PATHOGENS IN NON-ALCOHOLIC BEER

Alex Thompson
Brewing and Fermentation Associate
Clemson Cooperative Extension

Speaker Background

- Current Position: Brewing and Fermentation Associate, Clemson Cooperative Extension
  - B.S. Food Science and Human Nutrition – Clemson University
  - M.S. Food, Nutrition, and Culinary Science – Clemson University
- Former brewer at Brewery 85 in Greenville, SC
- US Army and OEF Veteran
- Current member of South Carolina Brewers Guild and Master Brewers Association of the Americas – District Carolina (Scholarship Committee)

Clemson Cooperative Extension Fermentation Program

- Funded by Clemson Cooperative Extension Innovation Award – April 2022
  - Goal: To develop job training, product testing, and research capabilities within Clemson Cooperative Extension to the assist the South Carolina brewing and fermented product industry

- Need in South Carolina: According to Brewers Association (2023 data)
  - 135 craft breweries (3.4/capita, 21+)
  - $844 million economic impact
  - 137,969 barrels produced (1.1gal/capita, 21+)
  - North America fermented foods revenue total USD 233 billion in 2024 and projected to grow 4.4% from 2024 to 2031.

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SOUTH CAROLINA

FIND A BREWERY ▸

STATE LAWS ▸

134
Craft Breweries
(RANKS 24TH)

3.4 Breweries per Capita*
(RANKS 32ND)
*per 100,000 21+ Adults

ECONOMIC IMPACT (2023)

844
Million Economic Impact
(RANKS 25TH)

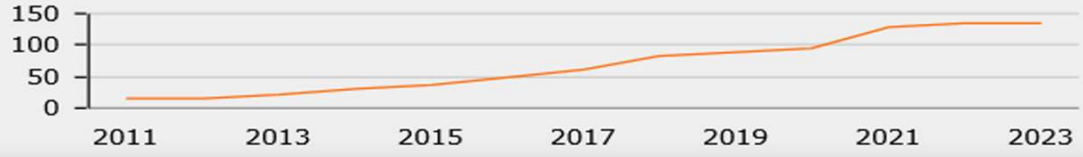
211.8
Impact per Capita
(RANKS 46TH)

PRODUCTION

137,969
Barrels of Craft Beer Produced per Year
(RANKS 35TH)

1.1
Gallons per 21+ Adult
(RANKS 42ND)

NUMBER OF CRAFT BREWERIES OPERATING PER YEAR



Brewing Program Overview

- Self-paced online training
  - 7 modules over 14 weeks
  - 5-day hands-on training in laboratory and at partner breweries

- Module Topics
  - Malt styles and biochemistry
  - Hop botany and utilization
  - Brewing water quality
  - Yeast biology and metabolism
  - Brewery processing and packaging
  - Brewery cleaning, sanitation, and safety

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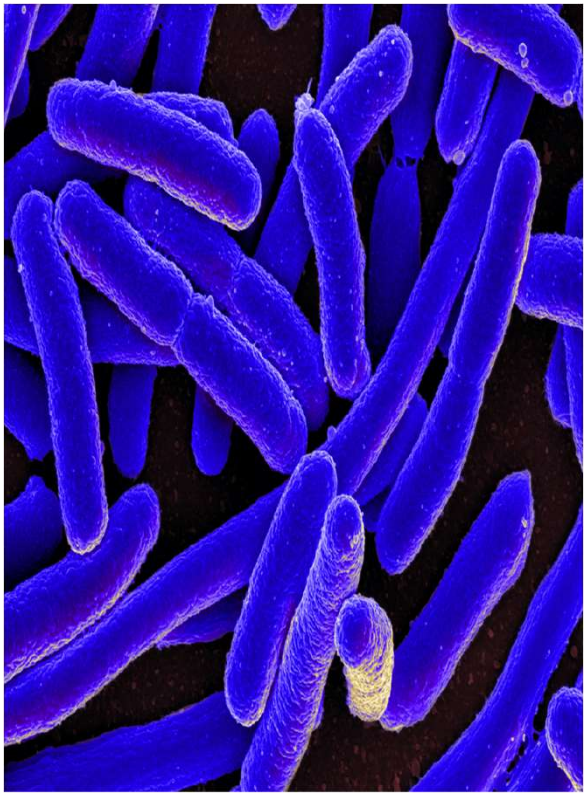
Pathogens in Breweries

- Beer is typically a low risk of pathogenic contamination due to factors such as:
  - pH (3.3 to 4.4)
  - ethanol concentration (3%-14% by volume)
  - CO2 concentration (0.5% w/w)
  - Low O2 levels (<0.1ppm)
  - Hop iso-α acids (17-55ppm)
- Low-alcohol (LA) and non-alcoholic (NA) beers are more susceptible to pathogens



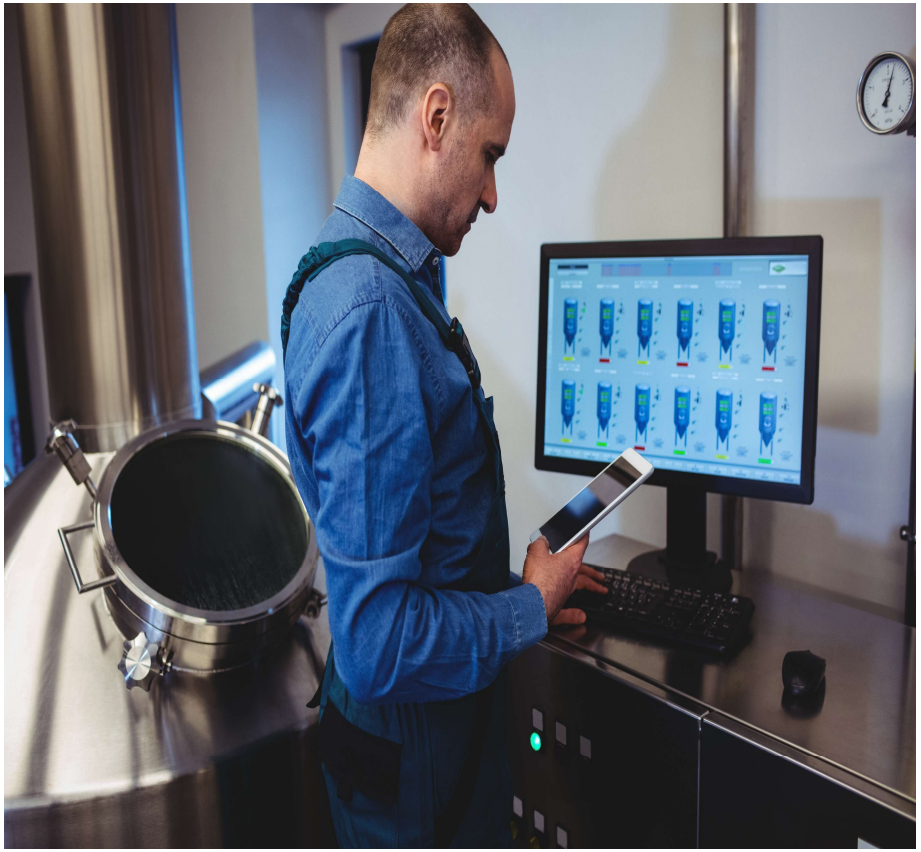
Non-alcoholic beverage trends

- According to Nielsen IQ over a 52-week period ending Jan. 4, 2025
  - **27% increase** in sales of non-alcoholic beer, spirits, and other beverages (THC-beverages included)
  - **$829.2 million** in total spending in 2024
  - NA beer accounts for **$699.2 million** of sales
  - **25% growth** in NA beer from 2023

Non-Alcoholic and Low-Alcohol Beer Production

- Physical – Dealcoholization
  - Expensive
  - Full fermentation prior to alcohol removal
  - Better flavor

- Biological – Arrested Fermentation
  - Low cost of entry
  - Approachable for small breweries
  - Sweet or “worty”



Physical Production

- Two primary physical methods

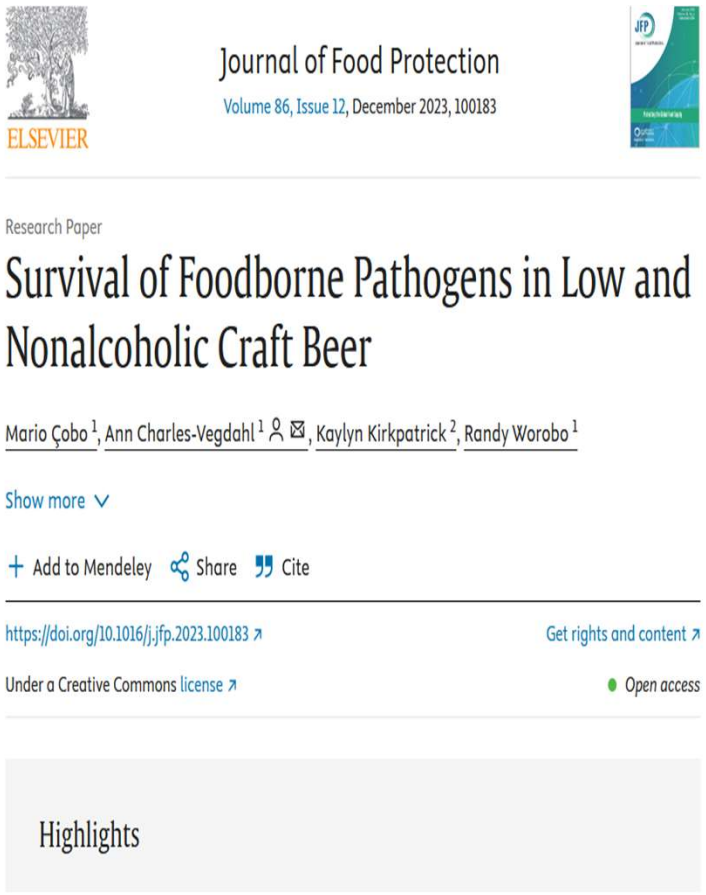
- Vacuum distillation
  - Beer is boiled under a vacuum
  - Reduces boiling point to ~90F
  - Minimizes volatile loss
- Filtration
  - Membrane filters out water and alcohol
  - Leaves NA beer concentrate

Biological

- Beer is produced using a **high temperature restricted mash (165-170F)**
  - Severely limits amylase activity
  - Produce limited fermentable sugar
- Wort acidified to pH 4.6 prior to fermentation
- Fermented using *Sachharomyces ludwigii*
  - Maltose negative

Survival of Foodborne Pathogens in Low and Nonalcoholic Craft Beer

- 2023 – Cobo et al – Cornell and BA
- Found **survival of *E. coli* O157:H7 and *S. enterica* for up to 2 months at 4 and 14°C** in low alcohol and NA beers.
- Average LA and NA beers had pH between **4.0 and 4.5**, with some having pH of **5.0**.
  - Potential of *C. botulinum* growth



Effect of Carbonation on the Survival of *Escherichia coli* and *Salmonella* Enteritidis in Non-Alcoholic Beer

- 2026 – Rachon et al – BRI (UK), Asahi Breweries, and Johns Hopkins
- Growth in carbonated beer (2.5%v/v) vs same beer decarbonated
- No growth in carbonated samples
- 17% decarbonated had growth of *E. coli 0157* and *S.* Enteritidis
  - Total coliform counts over 10,000 cfu/mL

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Effect of Carbonation on the Survival of *Escherichia coli* and *Salmonella* Enteritidis in Non-Alcoholic Beer and the Microbiological and Physicochemical Quality of Draught Products

Grzegorz Rachon[a], Alice Foxall[a,b], Patrycja Mundzik[b], Wiktoria Swiatkowska[b], Masaki Shimokawa[c], and Scott J. Britton[d]

[a]Campden BRI (Nutfield), Gloucestershire, UK; [b]Campden BRI, Gloucestershire, UK; [c]Asahi Breweries, Ltd, Moriya-shi, Ibaraki, Japan; [d]Center for Biotechnology Education (CBE), Advanced Academic Programs (AAP), Krieger School of Arts & Sciences, Johns Hopkins University, Baltimore, MD, U.S.A.

ABSTRACT
This study investigated the microbiological quality of non-alcoholic draught beers and examined the effect of carbonation on the survival of pathogens, specifically *Escherichia coli* O157 and *Salmonella enterica* subsp. *enterica serovar* Enteritidis. Samples of non-alcoholic draught beers were collected from various outlets across the United Kingdom, while additional data from non-UK beers (United States, Belgium and Spain) were provided by an independent global brewery. One fully carbonated non-alcoholic beer (2.8 v/v) along with its decarbonated variants 1.9, 1.2, 1.0, 0.8 and 0.1 (v/v) were evaluated. Both carbonated and decarbonated versions were tested with and without the addition of sugars (1 g/100 mL of maltose and 0.25 g/100 mL of lactose). Beers were inoculated with three strains of *E. coli* O157 and *Salmonella* Enteritidis, and growth and survival were monitored over six months at five time points, in triplicate. Analytical results indicated that

KEYWORDS
Beer; carbonation; draught beer; microbial safety; NAB; non-alcoholic beer; pathogens

Salmonella enterica Tennessee in Non- Alcoholic Beer Under Low Pasteurization

- 2026 – Frierson et al, Virginia Tech
- Standard Process – 73.9C for 1 min (80-120PU)
- Low Temp – 52C for 1 min (~ 0.75PU)
  - Preferred for better quality
- Co-inoculated with *L. brevis*
  - Did **not** impact pathogen growth
- Low temp did **not** generate 5-log reduction
- *Salmonella* survival for **183 days**

Hop Water

- Hop water is a water-based beverage with steeped hops added
  - Produced by many small breweries in-house and commercially available
- Capitalizes on popularity of IPA's and alcohol-free/health-conscious trends
- According to NIQ
  - Sales rose **142.5%** from **$2.2 million** in 2022 to **$5.3 million** in 2023
  - Sales rose **48% to $7.8 million** in 2024

Acidification of Hop Water

- Hop water needs to be acidified to protect against pathogenic contamination
  - Typically acidified to 2.9 – 3.2 pH with citric or lactic acid
  - Acidified in the boil kettle during hop additions
- Hops raise pH by 0.03/g/hl (Cocuzza, S. 2019)
  - Recheck pH and adjust post dry-hopping of hop water
  - Dry hopping is the addition of hops to hop water post-production to increase aromatics

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Alex Thompson

Brewing and Fermentation Associate
Clemson Cooperative Extension

art6@clemson.edu
(864) 986-1286