High Gravity Brewing: Oxygen & Nutrient Needs

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Learning Objectives

- Discuss and identify oxygen & nutrients requirements
- Importance of free amino nitrogen (FAN) and oxygen for yeast
- Trial outcomes in high gravity beer and hard seltzers
- Yeast handling techniques for optimal high gravity fermentations and cost savings

Requirements for Fermentation:

Yeast Nutrition

Carbohydrates (carbon source: malt sugars)

Amino acids (nitrogen from malt)

Minerals (from malt and brewing water)

Vitamins (from malt)

Oxygen (from aeration or agitation)

Yeast Nutrition

Nitrogen

All-malt wort typically sufficient in nitrogen content, unless high gravity

Situations with higher nitrogen needs:

- High Gravity
- Increased Adjuncts
- Hard Seltzers
- Cider & Mead

Yeast Nutrition

Nitrogen

Used in production of proteins

Measured in the form of amino acids, ammonium ions, and small peptides (linked amino acids)

Typical recommendation 100-150ppm FAN (mg/L)

Yeast Nutrition

Nitrogen & Proteins

Protein

One of four main classes of bioorganic molecules (nucleic acids, lipids, carbohydrates)

Nitrogen → amino acids → protein

Universal workhouse of living organisms (enzymes, immunity, cell membrane transport, etc.)

→ Flavor production result of protein function

Organic vs Inorganic Nitrogen

Organic Nitrogen also known as FAN, or Free Amino Nitrogen

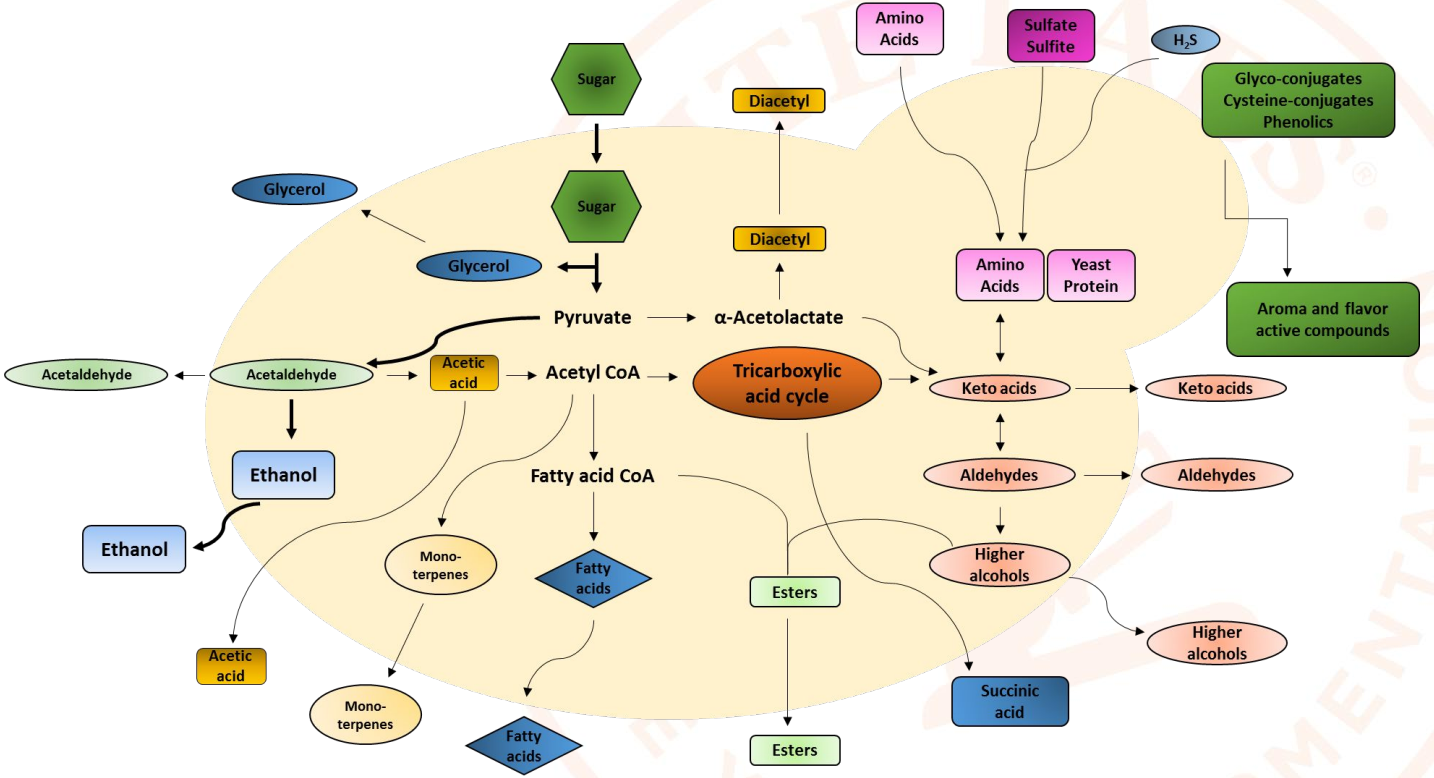
- Naturally occurring, usually coming from dead yeast hulls
- Requires more work to metabolize, i.e maltose vs glucose

Inorganic Nitrogen, usually in the form of DAP(Diammonium Phosphate)

- Will not affect color or yeasty flavor as much as organic
- Too much inorganic can cause urea or fusel alcohols

Together, known as YAN(Yeast Assimilable Nitrogen)

Yeast Flavor Development



Yeast Nutrition

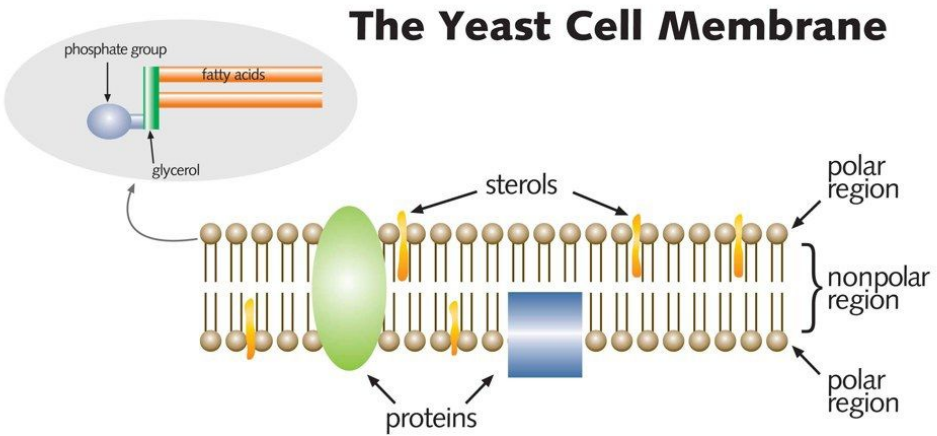
Oxygen and Lipids

Oxygen needed to synthesize sterols & fatty acids

Essential components of yeast cell membrane

Yeast growth is sterol-limited

Desired Range: 8-14ppm



Experiment Flow

WLP001 California Ale Yeast and WLP099 Super High Gravity Ale Yeast were tested in high-gravity wort (22°P & 25°P)

Fermentation standard conditions:

- Boiled wort
- Pitch Rate: 1 million cells/ml/°P
- Temperature: 20°C

Oxygen levels

Oxygen was tested in **FIVE** different profiles:

- No oxygenation
- Under oxygenation (7ppm)
- Recommended oxygenation (14ppm)
- Over oxygenation (>20ppm)
- Recommended oxygenation (14ppm) plus extra oxygenation every 24hrs for the first three days

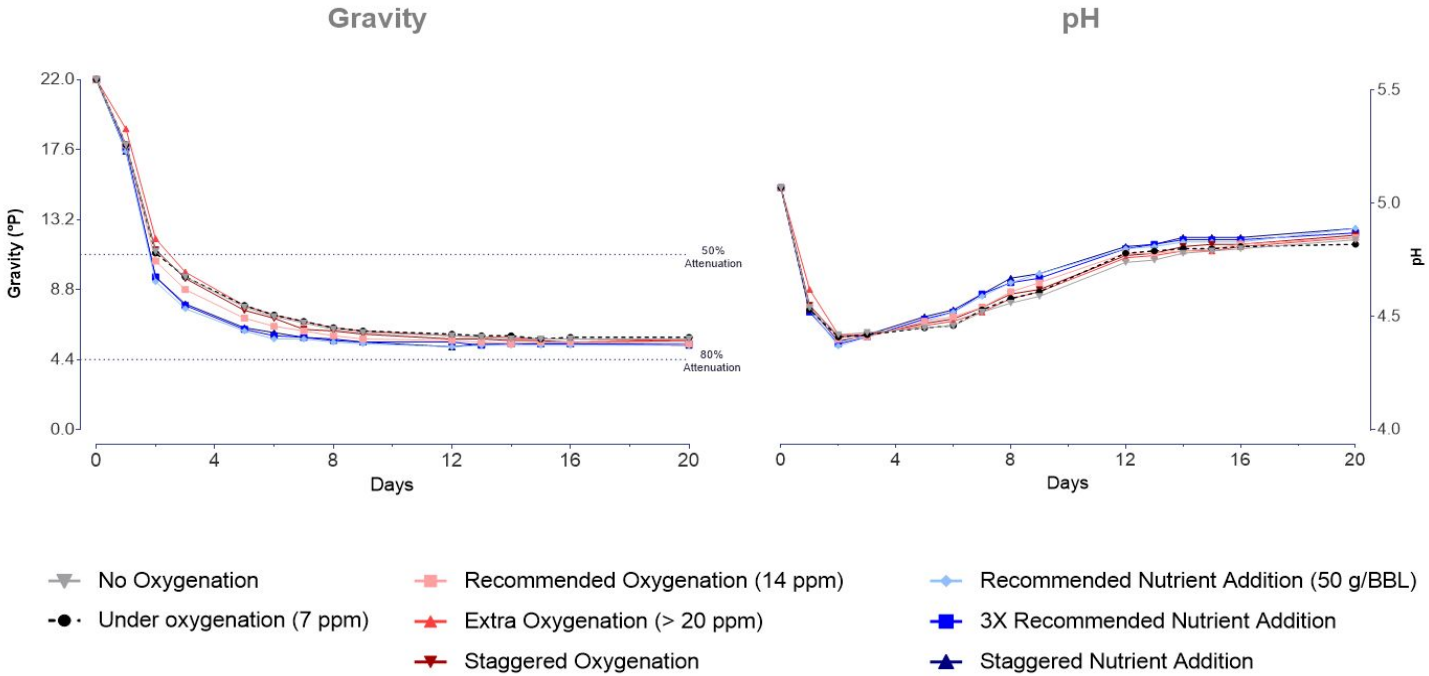
O = O

Nutrients levels

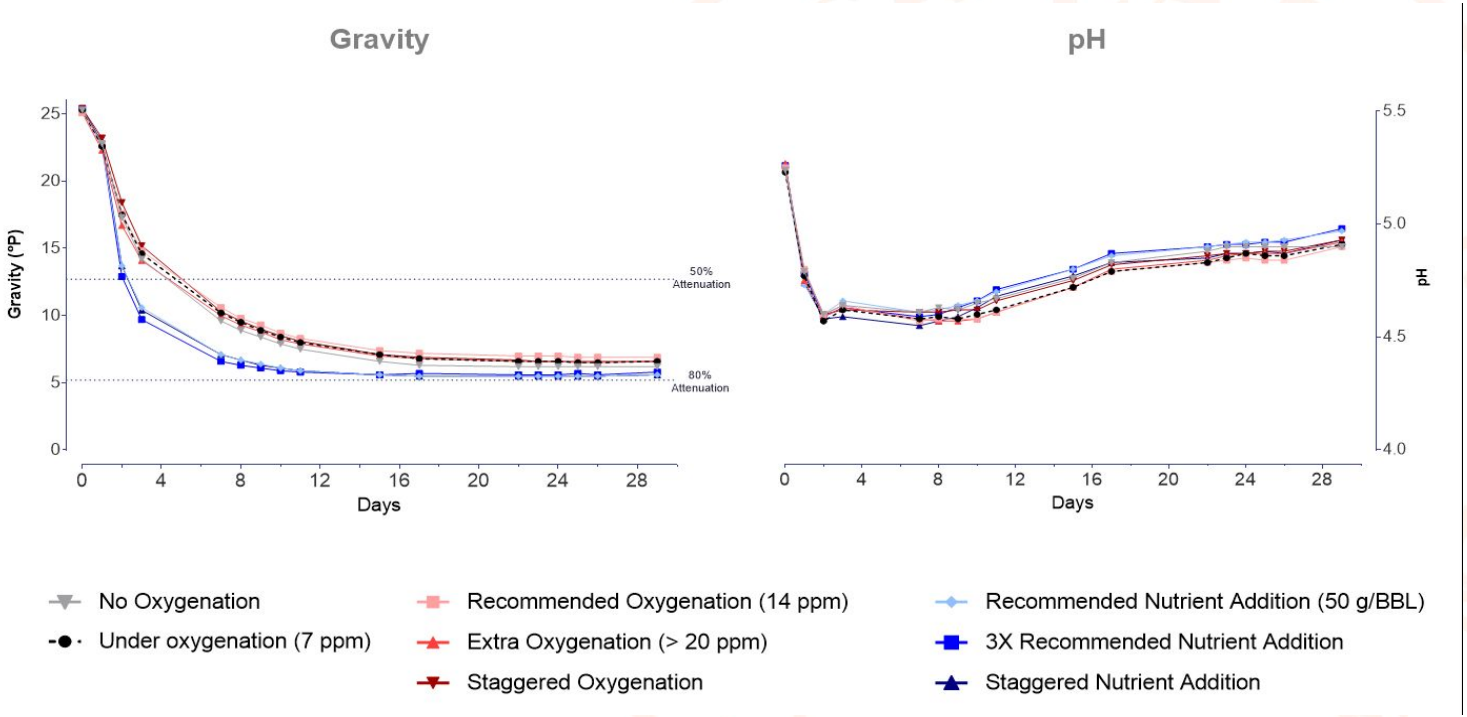
Nutrients were tested with **THREE** different profiles:

- Recommended oxygenation (14ppm) with an addition of FANMax Bio (recommended dosage 50g/BBL)
- Recommended oxygenation (14ppm) with an addition of FANMax Bio (3X recommended dosage)
- Recommended oxygenation (14ppm) with an addition of FANMax Bio (recommended dosage 50g/BBL) plus extra additions every 24hrs for the first three days

WLP001 - 22°P


Gravity
Gravity (°P)
22.0
17.6
13.2
8.8
4.4
0.0
50% Attenuation
80% Attenuation
0
4
8
12
16
20
Days
pH
5.5
5.0
4.5
4.0
pH
0
4
8
12
16
20
Days
No Oxygenation
Under oxygenation (7 ppm)
Recommended Oxygenation (14 ppm)
Extra Oxygenation (> 20 ppm)
Staggered Oxygenation
Recommended Nutrient Addition (50 g/BBL)
3X Recommended Nutrient Addition
Staggered Nutrient Addition

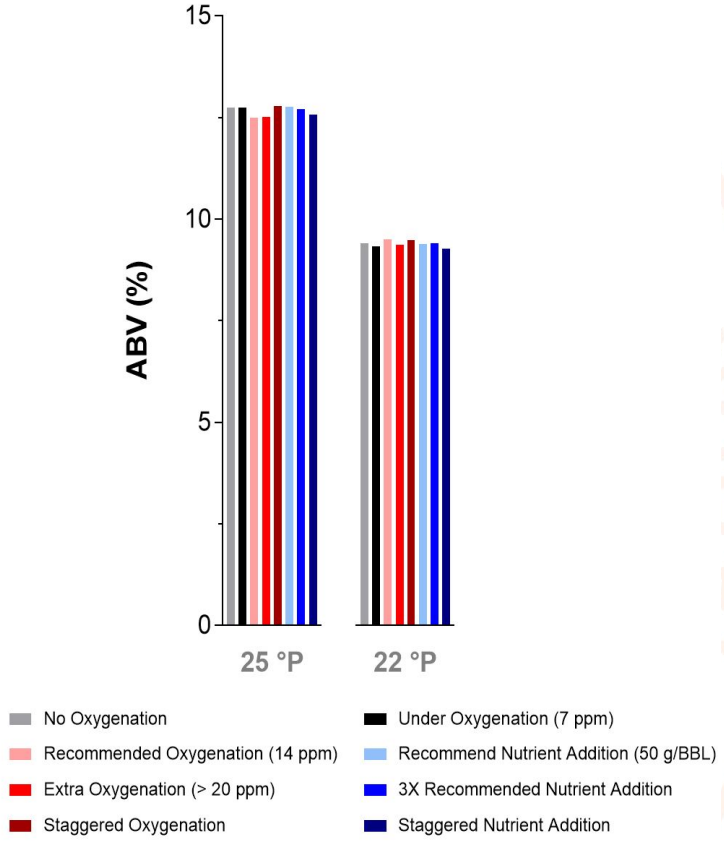
WLP001 - 25°P


Gravity
Gravity (°P)
25
20
15
10
5
0
50%
Attenuation
80%
Attenuation
0
4
8
12
16
20
24
28
Days
pH
5.5
5.0
4.5
4.0
pH
0
4
8
12
16
20
24
28
Days
No Oxygenation
Under oxygenation (7 ppm)
Recommended Oxygenation (14 ppm)
Extra Oxygenation (> 20 ppm)
Staggered Oxygenation
Recommended Nutrient Addition (50 g/BBL)
3X Recommended Nutrient Addition
Staggered Nutrient Addition

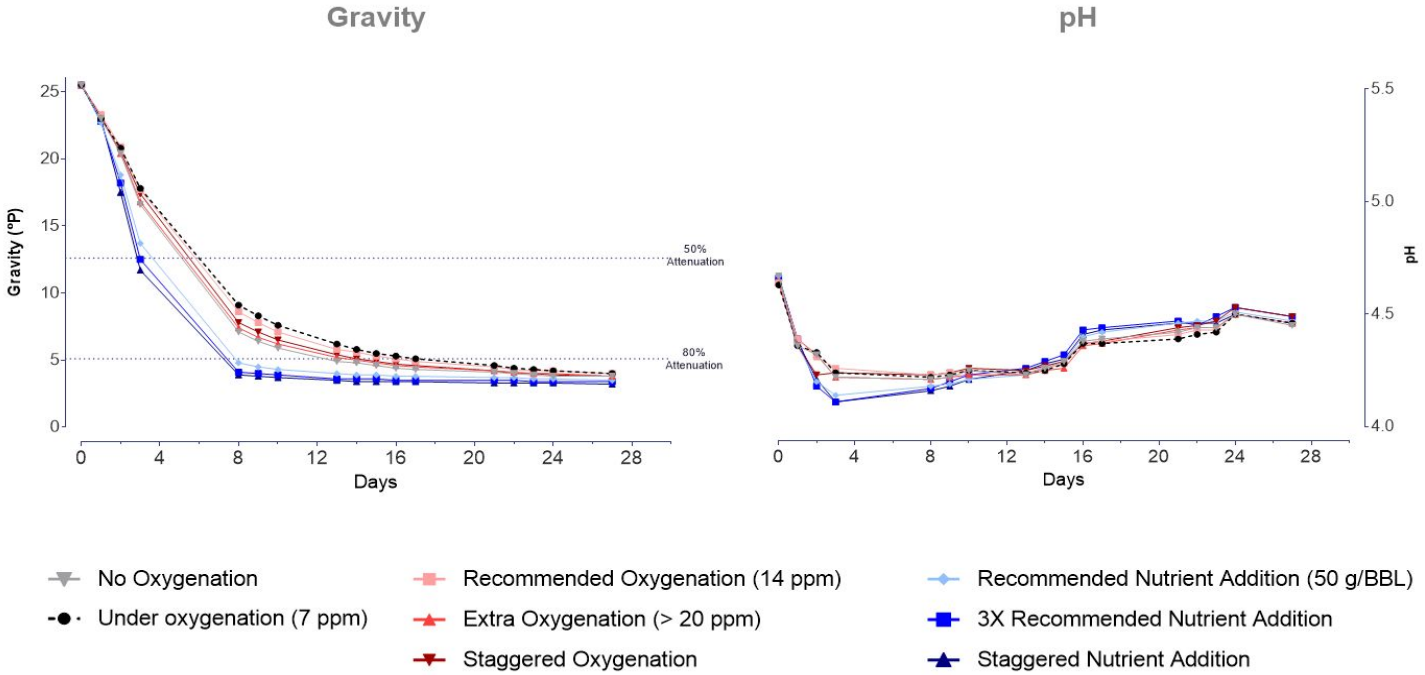
Ethanol Content

No significant change in ABV

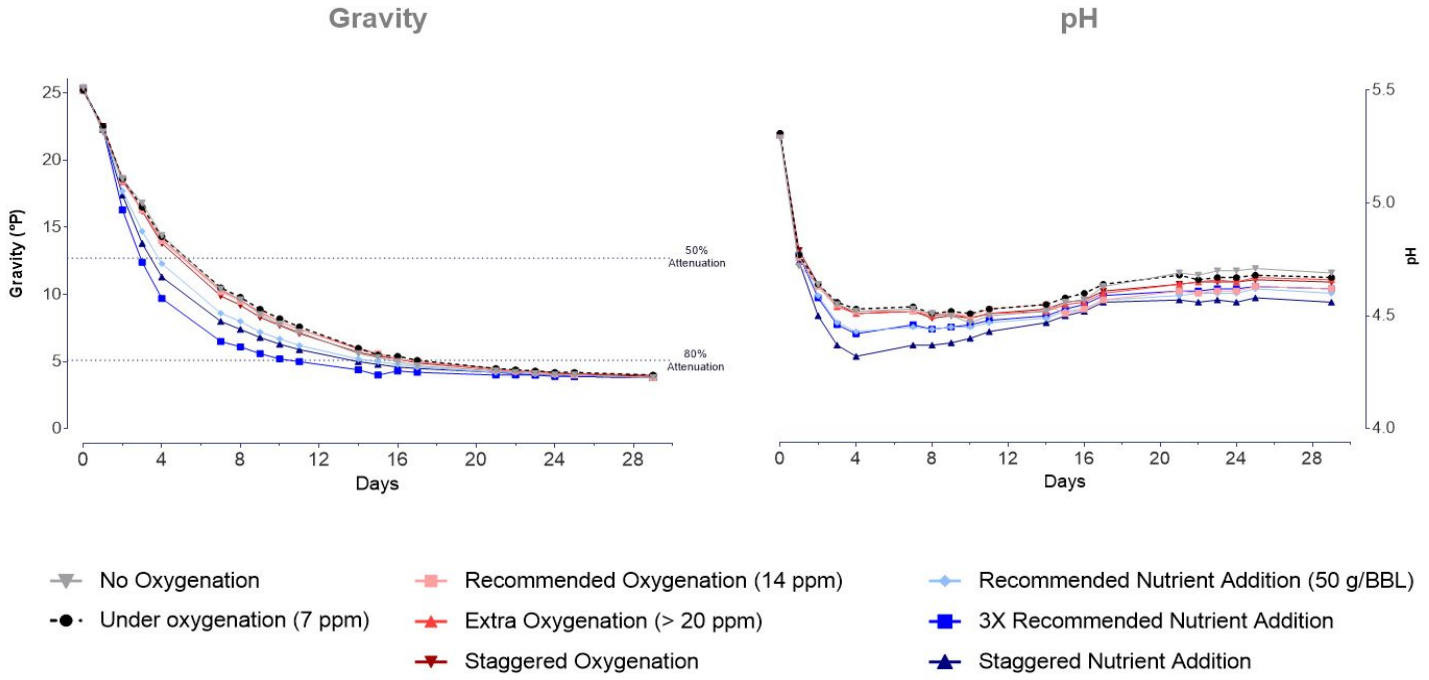
Fermentation speed more affected than overall attenuation



WLP099 - 25°P (Trial 1)



WLP099 - 25°P (Trial 2)



Discussion

- Addition of nutrients presented a significant impact on the fermentation timeline for both WLP001 and WLP099
- Different oxygenation levels had little to no impact on the attenuation curves (including no oxygenated wort)
- Addition of nutrients reduced the time to final gravity by around **50%** in both 22°P & 25°P wort, while maintaining nearly identically pH profiles
- Sensory Impact - A small triangle-tasting panel was run to determine if there was a difference in "off-flavor" due to the addition of nutrients. No initial variance of flavor or aroma was detected.

High Gravity Seltzer

- High Gravity study parameters were replicated with Hard Seltzers
- Without any source of nitrogen in seltzer production, increasing nutrient levels greatly decreased fermentation timelines

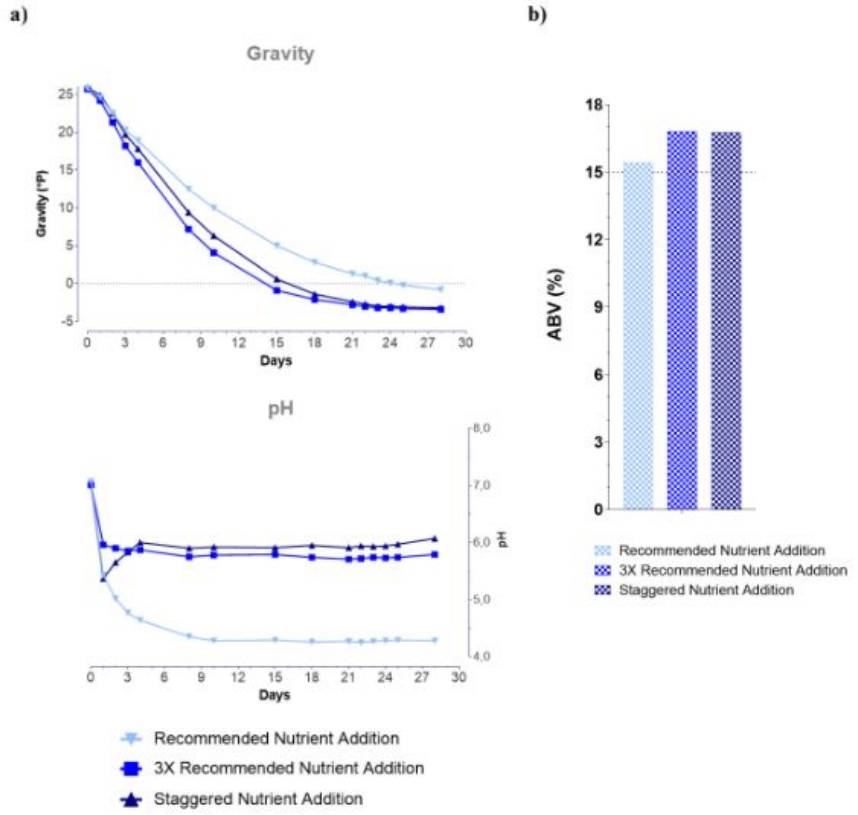


Figure 2. a) Attenuation and pH curves for Pinnacle G in 25 °Plato sugar wash supplemented with different amounts of SeltzerMax. b) Final ethanol production (v/v %).
Increasing the concentration of SeltzerMax had a significant impact in the fermentation and pH profiles.

High Gravity Seltzer

Pitch Rate

- An additional variable, pitch rate, was examined in this study

  (0.5g/L and 1g/L)

- By combining the extra nitrogen with doubling the pitch rate, led to a reduction of up to 7 days to reaching final gravity.

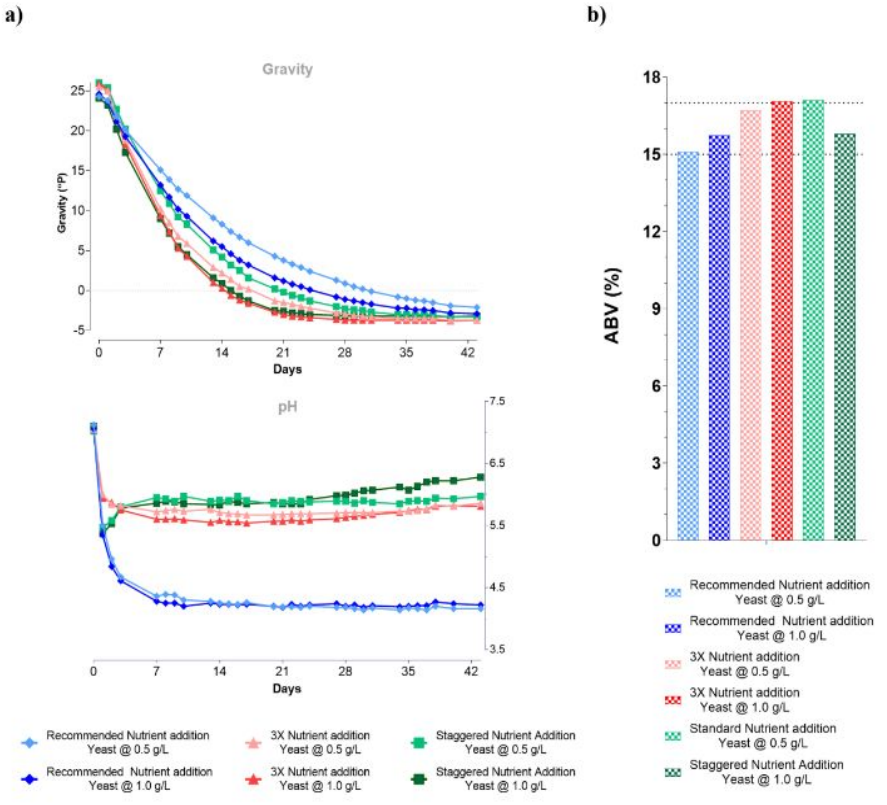


Figure 4. a) Attenuation and pH curves for different pitching rates of Pinnacle G in 25 °Plato sugar wash supplemented with SeltzerMax. b) Final ethanol production (v/v %).
Increasing the initial cell concentration had a significant impact on the fermentation speed.

High Gravity Seltzer

- A potential issue with extra nutrients is the flavor and color pick up
- Additional filtration equipment would be necessary to produce clean and clear seltzers

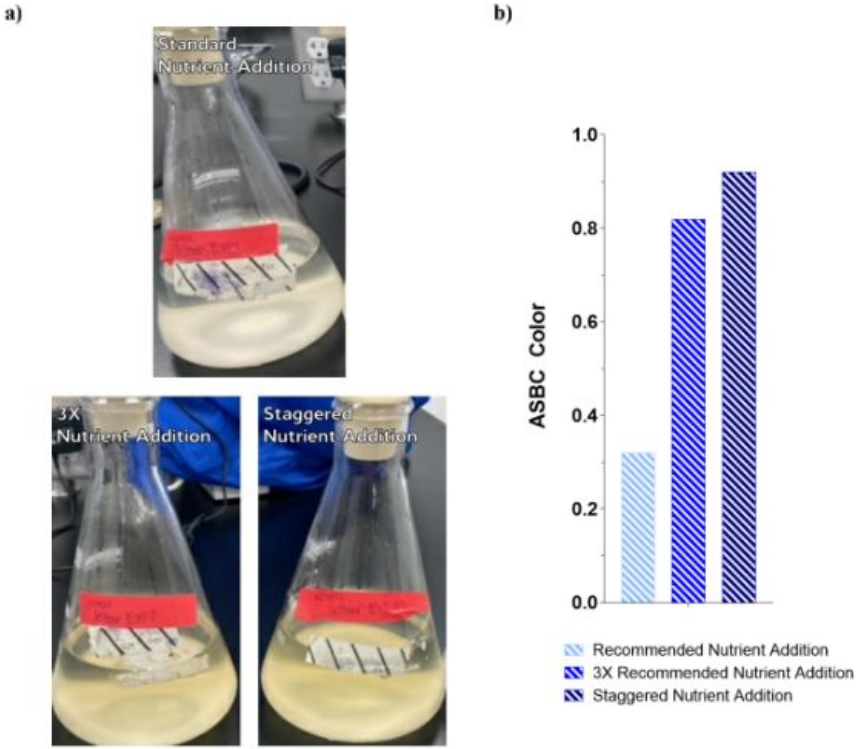


Figure 3. Color analysis of the final Seltzer product. The color development with the extra addition of nutrients was clear, both by a) visual inspection and b) quantification according to the ASBC methods.

Discussion

- Nutrients can shorten fermentation timeline in hard seltzer
- Nutrients additions act as a buffer and may require acid addition
- High nutrient load can lead to color development and flavor changes
    - Filtration and flavor additions may reverse this while still adding the benefits of a quick fermentation

Further Study

- ➔ Measure FAN and Zinc prior and after fermentation
- ➔ Performance of different yeast strains related to oxygen and nutrient additions
- ➔ Performance and effects of oxygen & nutrients on harvested yeast cultures from high gravity batches
- ➔ How pitching rates change the fermentation performance based on these oxygen and nutrient results
- ➔ Nutrient effect on the flavor and stability of the beer in various styles of high-gravity beer.

Generation “0”

Yeast grown from Gen-0 in a lab is healthier than the yeast at the bottom of the fermenter

- Grown in the presence of O2
- Low alcohol production
- Cell physiology
- Glycogen levels
- High viability (95%+)
- Little to no presence of hop matter and other trub

Yeast Selection

Plan before placing yeast orders:

- What brands will/can it be used in?
- How often will it be used?
- Fermentation timelines for each brand to aid with scheduling

House Ale Yeast
IPA
Porter
American Wheat
Imperial Stout
Amber Ale
Blonde Ale
Brown Ale

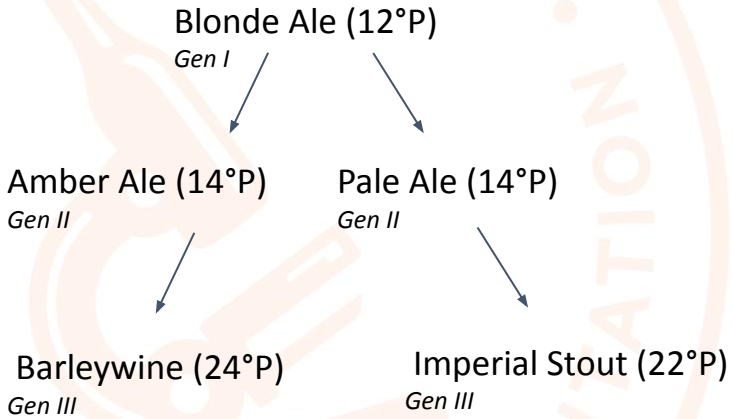
Belgian Wit Yeast
Witbier
Farmhouse Ale
Belgian Blond

Yeast Selection

It is important to know your cultures lineage

- What gravity beer did this come from?
- What was the quality of fermentation(s)?
- What generation is this culture?

- If increasing gravity, use cultures from lower gravity fermentations



Yeast Selection

- Proper yeast handling can be very cost effective for any strain type
- Example:
  - 10bbl, 25P, 66F
  - Fresh liquid pitch - $1000-$1500
  - 10bbl, 15P, 66F -
  - Fresh liquid pitch - $400-$500
- Use 3 generations drop $40-50/bbl to $12-$15/bbl

Learning Objectives

- FAN is necessary for healthy cellular function in fermentation
- Proteins are vital, proper protein function needs FAN
- More nutrient impacts high gravity fermentations
- Build up your culture from low gravity to high gravity - healthier and cost savings

Thank you very much!

Questions?