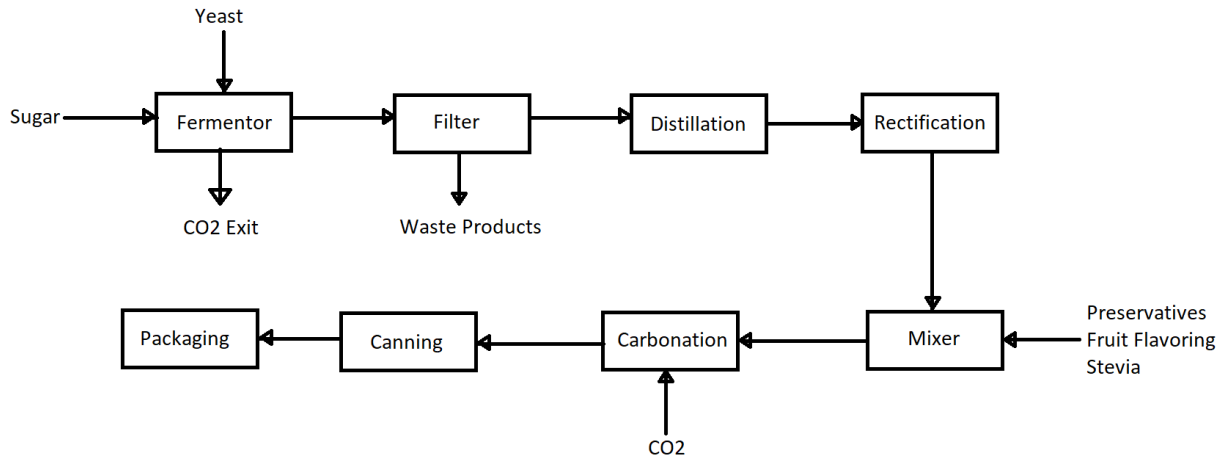

Figure 1. General Process Flow Diagram of Creating Canned Cocktails

Process Modeling and Calculation Methods

Our group will follow previous literature and current plant designs to help guide our design process. The project will be advised by Eric Anderson, Professor at the University of Virginia. We will model our fermentation process using MatLab and Excel and will switch to

Aspen v11 Plus for distillation. This modeling will begin with the introduction of sugar for our fermentation process and finish with our ready-to-drink canned cocktail. All inputs, outputs, side products, byproducts, and waste will be considered and properly accounted for so no stream or material is without a source and sink. This modeling will include factors such as scale, size of plant, and cost of operation, ingredients, and disposal. Additionally, to accompany our process modeling we will also consider and report any and all safety hazards or risks associated with our plant and the chemicals involved. Our team will write a Design Basis Memorandum in the Fall of 2022 and finish the technical design in Spring of 2023.

STS Project Proposal

On January 16th of 1919 the 18th amendment which prohibited the "manufacture, sale, or transportation of intoxicating liquors for beverage purposes," was ratified by 46 out of 48 states.(Eighteenth Amendment) The successful ratification of this amendment was a result of political movements by multiple religious and temperance groups advocating for banning of alcohol all throughout the 1800s and early 1900s and war time allocation pressures from World War I. This attempt to achieve temperance in the United States through government regulation was highly unsuccessful and inadvertently spurred an entire industry of illegal alcohol production and distribution involving speakeasies, bootlegging, and underground liquor distillation operations. In December of 1933 the 21st amendment was ratified repealing the failed 18th amendment (Britannica, 2020).

The failure of the 18th amendment is considered to mainly be a result of the societal resistance to adhering to the temperance lifestyle. However, another key aspect in its failure was the unaccounted for adaptability of technologies in liquor production. In the Appalachian Mountains of Virginia Scottish and Irish immigrants settled with prior knowledge of home

brewing techniques (American Addiction Centers, 2022). When the demand for illegal alcohol skyrocketed due to Prohibition, the existing production knowledge present in the Appalachians paired with the isolation of the rural geography provided the ideal foundation for an illegal moonshine production and distribution system.

I argue that limitations in regulation based intervention when attempting to dramatically shift the existing alcohol culture in the United States through the 18th amendment spurred rapid development of a technological system for illegal alcohol within the Appalachian Mountains leading to the ultimate failure of the prohibition movement. Technological Momentum is a theory that examines the connections between society and technology as they evolve with time. The theory states that in the early age of a technological system, a combination of technology and society, the societal elements outside of the system, the environment, have the majority of the influence (Hughes, 2009). Then, as the system matures and gains momentum its influence over the environment that was previously the driving factor increases (Hughes, 2009). Applying this concept I will describe the time dependent relationship between the environmental influence of the United States prohibition era regulations and the technological system of illegal moonshine production in the Appalachian Mountains of Virginia. I will compare the shifting magnitudes of influence between the environment of the United States drinking culture and developing technologies and infrastructure of illegal alcohol production from 1919 to now.

Conclusion

The deliverable of the technical portion of this project will be a full design of an operating canned cocktail production facility with an economic analysis. The STS research project analyzes moonshine production in Virginia post prohibition ratification using the theoretical framework of technological momentum. The combined STS and technical portions

will analyze the technological aspects of canned cocktail production, its relationship to societal shifts that initially spurred its development and the potential technological impact on society moving forward through the comparison and analysis of the historical moonshine example.

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