

A Novel Stabilization of Beer with Polyclar® Brewbrite™

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ABSTRACT

A procedure for stabilizing beer in the brewhouse using a proprietary composite of micronized polyvinylpolypyrrolidone and a selected carrageenan is described. The product, Polyclar® Brewbrite™, was added 10 min before the end of the kettle boil and significantly reduced the level of the haze-active tannoid (polyphenol) fraction. Additionally, its use allowed for increased precipitation of trub (spent hops, precipitated protein, and other insoluble material) and a brighter wort ex-paraflow. Wort yield showed an improvement of up to 3% compared to the yield of an untreated control. Beer treated with Polyclar Brewbrite also gave about a 10% reduction in the fermentation time as compared to the untreated wort. Both multiplication and fermentation rates of yeast were improved in the Brewbrite-treated wort. Pilot-scale and commercial trials confirmed that Polyclar Brewbrite provided enhanced beer stability, coupled with improved productivity.

Keywords: beer stabilization, brewhouse treatment of wort, fermentation time, shelf life, wort clarity, wort yield

SÍNTESIS

Se describe un procedimiento para estabilizar la cerveza utilizando un compuesto propietario de polivinilpolipirrolidona micronizada y una carraginata; estos compuestos son agregados en la sala de cocimiento. El producto (Polyclar® Brewbrite™) se agregó 10 min. antes del final del hervor, con una reducción significativa en el nivel de la fracción del tanoido (polifenol) activamente responsable de la turbiedad en frío. Su uso también permitió una mayor precipitación del trub (residuos de lúpulo, proteína precipitada, y otro material insoluble) y un mosto más brillante a la salida del enfriador. El rendimiento del mosto presentó una mejora de hasta 3% comparado con el rendimiento de un mosto de control. Cerveza tratada con Polyclar Brewbrite dio una reducción de 10% en el tiempo de fermentación comparado con un mosto de control. Se mejoró tanto la tasa de reproducción como la velocidad de fermentación de la levadura en el mosto tratado con Brewbrite. Los ensayos, tanto en planta piloto como en escala industrial, confirmaron que el Polyclar Brewbrite proporcionó una mejoría significativa en la estabilidad de la cerveza, a la vez de mejorar la productividad.

Introduction

Beer haze consists mainly of protein and polyphenol constituents, complexed together primarily via hydrogen bonding. Additionally, some carbohydrates and metal ions are known to contribute to haze formation in beer.

The susceptibility of beer to haze development can be tackled by reducing the levels of the haze proteins and/or polyphenols or by minimizing their molecular size. Our previous work (3) and the work of others (1,2,4,5) has shown that, for enhancing the colloidal stabilization of beer, a balanced adsorption of protein and polyphenol is more desirable than removing either polyphenol or protein alone. Currently, several factors drive the need for improving the colloidal stability of beer:

- Quality parameters, including both flavor and colloidal stability of beer

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- Growth in export beers—with long distribution chains
- Growth in franchised beers
- Cost reduction

Typically, beer is stabilized after fermentation, usually by the addition of process aids at filtration that can adsorb either polyphenol or protein haze precursors. The ability to stabilize beer in the brewhouse would have the benefits of process simplification, eliminating the need for any specialized additional plant and reducing the extent of downstream processing. This would increase the options available to the brewer to produce a high-quality beer in a cost-effective way.

Technical Description

Polyclar® Brewbrite™ is a proprietary composite of a selected carrageenan and a micronized polyvinylpolypyrrolidone (PVPP). Kappa-carrageenan is a marine polysaccharide composed of repeating units of galactose and galactose sulfate monomers (Fig. 1) derived from species of *Euchema* seaweed. PVPP is an insoluble polymer that has been used in the colloidal stabilization of beer for over 30 years. It acts by preferentially complexing haze-active polyphenols through the mechanism of hydrogen bonding. In its chemical structure, it resembles the amino acid proline (Fig. 2), which explains its high affinity and selectivity for haze polyphenols.

Under the scanning electron microscope, individual particles of carrageenan have the appearance of large but slightly geometric structures (Fig. 3, top). Particles of Polyclar Brewbrite have a more convoluted structure, increasing the surface area

available for the adsorption and flocculation of trub and haze precursors (Fig. 3, bottom).

Factors Affecting Polyclar Brewbrite Performance

Several raw-material and process factors affect the performance of Polyclar Brewbrite in practice. These include: malt variety, degree of malt modification, mashing temperature and profile, time of addition, dose rate, hot wort clarity, wort gravity, wort pH, level of cold break protein, and wort polyphenol levels.

Results and Discussion

On addition to wort, 10 min before the end of the kettle boil, there was a marked increase in trub collection compared to that in a control sample (Fig. 4). This was accompanied by improved wort clarity that was discernible both visually and analytically (Fig. 5 and Table 1).

Wort "Trub" and Wort Clarity

Analysis of the nonmicrobial particles in wort treated with Polyclar Brewbrite by the Elzone® technique, an electrolytic technique that measures a low concentration of particles dispersed in an electrolyte solution (Micromeritics Inc., Norcross, GA), confirmed a reduction in their size distribution, relative to that of the control wort (Fig. 6). It is this shift to a greater proportion of smaller particles that resulted in the improvement in wort clarity after treatment.

Wort treated with Polyclar Brewbrite was found to have smaller particles when compared with untreated wort samples. This was found through the entire range of percentile values, as shown.

Brewery Trials

Pilot-Scale Trial

Initial trials were made at a pilot scale to compare the relative efficacy of Polyclar Brewbrite treatment against addition of car-

rageenan alone. Both additions were made 10 min before the end of the copper boil. The protocol for the trial is summarized below:

- 100% malt lager at 11°P (5% alcohol by volume)
- Control: carrageenan alone, at 3.5 g/hL
- Test: Polyclar Brewbrite at 13.5 g/hL
- Isothermal fermentation: 12°C (6 days)
- Cold conditioning: 0°C (7 days)
- Filtration through cellulose sheets
- Packaging in bottles

Brewhouse results. In terms of brewhouse performance, both the control and test worts showed good clarity in the kettle (as-

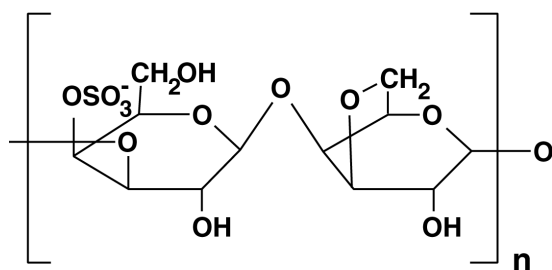


Figure 1. Structure of kappa carrageenan, a marine polysaccharide of galactose and galactose sulfate monomers. Its scientific name is β -D-galactose-4-sulfate-3,6-anhydro- α -D-galactose.

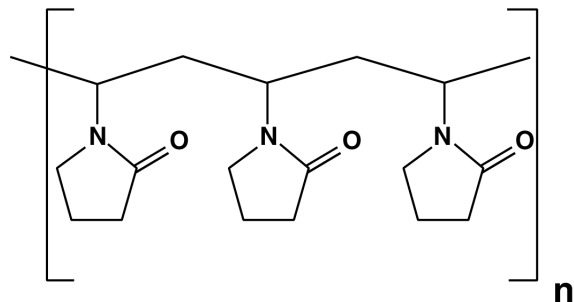


Figure 2. Cross-linked polyvinylpyrrolidone, a 2-pyrrolidinone, 1-ethenyl homopolymer.

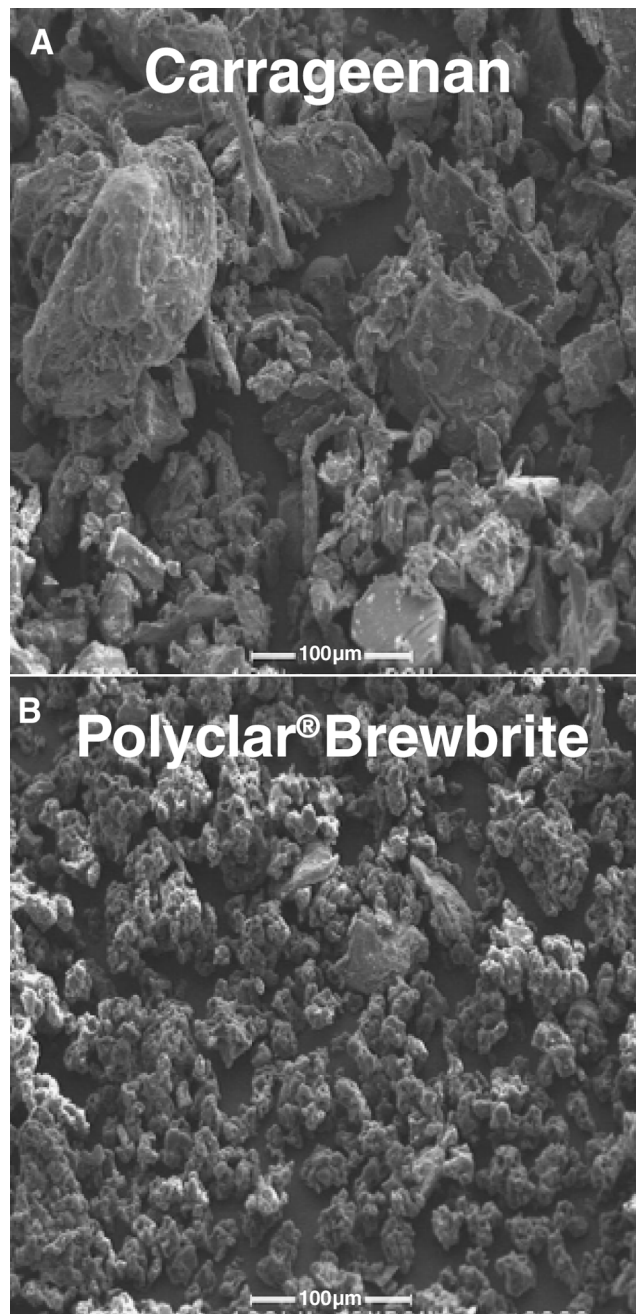


Figure 3. Scanning electron micrographs of carrageenan (A) and Polyclar Brewbrite (B). Bar = 100 μ m. Polyclar Brewbrite's large surface area helps in efficient adsorption, flocculation, or trub formation of haze-giving precursors.

sessed only visually) and trub collection in the whirlpool. The main difference was a ~3% increase in wort yield collected in the receiver for the Brewbrite-treated wort. Wort yield for the control was 93 L at 10.9°P and for the treated wort, 96.5 L at 11.1°P.

Fermentation and packaging results. The fermentation was followed by monitoring the gravity and cell numbers on a daily basis. The wort treated with Brewbrite showed a markedly higher peak yeast cell count ($65 \times 10^6/\text{ml}$ compared with $47 \times 10^6/\text{ml}$ for the control), suggesting that the PVPP had adsorbed components that normally limit cell division. The gravity drop (9.7°P for the treated wort and 9.5°P for the control) was also slightly greater in the case of the test wort. Fermentation performance and packaging remarks were good for both worts.

Comparison of tannoid levels in the pilot-scale trial. Polyphenol levels were followed through the process by measuring the levels of the haze-active tannoid fraction using a Tannometer (Pfeuffer GmbH, Germany). Tannoid values throughout the process were rescaled to 100 to allow direct comparison. It was clear that addition of the Brewbrite resulted in an immediate and very significant reduction in the tannoid content of the sample collected at the end of the boil (Fig. 7). This lower tannoid content was maintained through the remainder of the process up to beer filtration.

Beer analysis in packaged beer. Packaged beer was analyzed to compare the values of key parameters. Table 2 shows that the only major difference was better wort clarity of the test

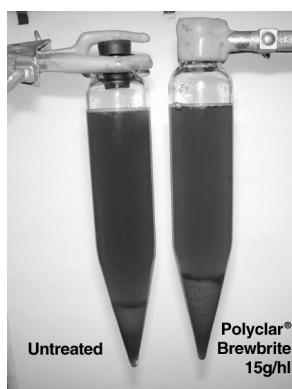


Figure 4. Trub from wort treated (right) and untreated (left) with Polyclar Brewbrite.

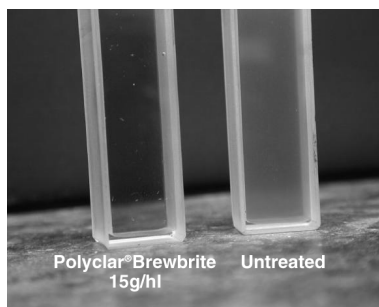


Figure 5. Clarity of wort treated (left) and untreated (right) with Polyclar Brewbrite.

Table 1. Haze formation in wort

Sample	Haze (EBC units) at 0°C
Untreated	12.3
Treated with Polyclar Brewbrite	7.1

beer, which would, in turn, improve the expected shelf life. Tasting tests showed no detectable differences in or preference for either beer, indicating that the Brewbrite treatment had no adverse impact on beer quality.

Commercial Trial

The successful pilot-scale trials were followed by trials in a small commercial brewery to evaluate Polyclar Brewbrite under production conditions. The protocols for the trial are summarized below:

- 100% malt lager at 13.5°P (5.5% abv)
- Control: carrageenan alone, at 3.9 g/hL
- Test: Polyclar Brewbrite at 15.0 g/hL
- Fermentation (regular): 13°C (6 days)
- Cold conditioning: 1°C (4 weeks)
- Filtration through Padovan horizontal leaf filter (TMCI, Padovan, Italy) using diatomaceous earth
- Packaging in kegs and bottles

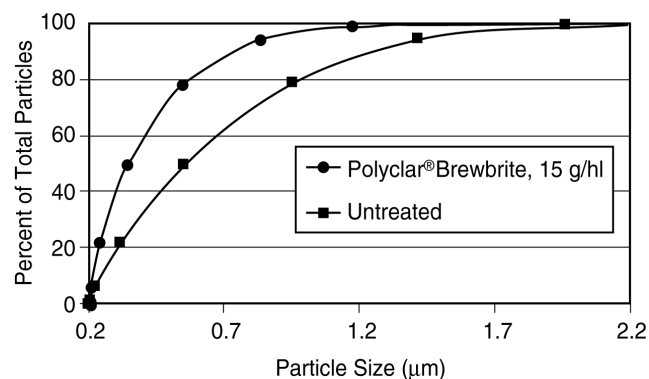


Figure 6. Elzone particle size analysis as a function of percentile of total number of particles in wort.

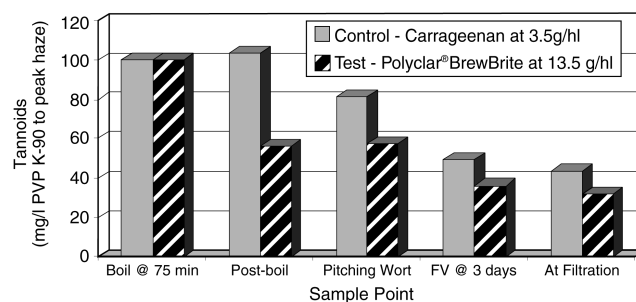


Figure 7. Tannoid content of treated and untreated worts, measured at several stages during the pilot-scale trial.

Table 2. Results of analysis of packaged beer treated with Polyclar Brewbrite and untreated beer

Parameter	Control (carrageenan alone)	Test (treated with Polyclar Brewbrite)
Ethanol % (v/v)	4.98	5.13
pH	4.19	4.20
Color (EBC units)	11.4	12.5
Head retention value ^a (s)	85, 163, 247	87, 162, 240
Bitterness (BU ^b)	21	20
Haze (EBC units)	0.33	0.13

^a Measured by the NIBEM foam stability tester. Three measurements are shown.

^b Bitterness units.

Increase in wort yield. Once again, Polyclar Brewbrite treatment of the wort 10 min before the end of the kettle boil resulted in an increase in the wort yield at kettle knock-out (Fig. 8). This increase was quantified as a 3.2% improvement over the untreated wort and greater than the increase achieved with carrageenan alone. If replicated in regular use, this would have very significant commercial benefits for breweries of all sizes.

Decrease in fermentation time. The gravity profiles of the control wort and the wort treated with carrageenan alone or with carrageenan and PVPP, Polyclar Brewbrite confirmed that addition of the latter resulted in faster primary fermentation (Fig. 9) with about a 10% reduction in the fermentation time to rack gravity (Fig. 10). Taken together with the data from the pilot-scale trial, this suggested that Polyclar Brewbrite addition could increase fermentation vessel throughput and reduce cycle times, to the economic advantage of the brewer. This could be especially useful in high-gravity fermentations where either a strong beer is produced or the beer is significantly diluted to sales strength.

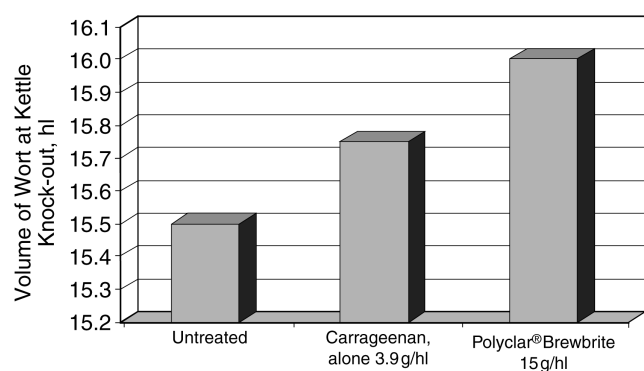


Figure 8. Increase (3.2%) in yield of wort treated with Polyclar Brewbrite as compared to yield of untreated wort.

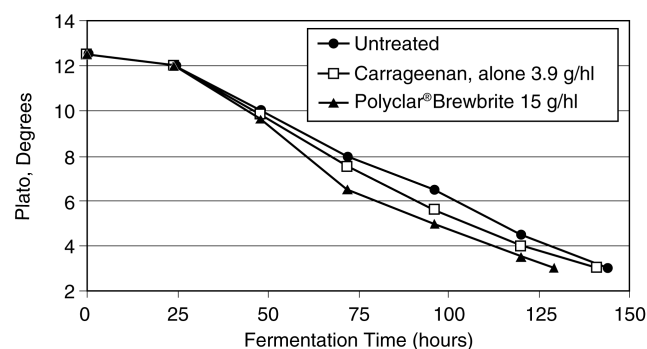


Figure 9. Fermentation time versus drop in gravity with addition of Polyclar Brewbrite to wort in a commercial trial.

Analysis of Packaged Beer—Commercial Trial

Haze precursors. Measurement of polyphenol and protein haze precursors confirmed the absence of tannoids in the Brewbrite-treated beer, together with better polyphenol stability values shown by both the T125 haze polyphenols measured by a PT-Standard nephelometer and total polyphenols measured by spectroscopy (Table 3). There was also a small improvement in the stabilization of the protein haze precursors, as measured by the saturated ammonium sulfate precipitation limit test.

Colloidal stability analysis. As the beer from this trial was produced under commercial conditions, it was subjected to heat-forcing tests to establish the likely colloidal stability. Each cycle comprised 24 h at 60°C followed by 24 h at 0°C, with

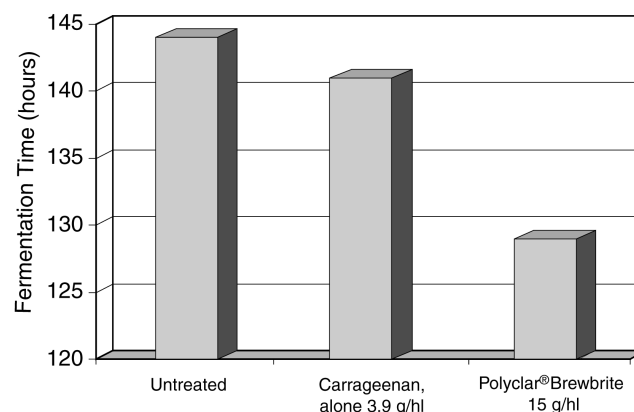


Figure 10. Decrease in fermentation time (10%) with addition of Polyclar Brewbrite to wort in a commercial trial.

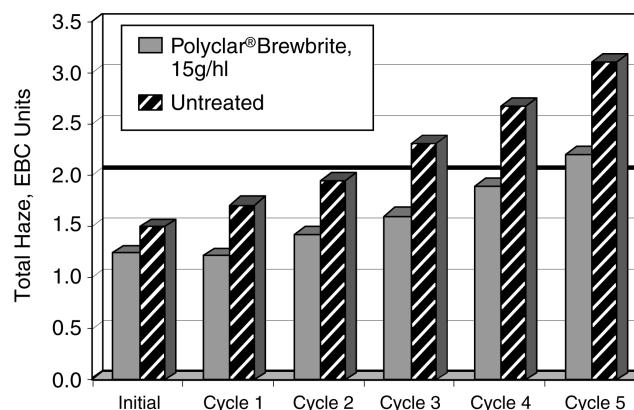


Figure 11. Haze formed in heat-forcing test of commercial beers. Each cycle (resulting in 2.0 EBC units of haze) indicates one month of predicted shelf life.

Table 3. Analysis of colloidal stability

Sample	Polyphenol			Protein	
	T-125 Reagent (ml/100 ml of beer)	Tannoids (mg PVP ^a /L)	Total polyphenol (mg/L)	P-40 Reagent (ml/100 ml of beer)	SASPL ^b (ml/100 ml of beer)
Untreated	11.7	39.0	168.1	22.0	14.1
Treated with Polyclar Brewbrite, 15 g/hl	62.2	Not detectable	137.5	27.9	14.6

^a Polyvinylpyrrolidone.

^b Saturated ammonium sulfate precipitation limit.

the total haze measured at 0°C on completion of each cycle. The results are shown in Figure 11.

Using a very strict haze cut-off of 2 EBC units, beer treated with Polyclar Brewbrite achieved approximately five cycles—equivalent to approximately 5 months of actual shelf life. The equivalent control beer achieved between two and three cycles on the same test.

Conclusions

The use of Polyclar Brewbrite resulted in a number of process and productivity benefits:

- Greater trub removal with enhanced wort clarity
- Increased wort production
- Decreased primary fermentation time
- Increased ethanol yield
- Improved total productivity of the brewing plant
- Extended shelf life of packaged beer

The work confirmed that it was possible to effectively stabilize beer in the brewhouse. However, if a longer shelf life is required, additional stabilization can be achieved by the addition

of PVPP or silica gel at filtration. This allows brewers the option of simplified processing of beer, together with the potential productivity improvements highlighted in the trials. Use of Polyclar Brewbrite offers very significant quality and economic benefits to breweries, regardless of scale.

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