Type them into questions box!

“Why am I muted?”
Don’t worry. Everyone is muted except the presenter and host.
Thank you and enjoy the show.

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Cloudiness in Beer: Considerations and Chemistry

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Co-produced with the ACS Division of Agricultural & Food Chemistry

Cloudiness in

BEER

Considerations and Chemistry

Featuring Charlie Bamforth

Distinguished Professor of Malting & Brewing Sciences at UC Davis
Which of these appeals to you most:

- The one on the left
- The one on the right
- No preference
- I would like both please!
Same beer, different bars, same day
84 No Preference: they generally wanted more information
Turbidity in Fresh Beer

- Yeast
- Bacteria
- “Non-biologicals”

Removing Turbidity From Beer

- Filtration
- Clarification agents
Powder-based Filtration

Diatomaceous Earth

Perlite

what is isinglass?

• Keratin
• Collagen
• Elastin
• Hordein
• A popular new style of beer
Development of Turbidity Problems Over Time

Precipitates

β-Glucan
Interaction of Incompatible Additions

Interaction of Incompatible Additions

+ propylene glycol alginate

**Audience Challenge Question**

A problematic substance for brewers is also which molecule that gives the mouth-puckering character to rhubarb?

- Acetaldehyde
- Diacetyl
- Oxalic acid
- Rhubarbium acid
- Ferulic acid
Bits

\[
\text{HO-\text{COOH}}
\]

Invisible Haze

Experience Timeless Taste

“A beer that lifelong lager drinkers and craft faithful...can agree on without a whole lot of compromise.”  – MarketWatch

Highest consumer-rated American Lager  
– Beer Advocate

Ranks in the 95th percentile amongst American Lagers  – RateBeer

Best American Lager  – Deadspin

THE BEER
Incoming light  Scattered light

"Forward" scattered light

Incoming light
Sources of Invisible Haze

Non-Biological Haze vs. Biological Haze

- β-glucan
- Pentosan (arabinoxylan)
- Starch
- Oxalate
- Dead Bacteria
- Can lid lubricants
- Proteins - polyphenols
Chill Haze and Permanent Haze

![Molecule structure](https://www.stonebrewing.com/blog/miscellany/2011/chill-hazethe-more-you-know)

Procyanidin B-3 (R = H)
Prodelphinidin B-3 (R = OH)

Siebert

![Polyphenol and Protein interactions](https://www.stonebrewing.com/blog/miscellany/2011/chill-hazethe-more-you-know)

Polyphenol molecule
Protein molecule with fixed number of polyphenol binding sites (i.e., haze-active)
### Carbohydrate

<table>
<thead>
<tr>
<th>Material</th>
<th>Stain</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>Niagara Sky Blue 6B</td>
<td>Carbohydrate stains blue</td>
</tr>
<tr>
<td></td>
<td>Thionin</td>
<td>Non-charged polysaccharides such as starch stain violet/blue, whereas acid polysaccharides such as alginates will stain rose-pink</td>
</tr>
<tr>
<td>Starch</td>
<td>Iodine/potassium iodide</td>
<td>Blue indicates the amylose component of starch. Reddish-brown indicates the amylopectin component.</td>
</tr>
<tr>
<td>β-Glucan</td>
<td>Congo Red</td>
<td>Red coloration</td>
</tr>
<tr>
<td>Protein</td>
<td>Orange G</td>
<td>Stains protein yellow-brown</td>
</tr>
<tr>
<td></td>
<td>Eosin yellow</td>
<td>Stains protein pink</td>
</tr>
<tr>
<td>Yeast cell wall material</td>
<td>Lactophenol Blue</td>
<td>Blue coloration</td>
</tr>
</tbody>
</table>

### Microbiological Analysis
A Holistic Approach

Steeping, Germination, Kilning → Milling → Mashing → Wort Separation

Barley → Malt → Milling → Mashing → Wort Separation → Sweet Wort

Pitching Wort → Cooling → Clarification → Boiling

Fermentation → Conditioning → Filtration & Stabilization → Packaging
Grist Materials

- Rice, corn, high maltose syrup and sucrose: no haze-forming stuff
- Higher protein and polyphenol malts: more of this stuff
- β-Glucan and arabinoxylan from poorly modified malts
- β-Glucan from oats, rye and torrefied and flaked barley
- Arabinoxylan from wheat grist items
- Low proanthocyanidin barleys/malts

Malting

Homogeneous modification (cell walls, protein, starch)
Hop Bill

- Polyphenols also in hops
- The more hop solids used in the brew the more polyphenols
- If the aim is to deliver a high IBU from a relatively low alpha hop, you will be adding a lot more polyphenol
- Hop extracts are devoid of polyphenols

Mashing

- Low temperature stand
- Amylolysis
- Calcium
- Oxidation
Wort Boiling

The more vigorous the boil, the better the hot break formation

Irish Moss
Cold Conditioning

- “Chilling out” and settling
- Isinglass
- Temperature versus time

Removal of Polyphenol

\[
\text{PVPP}
\]
Removal of Polypeptide/1

How to Treat Beer with Silica Gel

Removal of Polypeptide/2

Tannic acid

Wherein $R$ is
Removal of Polypeptide/3

Packaging

- Low oxygen
- Low iron, copper and manganese
- Packaging materials (or indeed lines) should not contribute materials that can give clarity problems e.g. lubricants, oils, dust
What about Beers that are Supposed to be Turbid?

• More challenging!
• Yeast counts and flocculation
• Additions

Cleaning and Hygiene

• Manual or Cleaning in Place
• Plant design and accessibility
Cleaning and Hygiene

Check out some on-line classes on beer quality – search

UC Davis Extension

Online Beer Quality Series

cwbamforth@ucdavis.edu

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Cloudiness in Beer: Considerations and Chemistry

Charlie Bamforth
Anheuser-Busch Endowed Professor of Malting & Brewing Sciences, UC Davis

Brian Guthrie
Corporate Research Fellow, Cargill, Inc. and 2018 AGFD Division Chair

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