Beer Stabilization Technology - clearly a matter of choice

Mustafa Rehmanji, Chandra Gopal and Andrew Mola

International Specialty Products

1361 Alps Road

Wayne, NJ 07470

U.S.A.

Scope of Presentation

- Mechanism of Haze Formation
- Upstream Stabilization : Polyclar Brewbrite
- PVPP
- Silica Gel
- Tannic acid
- Papain
- Admixture : Silica +PVPP

What is Beer Stability?

Beer stability is the extent to which a beer tastes and looks as good after aging as it did when it was first packaged. Stability is assessed by:

- **Changes in colloidal stability (HAZE)**
- **Flavor stability (oxidation and staling)**
- **Color increase**
- **Microbial stability**

Reference : Jean De Clerck, A Text Book of Brewing

Beer Stabilization Guidelines

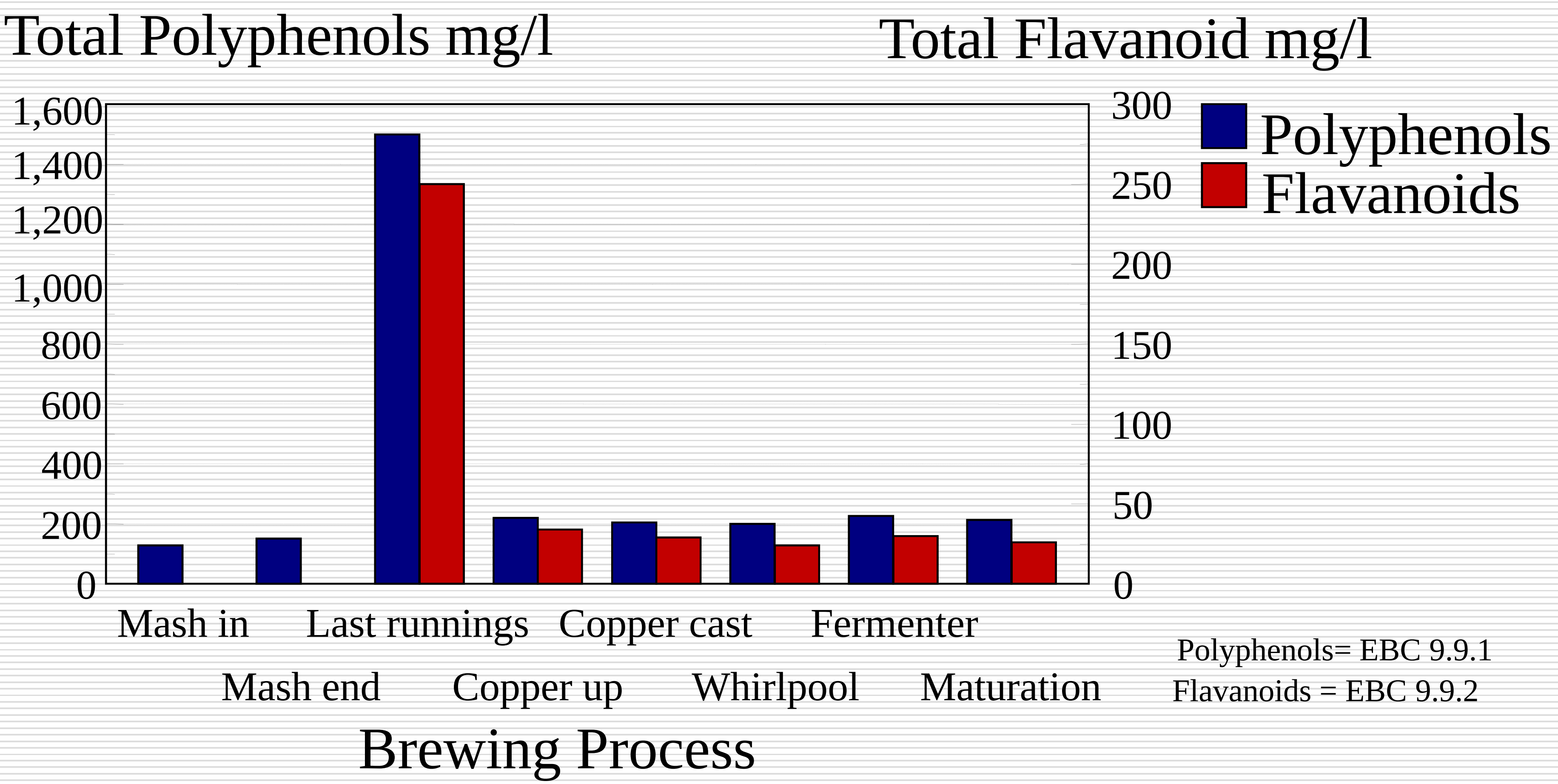
		Drinking Life	*Stabilization Requirements*
CASK BEER	(UK)	4 weeks	None - Low
KEG BEER		10 weeks	Low - Medium
EXPORT KEG		36 weeks	Medium
SMALL PACK	Bottle	up to 52 weeks	High
	Cans	up to 75 weeks	High

The extent to which a beer requires colloidal stabilization depends on the raw materials, process, required shelf life and storage conditions

Non-Biological Haze in Beer

- **Protein-Polyphenol** complexes - chill & permanent haze
- **Carbohydrates** - starch & ß-glucans
- **Oxalates**
- **Other constituents** - metal hazes, collapsed fob, PGA, filter aids, iso-α-acids etc.

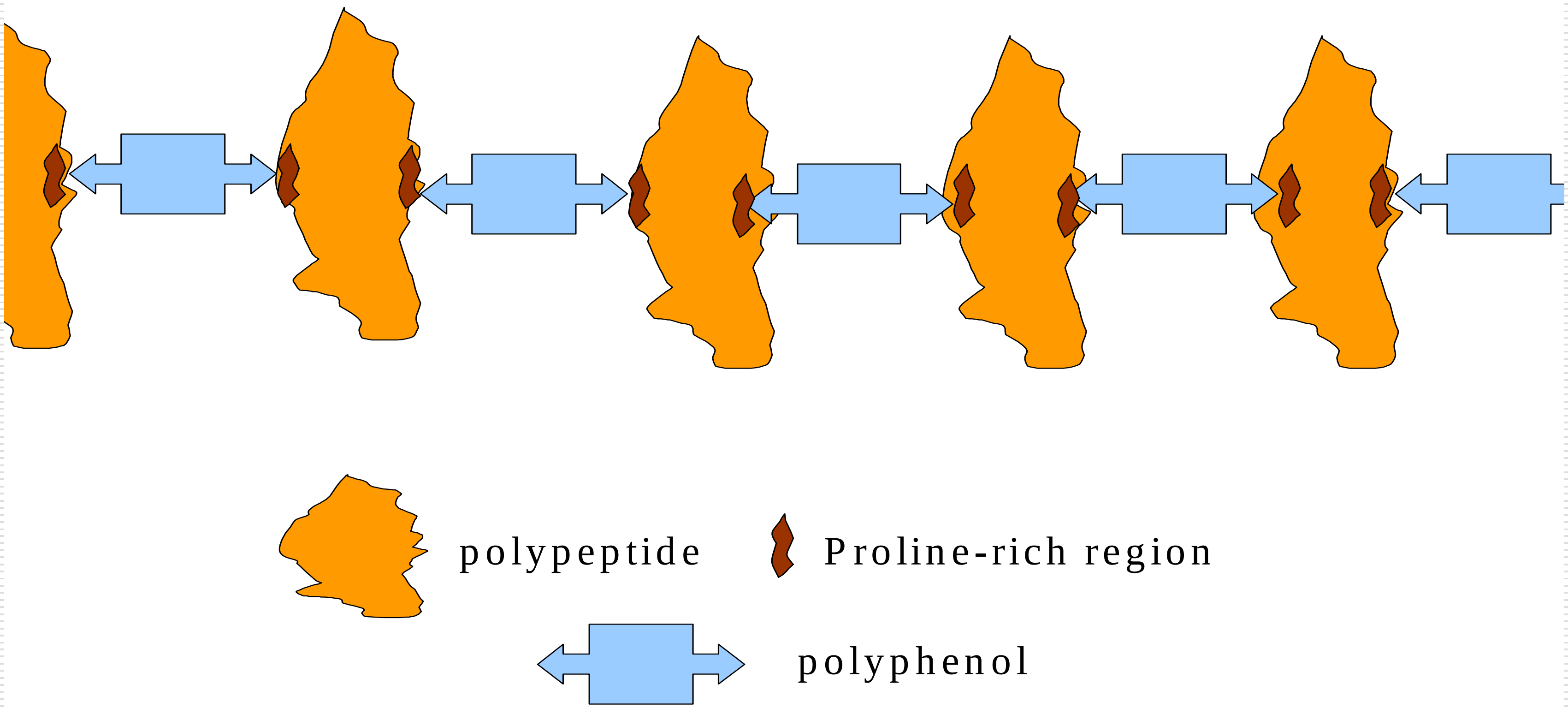
Change in Polyphenols and Flavanoids During Brewing



Step 1 – avoid use of very weak wort(<1.5 P)

Model for Protein – Polyphenol Interaction

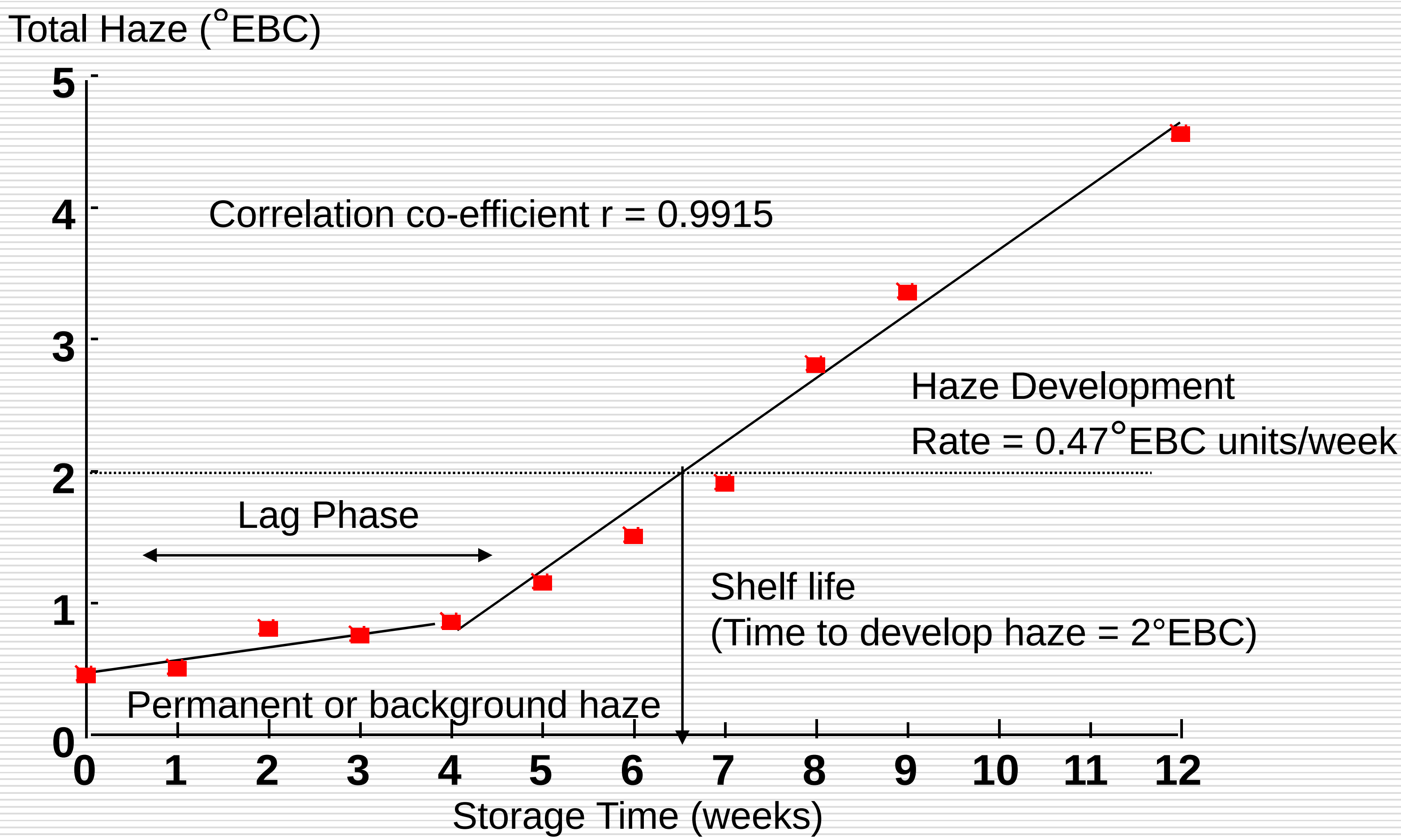
Polyphenols are depicted as having two ends that can bind to protein. Proteins are depicted as having a fixed number of polyphenol binding sites.



Courtesy : Karl Siebert, Cornell University

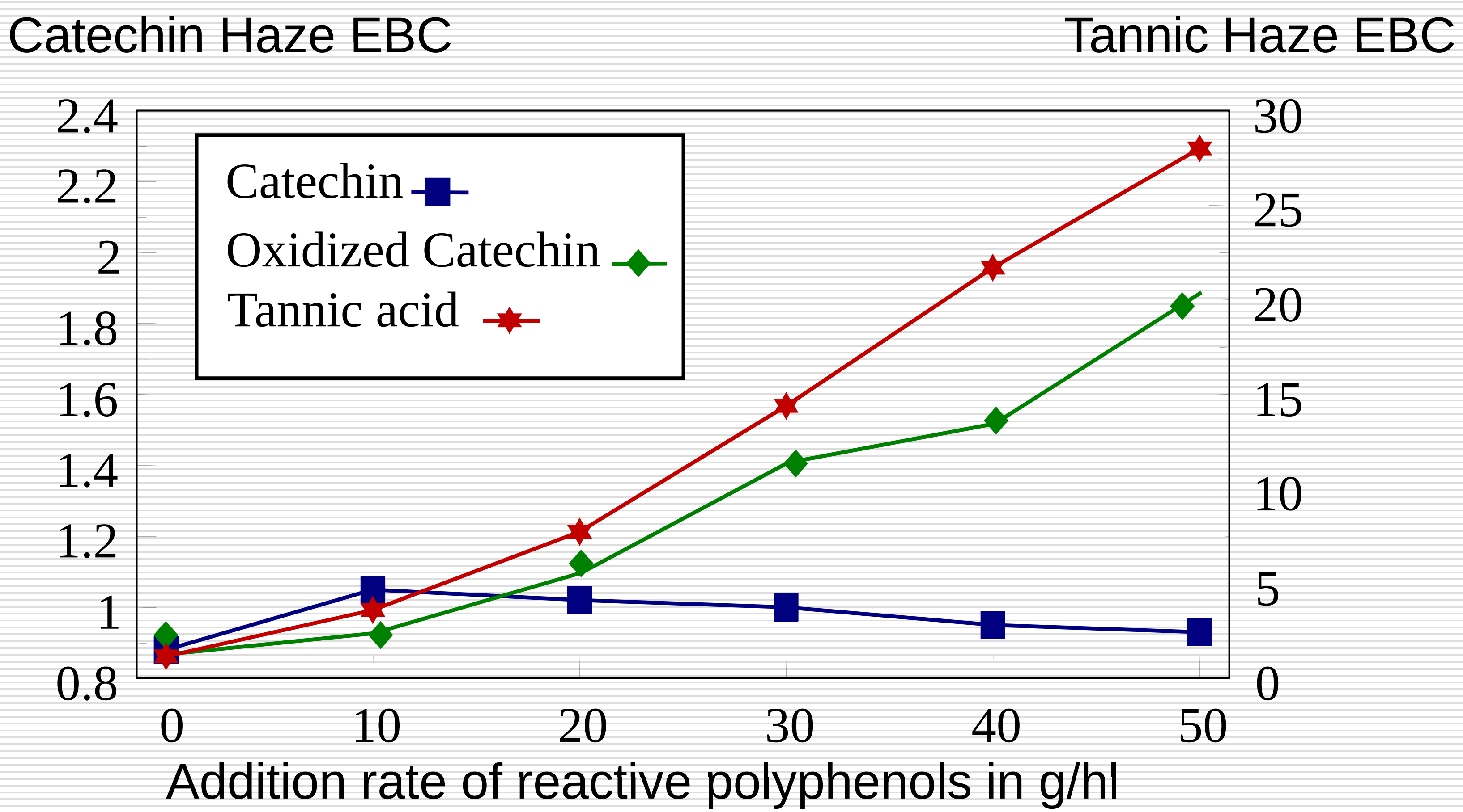
Formation of Protein-Polyphenol Haze in Beverages, J. Agric. Food Chem. 1996,44, 1997-2005

Chill-Haze Development & Shelf- Life Model (Forced Aging at 37°C) for a Stabilized Standard Lager Beer



Relative Haze Formation

Beer stabilized with 100 g/hl PVPP to remove reactive polyphenols



Step 2 – minimize oxygen pick-up! < 0.1 ppm

Carbohydrate Hazes

- **Prevention** - raw material selection
  - complete starch conversion
  - process effects – *identify sources of 'shear' damage*
- **Remedies** - enzymes - ß-glucanase,
  amylases
  dextrinases

Oxalate Haze - ‘Green Haze’

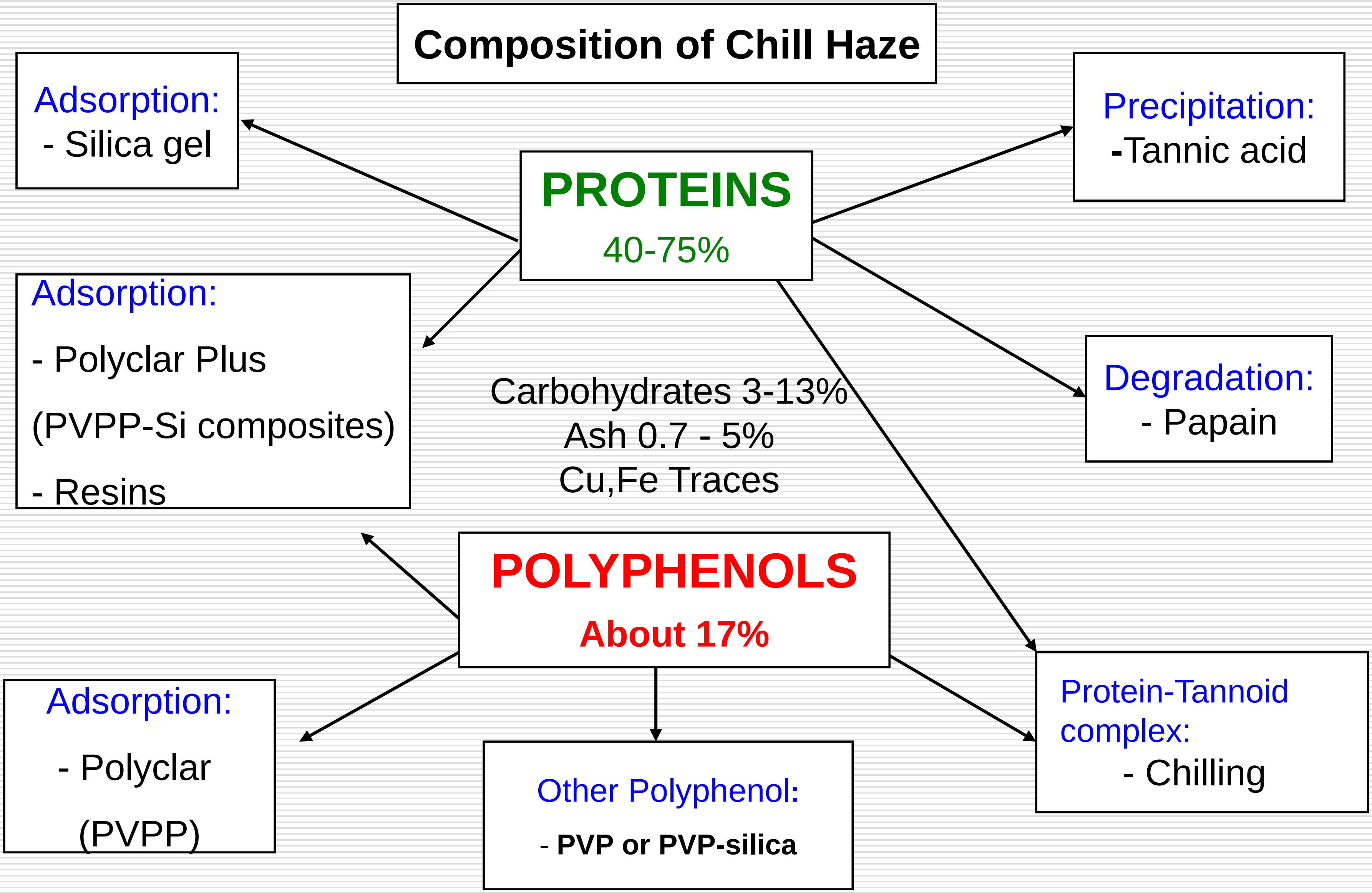
- ‘Beer stone’ - calcium oxalate
- Octahedral crystal
- Check oxalic acid levels in malt
- Treated by addition of calcium salts ($CaSO_4$) to brewing liquor to precipitate oxalate

Raw Material & Process Strategies to Optimize Colloidal Stability

Process	Polyphenol Reduction	Protein Reduction	Process Optimization
Raw material selection	Low proanthocyanidin malt Hop extract	Low protein barley	Low malt modification Coarse grind of malt
Brewhouse	High adjunct ratio Avoid weak worts	Mashing process pH, temperature Good hot break	Vigorous kettle boil for >60 min. Avoid excess mineral salts Cold wort filtration
Fermentation/ Maturation	Rapid onset to fermentation	Early yeast removal	Minimum 7 days maturation at -1^{O}C
Filtration			Low solids count Filter at -1^{O}C Avoid O_2 Pick up

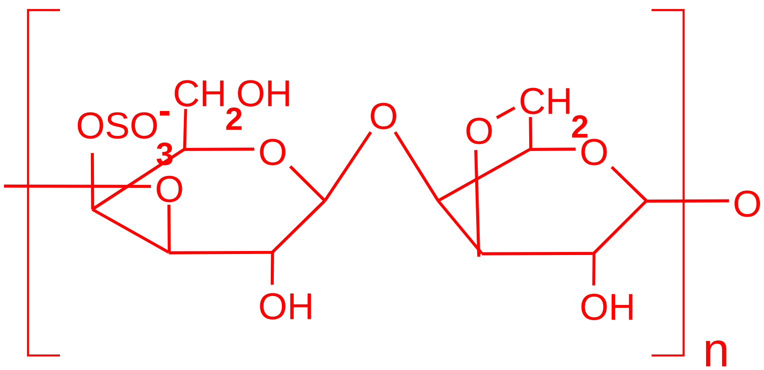
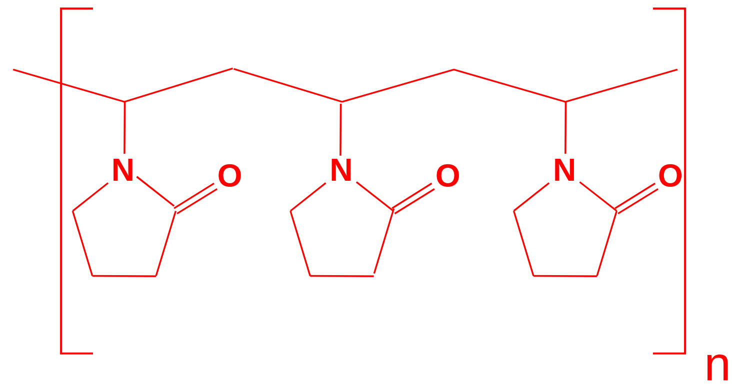
- *Step 3 – check & verify cold storage temperatures*

Colloidal Stabilization of Beer



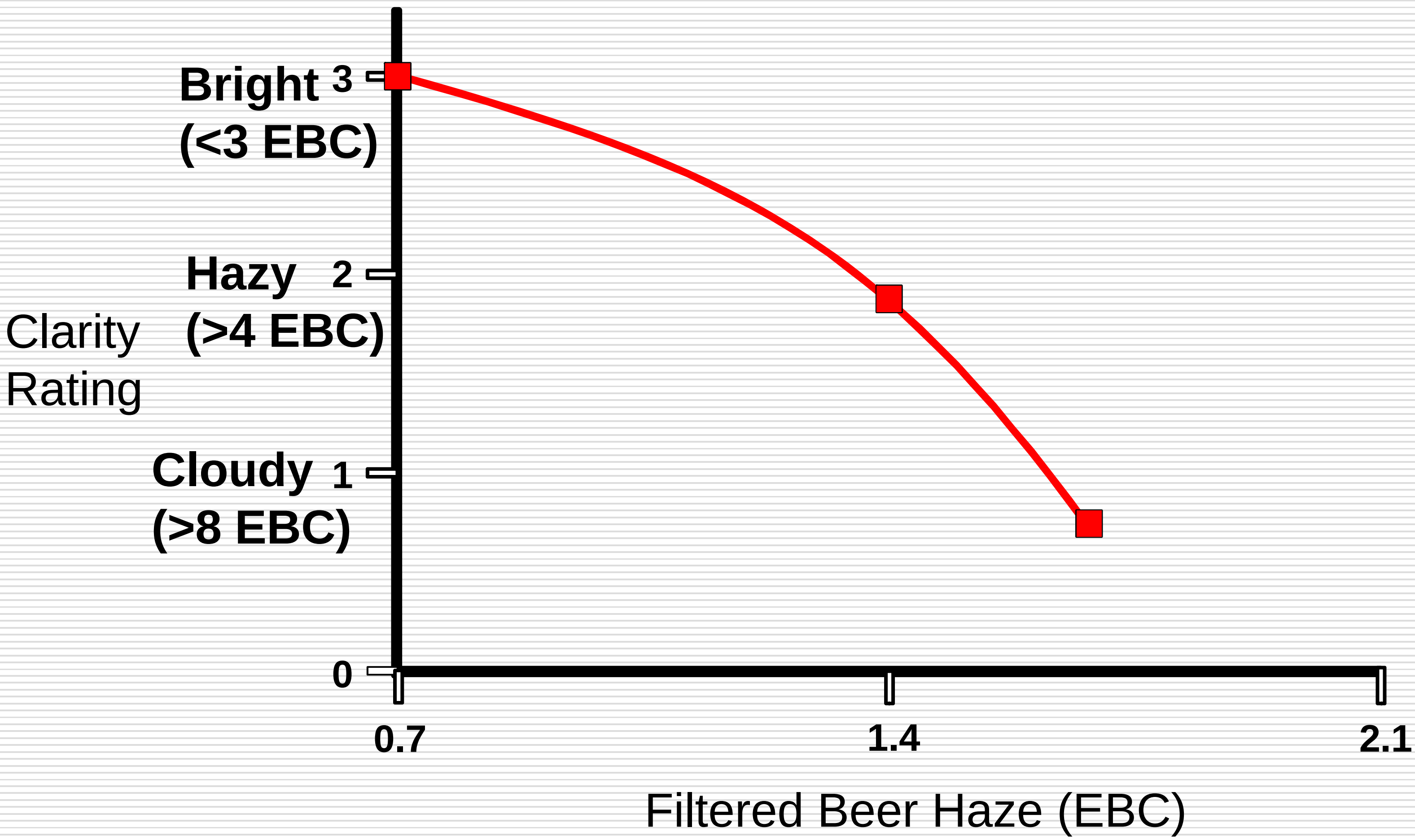
What is Polyclar Brewbrite ?

It is a proprietary composite of a selected Carrageenan and micronized PVPP

Kappa Carrageenan	PVPP
	
β-D-galactose 4 sulfate 3,6-anhydro-*α*-D-galactose	2-pyrrolidinone,1-ethenyl-, homopolymer
Marine polysaccharide of galactose & galactose sulfate monomers	**Cross-linked polyvinylpyrollidone**

Courtesy of Murphy-Savilles Clarification

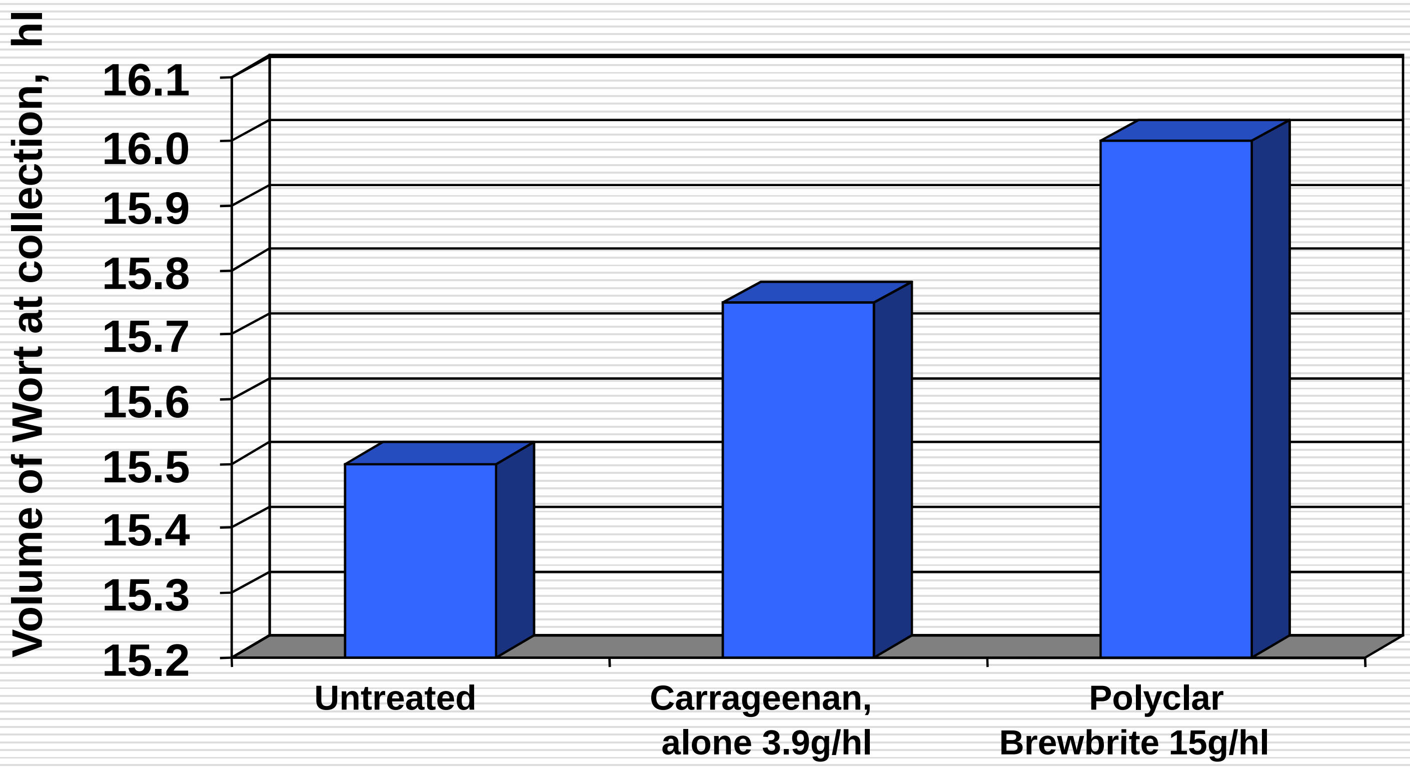
Effect of Cold Wort Clarity on Beer Clarity



Step 4 – wort clarity is very important and is related to beer clarity

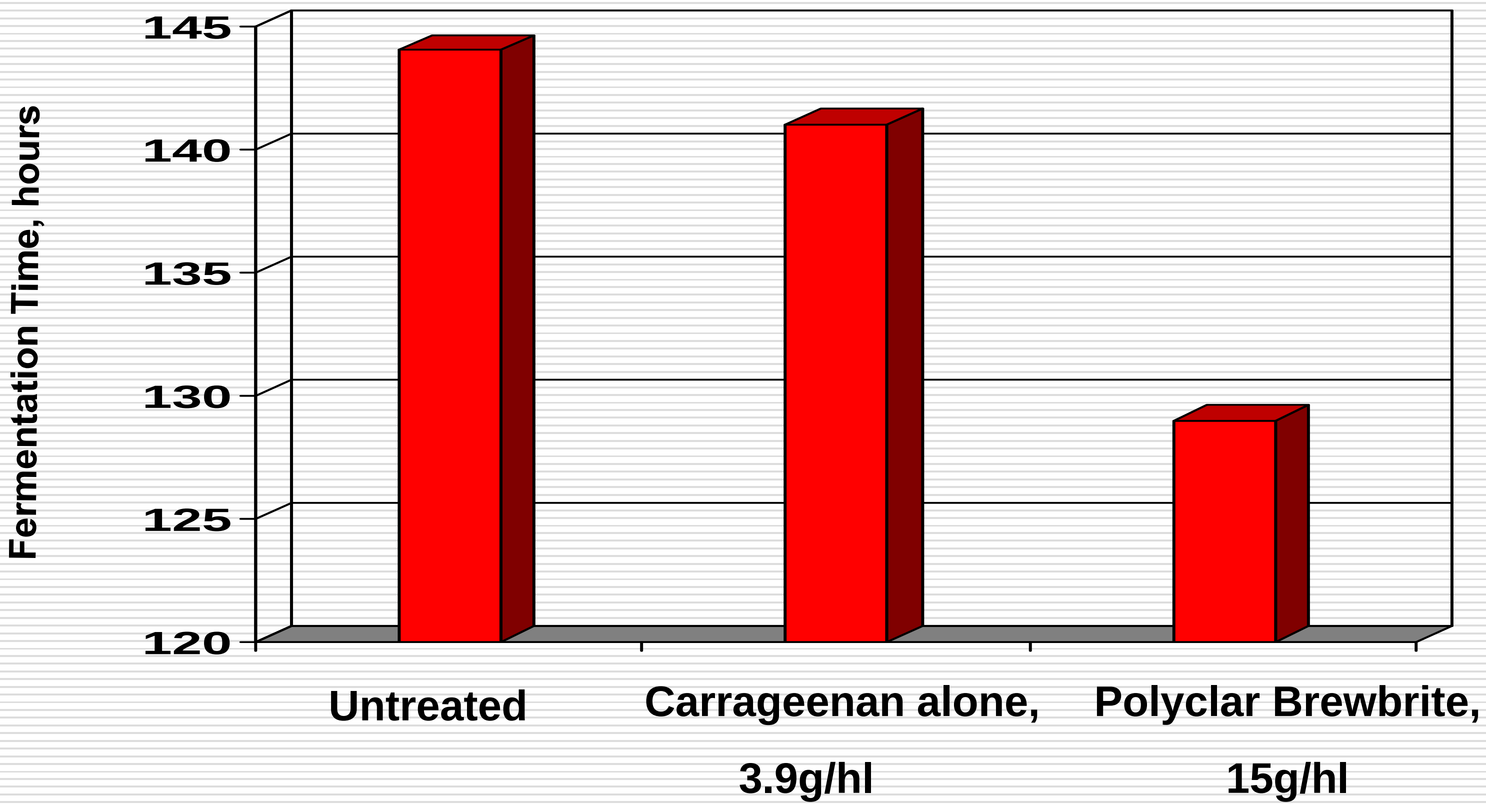
Increase in Wort Yield - Commercial Trial

➢ **Polyclar Brewbrite gave 3.2% increase in cold wort collected in FV as compared to untreated wort**



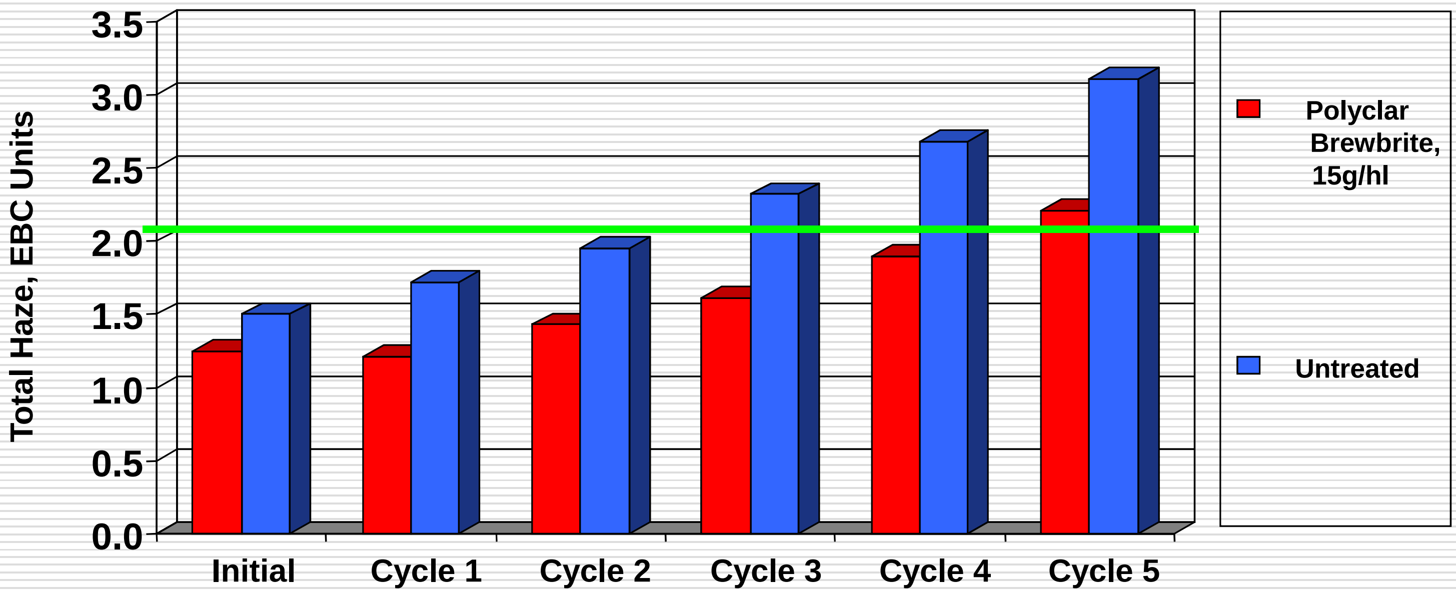
Decrease in Fermentation Time with Polyclar Brewbrite - Commercial Trial

- Polyclar Brewbrite gave 10 % reduction in fermentation time as compared to untreated



Analysis of Packaged Beer - Commercial Trial

Accelerated Forcing Test



Cycle = 24 hours at 60^{0}C followed by 24 hours at 0^{0}C

No. of Cycles (to reach 2.0 EBC Units) = month of predicted shelf life

Summary of Trial Results with Polyclar Brewbrite

- Enhances clarity of wort & beer
- Increases wort production
- Decreases fermentation time
- Improves total productivity of plant
- Extends shelf life of packaged beer
  - Longer shelf life requires PVPP treatment at filtration
- PVPP helps reduce astringency in beer*

* Measuring Astringency of Beverages using a Quartz-Crystal Microbalance J.Am.Soc. Brew. Chem. 61(3):119-124, 2003

PVPP - Methods of Use

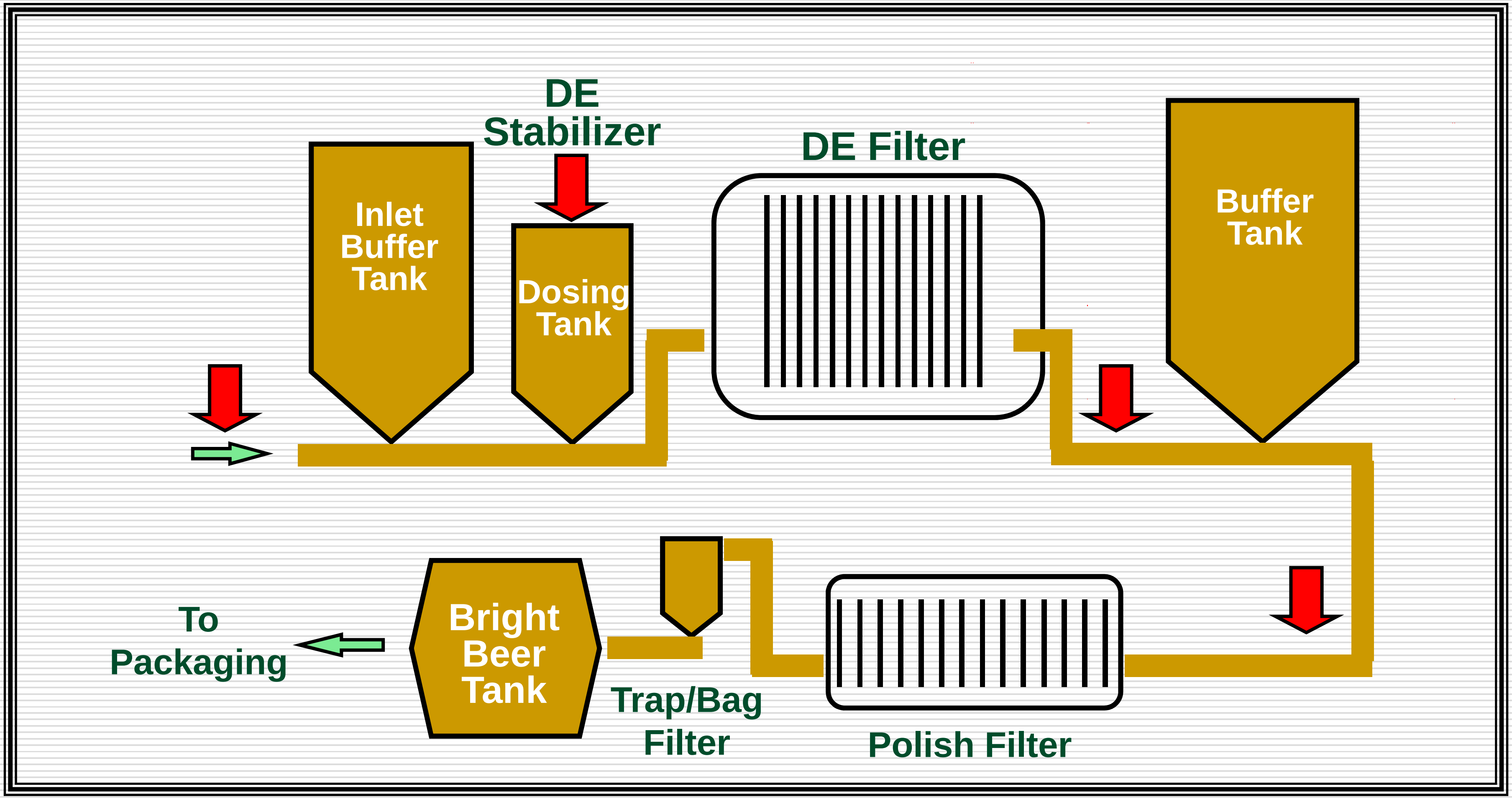
- **Single use**
  - Added prior to primary filtration and removed at the filtration stage
- **Regeneration**
  - Used after primary filtration on a horizontal leaf filter or candle filter and then recovered for re-use

Stabilization with PVPP

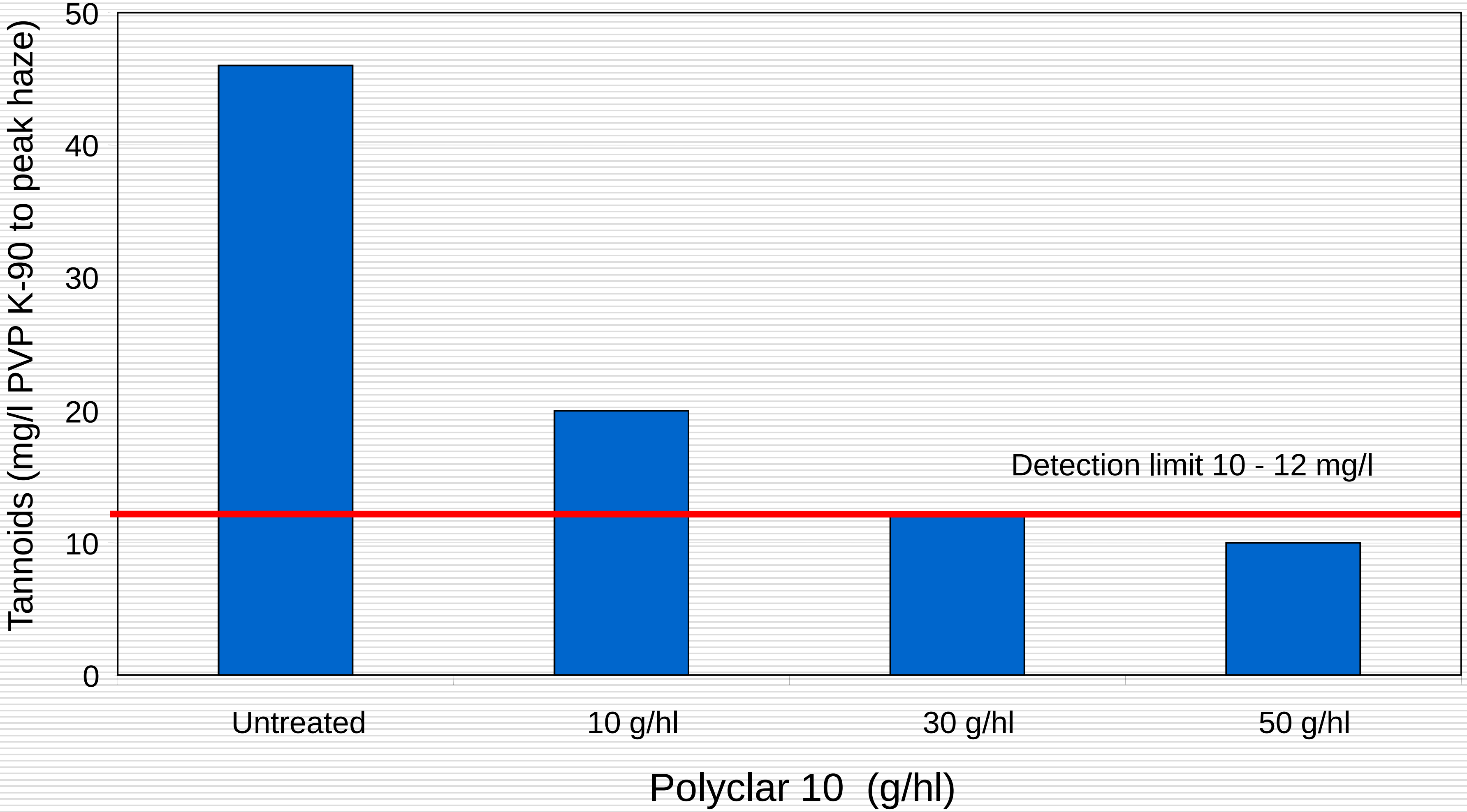
- Slurried in deaerated water (8 - 10% wt/wt)
- Hydrated for 1 hour (maximum efficacy)
- Added to beer during transfer
- **Single use** - usually added before DE filter

  - 5-10 min. contact time
- **Regeneration grade** - added after DE filtration

Possible Injection Points for Polyclar Plus and Polyclar PVPP

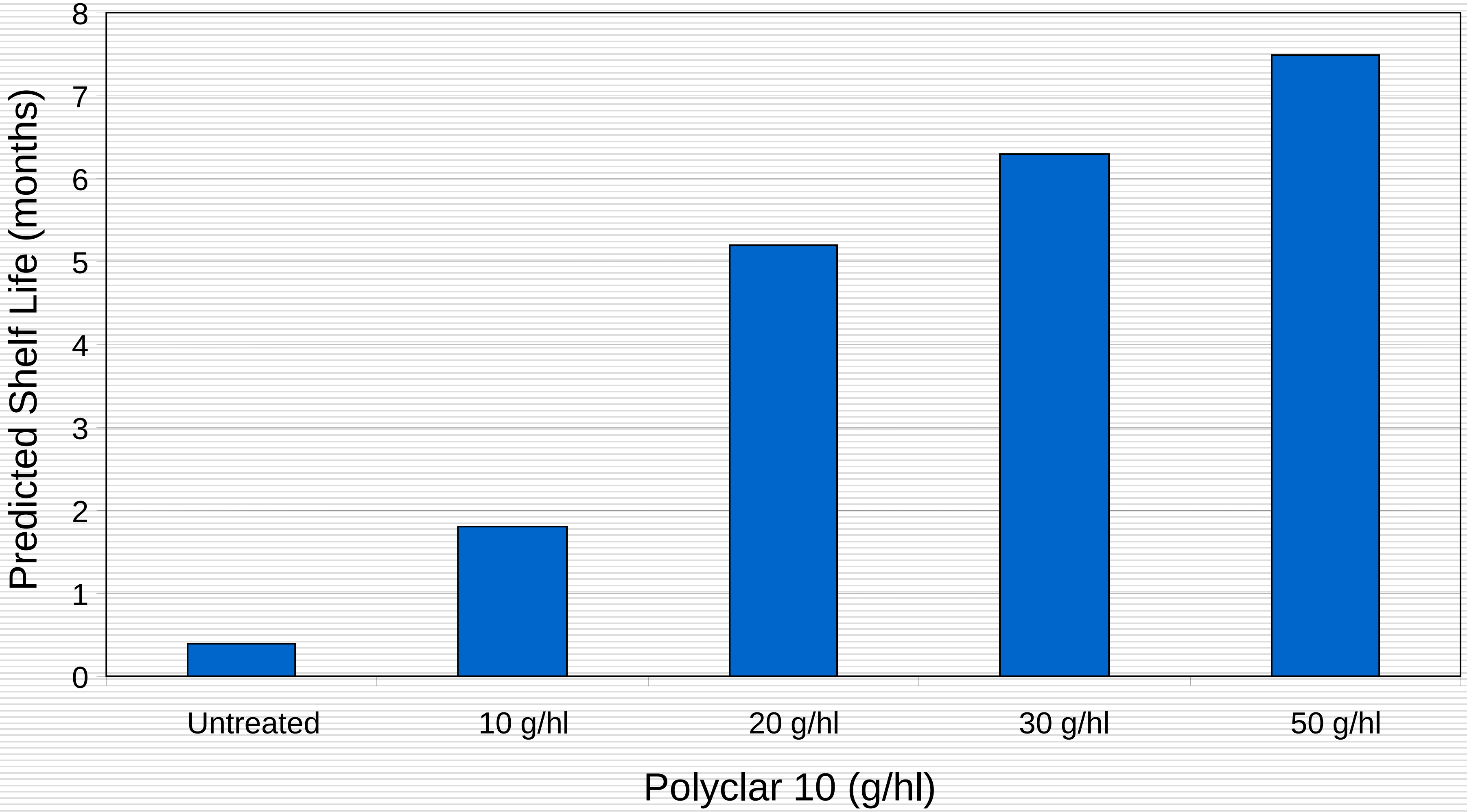


Tannoid Reduction with PVPP



- ***Step 5 – reduce the tannoids with PVPP***

Increase in Shelf Life of PVPP - Treated Beer



Hydrogels vs. Xerogels

Hydrogel

- **Contain 30-50% water**
- **Easier to disperse**
- **Used at up to ~150 g/hL**
- **Less effective than xerogels**
- **Greater permeability than xerogel**
- **Less microbial stability**

Xerogel

- **Contain 5% water**
- **Harder to hydrate & disperse (more dusty)**
- **Used at up to ~80 g/hL**
- **More effective than hydrogel**
- **Greater microbial stability**

Action of Silica gel

Protein adsorption follows three sequential steps:

- Diffusion of proteins from the beer matrix to the surface of the silica gel (relatively fast step)
- Attraction: Surface adsorption of proteins to the hydrated silica gel (relatively fast step)
- Penetration of the surface adsorbed proteins into the silica gel (rate determining step)

Protein Stabilizers - Tannic Acid

- From (Chinese) gallnuts
- Complexes with haze-active proteins
- Used at low dosage rates 4-10g/hL
- Added between FV & MV, or,
- In-line to DE filter
- Minimum contact time 10 min.
- Cannot be used at the same time as PVPP, but can be used sequentially – *tannic first, then PVPP*

Protein Stabilizers - Papain

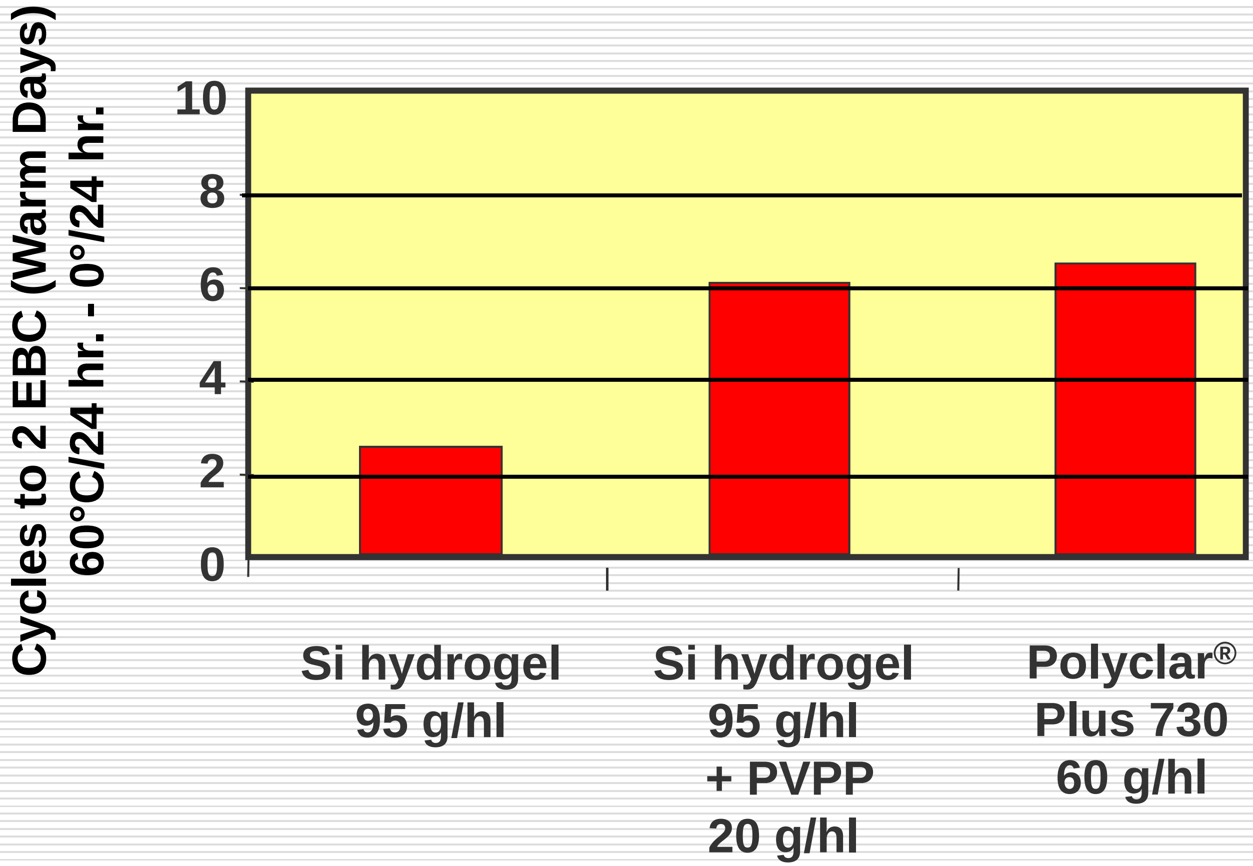
- Proteolytic enzyme - from papaya
- Four *iso*-enzymes
- Degrades proteins - non-specific
- Used at low concentrations 1-6 g/hL
- Added at maturation or beer filtration
- Activated during pasteurisation
- Persists in beer
- Adverse impact on beer foam

What is Polyclar® Plus ?

A proprietary composite of micronized Polyvinylpolypyrrolidone (PVPP) and selected Silica Xerogel

Predicted Shelf Results- Plant Trial with Polyclar Plus 730

(Composite 70%Si + 30%PVPP)



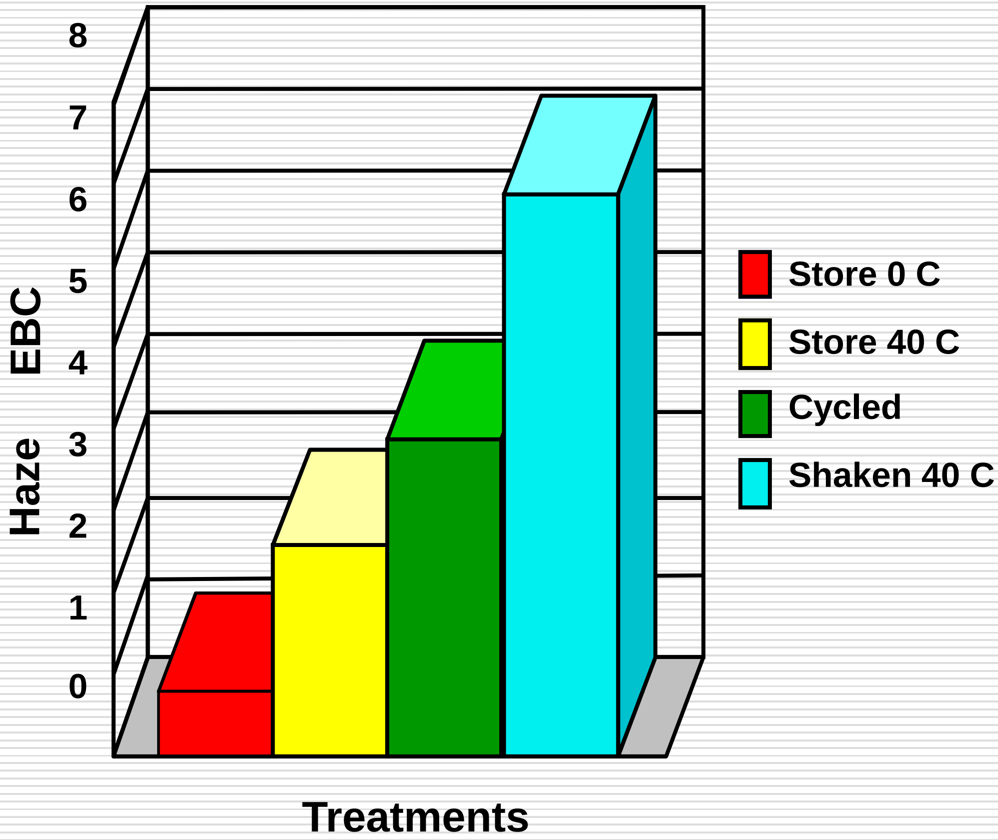
➢ ***Step 6 – Balanced stabilization is efficient and cost effective***

Brewery Trials – Filter Pressures, Run Lengths & Beer Stability with Polyclar Plus

Stabilizer	Dose rate g/hl	ΔP/hr*	Filter Run Time (hr.)	Total Haze** (EBC)
Xerogel only	35.8	0.49	6.4	6.9
PVPP only	12.6	0.35	7.4	3.6
Polyclar Plus 730	33.0	0.25	12.0	1.2

*Pressure increase at steady state
**Total haze measured at 0^{o}C after 5 days incubation at 60^{o}C

Beer Transport



➢ *Step 7 – don't forget the beer after it leaves the brewery!*

Seven Steps to Colloidal Stability

1. **Avoid use of very weak wort(<1.5 P)**
2. **Minimize O_2 pickup throughout the brewing process(<0.1 ppm dissolved O_2 in beer ex-fermenter and into package)**
3. **Cold store, transfer & filter beer at 0^{o}C, or below**
4. **Wort & beer clarity are important** ***– optimize finings & filter aid use***
5. **Ensure that the tannoids are reduced (removed) from fresh beer** ***– use PVPP***
6. **Balanced stabilization is efficient and cost effective** ***– silica + PVPP***
7. **Consider beer transport & storage**

Thank You!