Crisp Malt Webinar Series: Conditioning
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Conditioning

- Definition
- Objectives
- Process Overview
- Flavour development
- Sedimentation
- Process Aids
- Non-biological haze
- Filtration
- Haze Control & Stability

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Definition

- Conditioning, maturation, lagering or aging
- Converts green beer into matured beer
- A process to improve beer flavour and stability
- Occurs after primary fermentation
- Can be warm or cold
- Conditioning in package is a form of secondary fermentation.

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Objectives

- Purge the beer of volatiles using secondary fermentation or pure CO_2
- Increase the CO_2 content by secondary fermentation or pure CO_2
- Flavour modification of diacetyl, sulphurs and acetaldehyde
- Additions to modify flavour and aroma
  - Hops
- Sediment yeast
- Improve colloidal stability
- Add process additions for haze stability and head retention
- Minimise oxygen pick up

Process Overview

- At the end of primary fermentation
- Diacetyl is reduced
- The temperature is reduced and the yeast harvested
- Some secondary fermentation
- Flavour and aroma can be adjusted by adding hops
- Stability aided by adding process aids
- Rousing the tanks using CO2 or recirculation will improve the extraction and drive off volatiles
- Transfer the beer to a cask or a 2nd vessel leaving solids behind and chill for carbonation or stabilisation and filtration.

Flavour Development

- Diacetyl is converted to Acetoin & 2,3 Butanediol
  - Adequate levels of healthy yeast needed in suspension
  - Diacetyl reduction is increased with elevated temperatures
  - In house checks can be done by heating to 70°C and assessing the sample
- Sulphur
  - Sulphur is driven off by vigorous fermentations
  - Lager fermentations have less vigour and lager yeasts generally produce more sulphurs – maturation mellows the flavours.
- Acetaldehyde
  - High levels at the start of fermentation
  - Levels reduce late on and in maturation
  - High levels late on are indicative of yeast issues.

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Flavour Development

- Dry hopping
  - Start / mid of fermentation
    - Fruity oils
    - The hops will settle out with the yeast
    - Possibility of over foaming
    - Don’t reuse the yeast
  - Late fermentation
    - Good mixing
    - Don’t reuse the yeast
  - End of fermentation
    - Cool down to mid teens & add after yeast has settled
    - Remove after 24-48 hours to avoid hop burn

Sedimentation

- During conditioning we need to separate the yeast and the beer
- The yeast count should be below $1.5*10^6$ per ml before packaging or filtration
- The most common way of doing this is by sedimentation
- The factors affecting sedimentation are:
  - Time
  - Temperature
  - Agitation (like none)
  - Vessel height (higher tanks take longer)
  - Particle size
- The rate of sedimentation is governed by Stokes Law

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Sedimentation

- Stokes Law describes the rate at which a sphere falls through liquids.

$$V = \frac{d^2(\rho_p - \rho_l)g}{18\mu}$$

- V = Settling speed
- d = Particle diameter
- ρ_p = particle density
- ρ_l = Liquid density
- µ = Liquid viscosity
- g = Gravitational constant

- So
  - Larger particles settle quicker
  - Denser particles settle quicker
  - Less dense / viscous liquids settle quicker

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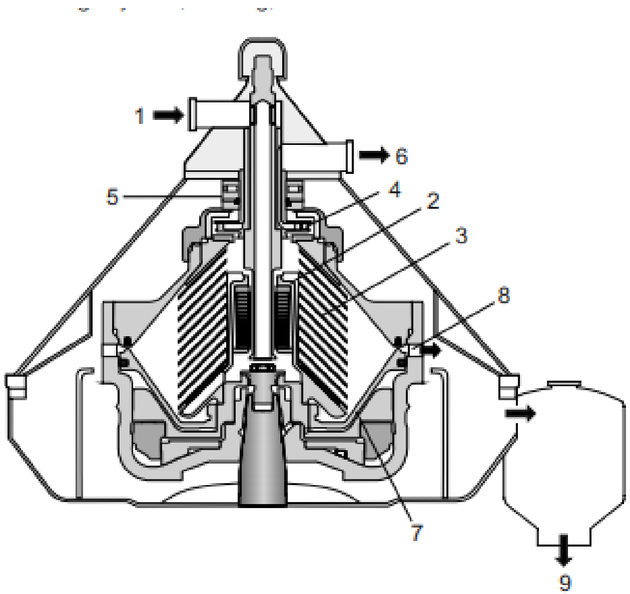
Sedimentation

- So what factors can the brewer use to increase sedimentation:
  - Chilling encourages particles to form
  - Finings cause particles to form larger units.
  - Gravity can be increased by using a centrifuge
- Finings
  - Auxiliary finings are negatively charged and flocculate positively charged protein and other materials
  - Isinglass finings are positively charged and flocks negatively charged yeast and proteins
  - Tank finings are plant derived or silica/polysaccharide blends and are a vegan option to isinglass

Sedimentation

- Centrifuges separate liquids from solids using centrifugal forces
- Disc bowl centrifuges are the most efficient for beer
- Beer enters the bowl from the top, the bowl spins at high RPM creating centrifugal forces that send the solids to the outside, the separated beer exits the centrifuge and the solids are ejected based on a timer or on turbidity.
- Centrifuges need to:
  - Minimise damage to yeast
  - Minimise temperature pick up
  - Minimise oxygen pick up
  - Maximse beer yield
  - Turbidity measurement and flow control

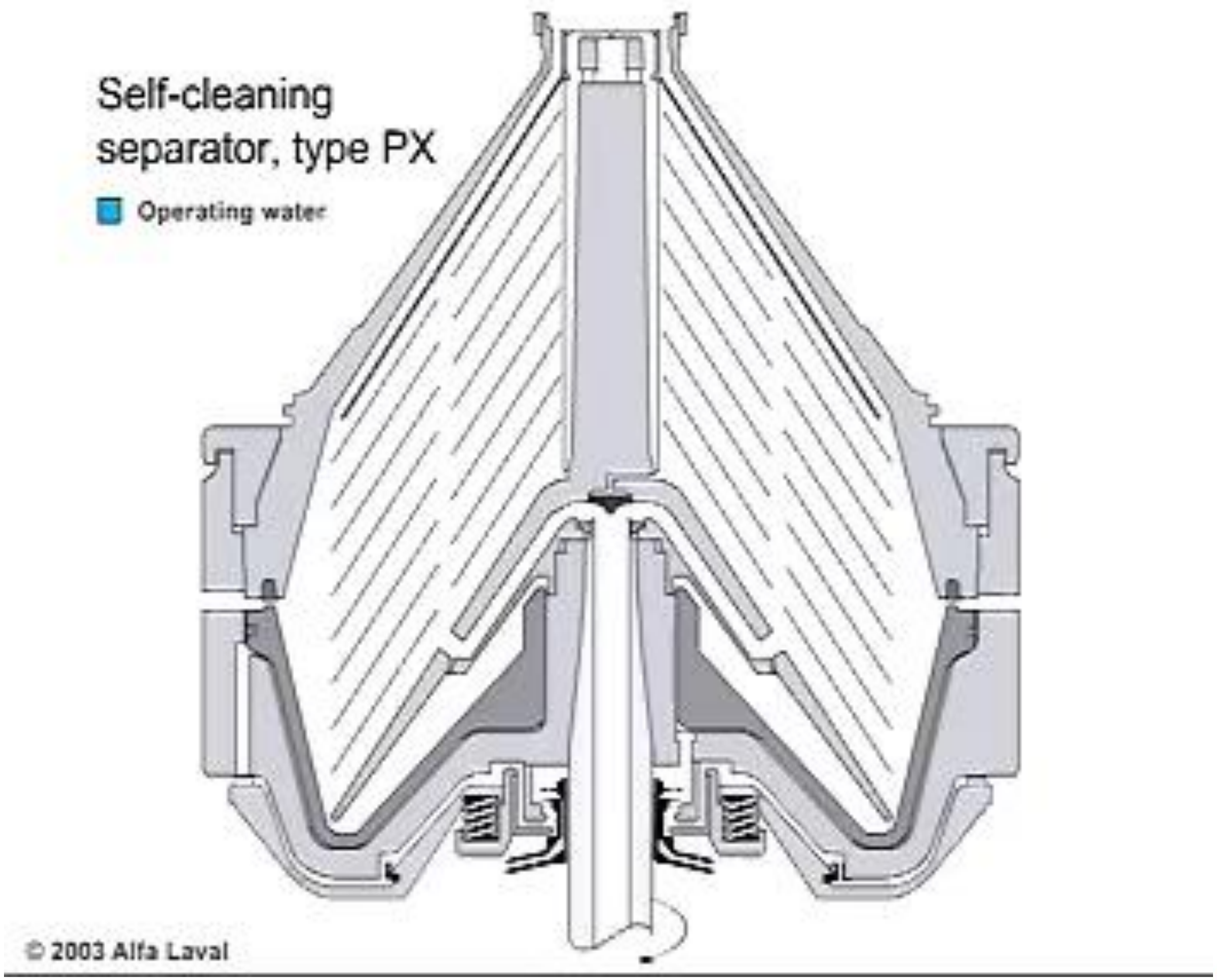


Typical bowl drawing for a solids-ejecting separator. The details illustrated do not necessarily correspond to the separator described.

1. Feed inlet
2. Distributor
3. Disc stack
4. Paring disc
5. Axial-Hermetic Seal
6. Clarified liquid phase outlet
7. Sliding bowl bottom
8. Solids discharge ports
9. Solids outlet from cyclone

Sedimentation

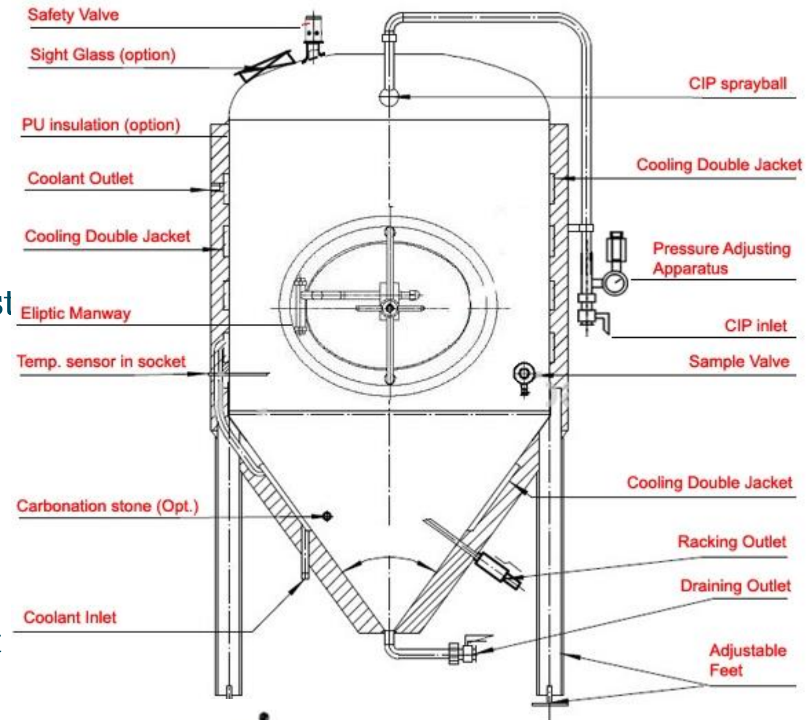
- How centrifuges work – Courtesy of Alfa Laval



Removing the sediment

- Vertical or horizontal vessels
- The sediment forms in the bottom of the vessel
- In conical vessels, the cone angle is designed for yeast to slide down for easy removal.
- Hops can make the sediment sticky and difficult to remove
- Racking arms take the beer from above the sediment
- Manual cleaning of racking, carbonation stones, sample tap and door rubber arm may be necessary
- Arms / probes passing through a glycol jacket could cause coolant contamination.
- Every time beer is moved it increases the risk of oxygen pick up or micro infection

Cylindrical-conical fermentation tank : 0.0 to 3.0 bar



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Cask Beer

- Aux finings usually added at the end of fermentation. The convection currents during cooling allows even distribution
- Casks can be filled direct from FV or from MV
- Tank finings trials make sure the isinglass dose rate is correct
- Yeast count should be below $1.5*10^6$ cells/ml
- Isinglass is added to the cask as the beer is filled or before dispatch
  - Aux and isinglass cant be added together
- Once filled left to condition for 5-7 days – secondary fermentation increases the CO2 content and the beer comes into condition.
- Priming's may be added to aid secondary fermentation
- Keep 2 cask samples – 1 for quality control before releasing and one for shelf life testing
- Check taste, secondary fermentation level (ABV increase) and sediment at the end of shelf life.

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Haze Formation

- Haze can be classified as biological and non-biological haze
- Non-biological haze in beer can come from:
  - Calcium oxalate
  - Starch
  - β-glucan
  - Protein & polyphenols
- By far the most common form of non-biological haze is formed from protein and polyphenols.
- Protein & Polyphenol hazes can be classed as:
  - Chill haze – a haze that re-dissolves when heated
  - Permanent haze – a haze that does not re-dissolve when heated
  - A mixture of the 2 - a haze that partially re-dissolves

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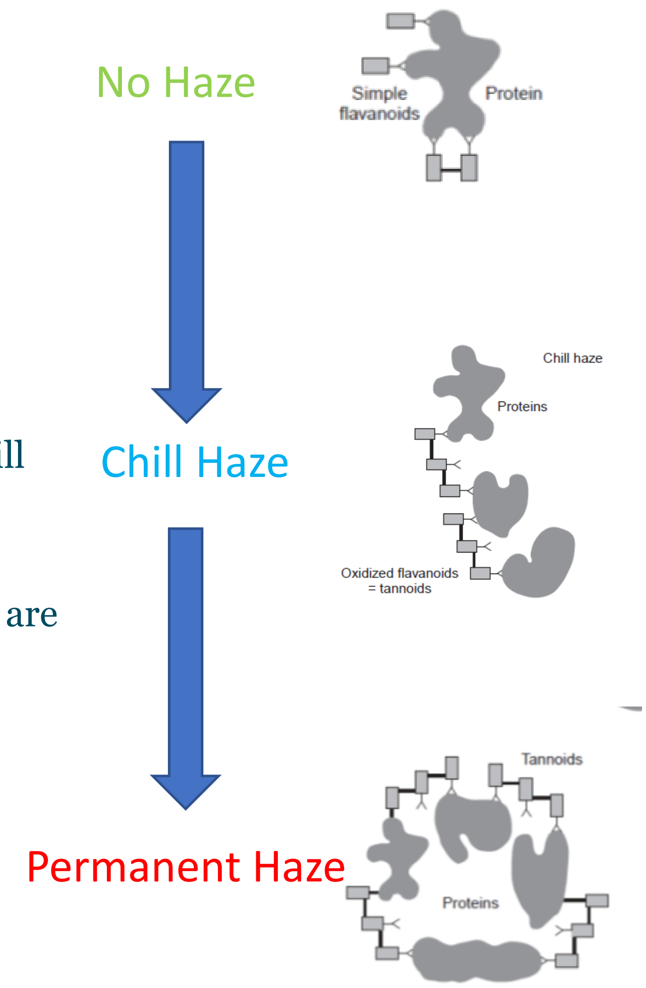
Haze Formation

- Protein & Polyphenol haze formation:
  1. Simple phenolic compounds oxidise to polyphenols
  2. Loose bonding of proteins and polyphenols produce a soluble colloid that is not visible
  3. Hydrogen bonds form between proteins and polyphenols producing a colloid insoluble at cold temperatures – a chill haze
  4. Clusters of colloids results in stronger bonds, the colloids are insoluble at warmer temperatures – a permanent haze
- Factors affecting haze formation
  - Oxygen – Polyphenols easily oxidise and become highly reactive
  - Metals such as copper and iron link oxidised polyphenols to protein



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Haze Formation

- To ensure haze stabilisation:
  - Condition beer cold – below -1°C for a minimum of 3 days to allow proteins to come out of solution
  - Do not allow beer to warm up during filtration – proteins will re-dissolve and pass through the filter bed.
  - Keep oxygen levels at a minimum
  - Reduce the sensitive protein levels in the beer
  - Reduce the polyphenol levels in the beer
  - Do not allow contamination with liquor or process aids containing heavy metals

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Stabilisation

Protein	Polyphenols	Oxygen
Low nitrogen malt	PVPP (polyvinyl poly pyrrolidone)	Slow non turbulent fill speed
Silica Hydrogel or Xerogels (adsorbent)	Malt with no proanthocyanidins (Clear Choice)	Bottom fill
Tannic Acid (precipitates)	Manage last running	Purge vessels and mains
Degradation Enzymes (Papain)		Manage PAA

- Silica hydrogel @ 120g/HL = £0.48 (£0.78 /brl)
- Single use PVPP @ 60g/HL = £1.68 (£2.73/brl)

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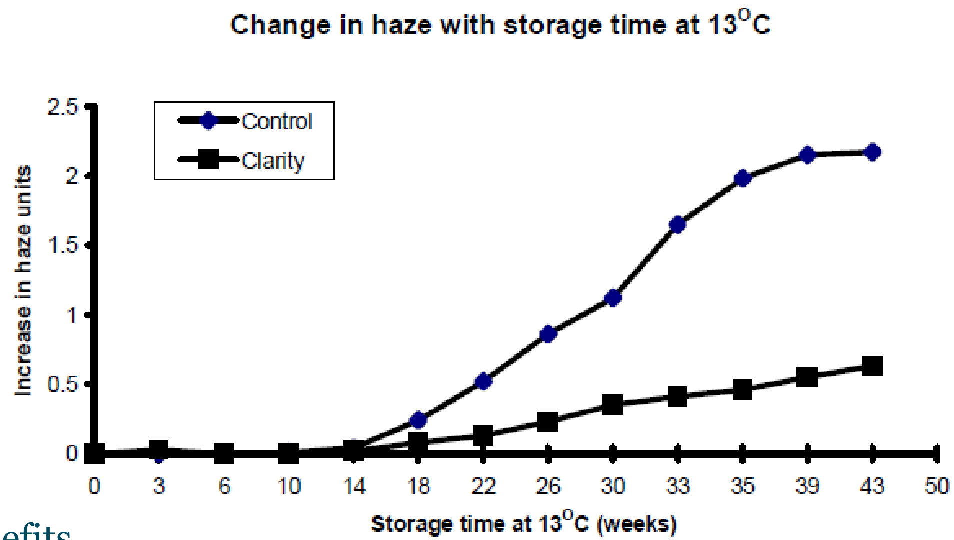
Clear Choice®

- The most reactive polyphenols are proanthocyanidins, 70-80% come from malt
- Proanthocyanidins belong to a flavonoid group of polyphenols located in the testa of all traditional barley verieties
- Clear Choice® is proanthocyanidin free!
  - Normal brewhouse processing
  - No need for processing aids
  - No dosing issues
  - Works for cask beer too!
  - Using as part of the grist brings benefits



	100% Standard Malt	50% Clear Choice, 50% Standard Malt
Total Polyphenols	200 – 250 ppm	120 – 140 ppm

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Beer Filtration

- Filtration aims to:
  - Remove almost all micro organisms
  - Remove suspended proteins and other organic debris
  - Clarify and stabilise the beer so its appearance does not alter over time
- Filters are either SURFACE or DEPTH
  - **Sieving or surface filtration** - The particles cannot pass through the small pores in the filter medium and build up on its surface
  - **Depth filtration** – Use a very porous and inert powder with huge surface area to form a filter bed, the solids get trapped in the powder.
  - **Depth filtration with adsorption** – The filter aid is not inert, it carries a surface electrostatic charge that attracts suspended matter .
- Surface filters block easily and a depth filter has a higher throughput and can remove more solids
- In all filtration monitor the inlet and outlet pressure

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Beer Filtration – Powder Filters

- Powder Filters use diatomaceous earth or kieselguhr, a natural product consisting of the fossilised skeletons of microscopic algae
  - Plate and frame sheet filters
  - Candle filters
  - Horizontal or vertical screen filters
- Sheets or mesh provide a support for the filter powder
- A coarse filter powder covers the support medium – this is the pre-coat
- A finer grade is applied to the pre-coat – this is the second pre-coat
- Now the bed is applied we can begin filtering – to stop it blocking we continually dose the body-feed. The grade is usually the same as the second pre-coat
- Depending on the grade of powder, particles above 0.5µ will be removed
- Filter powders pose a health risk

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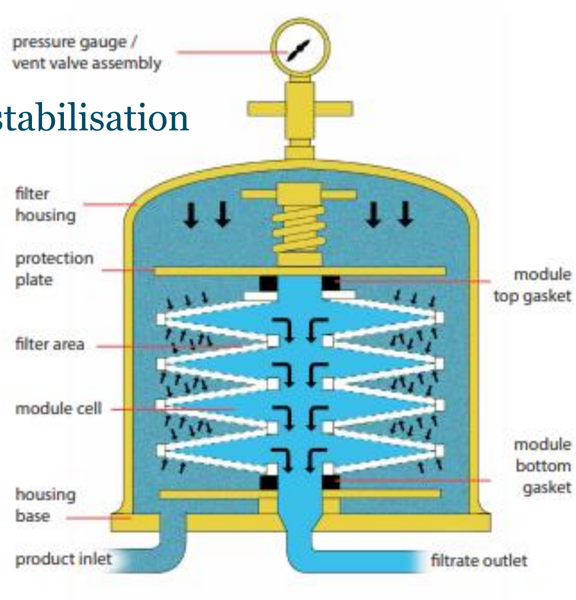
Beer Filtration – Sheet Filters

- Sheet filters – Sheets are impregnated with kieselguhr
  - Plate and frame
  - Lenticular
  - Cartridge
- The sheets can also be impregnated with silica gel or PVPP to aid stabilisation
- The sheets have different grades
- These filters need the incoming beer to have minimal solids
- Backflush to re-generate



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Beer Filtration – Membrane

- Membrane filters trap particles by virtue of their constant pore size
  - Sterile filtration – 0.45µ Absolute
    - Located just before the packaging line, they are guard or policing filters to ensure no contamination passes into package
    - Code 7 fittings – have a double seal
    - Integrity testing to verify operation
      - Bubble point – Liquid is held in the pores of the filter by surface tension and capillary forces – the minimum pressure required to force the liquid out of the pores is a measure of the pore diameter
- Cross Flow
  - Mainly used in big breweries but technology is now available to smaller breweries
  - Beer is pumped across the membrane at high pressure, the pores stop particles passing but block quickly.
  - As the beer is pumped fast, the solids are swept away opening up the bed

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Haze Management

- Whether the customer is expecting a visually bright beer or a cloudy beer – it needs to be consistent.

- Bright Beer
  - Visually assess the beer
    - In a glass in front of a light source
  - Or measure on a haze meter.
    - Measurement is based on the quantity of light scattered by the presence of suspended particles
    - The light beam is at 90^{o} or 13^{o}
    - 90^{o} detects particles <0.4μm that are invisible to the human eye
    - 13^{o} detects particles >0.4μm that are visible
    - Most beer specifications refer to EBC or ASBC, both of these are measured at 90^{o}. A measurement of below 0.7 would be acceptable for bright beer and below 1.5 for cask beer

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Haze Management

- The haze stability can be assessed by:
- Hot / Cold Cycling
  - Many different variations
  - Forcing tests hold the beer at 37^{o}C. 1 week is said to be the equivalent of 1 month of normal storage
  - The beer can also be put through hot/cold cycling.
    - 2 days at 60^{o}C & 1 day at -2^{o}C is equivalent to 6 weeks normal storage
    - 24hr at 30^{o}C & 24hr at 0^{o}C is equivalent to one month of normal storage
  - Chapon analysis is a quicker test
    - Ethanol is added to the sample and the beer is chilled to -8^{o}C for 40min
    - Only predicts chill haze
    - Rapid test to preform before packaging

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Haze Management

- We can look at real life data to show how haze prediction works!
  - Difference in beer matured at +4ºC and -1ºC
  - Difference between standard malt and Clear Choice® malt

	Control Malt		Clear Choice Malt®	
Temperature	+4°C	-1°C	+4°C	-1°C
Initial haze	0.4	0.4	0.7	0.7
Total haze 5 days @ 60°C	>12	7.9	1.2	1.2
Total haze 60 days @ 20°C	3.5	1.6	0.8	0.9

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Haze Management

- Keeping hazy beer consistent
- The haze in beer should not come from yeast
- Natural haze should come from proteins
- Control the yeast count by:
    - Counting the yeast under a microscope
    - Testing the solids using a bench top centrifuge
    - Dry hop once yeast count is acceptable
- Use mixture of un-malted and malted cereals in the grist
- Optimum haze potential from dry hopping is 3.8 - 4.3
- Experiment with wort recirculation

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Thank You

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