Production of Non-alcoholic Beer and Hard Kombucha

The Impacts of History on Alcohol Consumption of University Students in the Ireland

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Sara Reisz

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Technical Team Members:
Christopher Griffis
Gloria Zhao
Patrick Slavanera

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.

Signature _____Sara Reisz_____

Approved _____ Date _____
William Davis, Assistant Professor of STS, Department of Engineering and Society

Approved _____ Date _____
Eric Anderson, Department of Chemical Engineering

Introduction

Beer has been an important part of human history since 7000 BC when the Chinese first brewed it (Raihofer et al., 2022). Not only did it serve to intoxicate the drinker, but it was usually the only safe drinking source where clean water was scarce. Over generations, the art of brewing beer has developed and improved tremendously with new technologies, while keeping the same traditional knowledge. Non-alcoholic beer has a much shorter history. During the early days of the prohibition era in the United States, 'near beer' gained popularity (Ruf, 2022). The brewers would make beer as usual and then boil off the remaining alcohol to have an ABV of less than 0.5%. While its popularity died off after the repeal of prohibition until the 1990's, the demand for it has increased greatly in recent years (Ruf, 2022). Another beverage that has increased in the industry within the past ten years is hard kombucha, a fizzy sweet-and-sour drink made from tea and yeast, with the addition of alcohol (Wang et al., 2022, p. 1). These relatively new and growing industries allow us to take part, create new technologies, create an upscale process to enhance non-alcoholic beer and use the removed alcohol to make hard kombucha for our customers.

However, the alcoholic beverage industry still remains the highest beverage market, with a value of USD 1,949.2 billion in 2021 (Fortune Business Insights, 2023) compared to the NA beverage market, with a value of USD 820 billion in 2020 (Allied Market Research, 2022). Drinking alcohol comes with consequences: health issues, cancer, learning and memory difficulty, mental health issues, social problems, dependence, injuries, violence, alcohol poisoning, and miscarriages (Centers for Disease Control and Prevention, 2021). I want to specifically focus on the ramifications of the consumption of alcohol within Ireland today and how religion, the role of the English influence, brewing and distilling industry, and the weather

has contributed to this (Delaney et al., 2011, p. 1). Some questions arise when considering this topic: How does Ireland's history affect alcohol use among students today? Amid Ireland's drinking culture, what societal pressures drive youth to drink? Can non-alcoholic beverages be promoted without challenging Irish drinking traditions? Does introducing non-alcoholic drinks deter or encourage early alcohol initiation? Can individuals drinking non-alcoholic beer feel the effects of alcohol when in a drinking environment? I will approach this study using two STS concepts: the socio-ecological method and actor network theory.

Production of Non-alcoholic Beer and Hard Kombucha

The non-alcoholic beer and hard kombucha industries are two rapidly growing markets. Non-alcoholic beer sales have "climbed ninety percent over the last decade" (Smith, 2022). Additionally, over the next seven years, hard kombucha sales are expected to have a compound annual growth rate of 23.76% (Maximize Market Research, 2023). Focusing on non-alcoholic beverages, many people are leaning towards them as a healthier alternative to alcoholic ones: non-alcoholic beer contains fewer calories and sugars than alcoholic beer (Maximize Market Research, 2022) and has been shown to help "maintain blood electrolyte homeostasis during exercise" (Castro-Sepulveda et al., 2016, p. 6). Current target demographics for non-alcoholic beer include those who want to reduce alcohol intake, those who abstain from alcohol for religious or health reasons, and those who enjoy the ritual of drinking but do not want to experience the effects of alcohol. Despite the market growth and demonstrated interest, however, non-alcoholic drinks are currently not prevalent or available mainstream due to it being an expensive process to make (Salanta et al., 2020, p. 16). While the process technology has been researched, it has not been implemented yet on a widespread, commercial scale because the process is not profitable.

To address the potentially lucrative non-alcoholic beverage market, a number of dealcoholization methods have been developed in recent years. Two such methods include thermal and membrane separation. Thermal separation involves vacuum distillation to separate the alcohol from the beverage based on differences in their volatilities, whereas membrane separation, most notably reverse osmosis (RO) membrane filtration, involves pushing a beverage across a semipermeable membrane and separating water and ethanol from the rest of the beverage based on particle size selectivity (Jackowski & Trusek, 2018, p. 35). However, there is a fundamental problem with these methods concerning their large-scale implementation feasibility. These dealcoholization methods, while valid processes, are too expensive by themselves to be implemented on a commercial scale. Companies currently trying to produce non-alcoholic drinks view the process as a standalone entity by making them exclusively, therefore failing to take into account the profitability of catering to two separate audiences: people who want alcoholic drinks and people who want non-alcoholic drinks. If the current approach by these companies continues to be taken, beverage companies will continue to fail at making profitable non-alcoholic beverages and will continue to ignore the demographics of people interested in novel non-alcoholic and alcoholic beverages, leading to wasted potential areas for profit.

The aim of this technical project is to avoid this scale-up feasibility obstacle by designing an industrial-scale manufacturing process that produces two beverages — a non-alcoholic beer and an alcoholic kombucha — to make this process commercially profitable. The first part of the process will involve brewing beer and converting it to non-alcoholic beer via reverse osmosis. The creation of beer will follow standard brewing procedures, in which malt kernels are milled,

water is added, enzymes are activated via heat, and yeast is added to convert sugars to ethanol during fermentation (Grover et al., 2022, p. 202). Then, reverse osmosis membrane filtration will separate the ethanol from the beverage. The second part of the process will involve fermenting kombucha and injecting it with the removed ethanol from the beer. The fermentation of kombucha involves steeping tea, adding sugar and symbiotic culture of bacteria and yeast (SCOBY), removing SCOBY after fermentation, and carbonation (Wang et al., 2022, pp. 2-3), after which ethanol will be infused in the final beverage.

Initial design data for the manufacturing process will be obtained from research articles pertaining to the non-alcoholic beer and kombucha processes. We will use computational tools, such as Aspen Plus and Matlab, to generate, test, and monitor unit operation for process optimization. We will be reaching out to Geoffrey Geise, associate professor at the University of Virginia who specializes in membrane research, to inform our membrane selection, assist in design specifications, and operate modeling software to design and perform analysis on the filtration membrane system. Lastly, we will be using hand calculations and Microsoft Excel to solve material balances and compare results with simulation software. Additionally, we will reach out to and visit Three Notch'd, a specialty local brewing company, and conduct an interview to gain insights into commercial brewing design.

An iterative process will be used to optimize our process: each iteration of the system design will provide design data for the next. To demonstrate the value of the system, we will perform an extensive economic analysis on our end design to determine if our process is commercially viable.

The Impacts of History on Alcohol Consumption of University Students in the Ireland

While Ireland has a fascinating and rich history, dating back to 33,000 years ago, there is an important question to start this research. When was alcohol first used, brewed, distilled, created, or introduced in Ireland? Some believed that monks returning from the Mediterranean sea brought back the knowledge of distilling poitin (uisce beatha, “water of life," or Irish moonshine) sometime during the 6th century (Mulryan, 2016). According to Mageoghagan (1627), the first record of this appears in 1405, where the head of a clan passes away from taking a drink of the “water of life.” Since then, whiskey, beer, wine and other spirits have become a central part of Irish culture.

With a population of just over 5 million people, Ireland ranks fifth in Europe at 12.7 liters of alcohol consumption per capita (World Health Organization, 2022, p. 52). The World Health Organization (2019, p. 268) released a report, covering alcohol and health, which notes that 84% of the Irish adult population - 15 years or older, which totals 3.0 million people - drinks alcohol. They also state that almost 40% of adults engage in heavy episodic drinking, putting Ireland above Britain at 28% and below Austria at 40.5%. Just between 2021 and 2022, alcohol consumption per capita increased 7.6% (Alcohol Action Ireland, 2023). Since the 1980’s Ireland has tried to combat severe alcohol consumption. However, after many sponsored reports, increasing disposable income, and lowering of the price of alcohol, Ireland has not had major success in improving alcohol abuse and consumption. It was not until 2018, when the government signed the Public Health Alcohol Act, that things began to shift. This act implements the world's most stringent measures governing the sale, promotion, price, and labeling of alcohol (Drinks Ireland, 2018). Ireland has recently begun a new mandate that will be in full effect by

2026 which includes health labeling on alcoholic beverages to warn customers of calorie count, liver diseases, risk of cancer, and possible miscarriages (Burki, 2023).

With statistics about high alcohol consumption so high and on the rise, we have to think about why. How has the history of Ireland, social and technological, influenced alcohol consumption of students in secondary school and university in Ireland today? The findings from the WHO report directly correlated to four main roots: religion, role of the English influence, brewing and distilling industry, and the weather (Delaney et al., 2011, p. 13). With a culture rooted in drinking, what are the social pressures on young people to drink? Iwamoto (2013, p. 2) claims that masculine norms and peer pressure to adult conformity drives adolescents to engage in drinking, even binge drinking. How can we promote NA beverages while still maintaining this culture? Does introducing NA drinks to young people promote less drinking or encourage them to start earlier? Can other people who are drinking influence a person who is drinking a NA beer to feel the same effects of drinking alcohol? I will hopefully be able to address these questions and the many more that will arise while I am researching this topic.

I will perform this research with the social-ecological method, a useful tool to understand the complex factors within individuals, relationships, community and society that contribute to alcohol consumption and ways in which can prevent the abuse of it (Agency For Toxic Substances and Disease Registry, 2015). If I can understand how these relationships work, I can propose a way to encourage NA beer rather than alcoholic drinks to young people. I am also interested in using Actor Network Theory (Latour, 1992) to understand the human (ex. Peer pressure, mental health, individual choice) and non-human (ex. Brewing technology, marketing, regulations) factors that have the ability to influence and shape how Irish youth uses alcohol. I

want to be able to open the black box and explore the connections of seemingly stable and established entities.

Conclusion

The final product of my technical work will be a full design of the brewing process, including machine units, stable parameters, cost, and economic value. We will not be creating a physical model, but we will be using Aspen software as well as others. After my STS research is complete, I will have an improved understanding of the negative effects of alcohol consumption in Ireland and the historical background that has shaped Ireland's drinking culture. If these deliverables are successful, a production design of two emerging market drinks will be useful in increasing profitability in this new frontier, and more people will be aware of the reason for the 'drunken Irish' stereotype.

References

Agency For Toxic Substances and Disease Registry. (2015). *Chapter 1: Models and Frameworks | Principles of Community Engagement | ATSDR*. Cdc.gov. https://www.atsdr.cdc.gov/communityengagement/pce_models.html

Alcohol Action Ireland. (2023, March 30). *Annual alcohol consumption data 2022*. https://alcoholireland.ie/annual-alcohol-consumption-data-2022/#

Allied Market Research. (2022). *Non-alcoholic Drinks Market by Product Type (Soft Drinks, Premium Water, Tea & Coffee, Juice, Dairy Drinks, and Others), DistributionChannel (Supermarket/Hypermarket, Convenience Stores, Specialty Stores, Online Retails, and Others), and Price Point (Standard, Premium, and Luxury): Global Opportunity Analysis and Industry Forecast, 2022-2031*.

Burki, T. (2023). World's first alcohol health labelling policy to be introduced in Ireland. Lancet Oncology, 24(7), 722–722. https://doi.org/10.1016/s1470-2045(23)00272-3

This article discusses a new policy of alcohol drink labeling so that consumers have a better understanding of alcohol content and health risks. This policy is due to the lack of knowledge the people have, which then leads them to consume more alcohol than they should, resulting in cancer, alcoholism, and alcohol abuse. It provides an insight into the steps Ireland is taking to combat the high alcohol consumption statistics provided in other articles and to signal that alcohol is not an average commodity, alongside marketing restrictions and minimum pricing. Although these steps are tackling alcoholic drinks, another step would be to promote non-alcoholic drinks as well.

Carroll, R. (2023, May 22). Ireland to introduce world-first alcohol health labelling policy. *The Guardian*.

https://www.theguardian.com/world/2023/may/22/ireland-to-introduce-world-first-alcohol-health-labelling-policy

Castro-Sepulveda, M., Johannsen, N., Astudillo, S., Jorquera, C., Álvarez, C., Zbinden-Foncea, H., & Ramírez-Campillo, R. (2016). Effects of Beer, Non-Alcoholic Beer and Water Consumption before Exercise on Fluid and Electrolyte Homeostasis in Athletes. *Nutrients*, *8*(6), 345. https://doi.org/10.3390/nu8060345

Centers for Disease Control and Prevention. (2021, December 29). *Drinking Too Much Alcohol Can Harm Your health. Learn the Facts | CDC*. Www.cdc.gov; Centers for Disease Control and Prevention. https://www.cdc.gov/alcohol/fact-sheets/alcohol-use.htm#:~:text=High%20blood%20pressure%2C%20heart%20disease

Delaney, L., Kapteyn, A., & Smith, J. P. (2011). Why do some Irish drink so much? Family, historical and regional effects on students' alcohol consumption and subjective normative thresholds. *Review of Economics of the Household*, *11*(1), 1–27. https://doi.org/10.1007/s11150-011-9134-5

This research explains how family, the Church, English influence, the brewing and distilling industry, and weather contribute to the Irish drinking behavior of college students and how some drink more than others. It provides statistics of college students, which directly relates to one of my research questions. Although my paper is not directly comparing student's drinking habits, it provides an abundant amount of historical, social, and technological knowledge to understand the Irish culture on drinking. By understanding this research, I can anticipate how promoting non-alcoholic beer will be subjective to the cultural context.

Drinks Ireland. (2018). *Public Health Alcohol Act*. Www.ibec.ie. https://www.ibec.ie/drinksireland/alcohol-in-society/public-health-alcohol-act#:~:text=The%20Public%20Health%20(Alcohol)%20Act

Fortune Business Insights. (2023). *The alcoholic beverages market is projected to grow from $2,134.8 billion in 2022 to $4,102.3 billion by 2029, exhibiting a CAGR of 9.78% during 2022-2029*.

Grover, N., Nehra, M., & Sk, G. (2022). Non Alcoholic Beers: Review and Methods. *Madridge J Food Technol*, *7*(1), 200–206. https://doi.org/10.18689/mjft-1000130

Iwamoto, D. K., & Smiler, A. P. (2013). Alcohol Makes You Macho and Helps You Make Friends: The Role of Masculine Norms and Peer Pressure in Adolescent Boys' and Girls' Alcohol Use. *Substance Use & Misuse*, *48*(5), 371–378. https://doi.org/10.3109/10826084.2013.765479

This research paper suggests that masculine norms contribute to alcohol use of adolescent boys through peer pressure and conformity to adult norms, compared to adolescent girls. This gives an understanding on the social pressures that young people face, which helps to navigate the success of implementing and introducing non-alcoholic beer to younger consumers. The promotion of NA beer will most likely focus on male college students if it is assumed that these trends follow adolescents as they age.

Jackowski, M., & Trusek, A. (2018). Non-alcoholic Beer Production – an Overview. *Polish Journal of Chemical Technology*, *20*(4), 32–38. https://doi.org/10.2478/pjct-2018-0051

Latour, B. (1992). Where are the missing masses? The sociology of a few mundane artifacts. In *Shaping Technology/Building Society: Studies Sociotechnical Change* (pp. 151–180). Massachusetts Institute Of Technology.

This discusses the method of approaching the technical and non-technical as human and non-human actors in the construction of social realities. I think this theory best suits the questions I ask because it explores how government policies, the brewing industry, the social pressures, and many more come together and shape the development of the network of alcohol consumption of college students. Alcohol consumption is not merely a result of determinism or construction, but a mixture of both, which is what I think Actor Network Theory represents.

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Maximize Market Research. (2023, April 18). *Hard Kombucha Market Size to hit USD 181.88 Mn by 2029 at a CAGR of 23.76 percent – Says Maximize Market Research*. GlobeNewswire News Room. https://www.globenewswire.com/news-release/2023/04/18/2648819/0/en/Hard-kombucha-Market-size-to-hit-USD-181-88-Mn-by-2029-at-a-CAGR-of-23-76-percent-Says-Maximize-Market-Research.html

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Raihofer, L., Zarnow, M., Gastl, M., & Hutzler, M. (2022). A Short History of Beer Brewing. *EMBO Reports*, *23*(12), e56355. https://doi.org/10.15252/embr.202256355

Ruf, M. (2022, April 1). *The History of Non-Alcoholic Beer in America*. NA Beer Club. https://nabeerclub.com/history-non-alcoholic-beer/#:~:text=Anheuser%20Busch%20and%20Pabst%20were

Salanță, L. C., Coldea, T. E., Ignat, M. V., Pop, C. R., Tofană, M., Mudura, E., Borșa, A., Pasqualone, A., & Zhao, H. (2020). Non-Alcoholic and Craft Beer Production and Challenges. *Processes*, *8*(11), 1382. https://doi.org/10.3390/pr8111382

Smith, S. (2022, July 28). *Trends Revealed: The Non-Alcoholic Beer Market Is Bubbling Up*. Blog.hubspot.com. https://blog.hubspot.com/the-hustle/the-non-alcoholic-beer-market-is-bubbling-up

Wang, B., Rutherfurd-Markwick, K., Zhang, X.-X., & Mutukumira, A. N. (2022). Kombucha: Production and Microbiological Research. *Foods*, *11*(21), 3456. https://doi.org/10.3390/foods11213456

World Health Organization. (2019). WHO Global Status Report on Alcohol and Health | NCD Alliance. In *Ncdalliance.org* (pp. 2–426). https://ncdalliance.org/resources/who-global-status-report-on-alcohol-and-health

This report covers information related to Ireland's alcohol consumption levels and patterns, health consequences of mortality and morbidity, and policies and interventions. Although my topic focuses on college students, it supplies a holistic picture on the total population in Ireland which can generate good overarching statistics. It confirmed my other research that stated that beer had the highest alcohol per capita consumption, which further means that non-alcoholic beer might be a great alternative as this is the favored beverage for consumers.

World Health Organization. (2022). *The European Health Report 2021. Taking stock of the health-related Sustainable Development Goals in the COVID-19 era with a focus on leaving no one behind.* (pp. 2–258). Copenhagen: WHO Regional Office for Europe.