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BETTER BREWING *with* PROCESS AIDS

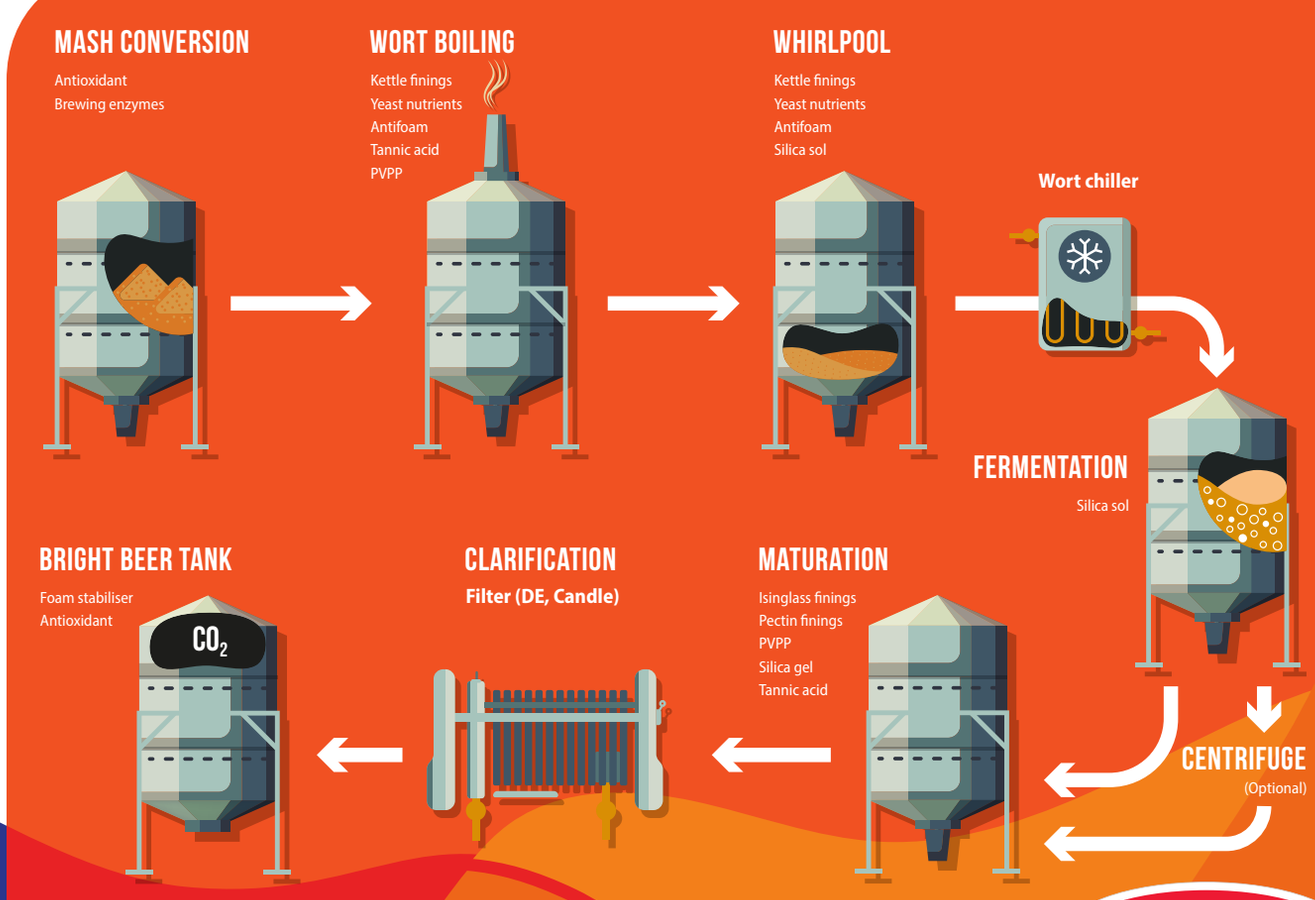
The first beers are thought to have been discovered by accident thousands of years ago. Grain became wet allowing the seed to germinate and produce amylolytic enzymes. These enzymes broke down the starch in the grain into simple sugars that were fermented by wild yeasts, and so beer was born.

The brewing process has evolved a great deal since then. We've traded ancient clay pots for stainless steel tanks with temperature control. Ingredients have also evolved. Clean water is easy to access. Modern malts have consistent levels of enzymes and proteins and are manipulated to produce a range of flavors. Hops are bred to have wildly diverse aromas and levels of bitterness. Yeast labs produce a variety of high purity strains to ferment different beer styles.

In addition to water, malt, hops and yeast, some brewers choose to make other additions throughout the process. Yeast nutrients boost fermentation performance and enzymes may be added to improve brewing efficiency, flavor or beer stability.

Process aids are also popular additions to beer as they can increase efficiency, reduce waste and improve the overall quality and profitability of the product. There are different types of process aids including finings, antifoam and stabilizers that can be used throughout the brewing process from brewhouse right through to maturation and storage (Figure 1).

FIGURE 1: Overview of brewing process and addition points for different types of brewing process aids.



LALLEMAND

FININGS

Beer haze can result from a combination of many factors including protein levels, presence of polyphenols and yeast strain. These haze factors will be removed to some degree during the brewing process by precipitation of proteins as trub in the kettle and flocculation of yeast in the fermentation and maturation tanks. But these processes can be slow and inefficient. The addition of finings to the kettle or during maturation can improve beer haze, reduce maturation times, increase yields and increase filtration efficiency.

Kettle Finings

Irish moss is several species of seaweed rich in carrageenan that have been historically used in the brewing industry for clarifying wort. **Carrageenan** is a high molecular weight polysaccharide which exists in three isomers with only the kappa and iota isomers having an increased capacity to adsorb proteins and clarify wort. The red seaweeds *Eucheuma cottonii* have almost pure forms of the kappa and iota isomers which are extracted, dried, and then processed in alkali to clean as well as increase its ability to form gels.

Carrageenan is added to the kettle at the end of the boil where it forms a random coil and reacts strongly with soluble proteins. Once cooled, the k-carrageenan adopts a more helical formation and the carrageenan-protein complex forms a gel which precipitates out of solution, removing their ability to later combine with polyphenols and cause a haze. Carrageenan can also improve hot trub compaction in the whirlpool which reduces waste and improves filtration efficiency.

Carrageenan is supplied in a powdered, granular, or tableted form, each with their own advantage.

Carrageenan tablets are easier to use and produce consistent results, which can be useful for smaller brewers. The tablet form normally contains a dispersant like sodium bicarbonate which ensures faster dispersal allowing for later addition in the kettle or whirlpool.

Carrageenan granules are a highly pure form that do not contain a dispersant. The higher purity allows for lower dose rates compared to other forms. Their granular form does not form aerosols making them less hazardous to use. However, dose rates need to be measured out each time for addition to the kettle 10 minutes before the end of boil.

Carrageenan powder must be rehydrated in cold water to form a slurry prior to addition, which facilitates automated dosing via measuring devices. Rehydrated carrageenan powder is added 5 minutes before the end of boil or during wort transfer to the whirlpool.

The dose rate of carrageenan is affected by pH and protein levels. Successful fining is achieved within a narrow pH range of 5.0-5.3. Higher dose rates are required at lower pH and worts with a pH < 4.5 will fail to fine. Protein levels can vary with the barley variety, harvest season, malt variety and quality as well as the vigor and length of the wort boil which affects the coagulation of proteins. Higher levels of protein in the wort will require higher dose rates for efficient fining. The optimal dose rate should be identified by carrying out a lab scale fining optimisation test, which should be repeated after any raw material or process change.

Beer Finings

Beer fining agents facilitate clarification by significantly increasing the speed of sedimentation of particles in beer. They do this by binding to haze causing particles and increasing their size resulting in proportionally faster sedimentation. The mechanism with which the beer fining agents attach to the particles is not a simple process and its success is dependent on a variety of factors including the type and format of the beer fining agent. Beer finings have the added advantage of decreasing energy use by significantly reducing maturation times; saving on the refrigeration used as well as improving turnaround of the vessel.

Isinglass is a beer fining agent with a long history intertwined with the UK cask ale industry and has an unsurpassed ability to produce a compact sediment and excellent beer clarity. It can remove both yeast and protein particles and is often used as pre-treatment prior to filtration or centrifugation.

Isinglass is composed of collagen, which is extracted from the swim bladders of fish. The specific amino acid sequence and structure of collagen varies between different fish species. Isinglass from different sources will vary in fining ability, thermal stability and viscosity.

The mechanism by which isinglass works is not fully understood, but the generally accepted model is that it develops a positive charge which it uses to attract negatively charged yeast particles to form a neutral precipitate. Isinglass is acidified to induce this positive charge before adding to the beer by dosing inline to ensure maximum mixing and contact with the beer.

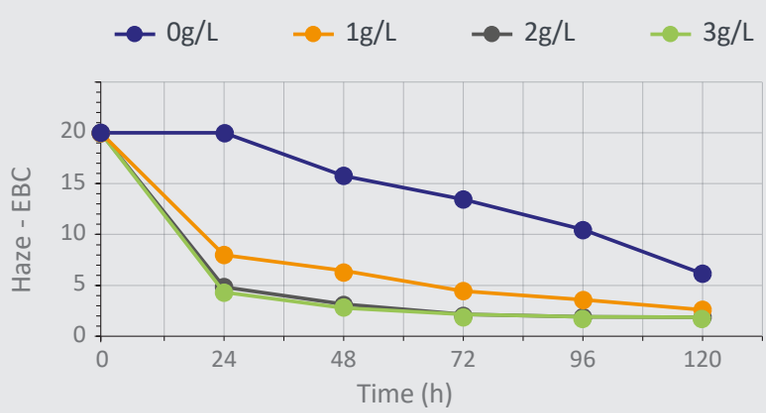
Isinglass is available in three main forms:

- *Ready for use (RFU) isinglass* comes pre-dissolved in acidic solution ready to be dosed directly into beer. This form is the most unstable at temperatures above 15°C and is normally reserved for local supply.
- *Isinglass paste* must be dissolved in food grade acid solution (sold separately) to activate it prior to use. In this form the isinglass is much more temperature stable and tolerant to conditions during shipping and transportation.
- *Dried/Powdered isinglass* is the most stable form with the highest temperature tolerance and the longest shelf life. The dried form requires mixing equipment to rehydrate and dissolve into a solution ready for dosing into beer. It is sometimes packaged with food grade acid for activation and a dispersal agent for ease of mixing.

Auxiliary finings are traditionally used for the production of cask beer in conjunction with isinglass to promote faster flocculation and improved clarity than isinglass alone. For this reason, it is mainly used in the UK market.

Silica acid sols are produced from a solution of carefully selected sands, water and soda called water glass. They are similar in composition to the silica gels used for beer stabilisation but produced to different specifications. They work by cross linking between particles and forming a hydrogel in wort and beer, adsorbing the protein and yeast particles as they sediment. They have become popular with vegan brewers because of their inorganic nature but also because of the good clarity and rapid sedimentation of yeast and protein particles. However, their dose rate needs to be balanced as higher dose rates can lead to bulky sediment which in turn contributes to process loss. Silica sols are available in liquid form for dosing directly into beer.

FIGURE 2: Effect of Isinglass rate on haze reduction



Pectin Finings are used widely in the food industry and can also be applied in brewing to improve clarification and processing times of bright beer post fermentation. Pectin is a natural polysaccharide extracted from citrus fruits and apples, and as such it is suitable for vegan production. The fining activity of pectin occurs by interaction with calcium ions to forms a 3-dimensional structure which then traps proteins and yeast particles (Figure 2). The efficiency of this fining activity is dependent on the degree of esterification as well as the ratio of free calcium to the added pectin.

The performance of pectin finings is also affected by the pH of the beer with an optimal range between pH 4.0-4.3. The interaction between the pectin finings and the haze forming particles is rapid and clarification is normally evident within 2 hours and significantly improved sediment compaction is achieved within 24 hours.

Pectin finings are available in two forms:

- *Ready for use (RFU) liquid pectin finings* can be dosed directly into the beer. However, this product is relatively unstable with a short shelf life and maximum temperature of 20°C, so it is restricted to local supply.
- *Powdered pectin finings* are more stable with a longer shelf life and wider distribution. It must be prepared in a deaerated solution before being dosed into beer.

Sediment volumes tend to be bulky at high dose rates, so benchtop optimisation is advised to confirm the optimum dose rates.

STABILIZERS

After packaging, beer may tend to form haze through the interaction of polyphenols with haze causing proteins rich in the amino acid proline. The time required for proteins to bind and for the resulting haze to become visible determines the shelf life of the beer. **Beer stabilizers** are employed to inhibit this process by disabling or breaking down these components to prevent haze. The result is better flavor and visual stability and an increased shelf life.

Silica gels are chemically inert beer stabilizers which remove haze causing proteins. They have a small particle size but a large surface area due to their highly porous nature. Hydroxyl groups concentrated on the surface and in the pores of the silica gel interact with the proline element of haze causing proteins, resulting in their adsorption and removal from the beer.

Silica gels are classified into two forms according to their water content:

- *Xerogels* contain 25% water, have lower density and require special equipment to manage dust produced during use. They are more expensive, but require lower dose rates.
- *Hydrogels* contain 60% water and are free from dust and easier to use.

Silica gels are applied during maturation or combined with a filter aid such as diatameous earth (DE) or perlite and dosed into the beer flow before the filter. There are specific silica gels with a tighter particle size range optimized for crossflow filtration.

PVPP (polyvinylpolypyrrolidone) stabilizes beer by adsorbing polyphenols derived from malt and hops that are responsible for haze development. The molecular structure of PVPP closely resembles that of the amino acid proline which enables binding to polyphenols.

There are two main types of PVPP:

- *Single use PVPP* is broken down into smaller particles during manufacturing to provide a large surface area over which polyphenols can be rapidly adsorbed.
- *Regenerable PVPP* can be recycled and becomes cost efficient when large volumes are stabilized because of the capital investment and costs associated with PVPP regeneration.

Ideally, PVPP is slurried and dosed into the beer stream enroute to the maturation tank or the filter where it can also be mixed with a filtration aid to improve efficiency and save on capital cost. When used prior to filtration, a rehydration period is required to allow particle swelling to improve efficiency. **It can also be used upstream in the kettle at end of boil, but this reduces its ability to bind polyphenols from hops added post-boil.**

Both PVPP and silica gel have the advantage of being insoluble in water and beer so are completely removed from beer by the filter prior to packaging. As a result, their use is permitted globally and allowed under the German Reinheitsgebot rules.

PVPP and silica gel can be mixed in the same tank before being dosed into beer and indeed there are composite products available which include mixtures of PVPP and xerogel. These have the advantage of convenience as well as effectiveness as both components of colloidal haze are removed.

Tannic Acid

Derived from gallnuts, tannic acid is a naturally derived process aid which binds to and precipitates haze sensitive proteins delivering improved wort filtration and colloidal stability. Tannic acid also blocks the formation of aldehydes responsible for staling which helps protect flavour stability. Addition occurs in the mash to aid wort filtration, or at the end of the boil for stabilisation, so it is not effective for removing haze due to yeast or hops added in the fermenter. However, tannic acid is less efficient and more difficult to remove compared to silica sols, so it is less commonly used.

Enzymes

While not considered process aids since they are not removed from the finished product, enzymes can also be used to stabilize the beer and increase shelf life. Proteolytic enzymes will degrade haze causing proteins thereby preventing their binding to polyphenols. Specific and non-specific proteases are available for different applications. For a more detailed discussion about brewing enzymes, refer to our Better Brewing with Enzymes document.

ANTIFOAM

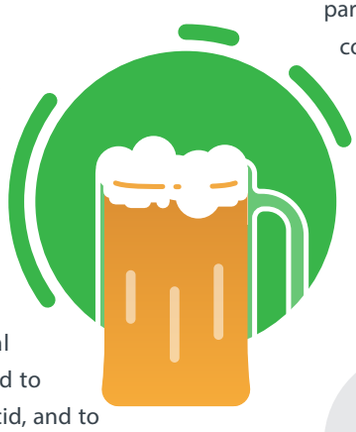
Antifoam is a process aid designed to control the foam produced in either the kettle or the fermenter allowing better utilisation of the vessel, especially when tank capacity is constrained. It is composed of a water-based emulsion of dimethylpolysiloxane, which is an insoluble silicone compound highly effective in foam suppression. Bubble collapse occurs because of reduction of surface tension in the liquid film.

By decreasing foam in the kettle and fermenter, proteins are not lost on the vessel surfaces from over foaming. As a result, foam positive proteins are preserved resulting in a higher quality foam in the packaged product. Antifoam also increases alpha acid utilization since fewer alpha acids are lost on the vessel surfaces.

To ensure efficient dispersal, antifoam is normally dosed inline enroute to the fermenter or added directly to the kettle. Its insoluble nature means that it is removed from the beer at the end of the fermentation by use of a filter.

Beer Foam Stabilizers

Beer foam quality is influenced by certain hydrophobic foam positive proteins. Negative factors such as the presence of external contaminants (i.e. grease or detergents) or lower protein levels resulting from the use of adjuncts will result in lower amounts of foam positive proteins and lower quality foam in the packaged beer. Negative factors such as the presence of external contaminants (i.e. grease or detergents) or lower protein levels resulting from the use of adjuncts will result in lower amounts of foam positive proteins and lower quality foam in the packaged beer. **Propylene glycol alginate (PGA)** interacts with and stabilizes foam positive proteins while also reducing the foam negative effects of external contaminants.



PGA is derived from alginic acid, which is a carbohydrate found in seaweed. It is produced by esterification to give a trouble-free method of enhancing and protecting beer foam. Many years of development have been undertaken to identify the ideal blend of seaweed species required to yield the right quality of alginic acid, and to optimize the critical esterification stage.

PGA can is available in two forms:

- *Powdered PGA* is stable and has a longer shelf life, but requires preparation by hydration before being dosed into beer.
- *Liquid PGA* is supplied as a ready to use product and is restricted to local supply due to a limited shelf life.

Antioxidants

Beer staling refers to the negative sensory and chemical changes which take place in beer during storage. These changes are caused by a variety of chemical reactions, one of the most prominent being the oxidation of organic compounds in beer. Organic compounds such as higher alcohols, polyphenols, amino acids, and lipids are altered by oxidation reaction. Oxidized polyphenols facilitate haze development while the oxidation of malt derived lipids give rise to the formation of trans-2-nonenal, which has a papery/cardboard aroma that is considered an off-flavor and is commonly detected in aged beers.

Antioxidants function by scavenging dissolved oxygen and blocking staling reactions. It slows the formation of these off flavors by blocking the formation of causative carbonyl compounds, particularly trans-2-nonenal, and in so doing improve flavor and colloidal stability while slowing the rate of color development.

Antioxidants are soluble in water and are normally added to the mash vessel to guard against malt lipid oxidation, or more commonly just before filtration to prevent oxygen ingress in storage.

CONCLUSION

Brewing beer is a complex process with many complex biochemical processes to control. Some of the largest and smallest brewing companies benefit from using **AB Vickers® process aids** and tapping into the significant expertise and resources offered by our team of brewmasters, industry experts, and R&D capabilities. **For every step in the brewing process, there is an AB Vickers® process aid available to improve process efficiency and consistency.**

TABLE 1: AB VICKERS PROCESS AIDS SOLUTIONS REFERENCE

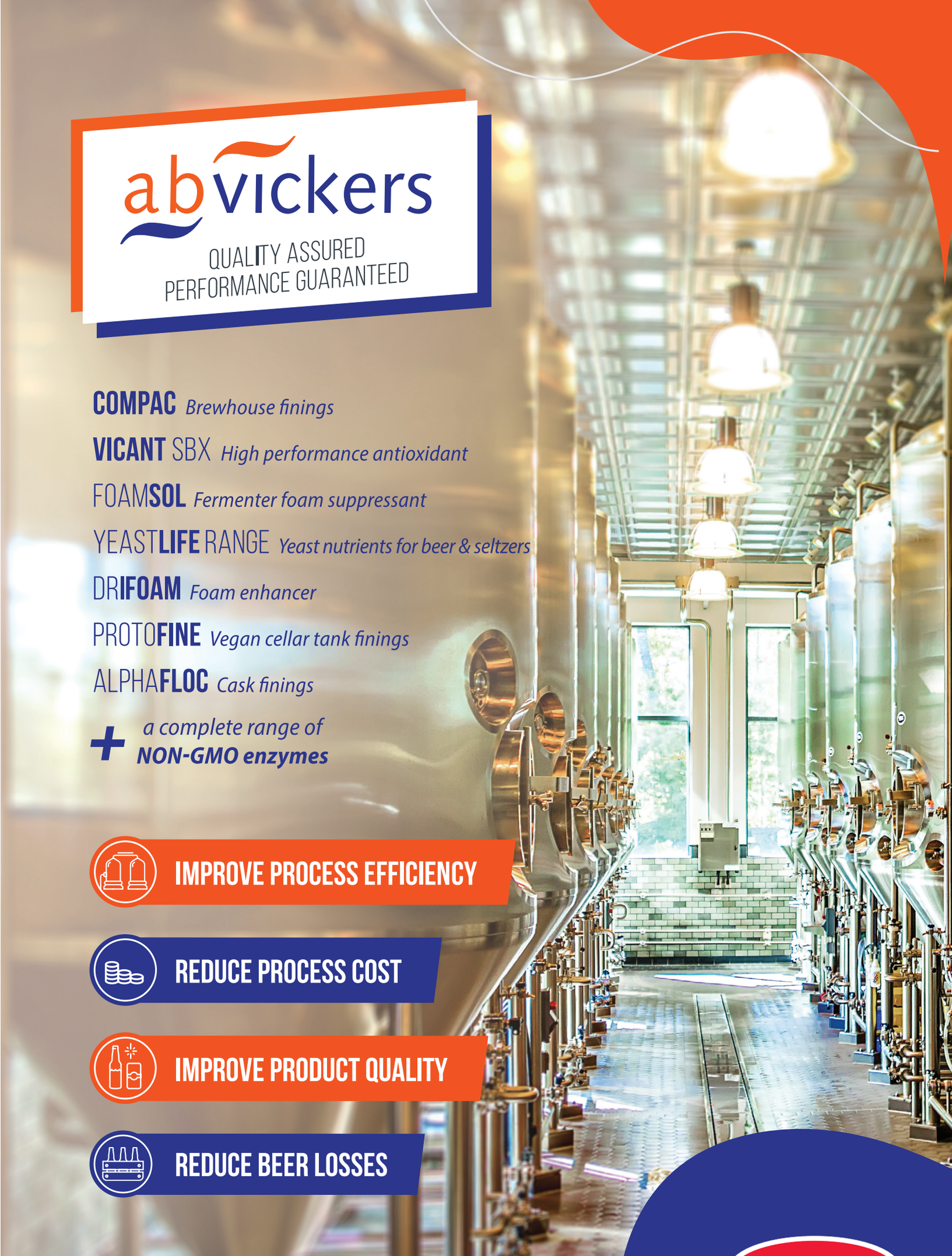
PROBLEM / TARGET	SOLUTION	PROCESS AID	APPLICATION POINT	DOSE RATE	TEMPERATURE / PH
Hazy wort / unstable beer / poor filterability	**Carrageenan / kettle finings**	**COMPAC** CG	Wort kettle	1-4g/hl	> 90°C pH 5.3-5.0
Hazy beer / long process times	**Isinglass / Beer finings**	CRYO**FINE**	Maturation Condition Tank	1-3g/hl	< 4°C pH 4.3 – 4.0
	Pectin finings / Beer finings *vegan / natural	PROTO**FINE**	Maturation CT	10-40g/hl	< 4°C pH 4.3 – 4.0
	Silica sol / Beer finings *vegan	PROTO**SOL**	Maturation CT	20-200ml/hl	< 4°C pH 4.3 – 4.0
Reduced vessel capacity	**Antifoam**	FOAM**SOL**	Inline to fermenter / Wort kettle	2-10ml/hl	10°C – 23°C FV > 90°C Kettle
Poor beer foam stability	**Foam stabiliser**	DRI**FOAM**	Post Filter / Final process	40- 60mg/l	< 4°C pH 4.3 – 4.0
Stale / Oxidated beer – short shelf life	**Antioxidant**	**VICANT** SB	Post Filter / Final process	2-3g/hl	< 4°C pH 4.3 – 4.0
Unstable beer	**PVPP**	ALPHA**CLAR** S	Maturation Filter	30– 50g/hl	< 4°C pH 4.3 – 4.0
	PVPP	DIVER**GAN**	Maturation Filter	20-40g/hl	< 4°C pH 4.3 – 4.0
	Silica hydrogel	BRITE**SORB** BK75	Maturation Filter	50-100g/hl	< 4°C pH 4.3 – 4.0

hL = hectoliter (for use in FV)

Temperature and pH recommendations are for optimal enzyme activity. Using conditions outside of this range will result in reduced enzyme activity and may require higher dose rates or longer reaction times.

TABLE 2: AB VICKERS PROCESS AIDS BENEFITS

PRODUCT	DESCRIPTION	BENEFITS
COMPAC CG	*Kettle finings* - A granulated form of the seaweed species *E. cottonii*, added to hot wort at the end of boil or in the whirlpool. Binds and precipitates soluble proteins.	• **Improves hot trub compaction leading to higher wort extraction** • **Improves colloidal stability** • **Longer filtration runs**
CRYO**FINE**	*Beer finings* - a purified form of isinglass which is added to the beer at the end of fermentation. This binds yeast and protein particles promoting sedimentation.	• **Promotes flocculation** • **Reduces cold storage time** • **Improves beer haze and stability**
PROTO**FINE**	*Beer finings* - a natural finings product which is plant derived and added to the beer at end of fermentation. Promotes sedimentation of yeast and protein particles	• **Reduces cold storage time** • **Improves beer haze and colloidal stability** • **Vegan friendly**
PROTO**SOL**	*Beer finings* - an alternative silica based finings product which is added to the beer at the end of fermentation. Promotes sedimentation of yeast and protein particles.	• **Reduces cold storage time** • **Improves beer haze and colloidal stability** • **Vegan friendly**
FOAM**SOL**	*Antifoam* - an insoluble silicone product, highly effective in foam suppression added to wort at the start of fermentation.	• **Provides increased fermentation capacity** • **Eliminates over foaming problems** • **Preserves foam positive proteins**
DRI**FOAM**	*Beer foam stabiliser* - Added to beer at the final stage of processing to protect and stabilise beer foam. The active compound propylene glycol alginate (PGA) is derived from a blend of seaweeds.	• **Retains existing beer foam characteristics** • **Protects against external foam negative contaminants**
VICANT	*Antioxidant*, designed to protect against the negative staling reactions which beer can be exposed to post fermentation.	• **Prevents staling** • **Improves colloidal stability** • **Slows rate of browning**
ALPHA**CLAR**	*Polyvinylpolypyrrolidone (PVPP)* - Insoluble polymer added to beer during final processing to bind and remove polyphenols responsible for haze development.	• **Improves colloidal stability** • **Prevents haze formation** • **Extends beer shelf life**
BRITE**SORB** (BK75)	Insoluble *silica hydrogel,* added to beer during final processing to bind and remove haze active proteins.	• **Improves colloidal stability** • **Prevents haze formation** • **Extends beer shelf life**



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QUALITY ASSURED
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COMPAC *Brewhouse finings*

VICANT SBX *High performance antioxidant*

FOAM**SOL** *Fermenter foam suppressant*

YEAST**LIFE** RANGE *Yeast nutrients for beer & seltzers*

DRI**FOAM** *Foam enhancer*

PROTO**FINE** *Vegan cellar tank finings*

ALPHA**FLOC** *Cask finings*

\+ *a complete range of* ***NON-GMO enzymes***

IMPROVE PROCESS EFFICIENCY

REDUCE PROCESS COST

IMPROVE PRODUCT QUALITY

REDUCE BEER LOSSES