

Clear Beer Through Finings Technology

Ian L Ward

Clear Beer

For hundreds of years, beer clarity in the U.K. was achieved not by lagering or filtration, but rather by the application of unlikely marine derived polymers which collectively became known as finings. Finings was the only route available to brewers in the U.K. wanting to produce bright beer, since the climate does not permit natural lagering in the Bavarian style. As advancements arose in centrifugation and filtration, brewers discovered that the traditional cask beer fining technology had a relevance and synergy with the newer brewing techniques. Today, brewers use both kettle finings and isinglass in their filtered beer to enhance quality and improve process efficiency.

Beer Particles

Barring infection, beer clarity is compromised only by yeast cells and Non-Microbiological Particles (NMP). The term NMP covers a multitude of compositional species, although they are generally comprised of protein, usually associated with polyphenols and other species such as lipids and carbohydrates. All fining agents work by sticking small particles together to form larger aggregates which settle faster according to Stokes' Law (see panel).

Stokes Law

Stokes Law describes the settlement of solids in a non-solvent.

$$v = \frac{2(r_1 - r_2) \cdot r^2 \cdot g}{9h}$$

Where, v = rate of sedimentation of a spherical particle
 r_1 = density of the particle
 r_2 = density of the medium (wort or beer)
 r = radius of the sphere
 g = acceleration due to gravity
 h = viscosity of the medium.

Although the density and viscosity of beer is a dynamic system, in practise the brewer is less able to control these parameters to effect clarification. The g term may effectively be increased by means of a centrifuge or the radius of the particle may be increased by the use of finings. Centrifuges are particularly effective at removing yeast, but generally less effective on the very small particles that finings are particularly good at removing. Since the speed of settlement is proportional to the square of the radius a modest increase in particle size can yield a profound decrease in settlement time.

Fining agents share a common set of properties which enable them to act as sedimentation agents: large macromolecules; rigid structures, (usually helical), and charged at an appropriate liquid pH.

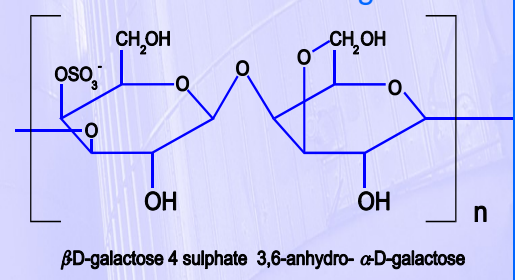
Clear in the Brewhouse

Producing clear beer starts even before the brewhouse with the selection of raw materials, notably malt. Malts with high nitrogen and polyphenol levels will inevitably produce beers which are difficult to clear and, after packaging, will be prone to colloidal instability. The use of cereal adjuncts such as wheat will also add more protein to the wort which will induce turbidity. The first point at which finings technology can be applied to assist the brewer is in the kettle, where kettle or copper finings are added to the wort to enhance protein removal as the wort cools.

Kettle Finings

Kettle finings have been used for many years and have become known as Irish Moss owing to the common name for the Atlantic red seaweed - *Chondrus crispus* which was used. The active ingredient in Irish Moss is a polysaccharide - k-carrageenan. In recent years, it was discovered that a Pacific seaweed, *Eucheuma cottonii* had a higher concentration of k-carrageenan than Irish Moss and by refining this material modern high activity kettle finings are produced. k-carrageenan in solution is negatively charged, owing to the sulphate groups along the polysaccharide backbone. It is these charged sites which interact with wort proteins.

Structure of k-Carrageenan



In solution at temperatures above 65°C, the carrageenan has a random coil structure. As the wort cools the carrageenan takes on a much more compact and ordered helical confirmation which is thought to drag the protein particles together to form aggregates. The aggregates, having a larger particle radius, settle faster as given by Stokes' Law.

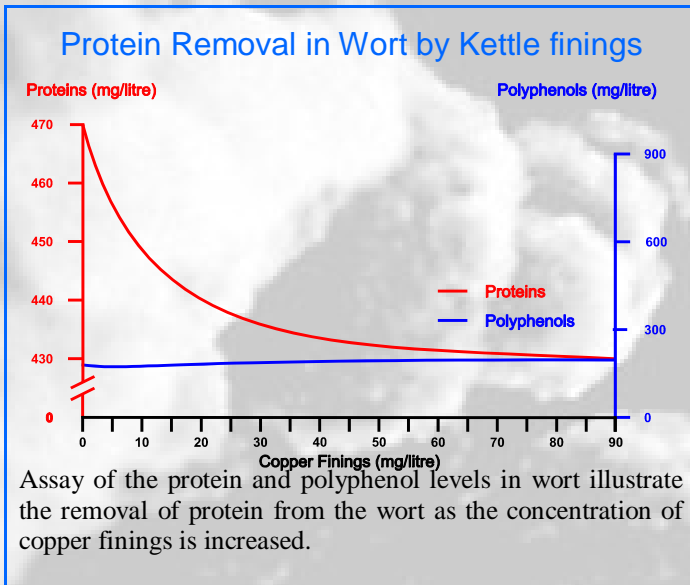
It is a commonly held misconception that kettle finings improve trub formation. Kettle finings are added in the kettle only to allow the carrageenan to dissolve. Wort proteins react with the carrageenan as the wort cools and settle as a cold break during fermentation to be removed along with the excess yeast.

Particles & Protein Removal

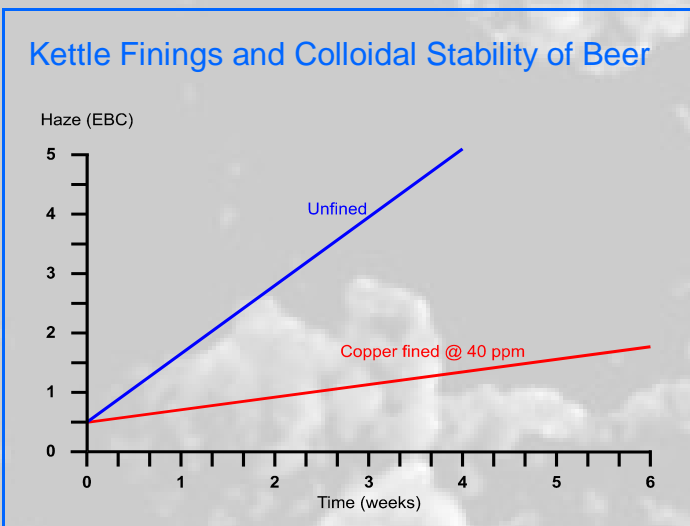
The removal of particles and protein from wort has been demonstrated by microscopic examination of pre-filtered beers and protein assay.

Kettle Fining Rate / ppm	Mean NMP Level (x 10 ⁶)		
	> 10mm	2-10mm	< 2mm
13	0.6	7.6	3.4
25	0.1	0.5	0.5
30	0.02	0.06	0.11

As the levels of kettle finings increase, the fine particle counts in each of the size bands counted decrease. It should be noted that the particles below 2 microns are mostly responsible for blinding filter pores. An order of magnitude reduction in particles in this size range will greatly improve filtration throughput.

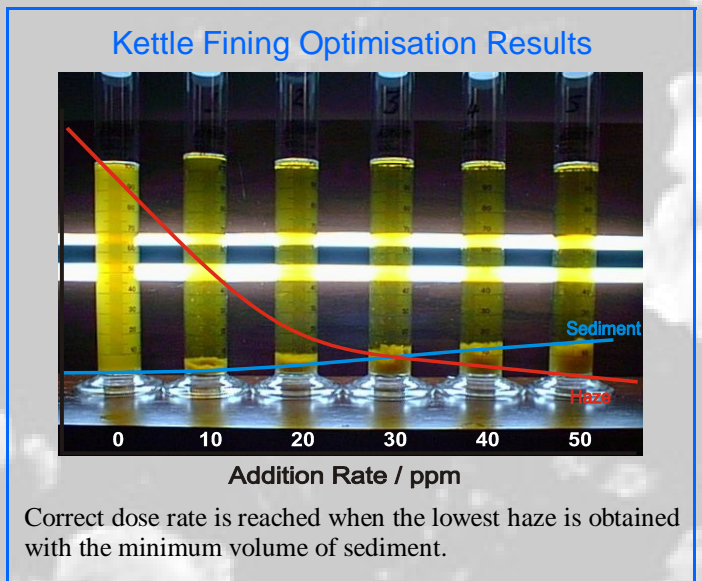


Since kettle finings remove both particulate and soluble protein, and soluble protein is a component of chill haze, it is unsurprising that the colloidal stability of kettle fined beers is enhanced.



Kettle Finings in Use

The seaweeds used to make kettle finings are washed and refined into either granules, tablets or powders. Granules tend to be only partially refined and so are cost effective and find use in larger, (>50 bbl), brew lengths. Tabletised products find use in breweries with shorter brew lengths owing to their ease of use. Powders tend to have fallen out of favour owing to their awkward handling characteristics. Several factors influence the way in which kettle finings work. The most important consideration is dose rate. As illustrated below, when the dose rate increases, the clarity improves, but the level of sediment increases. Over fining will give rise to beer losses in fermentation vessel.



Kettle finings should be added to the boil ten minutes prior to the end of the boil for a semi-refined product and five minutes for a refined material. The addition times reflect the length of time required to dissolve and disperse the carrageenan into the wort. Should kettle finings be added too early in the boil, then degradation of the polymer will occur and product efficiency is lost. The reaction between wort proteins and k-carrageenan is pH dependent and occurs at an optimum pH of 5.3. Below pH 4.4, the reaction does not occur and little benefit is gained from using kettle finings.

Wort pH	Optimum Rate / ppm	Clarity at Optimum Rate	Sediment Vol. at Optimum Rate / %
4.4	>40	E	0
4.7	40	B	12
5.0	30	A	10
5.3	20	A	10

Clarity is recorded on a visual scale with A being bright and E cloudy.

Clear at Condition

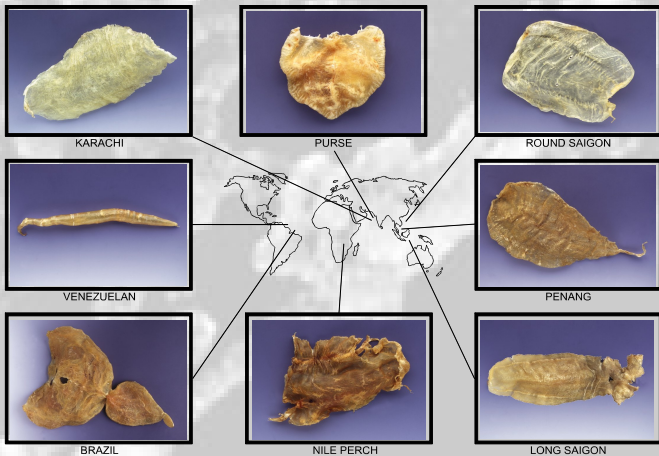
The wort correctly kettle fined ferments out to produce a beer with a manageable level of fine particles; it is at this point that isinglass may be applied to enhance filter performance, and drastically reduce conditioning times.

Isinglass Finings

Isinglass has, for many years, been used as a clarification agent in beer. Many theories as to its first use abound. Most centre on the concept of a large swim bladder being used as a vessel for carrying beer in the same fashion as wine skins, whereupon it was noticed that the beer had cleared. Whatever the origin of this unlikely marriage over the years, the knowledge surrounding its use has increased.

Where on Earth?

Isinglass is the dried swim bladder from various types of tropical fish, typically living in estuarine waters. The fish are all harvested for food and the bladders provide an additional cash crop.

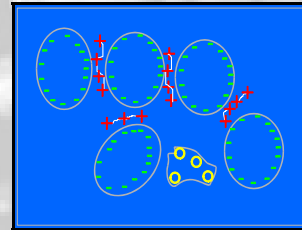
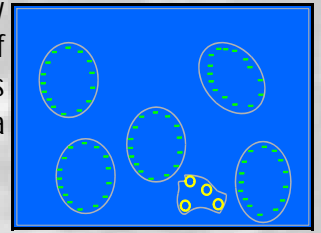


Isinglass from various regions and fish species from around the world. Due to climactic and political reasons not all the types are available throughout the year and so types must be blended to ensure consistent quality and performance.

The active ingredient in isinglass is the protein molecule collagen. Collagen is a rigid, linear, triple helical protein of molecular weight 360 kDa. As collagen possesses a high degree of structural order, it is temperature sensitive and is denatured at moderate temperatures into gelatine which has little or no fining activity. This has significant implications for the manufacture and storage of isinglass finings. Isinglass finings are prepared by dissolving the solid material in a dilute food grade acid. Isinglass is also processed into powders or pastes to obviate the need to store at low temperatures, however isinglass solutions should always be stored at temperatures below 20°C and used within 8 weeks of preparation.

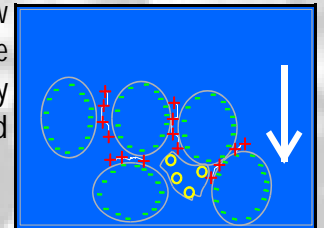
Reaction Mechanism

Unfined, unfiltered beer may be thought of as consisting of negatively charged yeast cells and uncharged NMP's in a buffered alcoholic solution.

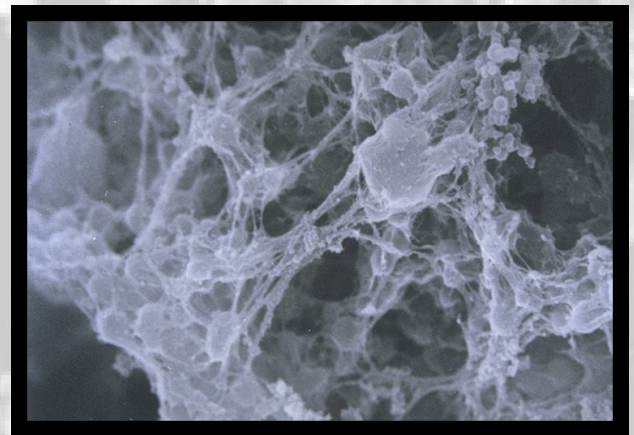


Positively charged isinglass is attracted to the yeast cell walls which possess a negative charge and adheres the cells together, thereby increasing the floc radius.

According to Stokes' Law the larger aggregates settle faster; as they do they enmesh the uncharged protein particles.



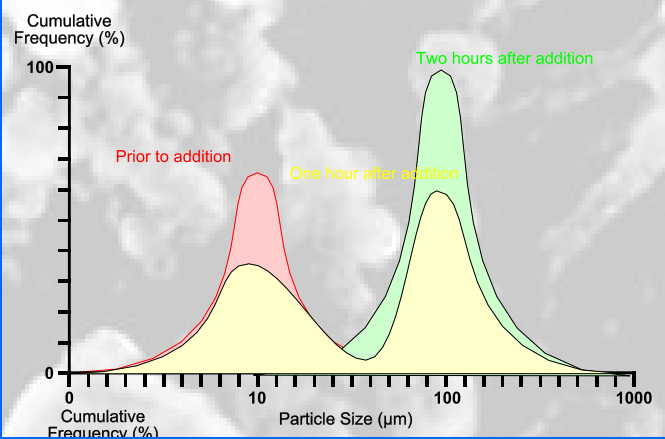
Yeast Enmeshed



The above electron micrograph shows the entanglement of yeast cells amongst collagen fibres.

The shift in particle size is a rapid reaction and is for the most part complete within two hours.

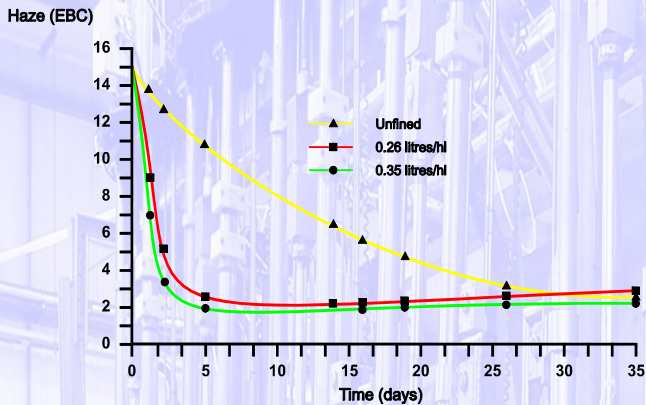
Particle Distribution Shift Upon Application of Isinglass



Fined Beer & Filtration

The rapid settlement of yeast and protein is seen by a rapid decrease in beer haze such that conditioning time can be reduced to as short as 3 days.

Haze Reduction After Isinglass Treatment



Very large savings in both cooling energy costs and capital investment in tankage may be made as a result of shorter conditioning tank residence time.

It is not only savings in cold conditioning time that can be gained by treatment with isinglass; filter performance is also enhanced. Faster filter throughput, lower differential filter pressures and a greater beer volume through the filter between recharge/cleaning are all obtainable.

Average Filter Performance Before and After Commencement of Isinglass Usage

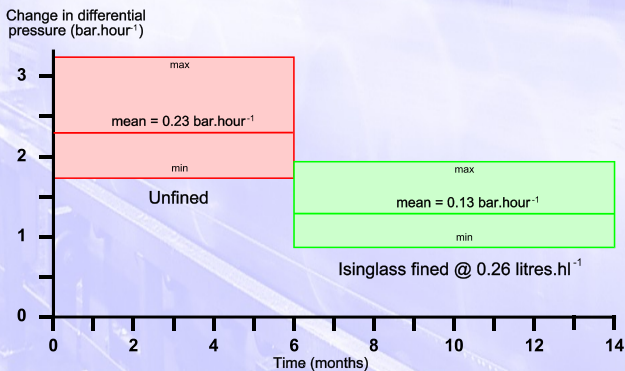


Chart illustrates the rate of change in pressure across a beer filter for six months prior to commencement of an isinglass trial, and during the trial. Lower filter pressures indicate less blinding of filter leaves and longer, faster filter runs are therefore possible.

It is well documented that isinglass enhances beer foam stability. Isinglass stabilises foam by removing head negative phospholipid material. The degree of foam stabilisation is dependent on the fining rate. The optimum rate will depend upon the level of head negative material to be removed, but is of the same order as normal isinglass fining rates. When phospholipid was added to beer, the foam stability was observed to drop significantly, but was restored upon fining with isinglass.

Isinglass Finings in Use

Isinglass finings should ideally be dosed proportionally, in-line during beer transfer. Dosing all of the finings into part of the beer, and then adding the rest of the beer on top with little rousing may result in under fining one portion of the beer, and over fining the other portion; this may result in poor clarity, and excessive volumes of sediment.

A number of factors affect isinglass performance. As with kettle finings, the dose rate is important; too little and the beer simply does not clear. If isinglass rates are too high the sediment will be fluffy and voluminous, causing wastage and poor filtration. Typical rates for filtered beers are between 0.25 and 0.5% of beer volume. For optimum fining performance, beer must be fined at the coldest point in the process. If the beer is cooled post-fining, fining performance will be poor, due to formation of chill haze after the fining action has taken place. If the chill haze is present prior to isinglass addition, then it is readily removed by fining. This is equally true for chilled and filtered beers as it is for cask beers, and supports the old wisdom of fining on a rising temperature gradient. Yeast count and quality will also affect isinglass performance. Observations have shown that providing yeast counts are maintained within reasonable limits, (0.5-3.0 x 10⁶ cells/ml), satisfactory fining performance is obtained. Very low yeast counts can result in poorly developed light flocs which are easily disturbed. It should be noted neither dead yeast cells, wild yeast nor bacteria respond to finings.

Summary

By careful application of finings, considerable benefits can be realised both in terms of beer quality : improved colloidal stability, head retention, post filtration beer haze and in processing advantages : shorter conditioning times, longer and faster filter runs. It is for these reasons that brewers all over the world have retained and developed the use of finings as processing aids. Should you require any further information, please contact us at the address below.



Brewers Wholesale Supply Inc.
312 Connell Hwy
Newport
RI 02840
Tel (800) 816 8542
Fax (401) 845 6746
www.brewerswholesale.com