
JAMES B. BEAM
K·Y INSTITUTE U·S
University of Kentucky

James B. Beam Institute

- World's largest teaching distillery

- First barrel filled March 14, 2024
- 80 barrels in first year
- Target: 150 barrels / year
- 400 gallon Cook & Ferm -> 1.25 barrel / batch
- Vendome 12" column still with doubler

- Boswell Family & ISC Maturation Facility with 660 Barrel K-Rax system

Leading the global advancement of the American whiskey industry through workforce education, scientific discovery, environmental sustainability, community and social responsibility.

SUNTORY GLOBAL SPIRITS

Pigman College of Engineering

Martin-Gatton College of Agriculture, Food and Environment

Gatton College of Business and Economics

College of Arts and Sciences

Research

- Collaborative Projects
- Confidential Projects

Education

- Certificate Program
- Internships and Scholarships
- Capstone Projects
- Industry Trainings and Workshops

Outreach and Community

Certificate in Distillation, Wine and Brewing Studies (DWBS) – 12 credits

1 Required Course

- Distillation, Wine and Brewing Science
- Spirit Chemistry

Pick any 3 Electives from the Following Courses

Brewing
Brewing Science & Technology*

Distilling
Bourbon Production Engineering
Distilled Spirits Production: Gin*
Spirits Commercialization

Food Systems
Food Fermentation
Sensory Evaluation of Foods

Wine
Introduction to Viticulture
Introduction of Enology*
Wine Appreciation*

General Topics
DWBS Independent Research
DWBS Experiential Learning
Craft Writing
Beer, Wine and Spirits Tourism*

*Must be 21 by first day of class

In Person & On-line Courses

Study Abroad Opportunities 2026 - Belgium

JAMES B. BEAM INSTITUTE
K·Y U·S
University of Kentucky

Dr. Tyler Barzee

Fermentation and Bioprocess Engineering Lab

Department of Biosystems and Agricultural Engineering

Harnessing microbes for food, fuel, and materials

Teaching:

- **Graduate Experimental Design/Stats Course**
- **Life Cycle Assessment for Bioresource Engineering**
- **Independent Study**: Biosystems Engineering, Agricultural and Medical Biotechnology, Chemistry, Chemical Engineering

- **Students**:
  - 6 Graduate Students (3 MS, 3 PhD)
  - 5 Undergraduate Students
- **Co-PI** NSF Research Experience for Undergraduates (REU) on Water Resource and Sustainable Engineering for Appalachia

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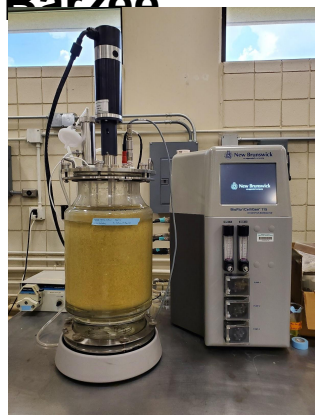
University of Kentucky

Dr. Tyler Barzee

- **Lab and Analytical Capabilities**
  - HPLC
  - Headspace GC
  - Mastersizer
  - Automated Fermentation Systems an Bioreactors
  - Lab-scale Distillation
  - Shaking Incubators
- **Goal:** Enable translation of high-impact ideas to industry and build a pipeline of talent through student projects



Kasu-tori Shochu Beverage Production by Re-Fermentation and Distillation of Sake Lees

Benjamin Lin
Primary Mentor: Dr. Tyler Barzee
Zac Byrd
Dr. Bradley Berron

Overview

- Background
- Hypothesis
- Methods
- Results
- Future Work
- Sources

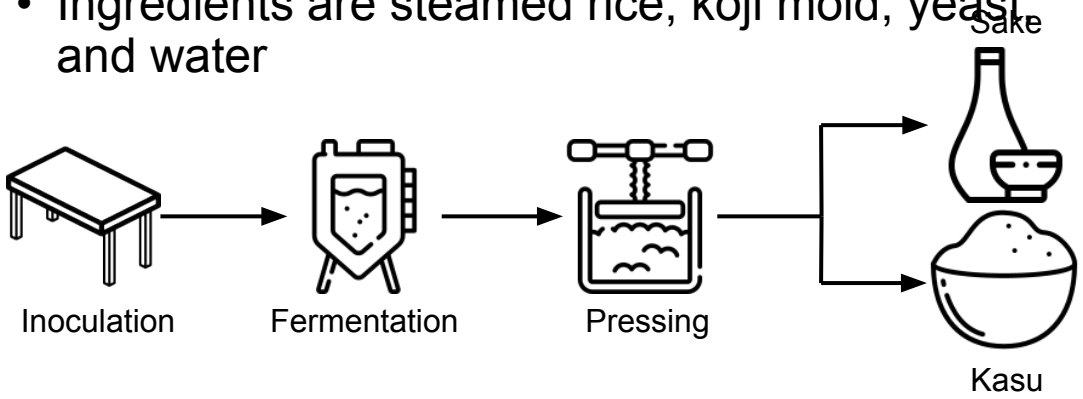
Importance of Brewing and Distilling

- In 2023, beer and spirits sales amounted to over $150 billion dollars in revenue.[1,2]
- An estimated 4.7 million metric wet tons of brewer's spent grains (BSG) was produced by American brewers[3]
- The Void Sake Co. in Lexington, KY is looking to create a product out of BSG with the James B. Beam Institute at UK
  - Currently donated as livestock feed

1) ("DISCUS Annual Economic Briefing: U.S. Spirits Revenues Maintain Market Share Lead of Total Beverage Alcohol Market in 2023" 2024)
2) ("National Beer Sales & Production Data," n.d.)
3) ("National Beer Day: Brewing Up Markets for Spent Grain | NIFA" 2022)

Sake Production at The Void

- Sake is a traditional Japanese alcoholic beverage
- Ingredients are steamed rice, koji mold, yeast, and water



- BSG from sake is known as kasu
- Spent grains often contain residual sugars, proteins, fibers, vitamins, and lipids[1]

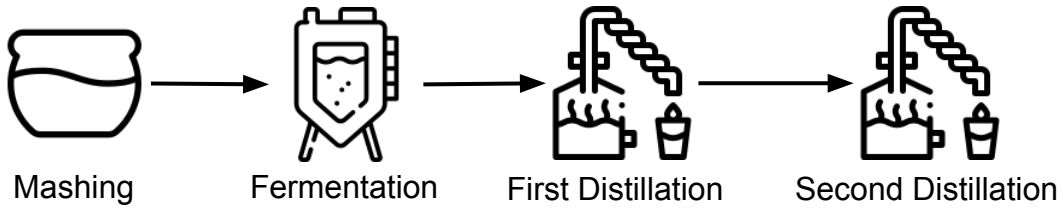
Diagram icons from https://www.flaticon.com /

Kasu and Kasu-tori Shochu

- Remaining materials in kasu include
  - Rice
  - Yeast
  - Koji
  - Sugar/starch
  - Leftover ethanol
- Kasu-tori shochu is a type of Japanese rice spirit
  - Kasu is one of the main sugar sources in fermentation
  - The Void Sake Co. expressed interest in producing kasu-tori shochu

Preliminary Studies

- Conducted over summer 2024

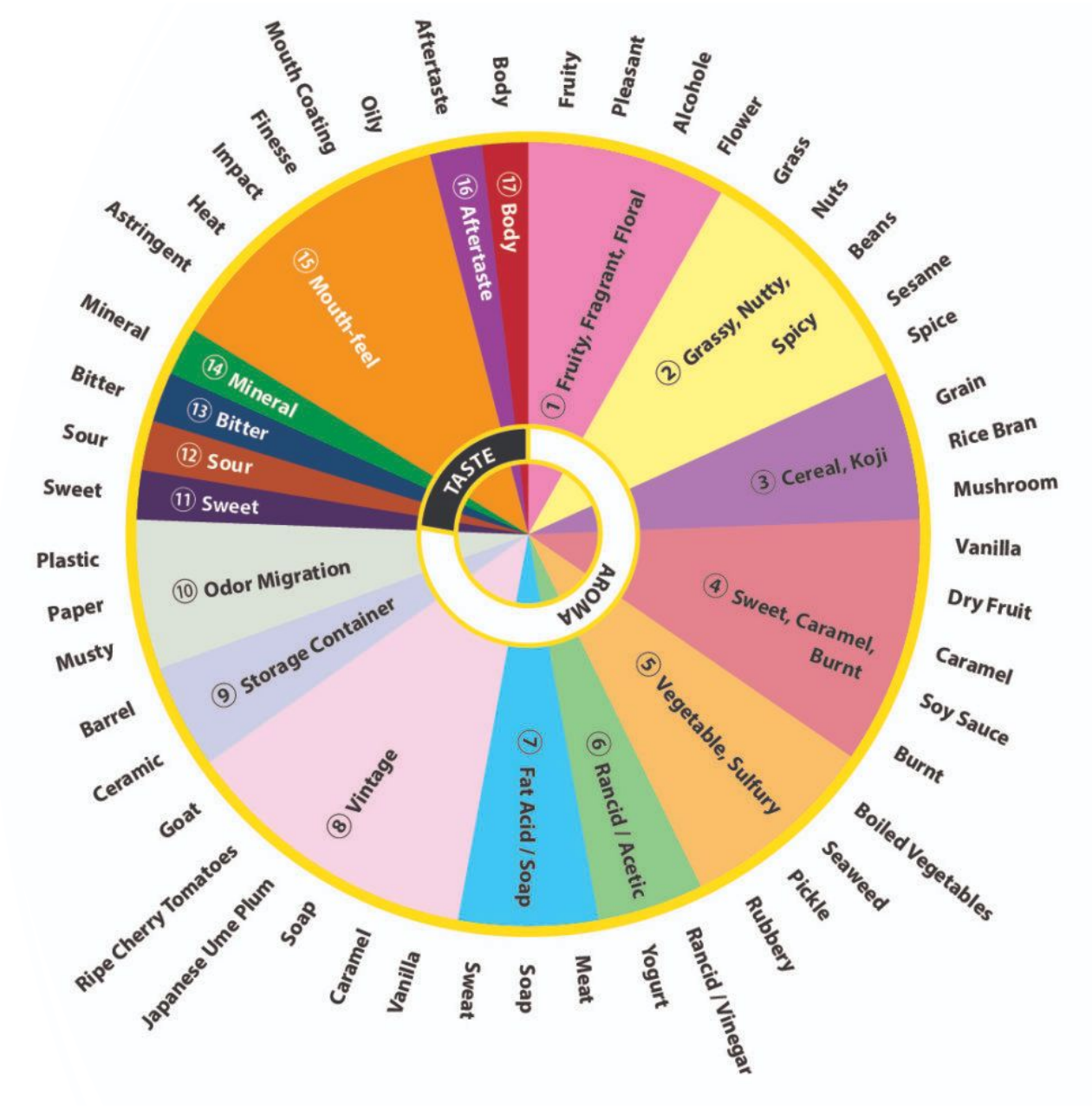


- Mashing
  - Varied concentration of mash
  - Examined purified enzyme additions for starch to sugar conversion (Saccharification)
    - Alpha-amylase (AA) and Gluco-amylase (GA)
- Fermentation
  - Compared two strains of *Saccharomyces cerevisiae:* FSI 927 *(*general distiller's yeast) and Kyokai 901 (sake brewing yeast)
- Distillation
  - Adapted JBBI's distillation method[1]

1) (Verges et al. 2023)

Key Results of Preliminary Studies

- Heating step is not necessary for starch conversion
- Main variables that impacted sugar concentration
  - Kasu concentration
  - Purified enzyme additions
- End distilled product flavor varied between mashing and yeast type
  - Evaluated by a blind sensory panel and gas chromatography



Flavor wheel from “RESOURCES - Shochu,” accessed December 2, 2024, www.sakeschoolofamerica.com.

Hypotheses

If changes in temperature, enzyme additions, or concentration influence starch saccharification, then there will be a difference in fermentable sugars available in the kasu mash.

If the yeast strain and yeast pitch rates influence the re-fermentation of kasu mash, then there will be different amounts of alcohol and byproducts after re-fermentation and distillation

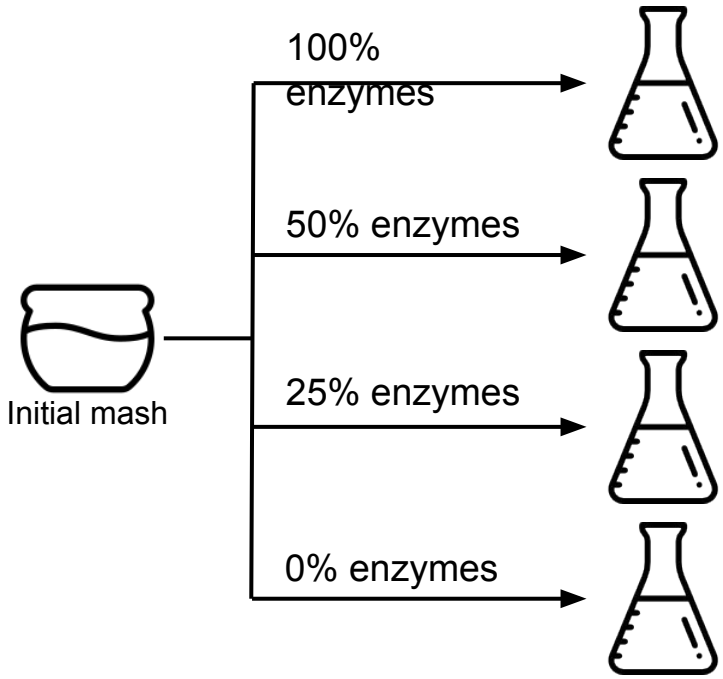
Main analysis methods

- High Performance Liquid Chromatography (HPLC) is a type of chromatography used to measure compounds
  - We measure concentration of sugars, ethanol, and other fermentation byproducts
  - Used standard method of processing and running samples
- Bio Processing Control
  - Machine that measures flow and volume of gas during fermentation

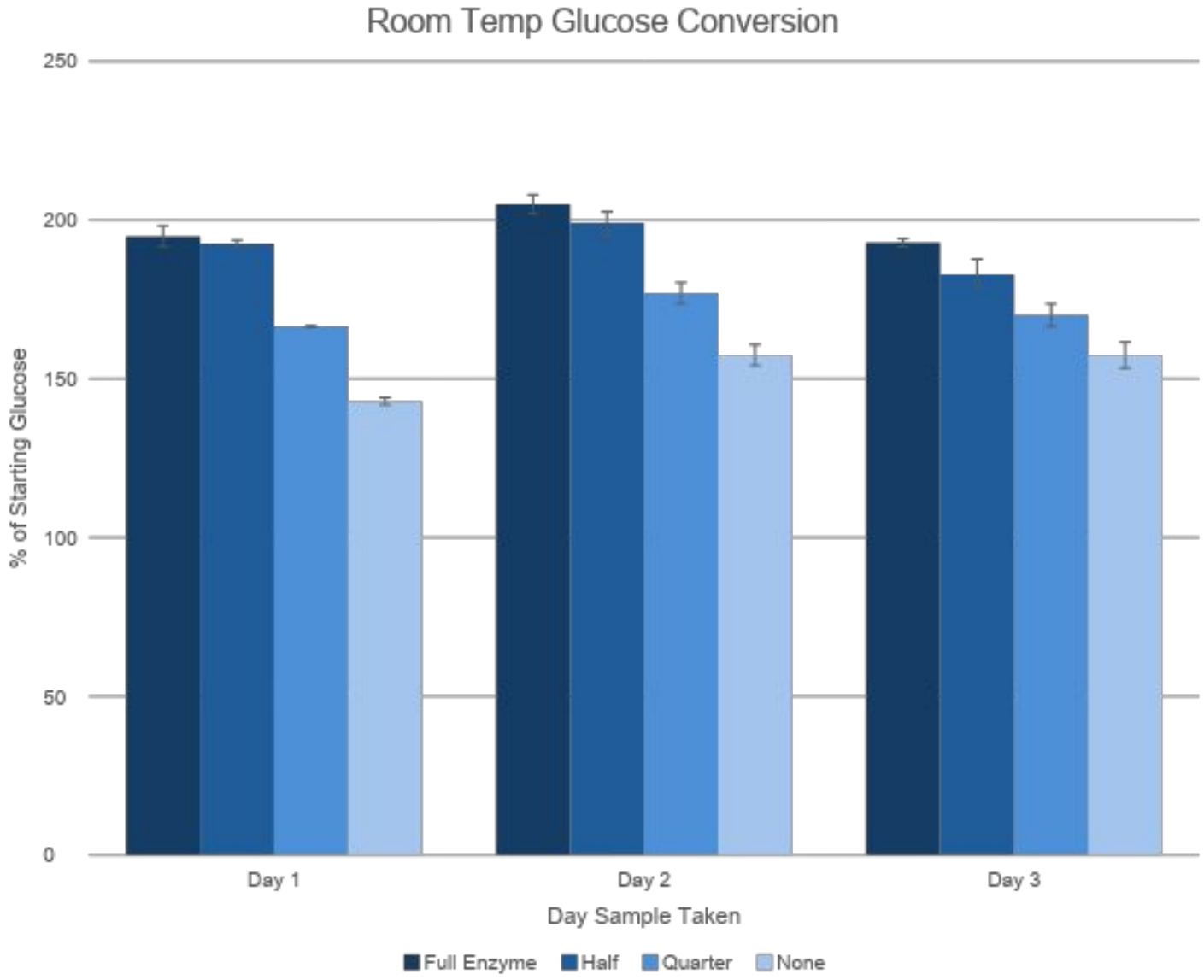
Methods

Experiment 1: Enzyme optimization at room temperature

- Added different enzyme pitch rates to mash
  - Standard enzyme pitch rate of (0.5uL of enzyme)/(mL of mash)
- Parameters: constant temperature (22 ºC), 1:1 concentration (Water:kasu ratio by volume), and three 400mL samples per treatment group
- Sampled starting mash, 24 hrs, 48 hrs, and 72 hrs and analyzed through HPLC



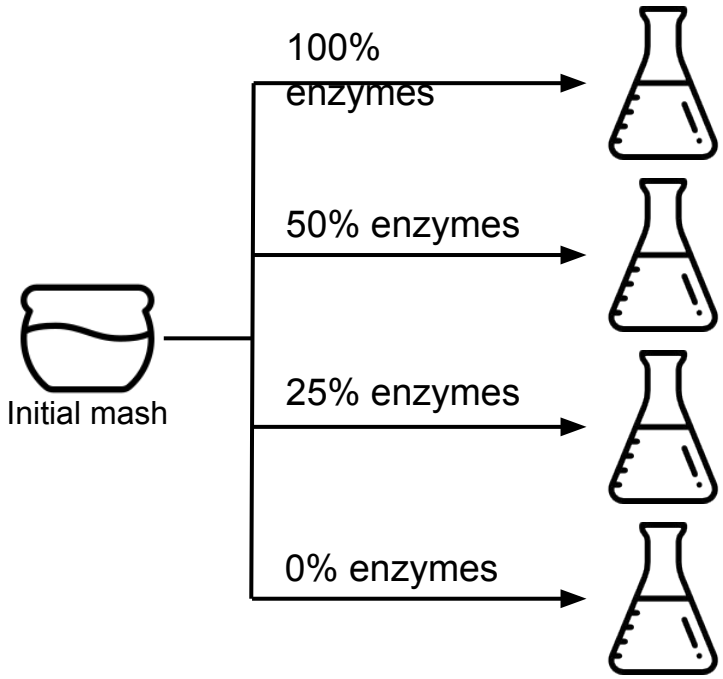
Experiment 1 Results



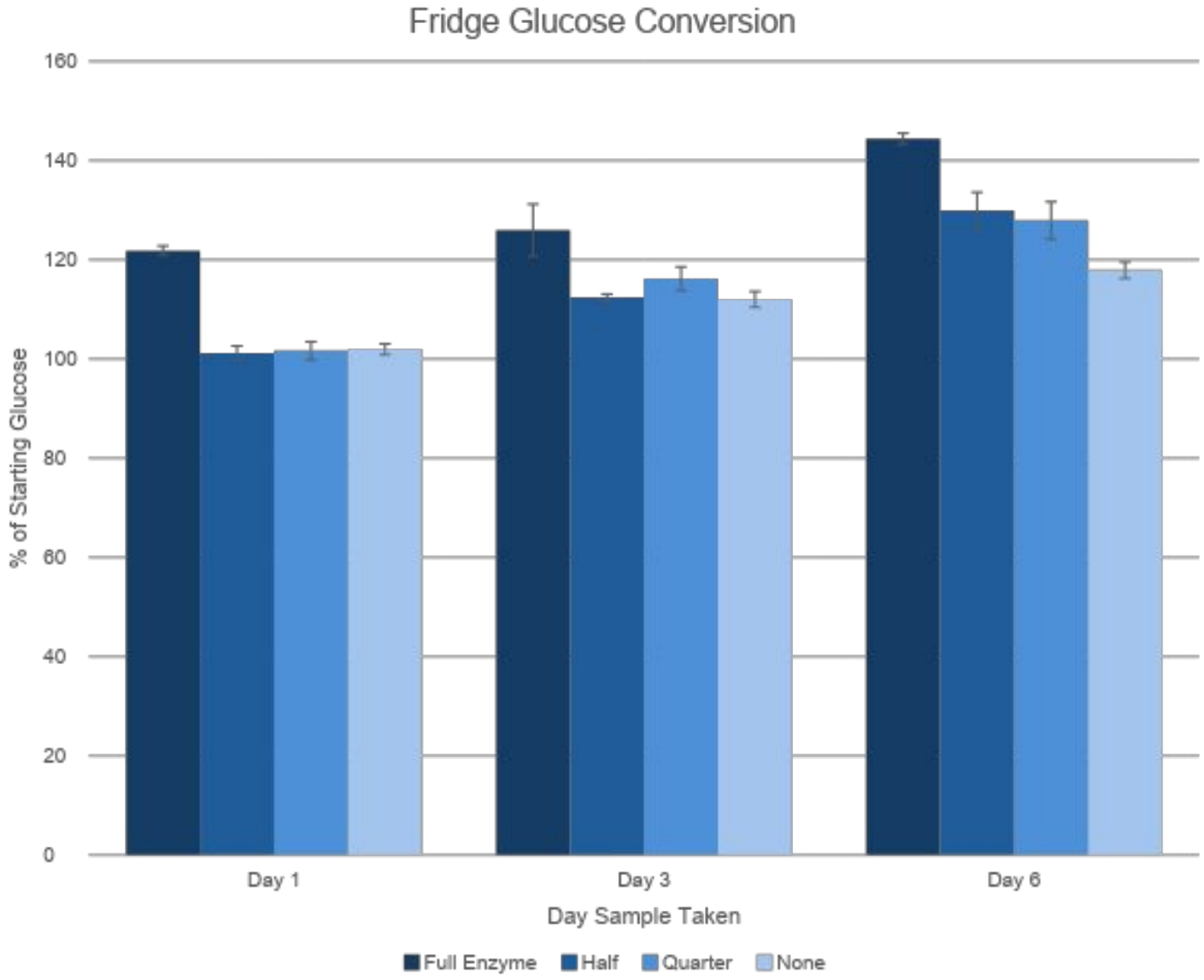
Methods

Experiment 2: Enzyme optimization in refrigerated temperature

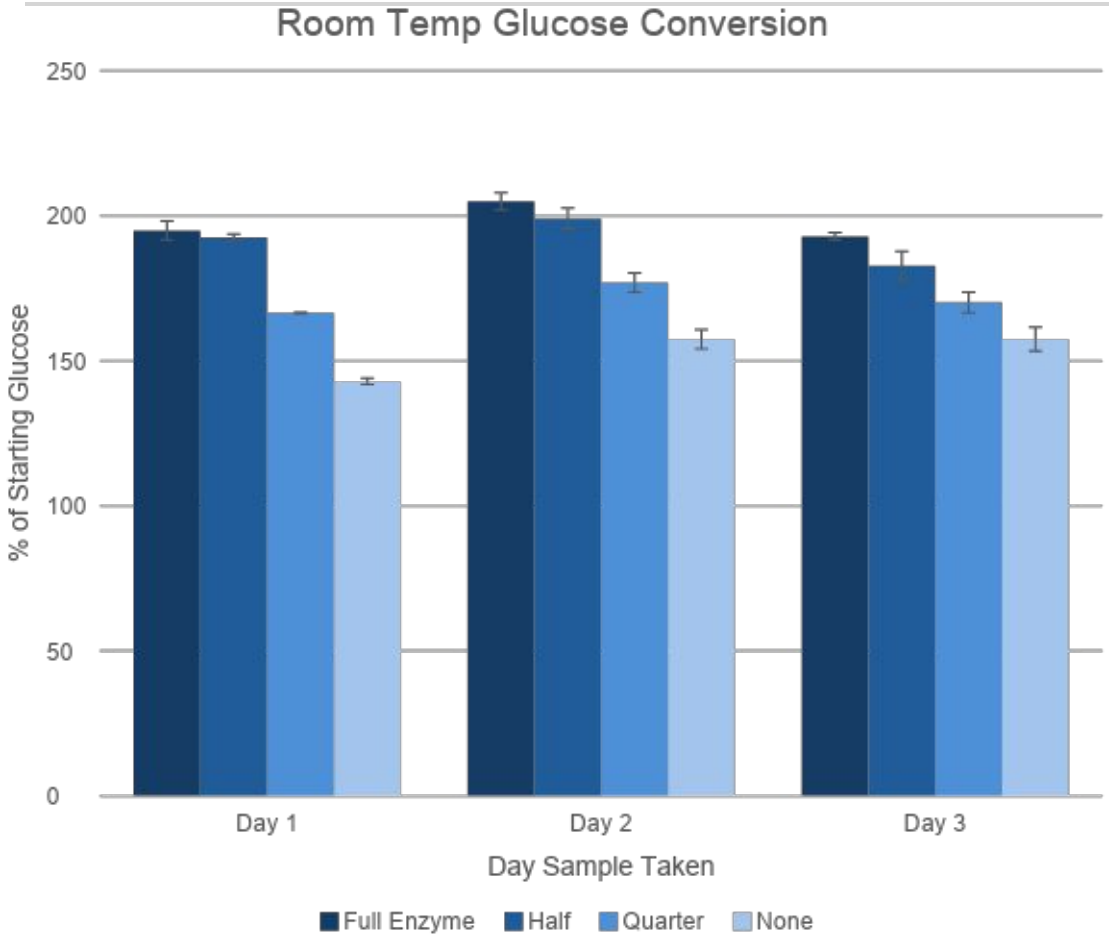
- Done on-site at The Void
- Added different enzyme pitch rates to mash
  - Standard enzyme pitch rate of (0.5uL of enzyme)/(mL of mash)
- Parameters: constant temperature (7 ºC), 1:1 concentration (Water:kasu ratio by volume), and three 400mL samples per treatment group
- Sampled starting mash, 24 hrs, 72 hrs, and 144 hrs and analyzed through HPLC

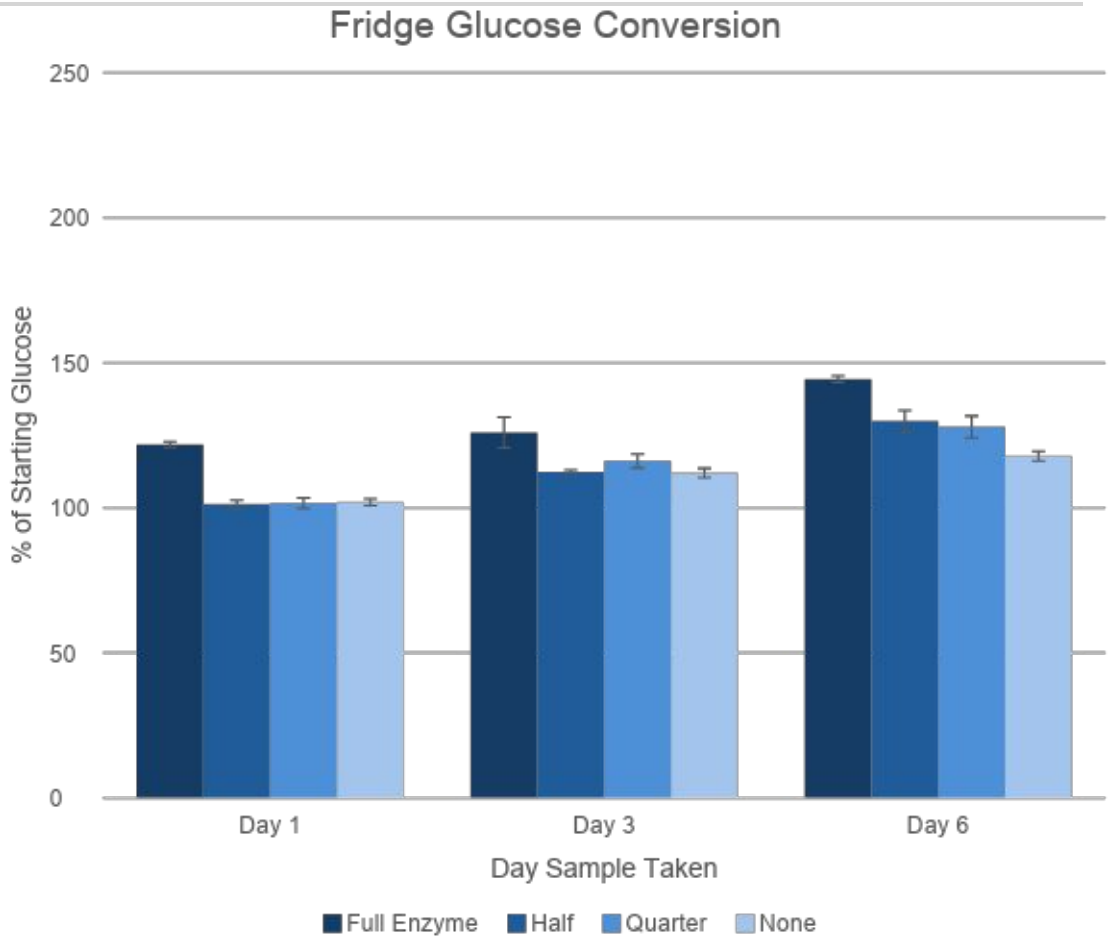


Experiment 2 Results



Experiment 1 and 2 Comparison

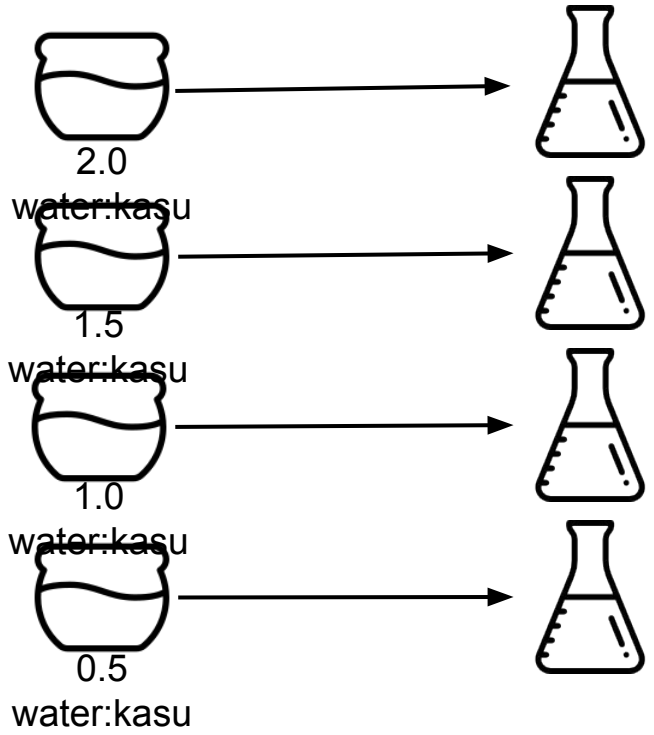




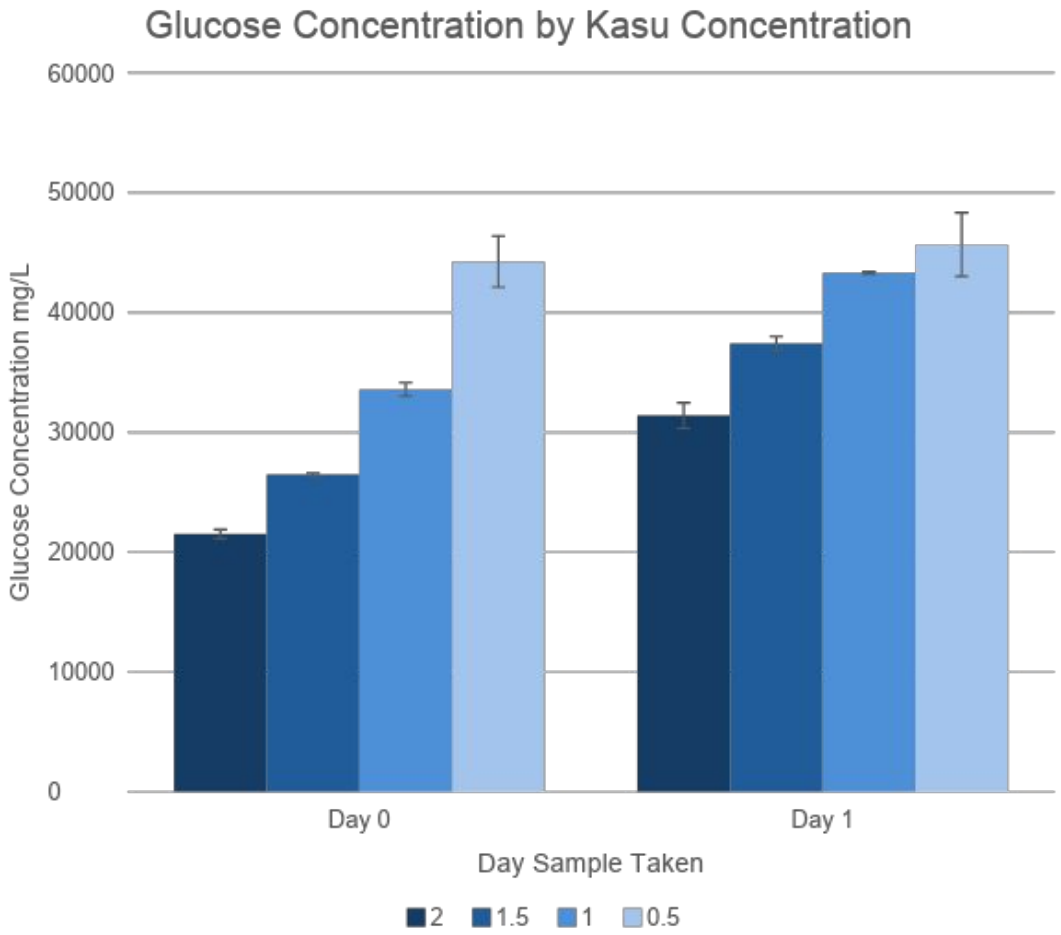
Methods

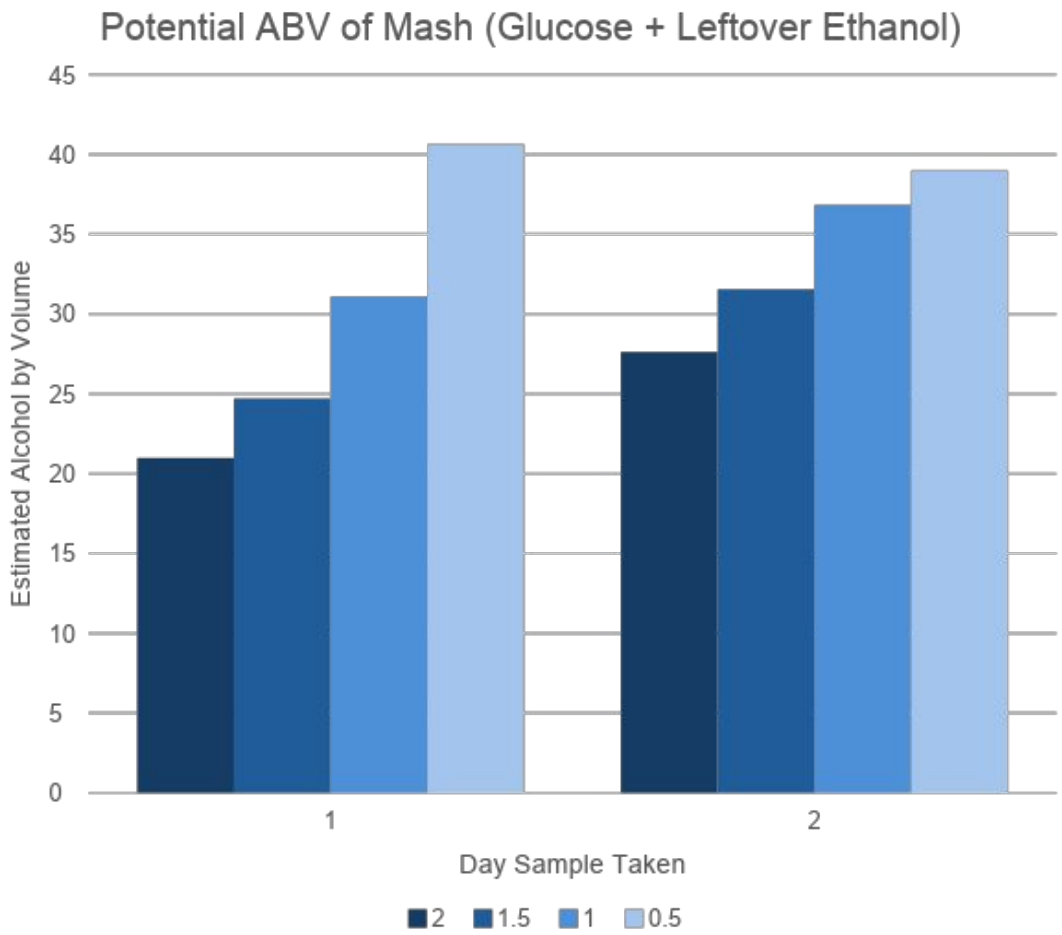
Experiment 3: Sugar characterization of mash concentration

- Vary concentration of water:kasu
  - Four water:kasu ratios used 0.5, 1.0, 1.5, and 2.0
- Parameters: constant temperature (22 ºC), 50% enzyme pitch rate, and three 400mL samples per treatment group
- Sampled starting mash, after 24 hrs, and analyzed through HPLC

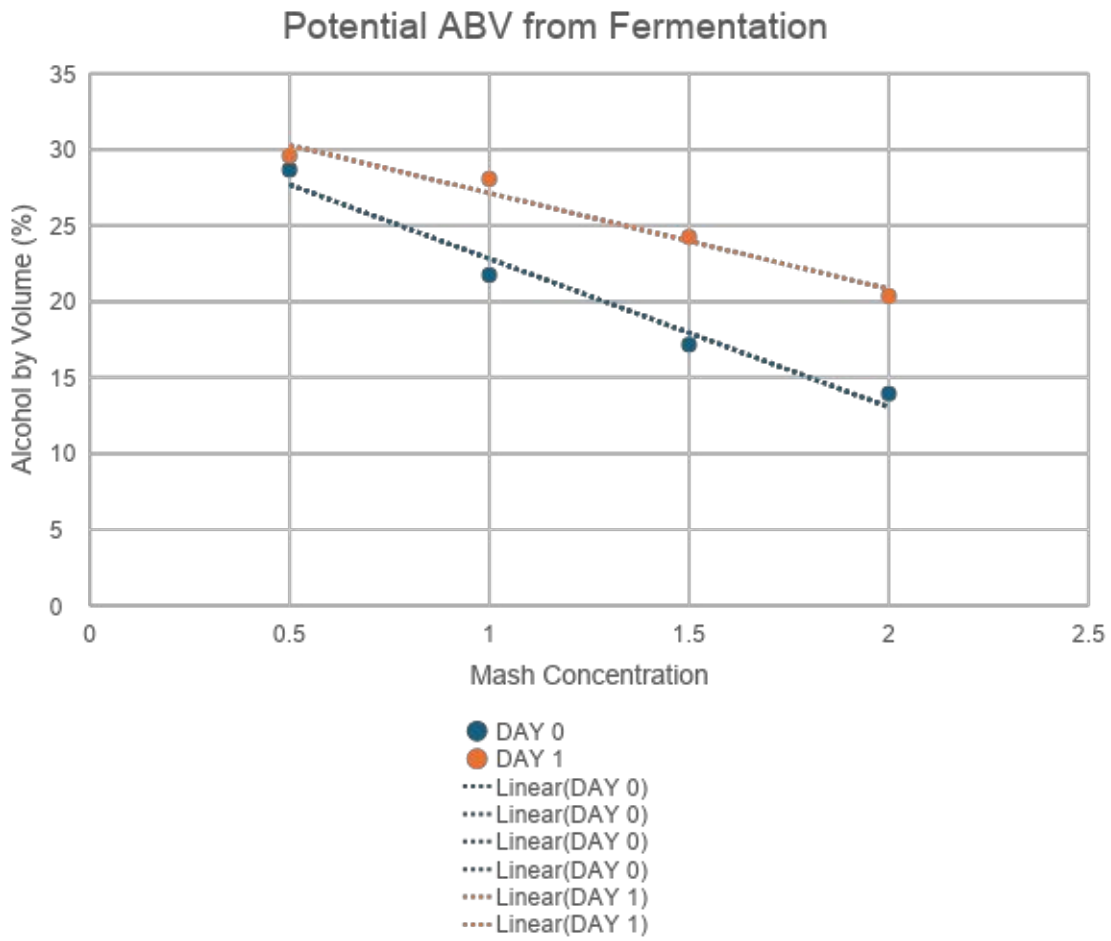


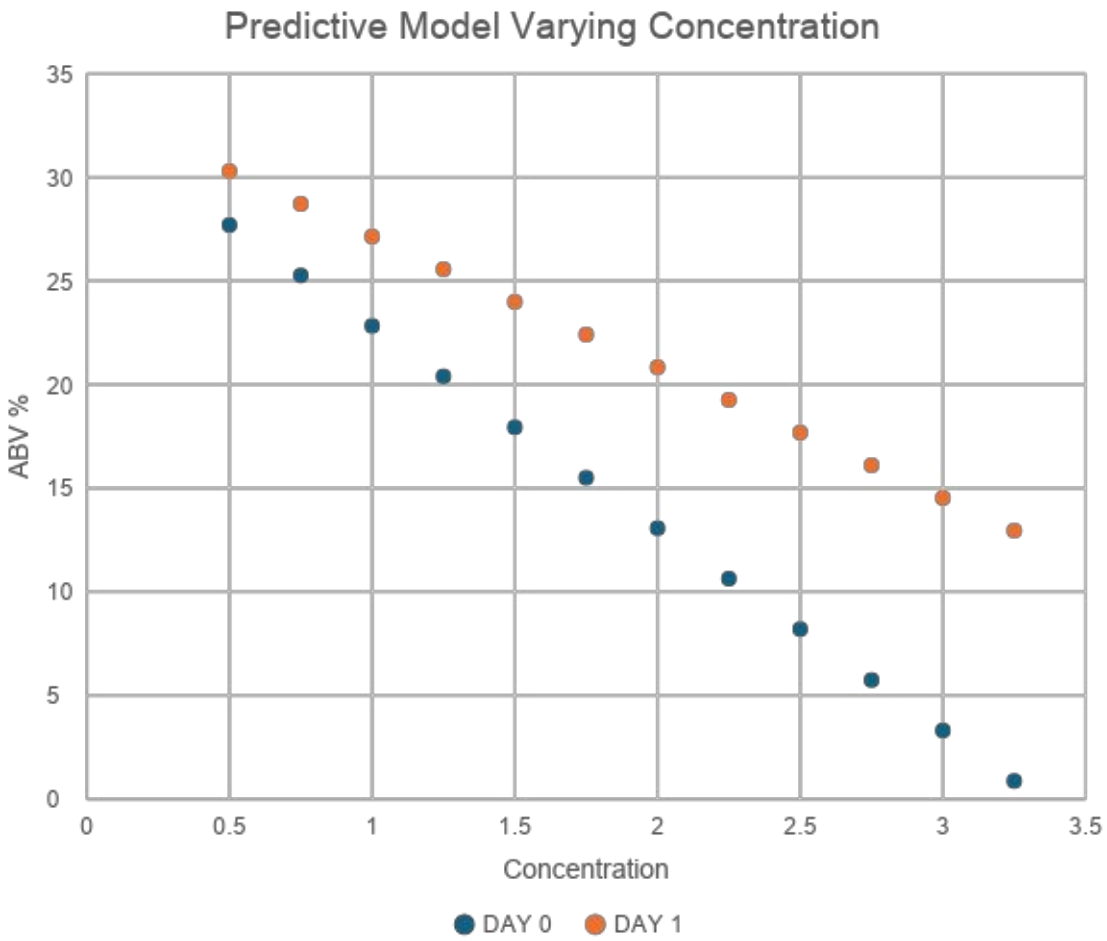
Experiment 3 Results





Experiment 3 Results: Potential Other Concentrations

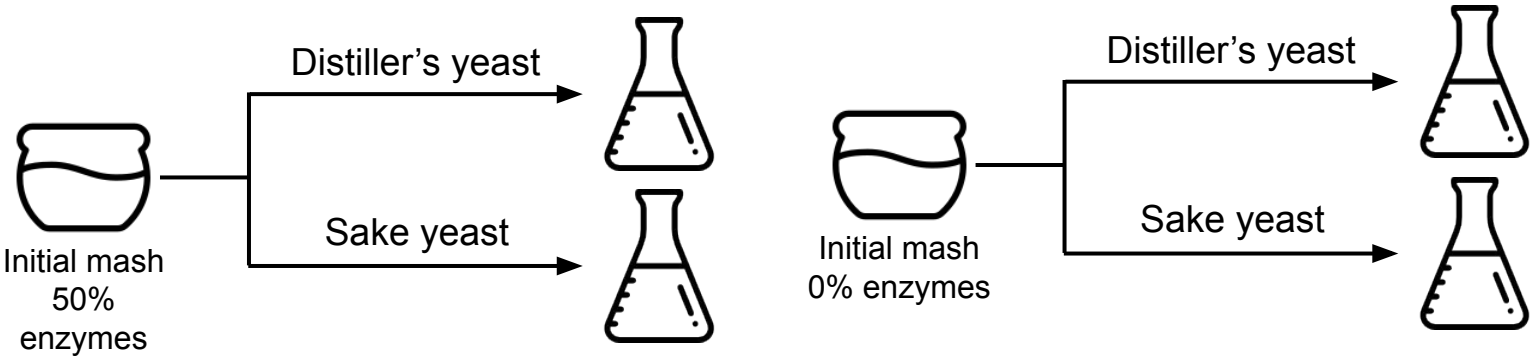




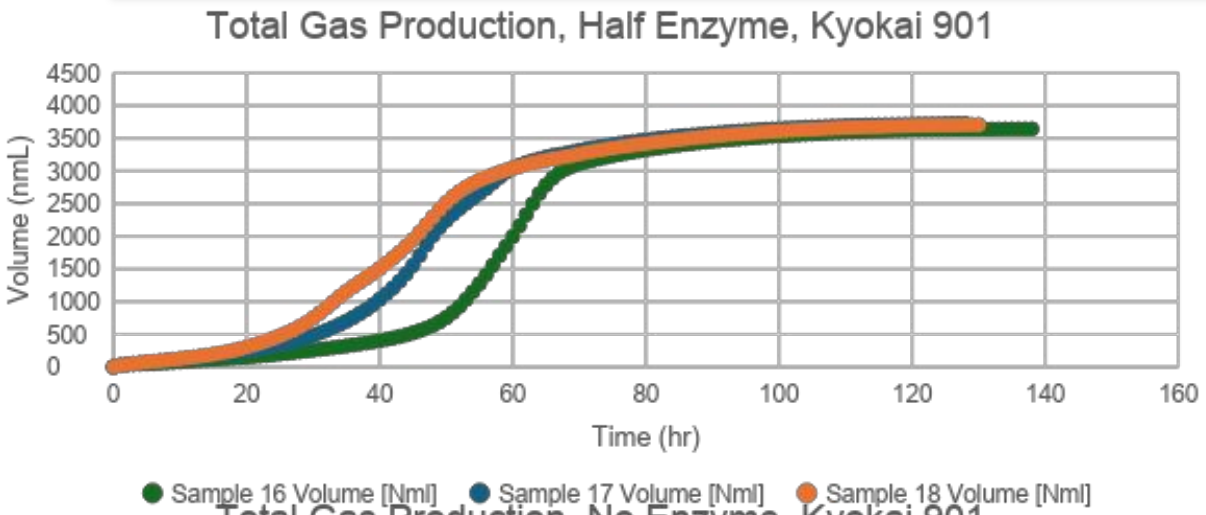
Methods

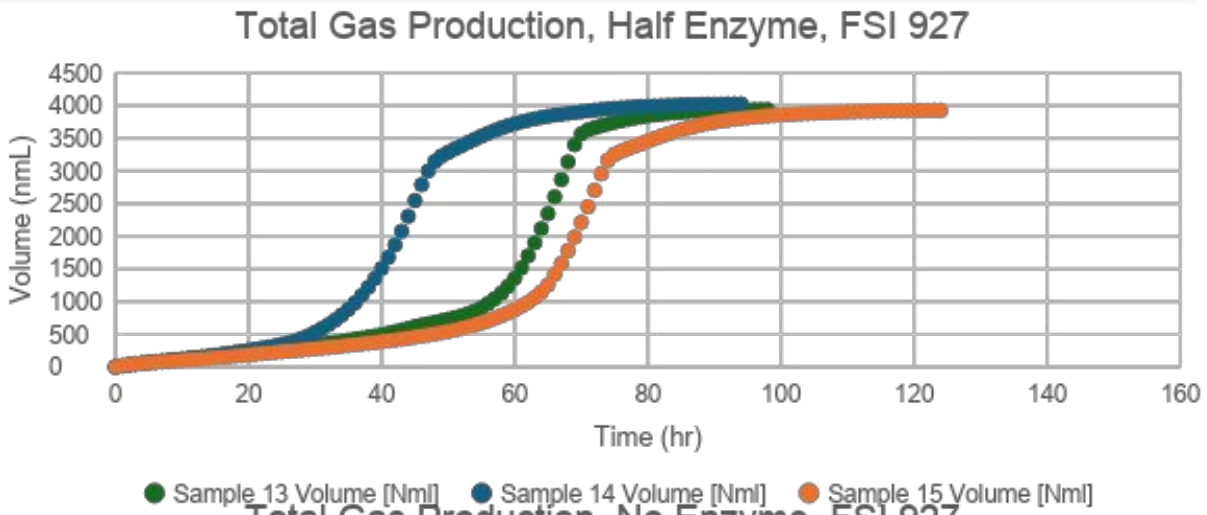
Experiment 4: Understand fermentation length

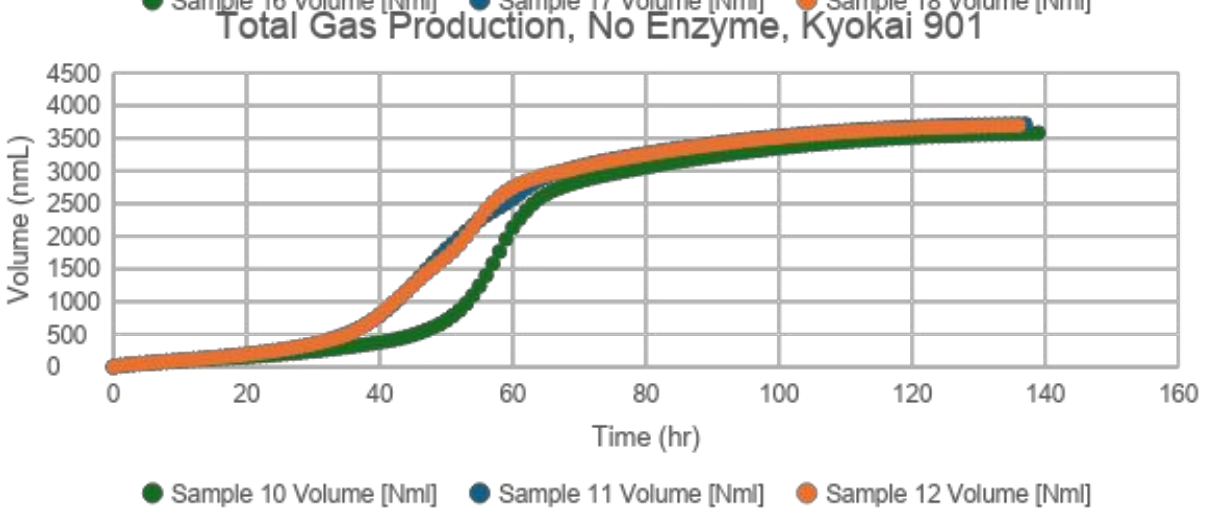
- Vary concentration yeast strain and enzyme amount
- Parameters: constant temperature (22 ºC), and three samples per treatment group
- Sampled starting mash and final mash, analyzed through HPLC and BPC

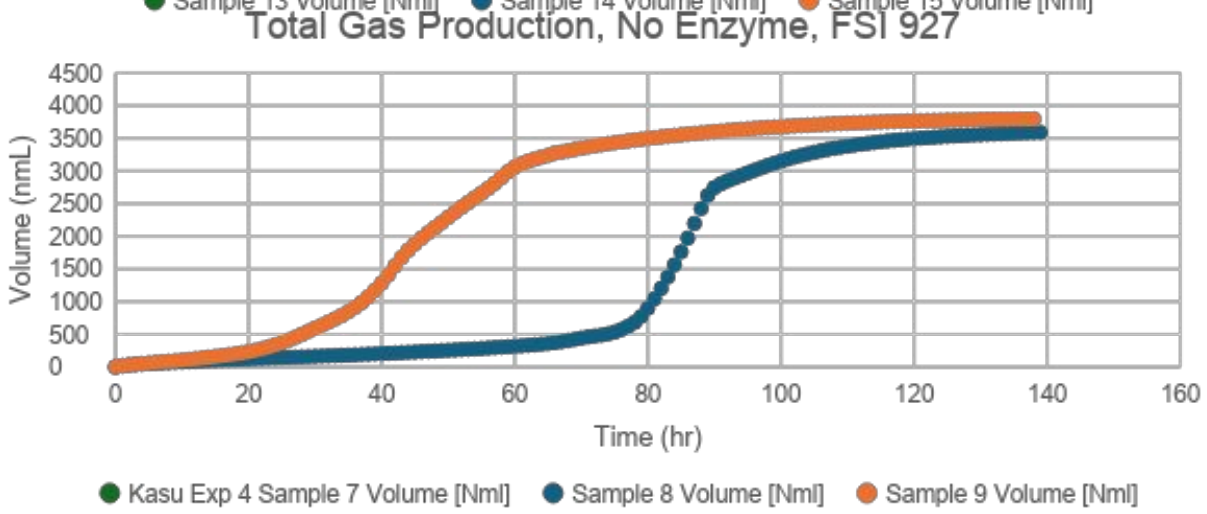


Experiment 4 Results

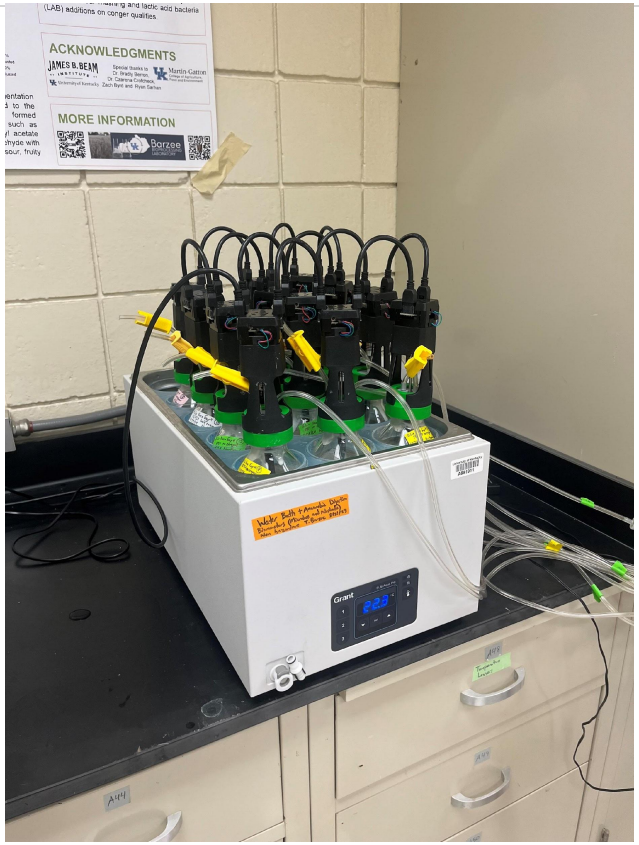


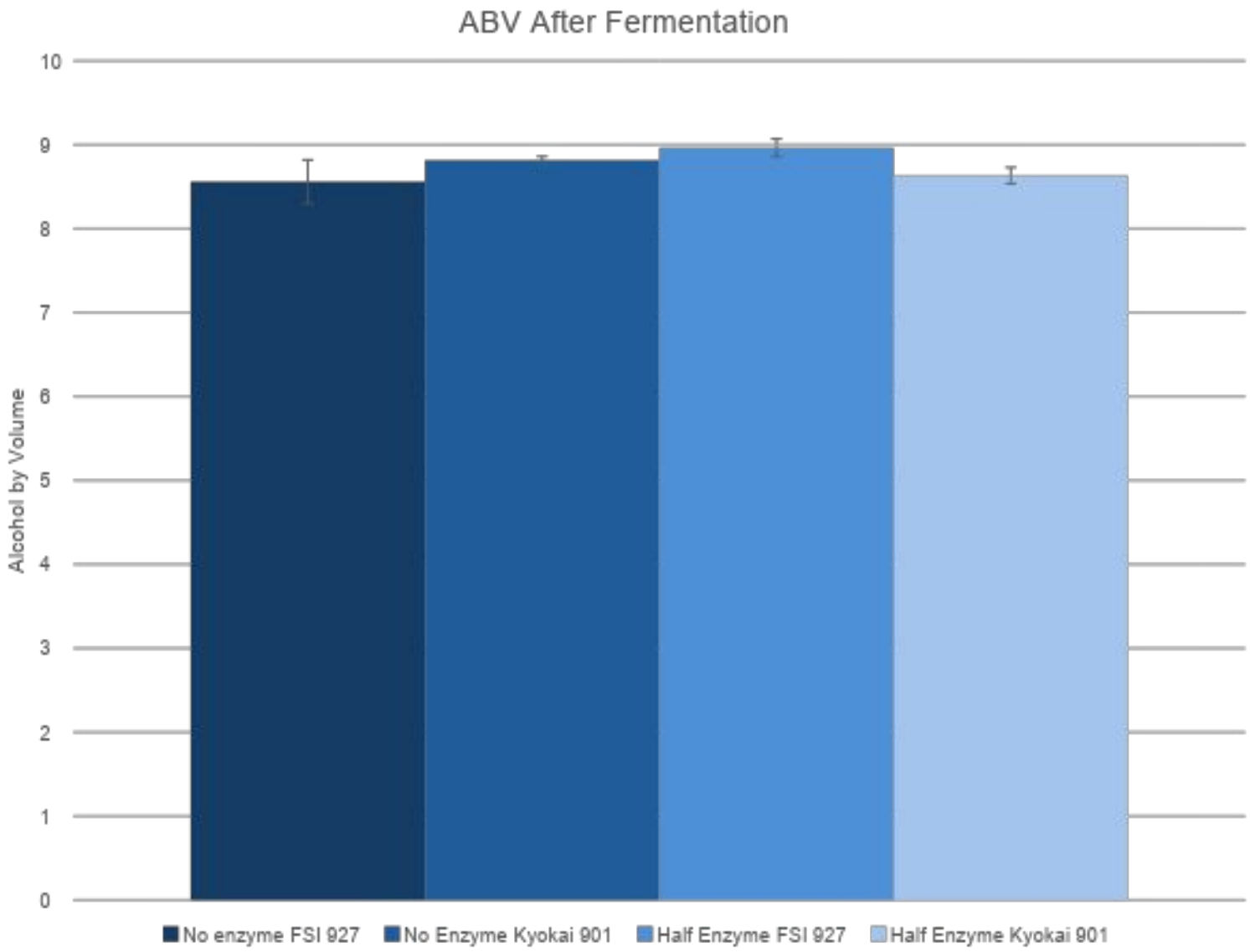






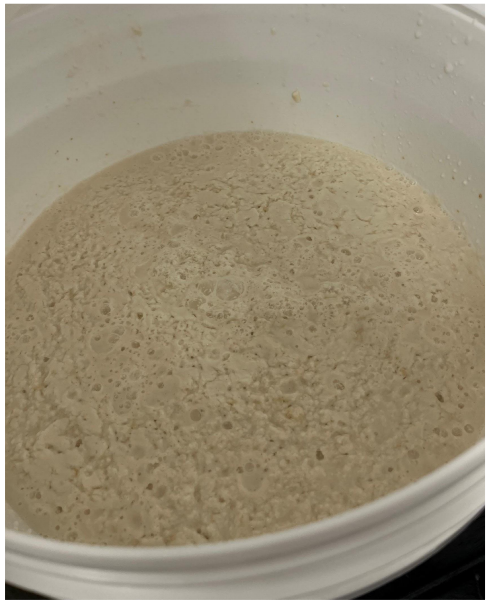
Experiment 4 Results Continued

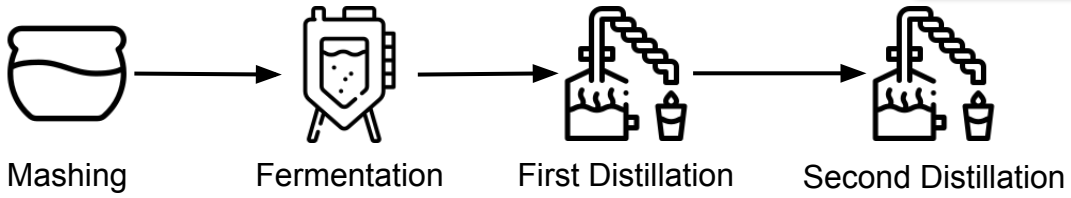




Methods

Experiment 5: Comparing yeast strains and pitch rates





- Parameters: 2:1 water:kasu concentration, 50% enzyme pitch rate, temperature (22 ºC), 4.5-gallon fermentations
- Four yeast starters used in their own separate fermentations
  - 1x FSI 927 ($4.54*10^9$ cells pitched)
  - 2x FSI 927 ($9.08*10^9$ cells pitched)
  - 1x Kyokai 901 ($4.54*10^9$ cells pitched)
  - 2x Kyokai 901 ($9.08*10^9$ cells pitched)
- Shochu processing
  - Fermentations were allowed 120 hours to ensure completion
  - ~3 gallons from each fermentation is distilled in first distillation
  - Each distillate was diluted to under 80 proof (40% abv) and distilled again

Results

- The results from experiments 1, 2, and 3 support the first hypothesis that temperature, enzyme addition, and kasu concentration impact fermentable sugars in the mashing process
  - Temperature- Room temperature mashing results in more fermentable sugars than refrigerated mashing
  - Enzymes- a 50% enzyme pitch rate produces comparable fermentable sugar concentrations to 100% enzyme pitch rate
  - Concentration- A 2:1 concentration has the ideal amount of fermentable sugar for fermentation

Future Work

- Experiment 5: Each distillate will be diluted to 40% ABV
  - Sensory analysis panel
  - Gas Chromatography
  - This experiment will prove or disprove the second hypothesis regarding flavor impact of yeast
- Research results will help model large scale production procedure
- Other starch/sugar sources can be considered
  - Sweet potato, barley, buckwheat, etc.

Potential Limitations

- Kasu is a byproduct
  - may have remaining living material and inconsistencies over time
- Kasu used in the project was the result of a single sake batch
- Production scaling will change efficacy of different methods compared to lab scale
- While the kasu is utilized in the process, wastewater from the distilling process will be produced as byproduct

Sources

- Ancuța Chetrariu and Adriana Dabija, “Spent Grain: A Functional Ingredient for Food Applications,” *Foods* 12, no. 7 (April 4, 2023): 1533, https://doi.org/10.3390/foods12071533.
- “DISCUS Annual Economic Briefing: U.S. Spirits Revenues Maintain Market Share Lead of Total Beverage Alcohol Market in 2023,” February 7, 2024, https://www.distilledspirits.org/news/discus-annual-economic-briefing-u-s-spirits-revenues-maintain-market-share-lead-of-total-beverage-alcohol-market-in-2023/.
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- Virginia L. Verges et al., “Lab-Scale Methodology for New-Make Bourbon Whiskey Production,” *Foods* 12, no. 3 (January 2023): 457, https://doi.org/10.3390/foods12030457.

Acknowledgements

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