

Beer stabilisation technology

Clearly a matter of choice

It is said “people drink beer with their eyes”. An important index of beer stability is the visual appearance of the product. With the exception of a few well known examples such as weissbier, consumers associate a star-bright product as a mark of freshness.

By **Chandra Gopal** and
Mustafa Rehmanji
International Specialty Products.

Whilst a beer is likely to deteriorate in terms of flavour before the appearance of haze, most consumers will probably notice the latter first! The challenge is to present a visually appealing product to the beer drinker, often some months after packaging. This long time frame is driven in many mature beer markets by a shift from draft beer consumption in bars to home-consumption from bottles and cans. A shelf life of six to twelve months is now common.

Mechanism of non-biological haze formation

When talking about haze, it is important to distinguish colloidal haze from microbiological haze: the latter being rare due to the significant improvements in hygiene control in breweries. Colloidal or non-biological haze comprises mostly proteins, polyphenols, carbohydrates and rarely other minor constituents like starch, oxalate and hydrolysed heading agent. The exact mechanism of haze formation is still the subject of academic investigation. Siebert proposed that two major constituents – haze-forming proteins and polyphenols – have specific structures that give them a propensity to interact and form colloidal particles. The haze proteins have regions rich in the amino acid



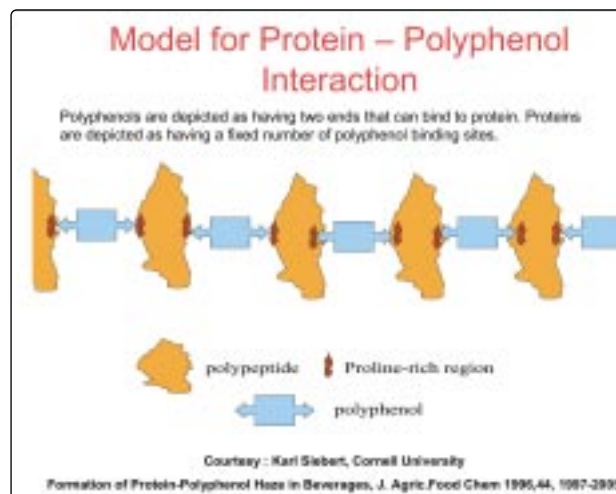
proline, to which the polyphenols attach, as shown in Fig. 1. Another model of chill and permanent haze development by O'Rourke proposed the driver in haze formation was the oxidation of flavanol oligomers (sometimes also called flavanoids) during beer storage. As monomeric and dimeric flavanols such as catechin and prodelphinidin polymerise, they have the capability to bridge a number of proteins forming a larger colloidal particle. This is initially visible as a chill haze due to the relatively weak hydrogen bonds linking the two as shown in Fig. 2. With further polymerisation, larger polyphenol molecules termed tannoids are formed, which are more tightly bound to the haze proteins, giving rise to permanent haze. Simple flavanols such as catechin *per se*, were not capable of haze formation, but that same molecule after oxidation, did produce haze,

implicating the important role of oxygen (either dissolved or as oxidising agents) in colloidal instability (Fig. 3). Many authors consider the oxidation of the dimers to be the key factor in the development of chill haze.

MAJOR FEATURE

Over the next fourteen pages we address the issue of colloidal beer stability. Proteins and polyphenols from the raw materials will inexorably polymerise over time and once the particles are big enough they will scatter light and cause a haze. The challenge is for your beer to pass its best before date with a haze below 2°EBC. We have brought together experts in the use of PVPP, silica gels, finings and gallotannins to tell you how to achieve it.

FIG. 1 below. Karl Siebert has proposed that the two major constituents –haze forming polyphenols and proteins - have specific structures that give them propensity to attach and form colloidal particles.



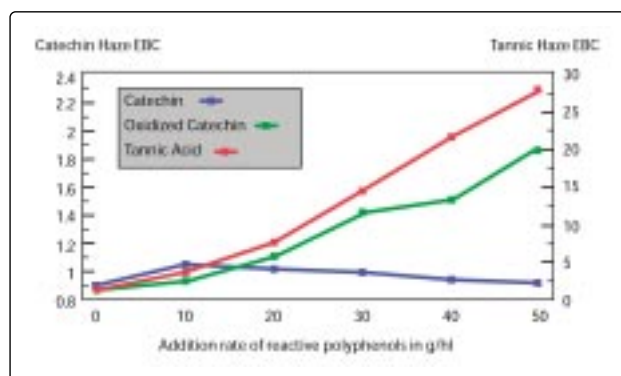


FIG. 2 top. O'Rourke et al proposed that simple flavanoids (flavanols) alone are incapable of causing haze; but following oxidation and polymerisation, the protein-polyphenol complexes linked by hydrogen bonds; produce a chill haze at 0°C. If the hydrogen bonds can be disrupted by warming the haze re-dissolves. Tannoids are capable of forming additional hydrophobic and ionic interactions with acidic proteins, which are not disrupted by warming and result in a permanent haze.

FIG. 3 above. Simple flavanoids such as catechin are not capable of haze formation but that same molecule after oxidation is an active haze producer after interacting with protein.

Achieving colloidal stability

Assuming that the freshly-packaged beer has no detectable tannoids present, during the initial storage of the beer there is only a slight increase in haze. As the lower molecular weight polyphenols polymerise and increase in size there is a significant increase in the rate of haze formation, as shown in Fig.4. Hence effective colloidal stabilisation requires the removal of the tannoids and a reduction in the level of flavanols (particularly dimers and trimers) in conjunction with haze active protein material. The extent of this reduction will depend on the shelf life requirements of the beer, the raw materials used and the brewing procedures employed. Use of stabilisers to achieve a target shelf life should be optimised and not be excessive – as this is expensive and may detract from beer quality.

At each stage in the process, it is important to pick out a few key strategies that can be adopted to reduce the formation and passage of haze precursors to the next step of the brewing process. In the brewhouse, avoiding the use of weak worts can play an important role as these contain very high levels of polyphenols that can pass

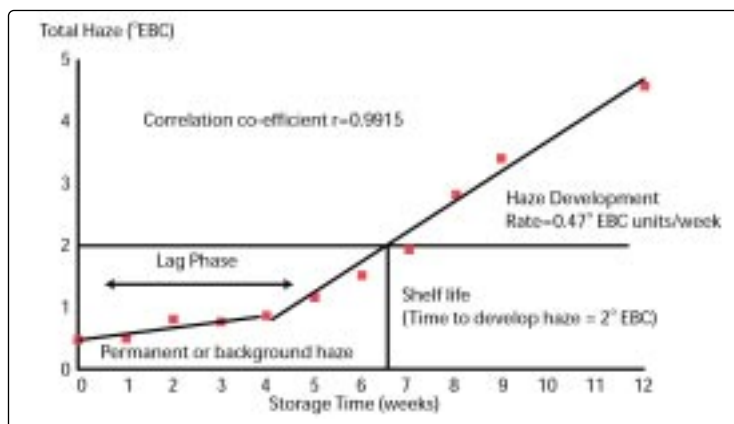


FIG. 4. As the lower molecular weight polyphenols increase in size through polymerisation, there is a significant increase in the rate of haze formation. A well stabilised beer is characterised by a long lag-phase, a slow rate of haze development and is still below 2° EBC haze at the end of its shelf-life.

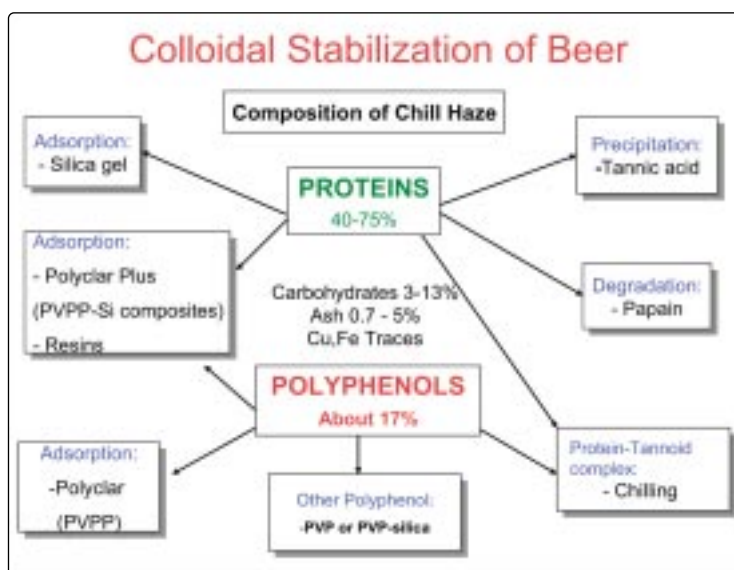


FIG.5. Options for beer stabilisation. The main stabilisation options are highlighted in terms of their mechanistic actions. Some of the advantages and drawbacks of each are summarised in Table 2 on page 17.

into the fermentation vessel. A vigorous kettle boil and effective hot and cold breaks will promote early polyphenol-protein precipitation. A rapid onset of fermentation and early removal of yeast, preventing cell lysis are important, as yeast mannans can contribute to the haze matrix. Oxygen exposure after initial wort oxidation must be strictly prevented and the beer at the end of fermentation chilled to -1°C or lower for maturation. Maturation time should be sufficient to allow the formation and precipitation of protein-polyphenol flocs in the cold storage vessel. Having formed these low temperature flocs, a temperature increase above 0°C would cause them to separate and

perhaps redissolve, so the beer must be held around -1°C into filtration. The use of isinglass finings, green beer centrifugation and 'tighter' beer filtration are all options to improve beer clarity and thus reduce the base complexes on which further haze material can build. This 'good brewing practice' will confer several months shelf life but beers with higher malt contents and a shelf life in excess of three months will demand some form of stabilisation treatment.

Options for beer stabilisation

Since the two major components of colloidal haze are the protein and polyphenol fractions, their reduction in beer prior to packaging is the obvious target.

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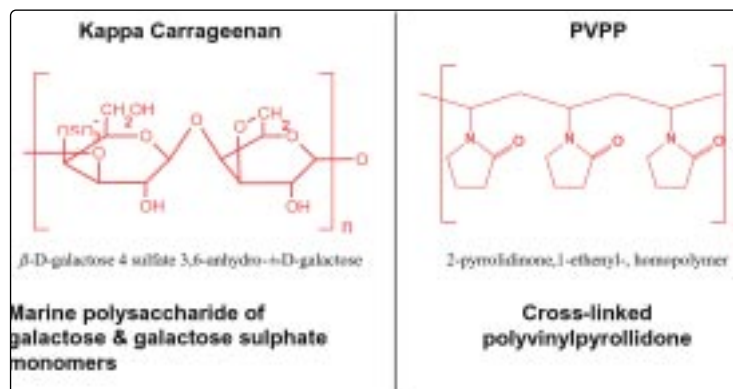


FIG. 6. Combining PVPP with κ -carrageenan – Polyclar Brewbrite provides wort clarification and beer stabilisation with a single addition to the copper about 10 minutes before the end of boiling.

“The brewer’s responsibility for beer clarity does not end with packaging, as the transportation and subsequent storage of beer can have a very significant impact on visual clarity. Excessive shaking (during transportation) may result in fobbing and the appearance of a collapsed fob haze or even ‘particulates’ before the beer reaches the customer.”

Figure 5 shows the most common options available to the brewer. The list is not exhaustive, as it excludes some older technologies such as formaldehyde, which were no doubt very effective, but may leave behind toxic residue in beer. Probably the most widely employed products today are silica gel for protein stabilisation and Polyvinylpyrrolidone (PVPP) for polyphenol stabilisation. The other major product categories are tannic acid and enzyme preparations (papain).

Both silica gel and PVPP have the advantages of being insoluble in water and beer and are classified as process aids: as such, their use is permitted on a global basis and specifically allowed

under the German *Reinheitsgebot*. They are sometimes referred to as ‘clean label’ products, as their insoluble nature and removal from beer prior to packaging means they are not required to be listed as ingredients.

Classically these treatments occur at maturation or filtration. However there is much current interest in upstream beer stabilisation where treatments are added directly to the boiling wort to spare for specialised equipment like as slurry tanks and dosing units at the end of the process.

Kettle finings in the form of κ -carrageenan is typically added ten minutes or so before the end of the kettle boil. A novel stabilisation agent harnesses the synergies of

wort clarification and polyphenol reduction by combining PVPP with κ -carrageenan, Fig.6.

The product is added directly into the kettle, or on transfer to the whirlpool. In use, better solid-liquid phase separation in the whirlpool has been noted in trials, with increased cold wort collection (Fig.7).

A more ideal cone is often observed in the whirlpool, after wort run-off. In some instances faster fermentation rates have also been observed (Fig.8). The key objective is to increase the shelf-life of the beer and using this simple procedure, a shelf life of 6 months or more (Fig.9) can be achieved without the need for capital investment in the brewery.

After packaging

The brewer’s responsibility for beer clarity does not end with packaging, as the transportation and subsequent storage of beer can have a very significant impact on visual clarity. Excessive shaking (during transportation) may result in fobbing and the appearance of a collapsed fob haze or even ‘particulates’ before the beer reaches the customer. High temperatures will accelerate haze development. The standard temperature for some heat forcing tests is often lower than ambient temperatures in many developing beer markets!

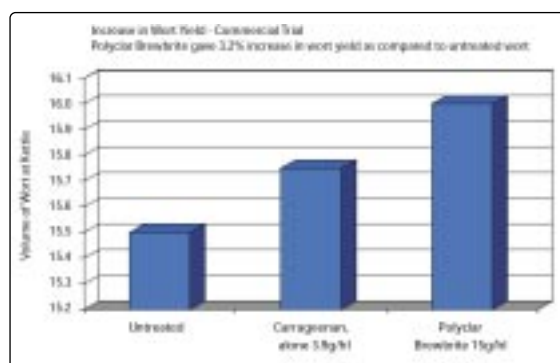
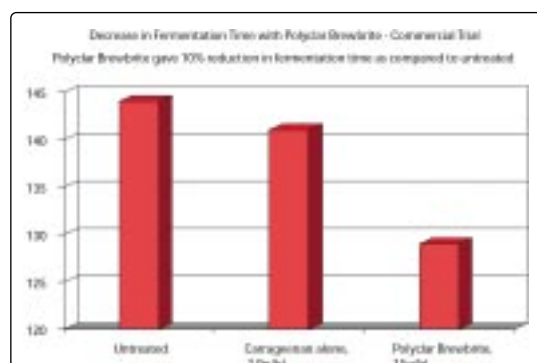
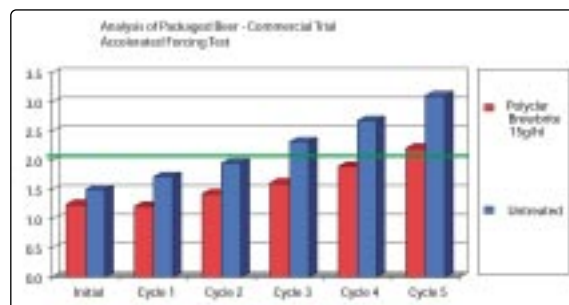


FIG. 7 above. Increase in wort yield with Polyclar Brewbrite. A better solid-liquid phase separation in the whirlpool aids wort run-off and improve yields without the need for trub-recycling and its negative quality impact.

FIG. 8 above right. Reduction in fermentation time with Polyclar Brewbrite. The combination of carrageenan and PVPP may decrease the time to rack gravity, without impacting the overall attenuation or flavour profile of the beer.

FIG. 9 right. Shelf Life of beer with Polyclar Brewbrite. The use of Brewbrite improved initial clarity compared to control and the predicted shelf life of the beer to around 6 months. In this instance, performance could be further enhanced by tighter beer filtration to produce an initial haze in the beer of <0.5°EBC.



Effective colloidal stabilisation requires the removal of the tannoids and a reduction in the level of flavanols (particularly dimmers and trimers) in conjunction with haze-active protein material.

Seven steps to colloidal stability

1. Avoid use of very weak wort (<1.5 P)
2. Minimise oxygen pickup throughout the brewing process (<100ppb dissolved O₂ in beer into package)
3. Cold store, transfer & filter beer at 0°C, or below
4. Wort & beer clarity are important – optimise finings, centrifugation & filter aid use
5. Ensure that the tannoids are removed from fresh beer and polymerised flavanols reduced by using PVPP. Reduce the levels of haze active proteins with silica gel, tannic acid or proteolytic enzymes.
6. Balanced upstream stabilisation is efficient and cost effective
7. Consider beer transport & storage conditions

Table 2. Good brewing practice strategies to optimise colloidal stability.

Process	Polyphenol Reduction	Protein Reduction	Process Optimisation
Raw material selection	Low proanthocyanidin malt Hop extract	Low protein (N) barley	Avoid excess 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 maturation at -1°C to form and settle hazes
Filtration			Low solids count Filter at -1°C Avoid O ₂ pickup

“At each stage in the process, it is important to pick out a few key strategies that can be adopted to reduce the formation and passage of haze precursors to the next step of the brewing process. In the brewhouse avoiding the use weak worts can play an important role as these contain very high levels of polyphenols that can pass into the fermentation vessel.”

Table 3. Summary of the most widely used stabilising agents for preventing chill and permanent haze development in beer.

Stabiliser	Action	Advantages	Disadvantages	Dosage range
Polyvinylpolypyrrolidone (PVPP)	Strong bonding to haze-active polyphenols via multiple bonding mechanisms	Selective for haze-active polyphenols Single use or Regenerable	Possible flavour loss if used in excess Capital cost for regeneration plant	5 – 40 g/hl
Silica hydrogel	Adsorbs haze-active proteins via hydrogen bonding	Selective for haze-active proteins	Higher usage rate	30 – 100 g/hl
Silica xerogel	As hydrogel	Selective for haze-active proteins Lower usage rate than hydrogel	Difficult to disperse Reduced head retention if used in excess	20 – 50 g/hl
Gallotannin (Tannic acid)	Adsorbs haze-active proteins by hydrogen bonding	Selective for haze-active proteins Low usage rate	Beer losses if used in tank Flavour harshness if used in excess	4 – 10 g/hl
Papain	Proteolytic enzyme – degrades proteins by hydrolysis	Low usage rate	Negative impact on head retention Persists in product	1 – 6 g/hl

The use of polyvinylpolypyrrolidone (PVPP)

The unit molecular structure of PVPP closely resembles that of the amino acid proline – in fact it can be considered as a chemical analog of polyproline – cross-linked polyproline. This structure facilitates its ability to adsorb those polyphenols responsible for haze development – both tannoids and polymerised flavanols. The adsorption of polyphenols by PVPP is through hydrogen bonding between the proton donor from the polyphenol and the carbonyl group from PVPP, together with π -bond overlap (delocalised electrons) polar and hydrophobic reactions. If that sounds complicated, in fact it can be easily explained by inspecting Figure 1.

Polyphenol adsorption is preferentially directed to the larger oligomers first as they have the highest number of potential bonding sites to PVPP. The advantage to the brewer is that the dosage rate of PVPP can be adjusted to reduce the polyphenols most likely to cause haze. Moreover, PVPP does not have any adverse effects on beer quality including flavour or foam stability.

PVPP can be used either as a single-use stabiliser, or on a regenerable basis. PVPP regeneration will become economical when large volumes of beer are being stabilised. The single-use grade is micronised during manufacture to give a particle with a large surface area over which the polyphenols can be rapidly adsorbed. This allows low, cost effective addition rates to be employed – typically 10 – 20 g/hl.

PVPP (and indeed silica gel) may be added at one of a number of stages in the brewing process after the end of fermentation. An addition of as little as 10 g/hl resulted in a >50% reduction in the tannoid content of a US lager (Fig. 2). Further increases, reduced this to below the detection limit for the assay (10–12 mg/l PVP K-90). The resulting increase in shelf life was also dramatic, with a 20 g/hl addition rate providing a predicted shelf life in excess of 5 months in this beer shown in Fig 3. Increasing the

dosage further yields a diminishing return.

This means that stabilisation must be balanced to achieve the most cost effective reduction of both the polyphenol and protein haze precursors.

PVPP in composite stabilizers

Products that combine both polyphenol and protein stabilisation efficacy are also widely available and include mixtures of PVPP and silica gel such as Polyclar Plus 730. These have the advantage of convenience and effectiveness – only one slurry is made for use and effectiveness is enhanced. The beer treated with the combined stabiliser provided the same shelf life at a lower overall powder addition to the beer stream (Fig.4). This can result in longer filter run lengths. A full-scale filtration and stabilisation trial confirmed that the PVPP-silica product, Polyclar Plus 730, gave lower filter differential pressure and a longer run length than the constituent components (Table 1). An explanation for this lies in the capacity of the PVPP particles to help disperse silica particles and form a more uniform and permeable bed on the DE filter.



● To enquire further about PVPP and combined stabilisation products contact ISP at:
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Waterfield, Tadworth, Surrey, UK
KT20 5HQ
Phone +44(0) 207 519 5054 or go to the international web site to find your local office
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Table 1. Increase in filter run length with combined application of PVPP and silica gel as an admixture – Polyclar Plus 730.

The mechanism of action is considered to be that the PVPP disperses the silica and enhances the permeability of the DE filter bed, leading to a lower filter differential pressure over time and a longer run.

Stabiliser	Addition rate (g/hl)	$\Delta p/hr$	Filter Run (hr)
Xerogel only	36	0.49	6.4
PVPP only	13	0.35	7.4
Polyclar Plus 730	33	0.25	12.0

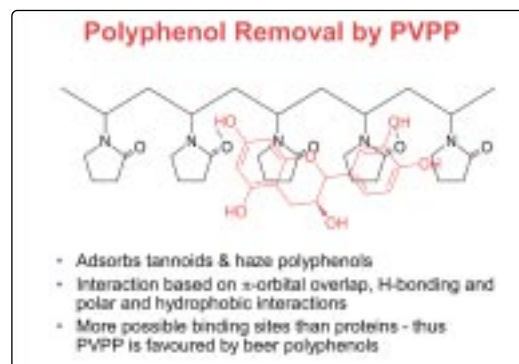


FIG. 1. The adsorption of polyphenols by PVPP is through H-bonding between the proton donor from the polyphenol and the carbonyl group from PVPP, together with π -bond overlap (delocalised electrons) polar and hydrophobic reactions (13).

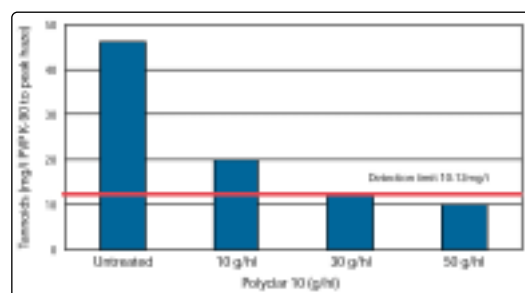


FIG. 2. Tannoid reduction in an American lager treated with PVPP. An addition of 10 g/hl resulted in >50% reduction in the tannoid content of the beer. At 30 g/hl, the tannoid level was below the limit of detection of the assay.

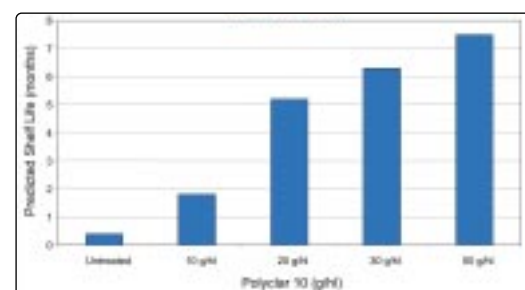


FIG 3. Increase in the predicted shelf life of PVPP-treated beer. An addition of 20 g/hl achieved a shelf life in excess of five months in a US lager. A longer shelf life can be achieved by the application of a protein stabiliser such as silica gel.

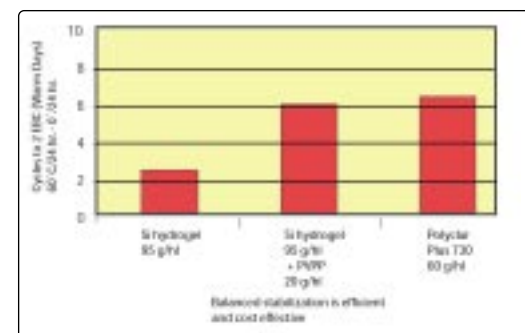


FIG 4. Stabiliser application and predicted shelf life. In brewery trials, the admixture of PVPP and silica – Polyclar Plus 730 – gave cost-effective reductions of polyphenol and protein by a single addition to the beer stream without the need for specialised equipment.

Silica-based colloidal stabilisation

The chemical characteristics that make proteins and polyphenols haze-active are the same features that enable their selective adsorption from beer by silica-based stabilisers. This article describes the structural features of these so-called sensitive proteins and tannoids and brings this together with the features that make silica-based stabilisers effective in assuring the shelf life of beer.

By **Sonya Broderick**
Ineos Silicas

*R*heinheitsgebot and FDA approved silica-based stabilisers are, through the selective adsorption of haze-forming (sensitive) proteins and polyphenols (tannoids) used to assure the shelf life of beer. Their amorphous structure makes them safe to handle while control of density and particle size distribution, enables stabilisation to be made either at maturation or at the filter. Using these products, cost savings in respect to brewing capacity may be realised either through reduced maturation times, extended filter run lengths or partial replacement of kieselguhr filter powder.

Interactions in beer between sensitive proteins and tannoid polyphenols can form a visible colloidal haze that limits a product's shelf life. Reducing the concentration of either one or both of these haze precursors serves to prevent haze formation and assure a product's shelf life.

Sensitive proteins and tannoids

Sensitive proteins range in size from 10 kD to 30 kD, are heavily glycosylated with glucose and represent 3–7% of total beer protein. In contrast to foam proteins, sensitive proteins are rich in the amino acids proline and glutamic acid. It is the presence of proline, with its ring structure and prominent carbonyl group, that makes these

proteins haze-active, but this also enables the selective removal of sensitive protein from beer by silica gel, Figure 1.

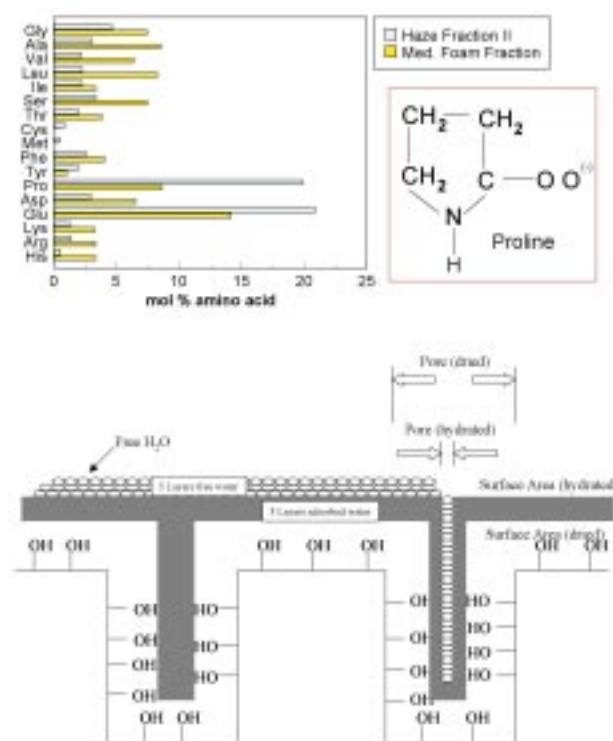
Tannoids as defined by Chapon are those polyphenols that precipitate with PVP (polyvinylpyrrolidone). These are flavanoids formed from the monomeric flavonols catechin, epicatechin, galocatechin and epigallocatechin. Their structure is likely similar to the polymeric proanthocyanidins, prodelpinidin B3 and procyanidin B3. These polyphenols have vicinal hydroxyl (OH) groups on their aromatic rings, which makes them haze-active but also enables their selective removal from beer either by PVP-coated silica gel, or PVPP.

Silica gel and protein adsorption

Silicas are broadly classified according to their water content as 'xerogels', 'semi-hydrogels' or 'hydrogels'. Generally the term 'xerogels' refers to silica gels having a loss on drying of about 25% or less, while hydrogels have a loss of 60% or more. Semi-hydrogels lie between these. The different moisture contents of silica gels gives rise to differences in the density of the powders so that low-density xerogels are dusty powders, while higher density semi-hydrogels and hydrogels are generally free from dust.

Amorphous silica gels used in the brewing process have small particle size (ca. 10 to 30 microns) and are highly porous having surface areas from about 300 m²/g to more than 700 m²/g. These are hydrophilic powders due to coverage of their surface by hydroxyl (silanol) groups, (Figure 2). It is the interactions of proline with these groups that enable the selective adsorption of sensitive protein from beer.

Effective protein binding occurs



within the silica pores where the concentration of hydroxyl groups is highest. The molecular size of sensitive proteins requires that silica has pores of sufficient size to allow the protein to enter and adsorb to the surface through hydrogen bonding with the hydroxyl groups. Figure 3 shows that optimum protein adsorption is attained with silicas having maximum surface area in pores in the range 3–12 nm (30–120 Angstroms). Adsorption follows a Type I adsorption isotherm, indicating monolayer coverage.

The solids content of the silica, the particle size and number of accessible hydroxyl groups determine adsorption capacity. Thus on a gram for gram basis, for a given pore structure silica xerogels provide greater protein adsorption than either semi-hydrogels or hydrogels.

Another important property of silica gels is their permeability, or

Figure 1 top. Amino acid composition of haze and foam protein and the proline structure (Asano, 1982).

Figure 2 above. Silica gel structure (Matsuzawa and Nagashima, 1990).

● The author

Sonya Broderick was recently appointed Applications Leader for INEOS Silica's global beverages business, her responsibilities include management of technical service to brewing customers and the design and implementation of projects to optimise customer's stabilisation requirements. To learn more about the use of silica based stabilisation agents call John Leake on +44 (0) 1925 416000 or john.leake@ineossilicas.com www.ineossilicas.com

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Table 1. Permeability controlled silica gels

	Hydrogel	Xerogel 1	Xerogel 2	Xerogel 3
Average particle size (microns)	18	12	12	12
Permeability (D'Arcy)	0.15	0.12	0.04	0.002

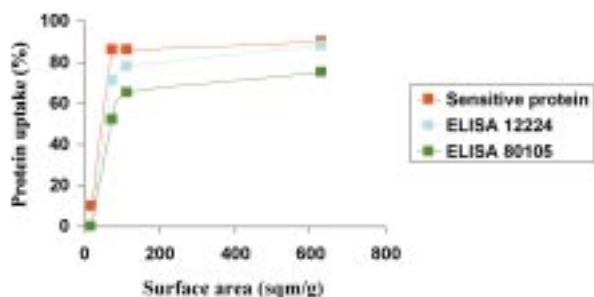


Figure 3 above. Protein adsorption versus silica surface area in the 40-120 Angstrom pore size range

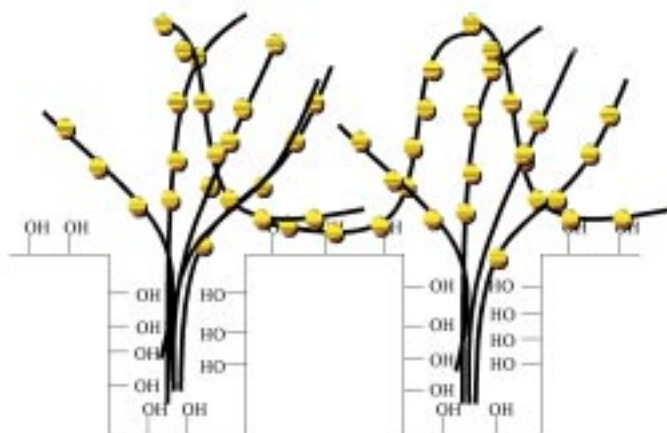
Figure 4 above right. Schematic of PVP-coated silica showing carbonyl adsorption sites as yellow markers.

PVP-coated silica gel and tannoids adsorption

Polyvinylpyrrolidone (PVP) is a water soluble polymer that is made insoluble in beer either by attachment to an amorphous silica carrier, Figure 4, or through cross-linking to form polyvinyl (poly) pyrrolidone (PVPP).

PVP interacts with tannoids through hydrogen bond formation between the vinyl carbonyl group and the polyphenol hydroxyl groups. The number of accessible carbonyl adsorption sites on the PVP dictates polyphenol adsorption capacity, while selectivity for haze-active polyphenols is determined by competitive adsorption. Thus polyphenols having high numbers of hydroxyls adsorb most readily and most strongly.

PVP-coated silica has fewer



hydroxyl adsorption sites than PVPP and is thus effective in adsorbing only the most haze-active polyphenols. Because both PVPP and PVP-coated silica use the same type of polymer, they essentially adsorb the same haze-active polyphenols.

Application to the brewing process

To assure colloidal stability, it is not necessary to remove all of the sensitive proteins or tannoids. Identification of a tolerable level of these can be used to define a beer composition at packaging delivers satisfactory haze stability. Concentration of either of the haze precursors can therefore be high in beer as long as the other is low, Figure 5. Consequently stabilisation costs per hectolitre can be balanced by using appropriate combinations of stabilisers to remove sensitive proteins or tannoids.

All of the products discussed can be used either in maturation or at the filter. The selection of product and application point is influenced by the brewery's powder handling systems and process set-up.

The difference in density between silica xerogels, semi-hydrogels and hydrogels in turn affects the rate of settlement of the powders in liquid. Thus, when added to the maturation vessel hydrogels will settle, in accordance with Stoke's law, more rapidly and cleanly than xerogels despite the latter becoming hydrated when added to beer or water. Hydrogels added to the maturation vessel settle rapidly to form compact sediment. Protein adsorption rate is quite high and adsorption capacity is reached in less than 24 hours (Figure 6) so that when maturation is employed to remove chill haze, maturation times

can be reduced. Thus brewing capacity is effectively increased without capital expenditure.

Typical dosing rates for silica hydrogels to assure stability lie in the range from about 50g/hl to 150g/hl, dependent upon the required shelf life requirements, beer quality and the use or otherwise of other stabilising aids.

The low density of xerogels does not however exclude their application at maturation. These can provide more rapid, and greater, protein adsorption than hydrogels and might serve to further reduce maturation time. Xerogel does however have a lower settling rate than hydrogel so that a proportion may carryover during transfer to filtration where it would be removed together with other beer solids.

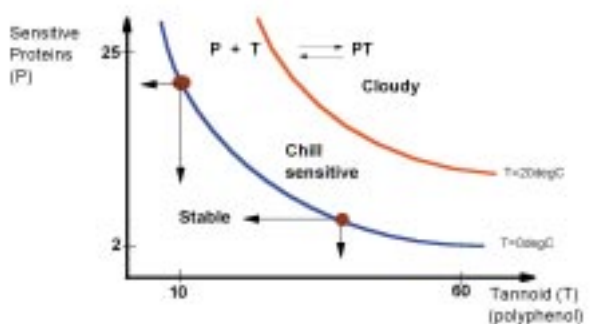
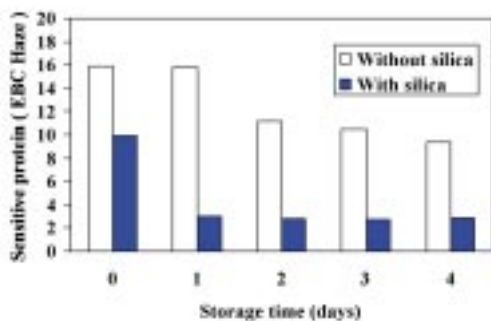
Stabilising beer at the filtration stage can increase process flexibility. The decision concerning stabilisation of a particular brand can be taken at this last stage of the process to coincide with packaging and sales demand.

Engineering narrow particle size distributions produces controlled permeability silica xerogels and hydrogels. Maintaining a small particle size provides for fast protein adsorption and substitution of lower permeability silica gels can extend filter run length and reduce filter aid demand, Figure 7 (page 22).

When applied at the filter, silica gel retains adsorption capacity for a prolonged period so that it actively removes protein across the filter run. Thus to maximise flexibility the dosing of silica can be reduced as filtration proceeds. This reduces the silica demand and the solids loading on the filter and makes the stabilisation process more cost effective.

Figure 5 below. Colloidal stability diagram.

Figure 6 bottom. Protein adsorption during maturation.



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T: +44 (0)1925 416100 F: +44 (0)1925 416116
- **INEOS Silicas Americas** 111 Ingalls Avenue, Joliet, IL 60435, USA
T: +1 815 727 3851 F: +1 815 727 5312
- **INEOS Silicas Asia Pacific Pte Ltd** No 3 Shenton Way, #15-08 Shenton House, Singapore 068805
T: +65 6325 0998 F: +65 6324 2243
- **INEOS Silicas Brasil Limitada** Rua Censo Strighi 27, 1ª andar c/ 12-Água Branca, 5036-010-São Paulo, SP Brazil
T: +55 (0)11 3613 9900 F: +55 (0)11 3613 9819
- **INEOS Silicas South Africa (Pty) Ltd** 160 Tedstone Road, PO Box 14016, Wadswill 1422, Gauteng, South Africa
T: +27 (0)11 820 7111 F: +27 (0)11 827 8822
- **INEOS Silicas Netherlands BV** Ix, Roccustraat 2B, 6245 AD Eijsden, The Netherlands
T: +31 (0)43 409 9333 F: +31 (0)43 409 4478
German sales representative T: +49 176 233 908 49 E: georg.raibel@ineosilicas.com

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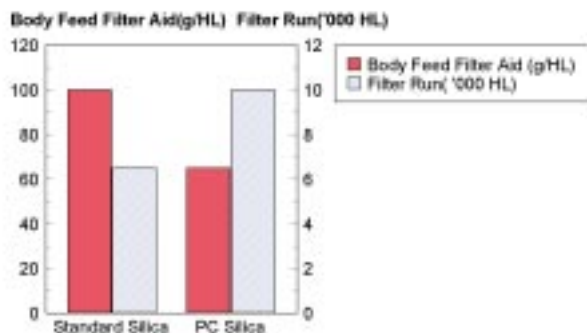


Figure 7. Benefit of permeability controlled (PC) silica gel on filter run length.

Typically xerogels are used from about 15g/hl to about 40g/hl, although there are examples of using these at more than 60g/hl. As with hydrogels the precise loading depends upon a number of influences.

Most often PVP-coated silica and PVPP are applied at the filtration stage, where they can be applied together with silica gel if required. This is because these products are

more expensive than silica gel and are generally used to extend the stability of beer for export. In this way the brewing process can be made more flexible to fit with changing packaging demands as orders are updated. The products are sometimes applied in maturation when particularly 'difficult to stabilise' beers are encountered. Used in combination with silica gel the extended contact time can serve to increase the product's effectiveness. Typical usage rates for these products are in the range 5g/hl to 20g/hl.

Dosing of the stabilisers to beer

The stabilisers are dispersed in cold de-aerated water using a low speed impeller to minimise aeration before dosing to the beer. Silica hydrogels and semi-hydrogels are prepared as a 20% w/v suspension.

Slurry make up time is typically in the order of 20 minutes, although it may be necessary to extend this time to break any lumps that might have formed in the product during transport and storage.

Silica xerogels and PVP-coated silica are prepared as a 10-15% w/v suspension, typically requiring no more than 10 minutes to disperse. Both slurries have low (water) viscosity over a wide range of shear rates. For stabilisation at the filter any of the products can be prepared in the same tank as the body-feed filter aid. If not required for immediate use, a flow of carbon dioxide or nitrogen may be bubbled through the suspension to prevent oxygen ingress. After use, the mixing vessel, pipework and the injection system should be thoroughly flushed to avoid blockages with any residual stabiliser or filter aid. ■

The use of clarification aids

"Carrageenan is the clarification aid of choice for clarifying wort. It is used throughout the brewing world and also extensively in the food industry as a thickening, stabilising and gelling agent."

At the end of primary fermentation beer contains large quantities of yeast and suspended protein/polyphenol particles. The techniques used to remove these are filtration, centrifugation and, for traditional cask ale, sedimentation under gravity.

By **Brian Evans**
A B Vickers

Clarification aids are used to assist in the removal of these suspended solids by the process of flocculation. As a result the brewer benefits from improvements in filtration or centrifugation, or in the case of cask ale, sedimentation speed.

Stoke's Law is helpful in understanding the action of clarification aids. It defines the rate at which a sphere (yeast or protein particle) falls through a liquid (beer or wort).

Simplified, the factors that result in the fastest rate of sedimentation are large particle size and

Stoke's Law:

$$v = \frac{2(\rho_s - \rho_l) \cdot r^2 \cdot g}{9\mu}$$

Where,

v = rate of sedimentation of a particle

ρ_s = density of the particle

ρ_l = the density of the liquid

r = the particle radius

g = acceleration due to gravity

μ = viscosity of the liquid

gravitational force, low liquid viscosity and low relative density. The point to note is that only two factors are of practical significance in the brewing process – particle size and gravitational force.

Clarification, in the context of the article, means increasing the rate of sedimentation. Stoke's Law demonstrates that this can be achieved by the use of agents that increase particle size – clarification aids, or gravitational force – the centrifuge.

The clarification aids in common use can be divided into carrageenan, for wort, and isinglass and auxiliary finings, for beer.

Carrageenan

Carrageenan is the clarification aid of choice for clarifying wort. It is used throughout the brewing world and also extensively in the food industry as a thickening, stabilising and gelling agent.

Carrageenan is a high molecular weight polysaccharide made from repeating units of galactose and anhydro-galactose, either sulphated or unsulphated (fig.1). About 25,000 of these units are linked in a linear form to produce a biopolymer.

Three isomers are present, *lambda*, *iota* and *kappa* – the latter being active in the role of clarification. Key to its performance in both the brewing and broader food application, is the ability of this isomer to form gels.

Carrageenan is produced from red seaweeds, *Rhodophyceae*. This is collected and dried, and then undergoes a sequence of alkali washing and rinsing which both cleans the weed and also increases

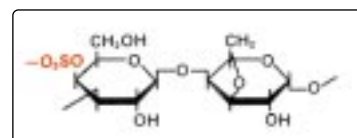


Fig.1 Structure of kappa carrageenan.

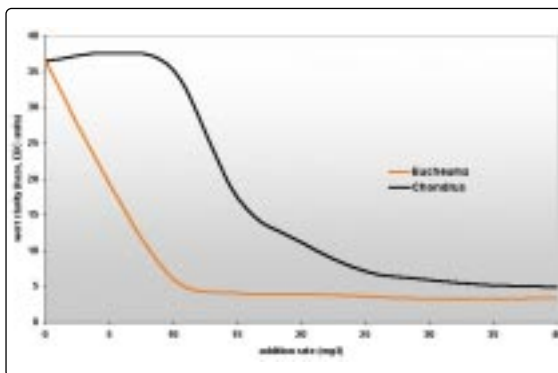
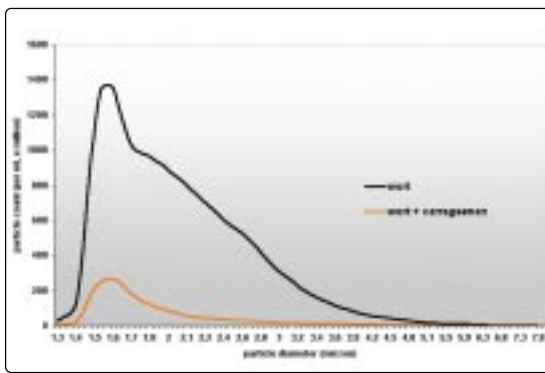


Fig.2 far left
Performance
comparison of
carrageenan from
Chondrus crispus and
Euchema Cottonii.

Fig.3. Particle size
analysis showing the
effect of carrageenan on
the removal of
proteinaceous particles
The benefits of this clear
wort are seen in easier
beer filtration and
improved cask ale
clarity.

the ability to form gels.

Brewers originally used unprocessed seaweed of the species *Chondrus crispus* (Irish Moss) to good effect. However, the developing interest in products for use in the food industry resulted in the establishment of species high in the kappa isomer. *Euchema Cottonii* is now the main species. It is farmed commercially, mostly in the shallow, warm waters of Indonesia. Its role as the most cost effective method of wort clarification is undisputed (fig.2)

The use of carrageenans

When added to boiling wort, kappa carrageenan reacts strongly with soluble proteins, notably the proline-rich haze precursor fraction. Direct reaction between soluble proteins and carrageenan, particulate proteins and carrageenan, and perhaps both, occurs. However, only when the treated wort is cooled does the carrageenan-protein complex precipitate out of solution. This feature is important when trying to understand the action of carrageenan. It is the tendency of

carrageenan to form strong gels when cold, aided by the presence of K^+ and Ca^{2+} ions, that underpins the clarification action.

The result of using carrageenan is a clear wort, with reduced concentration of proteinaceous particles (fig. 3)

Carrageenan is added to the kettle, preferably just before the end of the boiling stage. Sufficient time is needed for dispersal and dissolving, and a '10 minutes rule' has been adopted as the norm. Carrageenan is supplied in three



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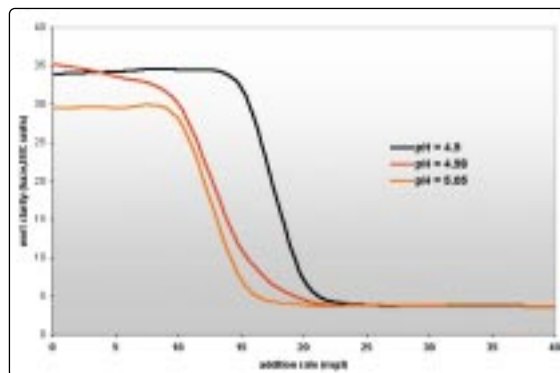
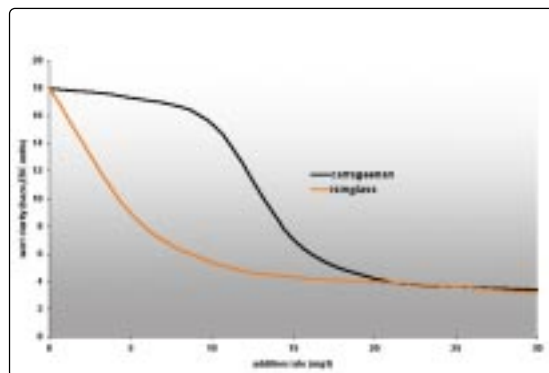
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Fig. 4 right. Effect of wort pH on carrageenan activity.

Fig. 5 far right. Effect of isinglass on the removal of wort proteins, compared with carrageenan.



forms – powder, dust free granules, and tablets. Each form has its advantages and adherents. Powders can be suspended as a slurry in cold water and automatically dosed via metering devices. Granules can be added manually, or via pneumatic systems. The tableted form of carrageenan has the benefit of containing a dispersant. It can therefore be added later in the process, directly into the wort receiver or whirlpool.

Carrageenan treatment rates

The correct treatment rate varies from wort to wort, but is typically in the range 1–3 g/hl. Certain factors impact on the function of carrageenan, for example grist make-up, malt quality, brewing liquor treatment, and wort pH (fig.4). It is good practice to identify the ideal addition rate using a simple optimisation test, and repeating this after any major raw material or process change.

Isinglass finings

Isinglass is arguably the processing aid with the longest history of use in brewing. Of the clarification aids it is most probably the most studied, and in terms of understanding how it works, perhaps the least understood. It has been used for cask ale clarification in the UK for at least 300 years. Its ability to remove not only yeast but proteinaceous particles has meant that it also finds application as a pre-filter treatment, and is regularly used in conjunction with centrifugation. Isinglass is obtained from the swim bladders of tropical and sub-tropical fish. This provides the industry with an extremely pure source of collagen.

Isinglass collagen is a fibrous protein which occurs in a rigid, rod-like triple helical structure – a biopolymer. It has a characteristically high proportion of hydroxyproline in its makeup. This

The first processing aid

Collagen from Russian sturgeon had been the traditional source of isinglass for brewing. An eight fold increase in price in the late 18th century encouraged chemist and inventor William Murdoch to develop local sources. For 15 years these were used by British brewers until, in 1809, their authenticity as a beer ingredient was challenged in court by Customs and Excise. Murdoch won the case. Amongst his arguments were that although it was added to beer, his isinglass was removed during clarification and was, therefore, not an ingredient.

imino acid initiates hydrogen bonding within the molecule, which is important in maintaining the helical structure. More importantly for the brewer, it is these bonds that endow the molecule with its clarification properties. The interaction between suspended beer solids and isinglass is complex and not fully understood. The accepted theory is that when it is

dissolved and added to beer the collagen molecule attains both positively and negatively charged sites. The overall charge is positive, and because of this it becomes attached to negatively charged yeast cells. Reaction with proteins is thought to be as a result of co-precipitation with this yeast-collagen complex. The deficiencies of this simple explanation are exposed by the observation that isinglass is a powerful clarifier of cold wort. (Fig 5) Clearly there are no yeast cells present to initiate clarification, and the pH is significantly different to that found of beer.

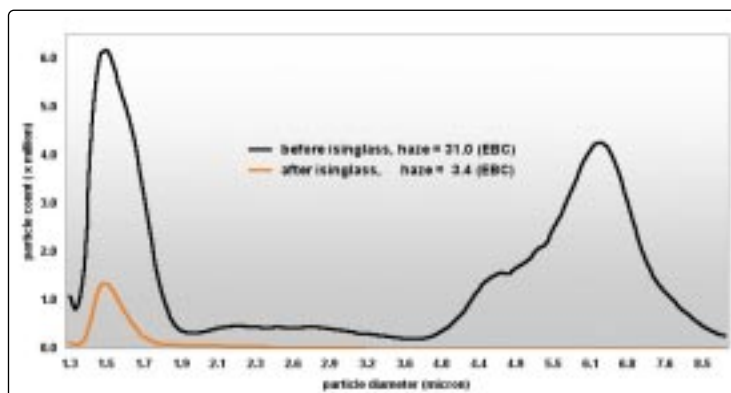
Recent work has shown that the helical structure is more important in the action of isinglass than is its overall positive charge.

Whatever the mechanism, isinglass can flocculate and sediment yeast cells, protein particles, or both, to an extraordinary degree. When added at a typical rate of 15 mg/l (dry weight) it is able to remove greater than 95% of suspended yeast cells and greater than 90 % of protein particles of haze forming size. (Fig 6) It has been calculated that this equates to removing around 30 times its own dry weight of suspended solids.

Using isinglass

Traditionally used as a clarification

Fig. 6 right.. Particle size analysis of beer with and without the addition of isinglass.



Auxiliary finings and isinglass are antagonistic and must not be mixed prior to addition to beer. The actual reaction time between auxiliary finings and protein particles is small and only a minimal time need be allowed before isinglass is added.

aid for cask ales, isinglass is now increasingly used as a pre-treatment for filtered beers. In either application it is added at the end of fermentation. It is regularly added to the beer stream after centrifugation. Here, its ability to remove small protein particles that may have passed through the centrifuge is utilised.

Isinglass must be added via an acidified solution. In this form it is viscous and needs thorough and immediate mixing after addition to beer. Maximum effect can be gained if it is added continuously in-line to the beer stream. Addition rates vary from one beer to another, and are best determined empirically. Typical rates for cask ales are in the range 3–6 g/hl, and for filtered beers 1–3 g/hl.

Isinglass is available in three main forms. The choice of which to use is dictated by the fact that the collagen molecule needs to be dissolved in acidic solution before use, and in this state is unstable at temperatures above 15°C. Ready to use liquids are ideal where there is a local supply and where usage dictates short stock holding, or where there is availability of cold storage. In all other situations finely milled powders or pre-hydrated, temperature stable pastes are more suited.

Auxiliary Finings

As the name suggests, auxiliary finings are used in conjunction with, and in support of, another clarification agent – isinglass. They were developed to help produce cask ale that had fast settlement times and a high degree of clarity.

As with carrageenan and isinglass their action relies on their polymer structure. They are supplied as acidified solutions of silicate, polysaccharide, or combinations of both. The silicate based products make up the majority of a wide range of products and the remaining section will concentrate on them.

The silicate auxiliaries are a family of dilute silicic acid solutions

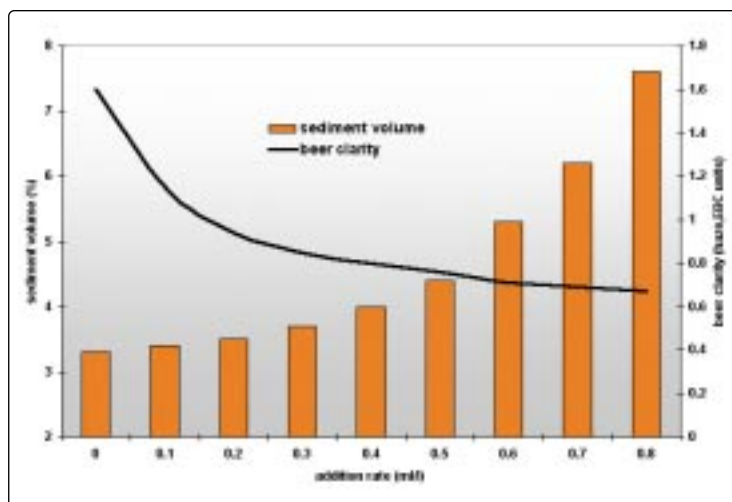


Fig. 7. The effect of auxiliary finings on beer clarity and sediment volume when added prior to isinglass finings.

which carry a strong net negative charge. As with isinglass, the mechanism is little understood. It is undoubtedly an over-simplification to state their action is based solely on the attraction to positively charged proteins. Clues can be gained, however, from observations made when silicate auxiliaries are added to beer:

- At low addition rates they show limited flocculation and sedimentation. Beer haze is often increased. Any solids removed are predominantly proteinaceous.
- At increased rates the degree of flocculation and sedimentation increases, some improvement in haze is observed.
- At these higher rates the sediment becomes bulky.
- At very high rates excellent clarity can be achieved as a result of the removal of yeast as well as protein particles.
- At these rates the flocculated solids hardly settle, forming a loose and very voluminous matrix.
- Isinglass works better in beers treated with low rates of auxiliary finings.
- The speed of flocculation, and settlement speed in beers treated with this combination of finings is significantly enhanced.

The action of silicate based finings can be thought of as being based on electrostatic attractions, enhanced by the tendency for the silicic acid unit to form gels in beer.

The overall net negative charge renders the silicate-protein complex attractive to isinglass. These excess charges may, however, at high addition rates cause repulsive forces to come into play, resulting in poorly formed sediments. Whatever the mechanism behind their action they certainly give extra clarity to beer when used in conjunction with isinglass, along with much faster rates of sedimentation.

Auxiliary finings and isinglass are antagonistic and must not be mixed prior to addition to beer. The actual reaction time between auxiliary finings and protein particles is small and only a minimal time need be allowed before isinglass is added. In practice this interval is anything between minutes and many hours.

Because of the great variety of auxiliary products on the market it is not possible to give a typical addition rate. These have to be ascertained empirically. Attention should be given to establishing a balance between a rate that is sufficient to achieve the desired clarity, but not so great as to cause unduly bulky sediment volumes.(fig. 7) ■

“Attention should be given to establishing a balance between a rate that is sufficient to achieve the desired clarity, but not so great as to cause unduly bulky sediment volumes.”

● To learn more about the use of finings agents call Brent Jordan on +44 (0) 1283 563268 or brent.jordan@lallamand.com www.lallamand.com

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Gallotannins in the brewery

Gallotannins are natural polyphenols, they were one of the first agents used in beer stabilisation. They were introduced to the scientific and practical brewing world by Prof. Jean de Clerck just after the Second World War. Tannic acid, the day-to-day name for gallotannins, is used in most brewery laboratories to determine sensitive proteins in Lundin fraction assays. In the 1960s tannic acid was introduced by a large brewery in the States and another in the Netherlands for protein stabilisation.

"Gallotannins, pre-dissolved in water, may be added in the brewing water or proportionally injected at the mixing point of the water and the grist. Further addition may be made to the sparge water."

By **Roger A. Mussche**
Belgian Fine Technology International

Today, gallotannins are selected on a tighter molecular weight basis and so different grades of tannic acid can be applied at several stages of the brewing process, up-stream at mashing, in the kettle as well as down-stream. Their functionality is unique and multi-functional including metal-chelating, aldehyde-binding, LOX-management, they have a reducing and radical scavenging effect in

addition to a protein-flocculation aid and thus a colloidal stabiliser on the protein-side.

Gallotannins

Gallotannins are extracted from gallnuts (Chinese or Aleppo), sumac leaves, tara (*Caesalpinia spinosa*) and teri pods (*Caesalpinia digyna*) or even from cell culture. They all have a polygalloylstructure on a central molecule like glucose.

The extraction of the ground and pelletised raw material is done with solvents including ethyl acetate which is particularly selective for

the gallotannins. The most difficult part of gallotannin production is the fractionation to yield the correct molecular weight for match the point of addition in the brewery. The crude extract is a mixture of molecular weights from 180 to over 2500 daltons (near the solubility limits). In general the molecular weight should increase as the gallotannin is used later in the brewing process.

At mashing-in

Specific molecular weight gallotannins, (SMW.TA) such as Beerotan Q (as supplied by BFTI) can be used up-stream in the brewing process. Gallotannins, pre-dissolved in water, may be added in the brewing water or proportionally injected at the mixing point of the water and the grist. Further addition may be made to the sparge water.

Figure 1 describes the advantages for the flavour stability and colloidal stability. The tannin-protein interaction is given in the

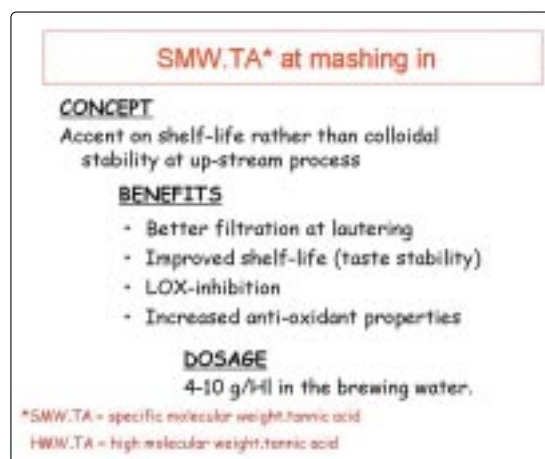
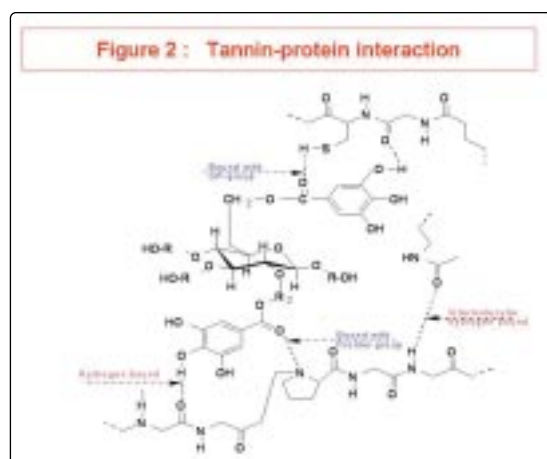
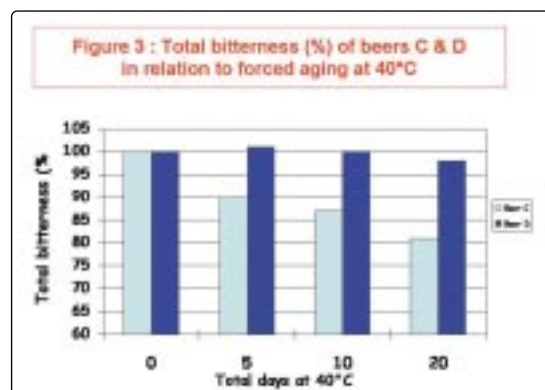
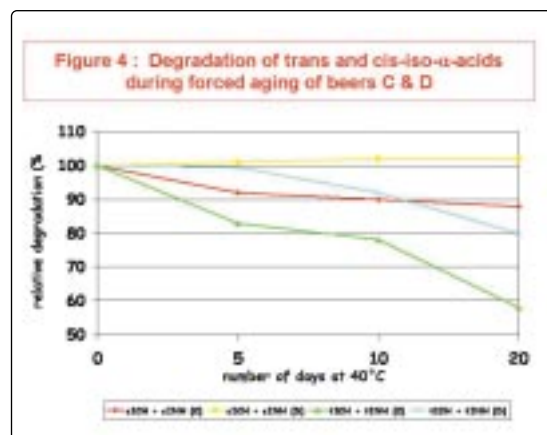


Figure 1.



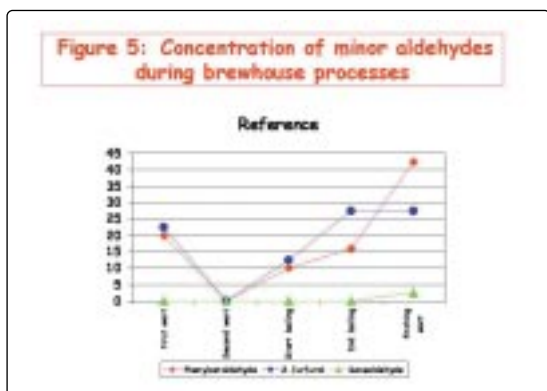


Figure 5a.



Figure 5b.

mechanism figure 2.

The impact of an early gallotannin addition on beer ageing and more specifically, on iso- α -acids degradation, is unequivocally positive as seen in Figures 3 and 4 which shows the decay of total bitterness and the degradation of various iso- α -acid isomers.

In the figures, beer C corresponds to the control beer without gallotannin dosage, whereas beer D was prepared with addition of gallotannins to the brewing and sparging liquor (10g/hl and 5g/hl, respectively). Both brewing trials were performed under comparable conditions (mashing-in at 62° C and pH 5.7).

Furthermore, it is remarkable that the addition of gallotannins results in a significantly lower amount of phenylacetaldehyde, furfural and benzaldehyde. Apparently, gallotannins can inhibit the *de novo* formation of these aldehydes during wort production (see Fig. 5a and 5b).

In support of the analytical results, flavour assessment of the gallotannin treated beers was pronounced better after forcing storage at 40°C

Gallotannins at wort boiling and in the whirlpool

Tannic acid at specific molecular weight (SMW.TA) added at a rate of 2 to 6 g / hl during wort boiling, is an easy tool to produce a pre-stabilised beer (Figure 6). The gallotannins are reacting with sensitive proteins and metals to form a more solid cone in the whirlpool. Furthermore, its addition is a very useful aid to shorten maturation time and to reduce the precipitate formed during maturation. When added at the end of wort boiling in the right dosage, it

can also result in longer filter runs.

Similar results are obtained by addition of SMW.TA at transfer to the whirlpool. Table 1 (below) shows that the use of SMW.TA in the copper gives approximately 50 % of the stabilisation using HMW.TA in maturation.

Gallotannins at filtration

The most economical and easy way to apply gallotannins is the addition of HMW.TA to the beer into the filter where it gives good performance for precipitate capacity

Table 1 : Stability results of gallotannin addition at wort boiling (EBC turbidity units)

Beer	Without treatment	Stabilisation in the copper		Stabilisation at maturation	
		SMW.TA		HMW.TA	
		6 g/hl	8 g/hl	6 g/hl	8 g/hl
1	43.9	34.4	31.0	24.1	17.8
2	49.4	37.1	34.1	26.0	18.9
3	23.7	45.8	44.2	34.1	27.9
4	74.5	59.3	53.7	43.6	34.1
5	47.4	38.8	35.3	29.1	21.9

This shows that the use of SMW.TA in the copper gives approximately 50 % of the stabilisation using HMW.TA in maturation.

SMW.TA : Specific molecular weight tannic acid as Bacteran Q
HMW.TA : High molecular weight tannic acid as Bacteran P, S

SMW.TA at boiling

CONCEPT

- Very easy stabilisation (of the protein components) without investment
- Complementary to PVPP
- Brings the impact of stabilisation forward in the process

BENEFITS

- Increased yield in the whirlpool
- Improved colloidal stability
- Increased anti-oxidant power (expressed in ITT)
- Shorter maturation time, less CT bottoms
- Longer filter runs

HMW.TA at filtration

CONCEPT

- Easy-to-use, in-line system

BENEFITS

- The most economical solution (combination of HMW.TA & perlite)
- Complete taste and colloidal stability
- Environmentally friendly solution

DOSAGE

1-2 g/hl proportionally dosed during filtration

A word about proteases

Various peptidases have long presented a cheap opportunity to prevent chill haze in beer. Enzymatic degradation by papain acts by a different mechanism altogether to the options described elsewhere in this feature in that it actually breaks down haze proteins, preventing any polyphenol-protein complexes from becoming sufficiently large to scatter light and thus form visible haze. Papain is a mix of peptidase enzymes extracted from the papaya fruit; this enzyme 'cocktail' has the significant disadvantage of being non-specific, that is it will break-down all proteins, including the foam-positive ones. As the enzyme is not de-activated by usual pasteurisation temperatures (in fact it increases in activity during the process) foam stability will deteriorate over time. Hence, it should be used with care.

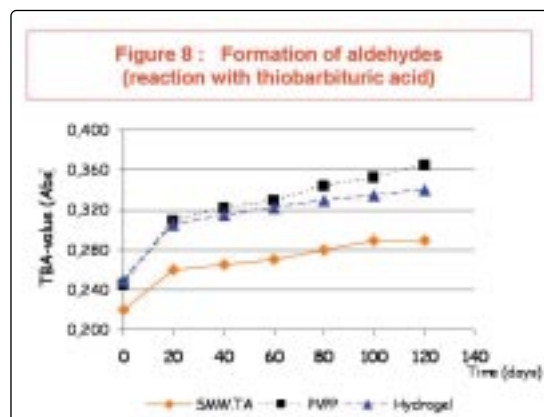
We have seen that the haze sensitive proteins contain significant levels of the amino acid proline in their molecular composition, these originate from the proline rich hordein (alpha gliadin) fraction of malted barley. The pyrrolidine ring makes the protein chain more rigid and adjacent peptide bonds lack a hydrogen on the amide nitrogen thus the carbonyl group preceding the ring is a strong hydrogen bond acceptor and will readily form a bond with the hydroxyl groups on the condensed polyphenols. DSM Food Specialties have launched Brewers Clarex which incorporates a proline specific protease derived from *Aspergillus niger*. Trials over 13 months storage at IFBM in France indicated superior performance against a control brew treated only with PVPP. Flavour and foam were unaffected.

ABOVE: Figure 6.

RIGHT: Figure 7.

Table 2 right.
Fig. 8 far right.

HMW.TA filtration regime	
Beer with low protein content (< 1.0 g/l)	Precoat
	500-1000 g/m ² Diatomaceous earth (D.E.) or perlite: 1 to 1.5 Darcy
	500-1000 g/m ² D.E. : ± 0.1 Darcy
	200-300 g/m ² mixture D.E./Perlite (1:1) : 1 to 1.5 Darcy
Beer with high protein	Bodyfeed
	75-150 g/m ² mixture D.E./Perlite (1:1) : 1 to 1.5 Darcy
	5.5-2 g/m ² HMW.TA
	Precoat
	500-1000 g/m ² D.E. or Perlite: 1 to 1.5 Darcy
	500-1000 g/m ² D.E. : ± 0.1 Darcy
	200-300 g/m ² mixture D.E./Perlite (1:1) : ± 1.0 Darcy
	Bodyfeed
	75-150 g/m ² Perlite: ± 1.5 Darcy
	5.5-2 g/m ² HMW.TA



and clarity. Guidelines for filtration conditions are given by the manufacturer. The benefits of HMW.TA addition before end filtration are summarised in Figure 7.

Table 2 summarises the filter conditions, but tailor-made advice can make the solution even more economical.

How gallotannins react and implications for beer stability

The haze sensitive proteins are generally recognised as the proteins precipitated by gallotannins.

If we can remove the most sensitive group of cationic proteins with an isoelectric point (Ip) of 5.3, we will obtain a "protein-side" stable beer (with a slight increase of the final beer pH by only 0.1 is based on the same principle of cation-stabilisation). Table 3 shows the

fractionation of beer proteins on the basis of their iso electric points, whereas Table 4 demonstrates the effect of HMW.TA on the sensitive proteins, but this is only an example of one study; a combined application of HMW.TA – PVPP is also included.

Gallotannins can also block the chain of aldehydes formation by chelating metals like Fe³⁺ and Cu²⁺. The formation of aldehydes in aging beer is measured with the thio barbituric acid (TBA) agent over intervals of 20 days. The results presented in figure 8 clearly demonstrate the effectiveness of gallotannins with regard to beer flavour stability. In conclusion, gallotannins are, as a bio-product, again in the centre of interest for brewers (specific action, no solid waste, high resistance to staling (RVS), shelf-life supporting, etc).

treatment) was also added 5 minutes before the end of the boil.

The effect of both products is remarkable on the sensitive proteins and the proanthocyanogens. A patented combined product will soon be on the market. The increase of the total polyphenols with ± 20 ppm is mainly associated with the analytical method, in fact the increase is between 3 and 7 ppm.

Some special cases

Combinations of gallotannins

To demonstrate the influence of raw materials and stabilisation methods on different beer parameters a lot of combined work was done. Table 6 shows some representative data obtained by measuring total polyphenols or polyphenolic fractions in two different beers, stabilised with gallotannins, gallotannins + PVPP (combined stabilisation) and PVPP respectively.

It's nice to see that the control brew with the polyphenol free hop extract has half the level of polyphenols as the control brew bittered with hop cones. The hop extract control brew has lower levels of total polyphenols, flavanoids and anthocyanogens than the hop cone brew after any of the treatments in the test

Comparison of different methods

A study was carried out to obtain a calculated comparison between most of the stabilisation methods, based on results with Tannometer – PPT analyser as described by Schneider & Raske. Fig. 9 shows the comparison (based on PPT-analysis) between the different ways of beer stabilisation. Table 7 is the legend to fig. 6.

It is important to note the by-pass operation for CSS and PVPP filter plate systems: the level of stability is

Table 3 : Protein fraction based on iso-electric points (Ip)

	Foam active	Haze active
General Ip	6.5 – 8.5	3.3 – 6.5
Ip adsorbed by silica gel	6.0 – 7.0 / 7.2 – 9.2	4.6 – 5.9 / 6.1 – 6.5
Ip precipitated by tannic acid	7.5 – 8.0	3.3 – 6.5 particularly 5.3

Table 4 : The effect of gallotannins on proteins, sensitive proteins – SASPL - proteins

PROTEINS	2.5 mg / l in EBC	5 mg / l in EBC	10 mg / l in EBC	AS mg / 100 ml
Addition Point HMW.TA (BP, 5)				
In filter 1.5 g/l	2.9 ± 0.2	6.5 ± 0.3	15 ± 0.35	11 ± 1
2 g/l	2.4 ± 0.2	5 ± 0.3	13 ± 0.35	14 ± 1
1.5 g/l; 15 g PVPP SMW.TA (BQ)	2.1 ± 0.2	4.4 ± 0.3	16 ± 0.30	11 ± 1
In lagging 7 g / hl	2.9 ± 0.3	7.0 ± 0.4	15.1 ± 0.4	10.9 ± 0.9

Combination of products

A novel approach is the use of SMW.TA and PVPP at the end of boiling.

The advantage of such a procedure includes the removal of sensitive proteins, the removal of sensitive polyphenols (proanthocyanogens). Both are easily removed at the whirlpool leading to a very clear wort and a faster start to fermentation. There is less sediment during maturation and more effective end filtration.

The addition is carried out at the end of the boiling:

- 5 minutes before the end – SMW.TA (Beerotan Q) is added from a 5 % water solution.
- 3 minutes before the end – PVPP (Polyclar 10) is added from a 5 % water slurry.

Table 5 (over the page) demonstrates the effect of both products. As reference 10 g / hl Daraclar 7500 (Grace Davison SHG

Table 5

	Total Polyphenols (mg/l)	Flavanoids as catechine e.g. (mg / l)	Proantho-cyanogens mg / l	Sensitive Proteins EBC	Cold haze 5 days 40 °C 1 day 0 °C EBC
Control	221	45	44	9.5	6.0
PVPP (15 g / hl)	170	38	38	9.0	5.0
SMW.TA (5 g / hl)	240	46	39	4.0	4.0
PVPP(15)/ SMW.TA (5)	200	37	36	3.5	2.0
Daraclar 7500 (10 g/hl)	220	43	42	9.0	5.0

controlled by gradually reducing the volume of beer going through the by-pass thus stabilising a higher percentage of the throughputs, as the adsorption sites are occupied. However, such systems are controlled from preset calibrations; the problem is how to perform real-time measurement of stabilisation.

Haze-makers

Separate gallotannins, (like Beerotan H) has been specially

developed to produce a stable haze in white beers, at a range of 10 – 20 ppm.

New tannins – a special case

ActiBREW™ is a natural condensed tannin extracted from carefully selected cocoa beans. It leads to a faster brewing process and has a positive effect on the colour and taste of the beer, without leaving any residues. It also improves the lauter-tun performance

with 25 %, increases the reducing power for a better flavour stability and gives an improved mouthfeel to the beer. The dosage rate is 180 mg per kg of grist and is added with the brewing water. This new product is available from BFTI.

In conclusion

Gallotannins are used through the whole process of brewing. As a natural processing aid, gallotannins are used for colloidal stability, shelf-life improvement, better lauter-tun performance, improved end-filtration with trub removal in the up-stream process

The latest generations as super-gallotannins can be applied in the down stream process of brewing without residue. Special analytical methods are developed with enzymes, as tannase and HPLC to evaluate the processing aid residues. ■

Table 6 : Polyphenols evolution of a treated beer (75% malt) with combined stabilizers

Beer 1 : 75 % malt and 100 % hop leaves (Sasaz)
Beer 2 : 75 % malt and 100 % polyphenols free hop extract

Beer	1a	1b	1c ₁	1c ₂	1d	2a	2b	2c ₁	2c ₂	2d
Total polyphenols mg/L	200	195	188	188	145	101	100	98	94	87
Flavonoids mg/L	40.4	38.1	37.9	36.2	37.5	22.5	22.0	21.0	20.0	17.5
Anthocyanogens mg/L	70.2	65.1	69.5	69.5	59.0	36.5	34.7	32.0	31.5	22.4

a : Control beer
b : 4 g / hl HMW TA to maturation tank + HMW TA to filter (2:2)
c₁ : 3 g / hl HMW TA to filter / 10 g / hl PVPP
c₂ : 6 g / hl HMW TA to mat'n tank and filter (4:2) / 10 g / hl PVPP
d : 40 g / hl PVPP

Table 7 : Legend to figure 9

Type of stabilisation	P40/T125 FIGURES	g/hl	Point of Addition
Polyclar 730	60/50	60 g	Filter
Polyclar 640	50/65	60 g	Filter
Divergen F	10/95	40 g	Filter
Divergen F – Silicasol 30 g / 20 g	40/75	50 g	Filter/Maturation
HMW.TA / PVPP 4 g / 35 g	95/80	40 g	Boiling: 2 g Filter : 2g + 35 g
HMW.TA 6 g	40/20	6 g	Boiling
Brewbrite 15 g	22/90	15 g	Boiling
CSS 60 g Handmann agarose filter	50/90	60	In CSS-Filter
Untreated	20/12		Just cooling

Note : 20/20 > unstable beer
50/50 > stable beer
80/80 > highly stable beer

Note:

-Polyclar 730 is a blend of 70 parts of Xerogel and 30 parts of PVPP

-Brewbrite is a mix of carrageenan and PVPP



● To find out more about the use of gallotannins in the brewing process, contact Roger Mussche at Belgian Fine Technology International
Leenstraat 8, 9070 Heusden Belgium
Tel: +32 (0)9230 3533
Fax: +32 (0)9231 8941
e-mail: info@bftico.com



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There are four different formulations to suit your addition point

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