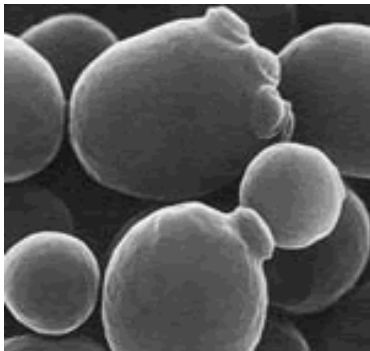


What Yeast has taught me about Brewing over the years



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What Yeast has taught me about Brewing over the years

There are 2 objectives to this Presentation.

- Explain what is available to the “Newly Hired” Brewer or Lab tech that has not had the benefit of attending Davis, Siebels or Nottingham to learn the Brewing Process and How to look for information to Help Troubleshoot Brewing Issues.
- Share some anecdotal fermentation problems that have been encountered over the years and what was done to investigate and in some cases actually resolve them.

What Yeast has taught me about Brewing over the years

- Problem- A 20 something walks into your Brewery and shows some smarts, is eager and wants to become the Head Brew Master in a Month. You point him/her to
 - The Practical Brewer – MBAA various authors
 - Malting and Brewing Science -J. S. Hough, D. E. Briggs, R. Stevens, T. W. Young
 - Technology Brewing & Malting – Kunze
- The response is some what negative as they pull out their iPad, iphone, Droid, Blackberry and start to “google” Brewing mumbling something about- just got done with school and never wanting to see another **text** book as long as they live.

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Hold On !!!

- Now is your challenge to direct them on an “internet search” to some Papers and Articles that Might be of interest. They can search them out—but some direction from you will make them think they are “finding” this treasure chest of Brewing Knowledge.

What Yeast has taught me about Brewing over the years

- Malting and Mashing

- Characterization of Malt Grist Fractions: Stubits, Teng and Pereira:- ASBC Journal 1986

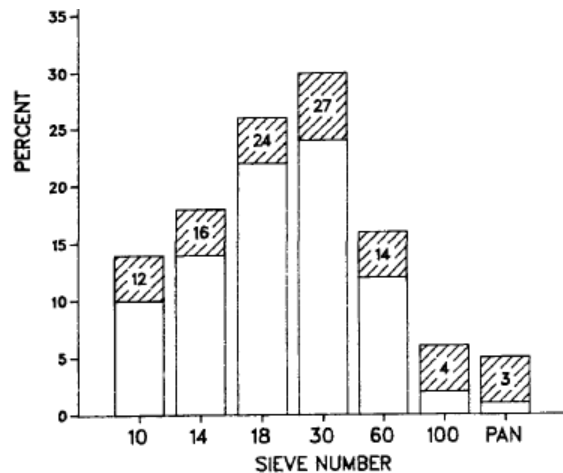


Fig. 3. Sieve analysis of optimum malt grist particle size distribution.

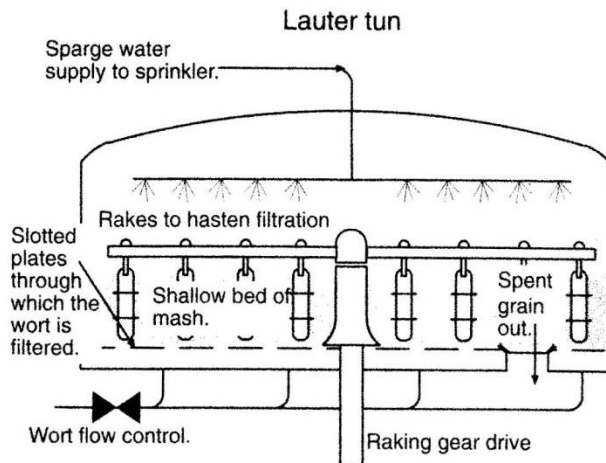
The relevance of each sieve retention and their contribution to “extract yield” and impact on Lautering

- Beta Glucans and Beta Glucanases in Malting and Brewing: Practical Aspects:- Bamforth – Brewers Digest May 1994

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Lautering and Mash Presses

- A Review of the Progress in Mash Separation Technology:- Andrews MBAA TQ 2004



A comparison of Lauter Tun Operations and Mash Press Operations- Pros and Cons

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Fermentation

- Utilization of Wort Carbohydrates: Panchal and Steward: Brewers Digest June 1979
-
- Fermentation- Yesterday, Today and Tomorrow: Steward MBAA TQ 1977
-
- The yeast *Saccharomyces cerevisiae*- the main character in beer brewing:- Lodolo, Kock, Axcell, Brooks FEMS 2008 (peer review)

What Yeast has taught me about Brewing over the years

- Fermentation- The “Black Box” of the Brewing Process: Steward and Russell, MBAA 1993

One of the “Key” take aways-

– Yeast Nutrients--

When yeast is pitched into wort, it is introduced into an extremely complex environment due to the fact that wort is a medium of:

- Simple sugars and dextrins
- Amino acids, peptides and proteins
- Vitamins
- Ions
- Nucleic acids
- Other constituents too numerous to mention

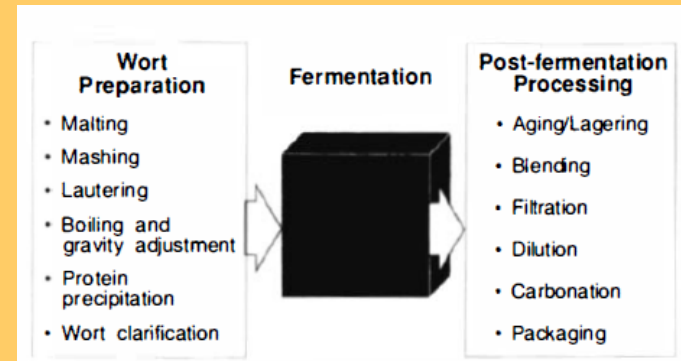


Fig. 1. Fermentation—the “black box” of the brewing process.

- *One of the major advances in Brewing during the past 20 years has been the elucidation of the mechanisms by which the yeast cell, under normal circumstances, utilizes, in a very orderly manner, the plethora of wort nutrients. [a statement made almost 20 years ago and is still timely]*

What Yeast has taught me about Brewing over the years

- Yeast and Fermentation Issues
 - PYF Malt: Practical Brewery Observations of Fermentability:- Armstrong and Benediak MBAA TQ (17 References)
 - The Effect of Trub on Fermentation:-Siebert, Blum, Wisk, Stenroos and Anklam MBAA TQ (38 references)
 - Fermentation Conditions associated with Incomplete Glucose and Fructose Utilization:-Hardwick and Skinner, MBAA TQ 1990 (13 References)
 - Low-Carbohydrate Beer Production: Issue with Sticky Yeast Beds:- Samp, Silbermann and Dennison (36 references)

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General Information

- The Importance of pH Control During Brewing:- Taylor MBAA TQ 1990
- Improvement for Oxidative Flavor Stability of Beer—Rapid Prediction Method for Beer Flavor Stability by Electron Spin Resonance Spectroscopy. M. Uchida, S. Suga, and M. Ono, ASBC Journal , 1996.
- Technological Approach to Improve Beer Flavor Stability: Analysis of the Effect of Brewing Process on Beer Flavor Stability by the Electronic Spin Resonance Method: Uchida and Ono ASBC Journal , 2000.

What Yeast has taught me about Brewing over the years

General Information

- Technological Approach to Improve Beer Flavor Stability: Analysis of the Effect of Brewing Process on Beer Flavor Stability by the Electronic Spin Resonance Method: Uchida and Ono ASBC Journal , 2000.

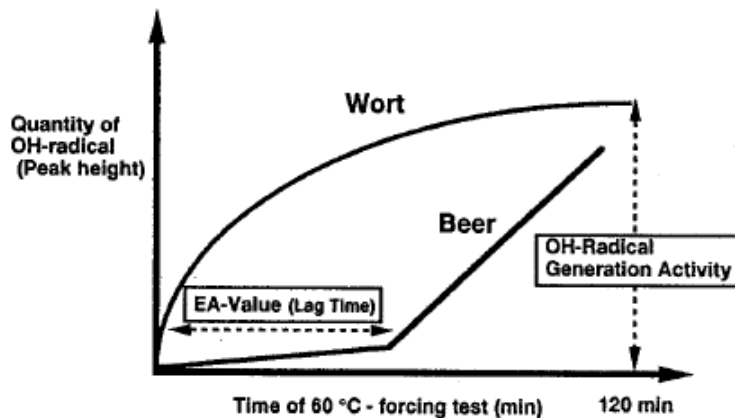


Fig. 2. Definition of OH-radical generation activity and endogenous antioxidant activity value obtained from the OH-radical generation curve in wort and beer.

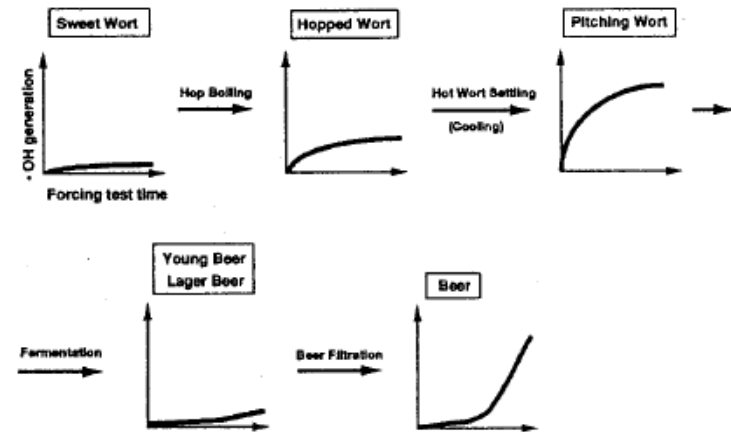


Fig. 1. Typical patterns of OH-radical generation for the stages in each brewing process. The vertical axis for all diagrams shows the quantity of the OH radical generated, and the horizontal axis for all diagrams depicts the 60°C forcing test time.

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Comment: This is only the tip of the Iceberg. A Search on the MBAA TQ Website for Diacetyl came up with 36 Articles, Oxygen 124 Articles and Yeast Flocculation over 200 articles in the TQ alone.

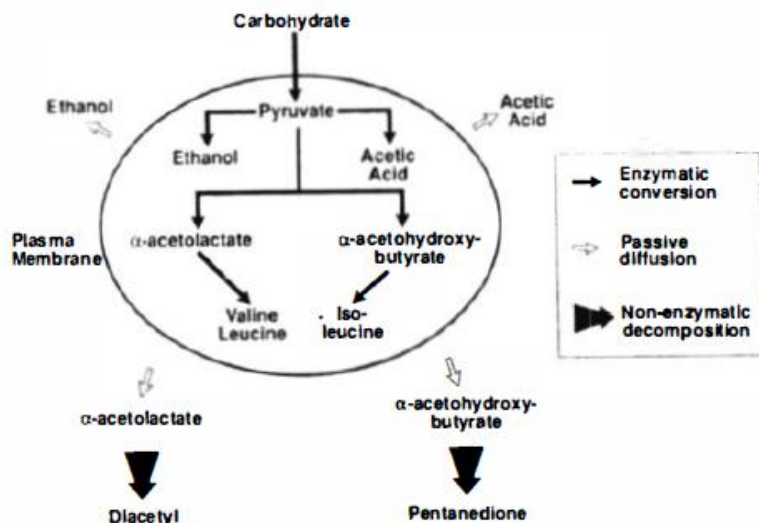


Fig. 2. Mechanism of diacetyl production in beer by yeast.

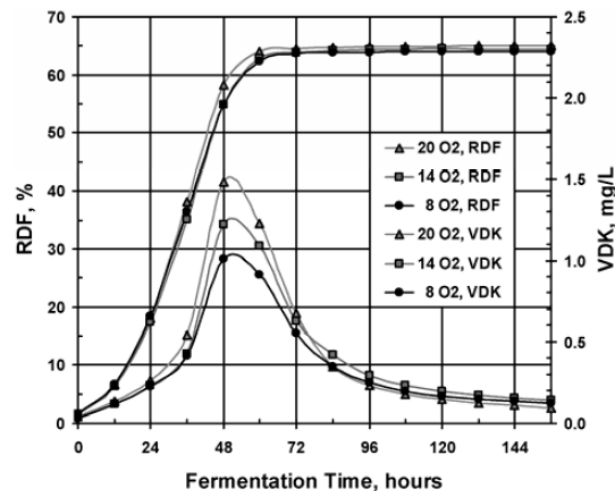


Figure 1. Real degree of fermentation (RDF) (top three lines) and vicinal diketone (VDK) (bottom three lines) results at three oxygen levels (8, 14, and 20 mg/L).

What Yeast has taught me about Brewing over the years

Articles ; Once you find a relevant article—the reference list alone on the Publication can be quite large.

Conclusion: It quite apparent there is a wealth of both basic and detailed publications for the “new” brewer to utilized. And for the seasoned brewer- So many Articles and so little time.

On to yeast and what it taught me about brewing.

What Yeast has taught me about Brewing over the years

A comparison of Yeast to the other ingredients

Malt, and Brewing Adjuncts come with a certificate of analysis. Water is analyzed in house

Malt- you know DP. Alpha Amylase, FAM, Beta Glucans, color, pH ,etc

Brewing Adjuncts- % Extract, Carbohydrate Profile, pH, color, etc

Water - Minerals --- Calcium, Potassium, Phosphate. Carbonates, Sodium, Chloride, Hardness, pH and most likely will adjust as needed to get the desired results.

Yeast may come with a description line- “was smuggled out the country under the 1st Brew Masters hat.

What Yeast has taught me about Brewing over the years

Key Point— Fermentation is a Biological Process –
just like Malting.

For every 2.0665 grams of Fermentable Extract results in

**1 gram of Ethanol + 0.9565 grams of CO₂ + 0.11 gram increase in Yeast mass
+Heat**

The Balling Values applied to Gay-Lussac equation (Wahl and Henius, 1908)

*We are growing yeast. Beer is a result of growing yeast and we try to
control the conditions to allow the yeast to grow and enjoy the food
we have supplied in the Wort.*

What Yeast has taught me about Brewing over the years

**Goal as Brewers—we give the yeast what we think they want
and the yeast tells us how we are doing—**

By Monitoring

- Temperature increase and rate of increase
- pH drop,
- Cell count increase and extract decrease
- CO₂ evolution,
- SO₂, H₂S, levels
- Fusel Alcohols/Ester ratio,
- Electronic Spin Resonance (ESR) or Electron Para Spin Resonance
- At yeast harvest - % DC, aroma and pH.

Question- So who is doing all the worrying ?? –

The brewer or the yeast ??

What Yeast has taught me about Brewing over the years

If One or More of the Above Parameters is NOT Right--
So we start asking questions:

-
First should we “reuse” this yeast – is the yeast healthy ???
– Is the “Vitality” OK ???

Vitality – as defined by factors Affecting Yeast Viability

and Vitality Characteristics: Review:- Heggart, et al MBAA TQ 1999

- **The capacity of the yeast to initiate metabolism rapidly after transfer from a nutrient poor to nutrient rich environment**
- **A measure of yeast activity or fermentation**
- **Cell count increase (mass) and related decrease of extract**
- **Rate of temperature increase**
- **CO₂ evolution**
- **A measure of vigor or physiological state of the living cell; The ability to endure stress and still perform**
- **The physiological state of the viable cell population; Fitness for use !!!!**

What Yeast has taught me about Brewing over the years

Conclusion- Tough Call. Because if the following does not happen-
“initiate metabolism rapidly”- then what “Happened” to our yeast ??

So now the “trouble shooting questions” start:

- pH of the Wort.
- TRUB- too much/too little – Malt FAN Levels
- Oxygen – How much at what injection rate and when (lots of anecdotal thoughts in this area). --
 - Air Contains 8490 mg/SCF of O₂ and Pure Oxygen 40,496 mg/SCF at STP
- Pitching Temperature and Wort Cooling rate.
 - Side Bar Question—do we set up our wort cooler more to make Hot Water or to get the Temperature and Cooling Flow rate optimal for the yeast.. Who runs the Brewery – Engineers or Brewers—Neither- it's the Yeast
- How we recovered the yeast and then stored the yeast prior to pitching ??
- Temperature/ Glycogen consumption/agitation.
- What was the Yeast Generation
- Are we selectively Cropping flocculent Yeast –Talk About a Can of Worms !!!!

What Yeast has taught me about Brewing over the years

Let's Dive Back into the Literature-

Selectively Harvesting Yeast ???

More significantly, the peak in cell age was observed to directly coincide with an increase in flocculation potential. It has previously been suggested that there may be an age related flocculation gradient within the cone of a cylindroconical vessel, **with yeast at the bottom being more flocculent(2,15). However, although the flocculation characteristics were not constant throughout the cone, cells present at the bottom of the cone were not the most flocculent.** This suggests that although old cells tend to be larger than younger counterparts (3), size alone is not sufficient for optimum flocculation. It is suggested that cell age plays a greater role in determining the flocculation potential of a cell than size. A relationship between age and flocculation has previously been identified and it has been proposed that the physiological characteristics of older cells may be a significant causative agent (54).

**The Impact of Sedimentation on Cone Yeast Heterogeneity:-
Powell, Quain and Smart J. Am. Soc. Brew. Chem. 62(1):8-17, 2004**

What Yeast has taught me about Brewing over the years

Selectively Harvesting Yeast ???

Analysis of fractions obtained during vessel cropping indicated substantial differences in terms of yeast parameters and environmental conditions. It is suggested that the variation observed arose as a consequence of the interaction between yeast and its environment, in addition to the timing of yeast sedimentation and internal cone storage conditions. In the current study, cells present at the bottom of the cone were deemed to be less healthy than cells located elsewhere within the cone. **In addition, highly flocculent aged cells were observed to be almost exclusively located in the central region of the cone.** It is postulated that progressive artificial selection for specific yeast fractions during cropping may influence the fermentation performance and flocculation characteristics of future yeast cultures. **Although a yeast crop may be considered by the brewer to be a homogenous culture in terms of vitality and viability, we demonstrate here, that in reality, it comprises a variety of individual cells, which may differ in respect to their fermentative capabilities.**

As such, it is suggested that the yeast crop should not be considered to be a single homogenous mass, but a medium comprising a diverse range of individuals exhibiting a variety of phenotypes.

What Yeast has taught me about Brewing over the years

Well There Goes That Theory !!!

What Yeast has taught me about Brewing over the years

The physical characteristics of the Fermenter

What's the Aspect Ratio ?—[Aspect ratio- asks the new brewer ??- Looks it up Kid – Fermentation- Yesterday, Today and Tomorrow, See Fermentation Systems]

Angle of the Cone if a Cylindrical Conical – what is Optimal ? 35, 45, 60 degree

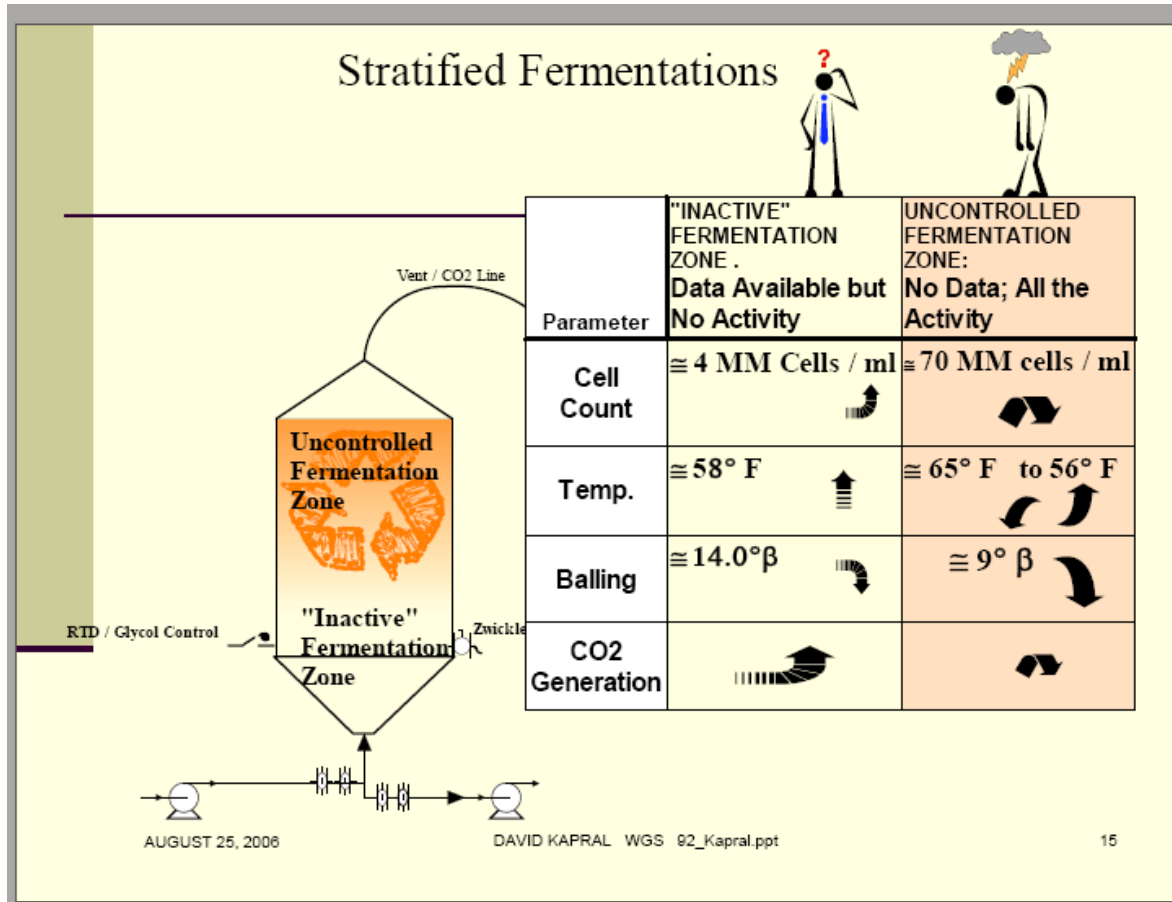
How did the Fermenting vessel fill with respect to time {pauses between brew-if multi brew filled vessel}

The Effects of Filling Procedures on Multi-Fill Fermenters.

Inlet Pipe diameter vs wort flow [11 feet/sec from Kaparl] . Degree of Mixing.

Stratified Fermentation ???

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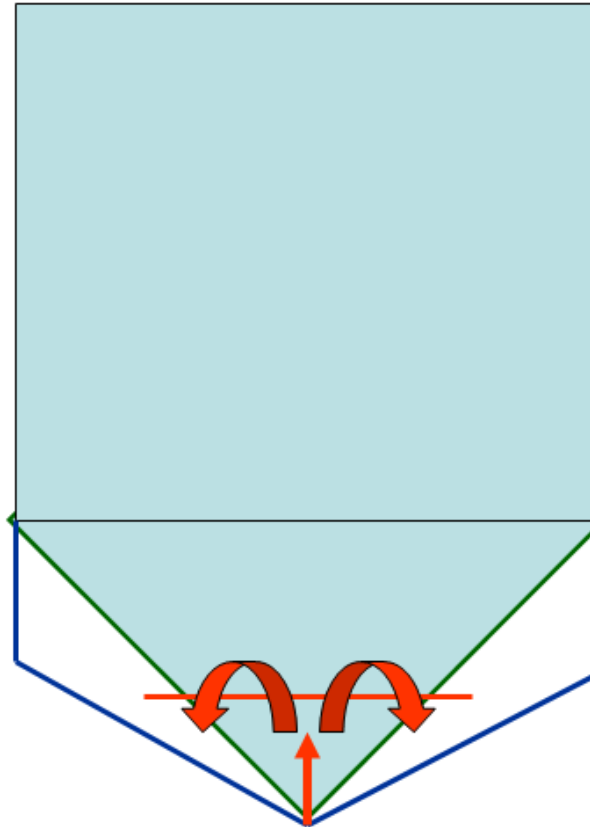
Borrowed Side from Dave Kapral

What Yeast has taught me about Brewing over the years

This diagram shows the difference between a 25 degree bottom (blue lines) and 45 degree bottom (green lines).

The 25 degree bottom promotes better mixing- even with a slower-less turbulent filling.

The 45 Degree bottom results in fermenter stratification- as the yeast layer does mix adequately and causes this layer (impacted by density and temperature to "float to the top")



What Yeast has taught me about Brewing over the years

Problem- Elevated SO₂ – TTB will not allow Beer with SO₂ levels greater than 10 ppm be sold.

Literature Search- 2 informative articles

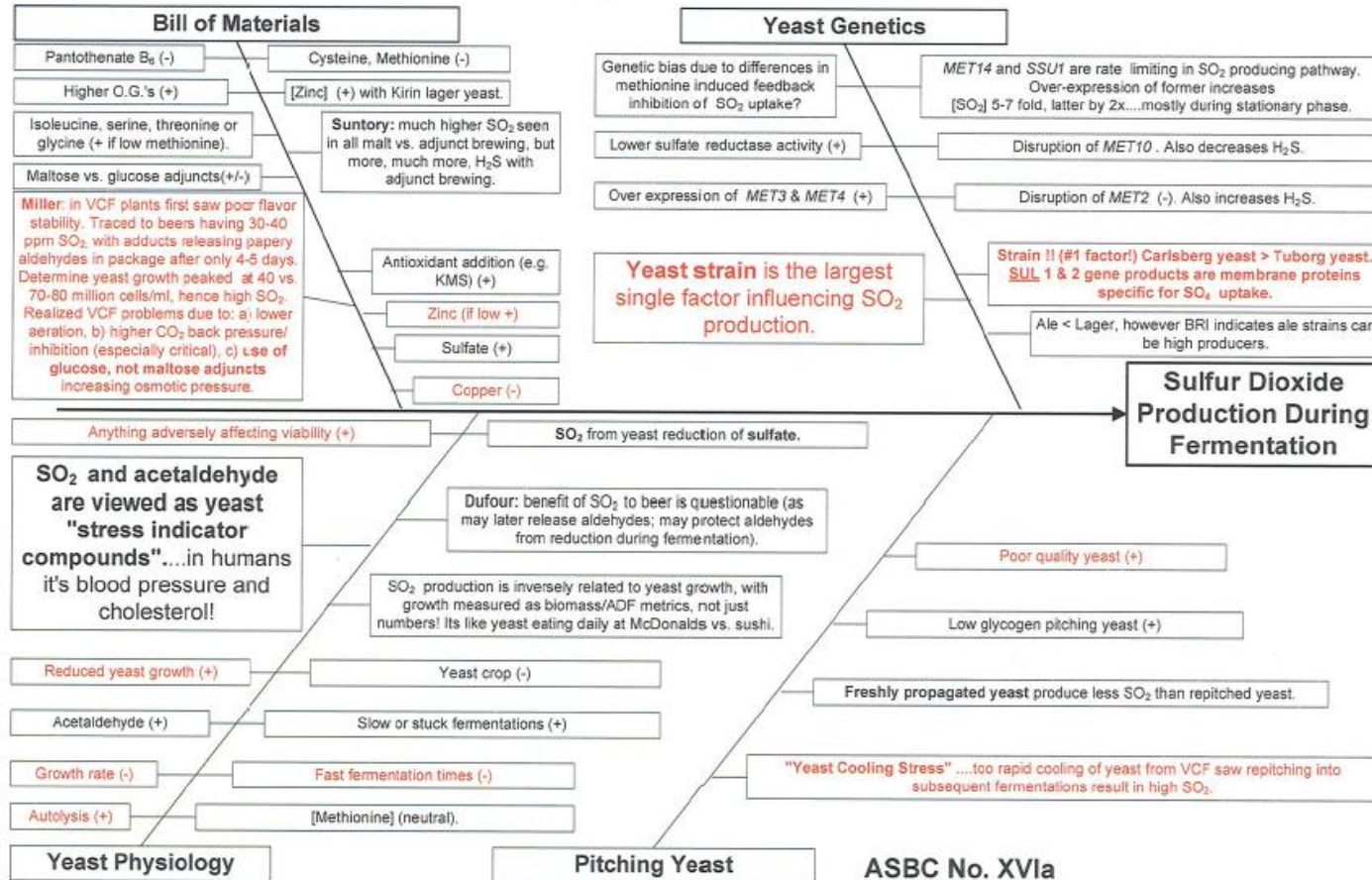
Alternation of SO₂ Production during fermentation:-Dufour, et al EBC Congress 1989
The Formation of Sulfur Dioxide During Fermentation:- Brewer and Fenton,

Both go into detail about how SO₂ is formed- “Sulfur Dioxide is in fact an intermediate in the biosynthesis of the sulfur amino acids cysteine and methionine. Good to know- but does not tell us how to fix it. The Yeast isn't happy. What Next-

Fishbone !!

What Yeast has taught me about Brewing over the years

PROCESS CONTROL FOR SULFUR DIOXIDE IN BEER: BILL OF MATERIALS & YEAST



ASBC No. XVIa
(Casey;
June/05)

What Yeast has taught me about Brewing over the years

SO₂ Increase seems to happen every year in the Late Fall.

HMMMMMM????



"Yeast Cooling Stress"too rapid cooling of yeast from VCF saw repitching into subsequent fermentations result in high SO₂.

Late Fall

Outside Temperatures lower

Glycol Cooling during Crash Cool Faster ??

Possible Correlation ??

What Yeast has taught me about Brewing over the years

Bringing on a New Yeast Strain.

What I call the “new kid in school”-

Remember when that new kid would show up at school the beginning of 5th grade. Your mind was reeling - Where did he come from ?. Is he better in math than me, heck is he a better short stop than me and what will those girls think of him ?.

He needs to be “checked” out.

Now in this day of mergers and contract brewing-- a new yeast strain might show up some day. Be ready

Where did the yeast come from ?

The answer “smuggled into the country from under some guy’s hat will not cut it”.

What Yeast has taught me about Brewing over the years

What does this yeast strain do well ?- hold up to long storage, handle a wide range in Carbohydrate Profiles and Gravity Levels

What does it do not so well and what is different about it compared to what you are use to ?

High Dead cell on reclaim, prone to “poor flocculation” properties, high or variable SO₂ production, tends to develop a house character.

Does it produce the Flavor and Flavor Stability needed for your Product based your brewery’s brew house and fermentation cellar design ???

*How do we deal with this yeast strain-- what is in the literature—
Literature might be a dead end.---*

Ask questions -- lots of Questions ???

What Yeast has taught me about Brewing over the years

Conclusion

Have my mentors, instructors, MBAA and ASBC presenters and colleagues done a good job teaching me about Brewing??

No question and I thank them all. But yeast taught me has been how to “*learn*” about Brewing- to do the research, the trial and error, cause and effect. What have I learned- lots but what is scary is what I still need to learn about YEAST.

Thank you for your time and attention