# A natural foam enhancer from hops

**IMPROVING FOAM STABILITY** | Alpha acids in hops are responsible for beers' bitterness via their thermal isomerization into isoalpha acids during the kettle boil. The alpha acids that don't isomerize are absorbed onto the trub and yeast during fermentation with little if any getting into the final beer. Interestingly, alpha acids are soluble in beer and when added post-fermentation can dramatically improve the foam stability and lacing of beers at very low concentrations. This study shows that alpha acids can enhance the foam stability and lacing of beers, similar to tetrahydro-isoalpha acids and better than isoalpha acids or propylene glycol alginate (PGA). Foam stability measurements were made using the NIBEM-T foam tester via EBC test method 9.42.

**BEER FOAM AND ITS APPEARANCE** can greatly influence consumer behavior. Foam quality is mainly determined by its ability to stand and cling to the side of a glass. Measurements of foam stand and lacing are standard quality control parameters at most breweries. It is desired to have a stable head of foam after a beer is poured into a glass container, and then to have that foam adhere to sides of the glass as the foam collapses. Many factors contribute to good beer foam including carbonation level, protein content, metal content, and perhaps most important isoalpha acid concentration. For many years it has been known that hops improve the foam stability and lacing of beer and that it is the isomerized alpha acids that are the major contributor to foam and lacing [1]. Recently the use of isomerized and reduced hop acids such as tetrahydro-isoalpha acids and hexahydro-isoalpha acids have proven to be extremely effective at improving foam stability and lacing of beers at very low concentrations, about 3 - 4 ppm [2].

Nearly 40 years ago *Asano* and *Hashimato* reported that alpha acids can contribute foam like isoalpha acids, though the lowest concentration they tested was about 26 ppm [3]. They made no comment that alpha acids were actually superior to isoalpha acids at improving foam stability. *Bamforth* and *Jackson* reported that alpha acids are equally as effective as the isoalpha acids when it comes to lacing, though no quantitative results were provided [4]. This study reports that alpha acids are significantly better than isoalpha acids at improving the foam stability and lacing of commercial beers at concentrations as low as 3 to 5 ppm. Also reported here is that alpha acids are even more effective at enhancing beer foam stability if the NIBEM-T foam test is performed on cold beers. Normally the NIBEM-T test is performed on beers stored at 20 °C, which is odd given that beers are poured and consumed cold. This study compares the foam enhancing properties of alpha acids, isoalpha acids, tetrahydro-isoalpha acids and propylene glycol alginates at various temperatures.

## Sample preparation and analysis

Alpha acids were isolated from $CO_2$ hop extract (obtained from Hops Extract Corporation of America, Yakima, WA) and formulated as a potassium salt in water to make a stable 20 percent w/w solution [5]. This 20 percent alpha acid solution was diluted with water, as were commercially avail-

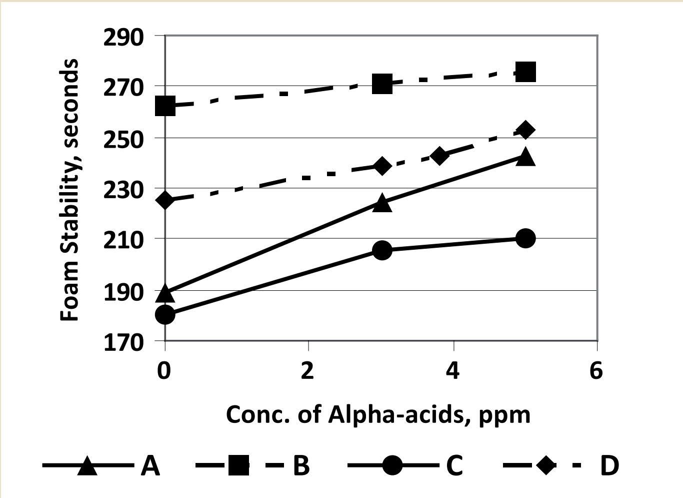


**Fig. 1**
**Effect of concentration of alpha acids on NIBEM foam stability of various beers**

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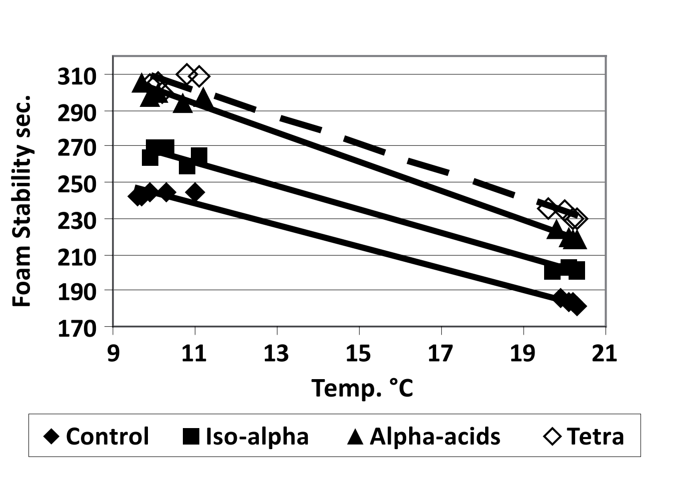


**Fig. 2 Temperature vs. NIBEM foam stability of beer A with 3 ppm hop acids**

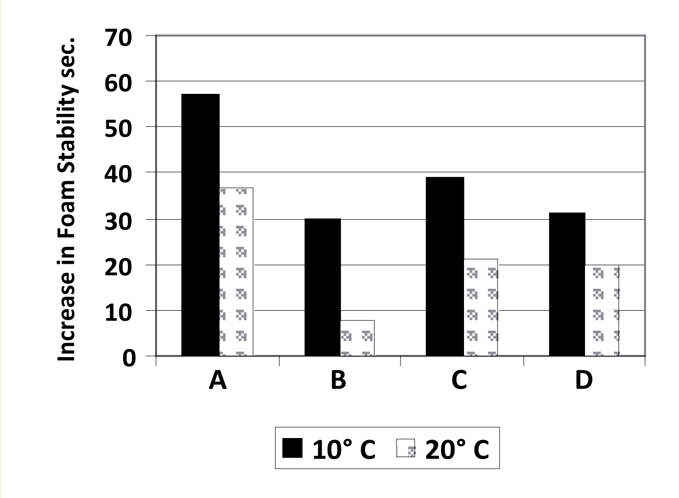


**Fig. 3 NIBEM foam stability results of various beers treated with 3 ppm of alpha acids and reported at 10 °C and 20 °C**

able 30 percent isoalpha acids, 10 percent tetrahydro-isoalpha acids (Hopsteiner), and propylene glycol alginate (PGA) before addition to bottles of commercial beer. After fobbing, the beers were recapped and allowed to stand at room temperature for at least one day prior to testing.

NIBEM foam stability measurements were made at 20 °C using a Haffmans NIBEM-T foam stability tester as described in EBC method 9.42 [6], though some beer samples were tested at cool to cold temperatures. Cool temperature testing was conducted in a refrigerated room of approximately 10 °C to minimize any temperature change during testing. After performing the foam stability measurements, some samples were further tested for foam cling via the method of Jackson and Bamforth [7], though quantification was done by absorbance at 240 nm. Visual assessment of foam cling was done by placing three bottles of cold beer on a pouring device [7] and pouring the beer into clean, 1-L glass beakers. Pictures of the beer foam and cling were taken after 60 sec, in 30 sec intervals until 8 minutes.

The concentrations of alpha acids, isoalpha acids, and tetrahydro-iso alpha acids in hop products were determined using HPLC method EBC 7.9 [6]. The concentrations of alpha acids and isoalpha acids in degassed beer samples were determined by HPLC at 270 nm using ASBC method of Beer-47 [8].

## Results and discussion

Alpha acids are effective at improving the foam stability of a number of beers as shown in figure 1. For beers with NIBEM foam stability in the range of 180 - 230 seconds (at 20 °C), addition of 3 ppm of α-acids resulted in an increase in foam stability in the range of 13 to 37 seconds. The greatest improvement in foam stability with alpha acids was with an American Premium Light Beer, beer A, which had the lowest concentration of isoalpha acids, approximately 5 ppm. The least improved foam stability was beer B, which had the highest concentration of isoalpha acids, 18 ppm. Beer C contained 8 ppm isoalpha acids and beer D contained 12 ppm isoalpha acids. In general the greatest improvement in foam stability came with beers low in isoalpha acid concentration, when testing was conducted at 20 °C. A possible explanation for these results could be that alpha acids and isoalpha acids competitively bind to the same foam active protein sites believed to be responsible for beer foam. Thus the higher the isoalpha acid concentration in a beer the less binding sites available for alpha acids. Interestingly, the addition of alpha acids did not significantly affect the bitterness or flavor of beers tested, even low IBU beers [9].

NIBEM foam testing and results are reported at 20 °C, even though beers are poured and consumed cold. *Van Akkeren* and *Ansem* reported that NIBEM foam test results are highly dependent upon temperature and that a correction factor of 4.6 - 6.7 seconds be added to every degree °C below 20 °C [10]. When beer A was treated with 3 ppm of the corresponding hop acids, isoalpha acids, alpha acids, and tetrahydro-isoalpha acids all had higher NIBEM results at lower temperatures. Alpha acids significantly improved the foam stability of beer A vs. isoalpha acids, especially at lower temperature (fig. 2). Although alpha acids foam stability was slightly lower than that of tetrahydro-isoalapha acids at the temperatures tested both had a steeper temperature vs foam slope than that of isoalpha acid and the control. It is believed that this steeper slope is indicative of the foam enhancing properties of these two hop acids.

Given the improvement in NIBEM test results when beers are tested cold vs. 20 °C reevaluation of the foam stability of the commercial beers tested earlier was conducted to see if this cold temperature effect was true with all the beers tested earlier. As expected, every beer saw an improvement in foam stability at 10 °C vs. 20 °C (fig. 3). An explanation for this behavior might be that alpha acids effectively displace isoalpha acids from foam-active proteins at lower temperatures, resulting in a greater improvement in beer foam stability. Beers B and C, which were both lagers showed the greatest improvement in foam stability at 10 °C vs. 20 °C, as compared with beers A and D which were light beers. The higher protein, alcohol content, and isoalpha acid concentration in the lager beers might have an influence in allowing greater interaction of the alpha acids with foam-active proteins at lower temperatures. Thus for some beers, it is important to perform the NIBEM foam stability test with cold beers in order to evaluate the foam-enhancing properties of alpha acids.

Non-bitter propylene glycol alginates (PGA) are used by some brewers to improve beer foam stability without increasing bitterness. Because PGA enhances beer foam

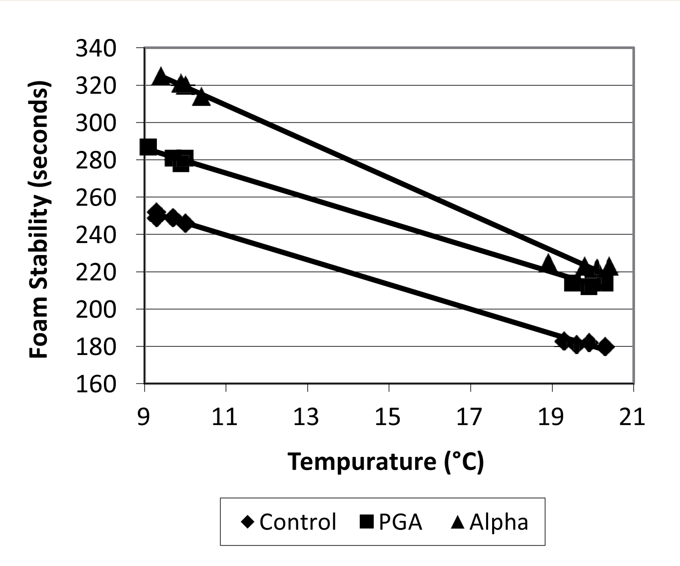


**Fig. 4 Effect of temperature on NIBEM foam stability of beer A treated with 35 ppm PGA or 4 ppm alpha acids**

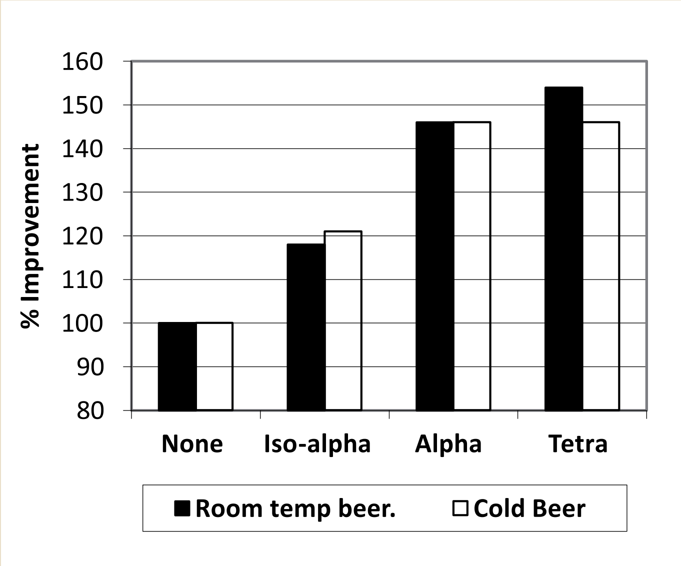


**Fig. 5 Effect of 3 ppm hop acids on lacing testing at 20 °C and 10 °C of beer A**

via a different mechanism than hop acids, beers were spiked with PGA or alpha acids and tested at different temperatures. At 20 °C, approximately 35 ppm of PGA added to beer A gave similar NIBEM results as 4 ppm of alpha acids. However, when these beers were tested at 9 - 10 °C the alpha acids treated beer saw an additional 100 seconds of foam stability vs. 65 seconds for PGA and 68 seconds for the control beer. The alpha acid treated beer had a greater temperature response to foam enhancement than PGA and the control beer (fig. 4).

To determine how well the beer foam stability held-up over time, two American Premium Lagers, both measuring 8 ppm of isoalpha acids, were treated with 3 ppm of alpha acids and had their foam stability measured over 32 weeks, stored and tested at room temperature. Both beers showed little to no change in foam stability at 20 °C, relative to the control beers, between weeks 2 and 32. Interestingly, HPLC analysis of the 32 week old beers saw about a 50 percent loss in alpha acids, yet the foam stability remained close to 90 percent of its original value. The loss of alpha acids could not be explained by formation of isoalpha acids, since the concentration of isoalpha acids also decreased. No new peaks were detected by HPLC.

Jackson and Bamforth described a method for measuring lacing or cling in beer [7]. But reproducibility proved challenging, possibly due to the method of pouring. However, using the Haffmans flasher, used in conjunction with the NIBEM-T meter, reproducible foam cling results were more consistently obtained. Also the wavelength of 230 nm used in Jackson and Bamforth's test method was changed to 240 nm since at 240 nm all three hop acids had the same absorbance at the same hop acid concentration. The addition of 3 ppm of alpha acids to beer A improved that beers' lacing dramatically better than 3 ppm of isoalpha acids and nearly as well as 3 ppm of tetrahydro-isoalpha acids (fig. 5). Interestingly, improvements in lacing are not affected by temperature since room temperature and cold temperature results were very similar.

Since the NIBEM method for testing foam stability generates a glass filled with foam, which is unlike the foam generated upon pouring a bottle of beer into a glass, the results of this study might not reflect what the consumer sees. For this reason cold bottles of beer were poured into glass beakers using a pouring device [7] and pictures were taken of the foam collapse. As vividly shown in figure 6, 4 ppm of alpha acids dramatically improved the foam stability and lacing of cold beer A. Interestingly 40 ppm of PGA added to beer A contributed little foam cling vs. the control beer. Visual assessment of foam stability and lacing, as seen in figure 6 confirms the results of the NIBEM testing. Alpha acids dramatically enhance the foam stability and lacing of beer at low concentrations.

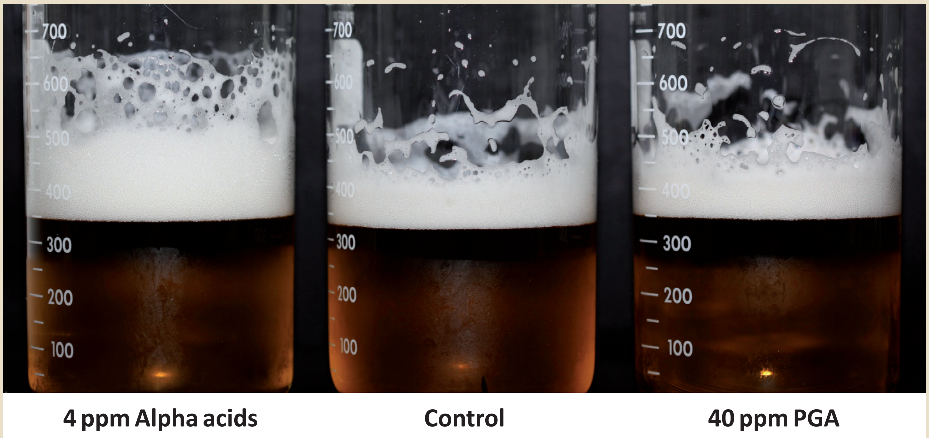


**Fig. 6 Foam cling and foam stand of beer A treated with 4 ppm alpha acids and 40 ppm PGA, 4 minutes after pouring**

## Conclusion

This study shows that alpha acids enhance the foam stability and lacing of beers similar to tetrahydro-isoalpha acids and far better than isoalpha acids. Some beers benefit more from alpha acids foam enhancing properties than others, especially low IBU beers. This study also confirmed that the NIBEM-T foam test is highly temperature dependent and beers tested cold gave considerably better results than beers tested at room temperature. Cold temperature foam improvements however were not the same for all the hop acids tested or PGA. Alpha acids like tetrahydroisoalpha acids had a greater foam enhancement response at lower temperatures vs. isoalpha acids and PGA. Visual assessment of foam from poured beer confirmed the NIBEM foam results in that alpha acids can dramatically improve the foam stability and lacing of beer. Commercial testing of alpha acids is currently underway at a number of breweries and similar results as reported in this study are being seen. ■

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