Brewhouse

(/images/BWI_Artikelbilder/BWI_2023/BWI_01_2023/brauwelt-slider-hopfen-u-leone-pixabay-2022.jpg)

14 February 2023

The myth of first wort hopping

HOP ADDITION | Does first wort hopping during lautering have a positive influence on the yield of bitter substances and on the beer quality? What kinds of results are currently possible through the use of hop pellets? The authors analyzed nine beers from brewing trials for bitter substances, aroma compounds, sensory attributes and aging indicators.

EARLY HOP ADDITIONS are normally carried out at the beginning of the boil or are added to the lauter wort in the kettle as it is being heated to boiling. Discussions on the topic periodically revisit the idea of adding hops even earlier, that is, to the first wort, the premise being that a higher yield for the compounds imparting bitterness to the beer can be achieved by doing so. And yet, the temperatures in the first wort are typically below 80 °C – temperatures at which no significant isomerization of the alpha acids takes place.

The earliest known mention of first wort hopping comes from the end of the 19th century [1]. It was thought that by adding the hops (whole hops were commonly used at this time) early in the brewing process, this would increase the yield of bitter substances. At that time, the substances in whole hops were extracted and dissolved into the wort more slowly than from pellets or extracts which are customary today. Later, in the 1960s, this practice was believed to impart a special hop aroma to beer. This was based on the idea that exposure to air (also common at this time) over the course of the lautering process would oxidize the non-polar sesquiterpenes, such as β-caryophyllene and α-humulene. In turn, their oxidation would result in epoxides which have a significantly higher solubility [2]. The aroma potential of the polar epoxides was estimated to be higher than that of the terpenes.

Generally speaking, first wort hopping – along with a better yield of bitter substances – was purported to impart a more intense hop aroma to the finished beer. Since the results were apparently not reproducible, first wort hopping has not been widely adopted. Since the 1970s, greater emphasis has been placed on avoiding the oxidation of wort during mashing, lautering and boiling. This has without a doubt improved the flavor stability of beer. Consequently, purposeful oxidation of hop aroma compounds has

largely been marginalized. However, the topic has continued to persist in certain brewing circles and has also been described in experimental trials [3, 4]. Given the fact that the results have as yet remained inconclusive and have yielded contradictory results at times, the authors decided to conduct their own experimental trials to investigate the phenomenon of first wort hopping.

Experimental trials

Bottom-fermented, pale lager beers served as the basis for comparison in the trials conducted on the 2 hl pilot brewery at St. Johann. The trial batches were divided into three groups:

- a control batch of wort (C) with a single hop addition at the beginning of the boil;
- a batch of wort with an equivalent hop addition after 50 percent of the first wort (FW) was collected; lautering was normal, i.e., the inclusion of air was kept to a minimum;
- a batch of wort with an equivalent hop addition after 50 percent of the first wort was collected with aeration of the first wort (AFW); this was intended to simulate the oxygen levels customary in wort produced in a 1950s brewhouse.

Three different varieties of type 90 pellets were used for hopping:

- Diamant (2019 harvest), 5.7 percent alpha acids by weight, HSI of 0.31, which is considered fresh;
- Hallertauer mfr (2019 harvest), 2.9 percent alpha acids by weight, HSI of 0.45, a moderate degree of aeration reflecting the conditions around 1960, when whole hops was stored cold but without packaging which afforded protection from oxygen;
- Hallertauer mfr (2020 harvest), 5.8 percent alpha acids by weight, HSI of 0.33, which are also considered fresh.

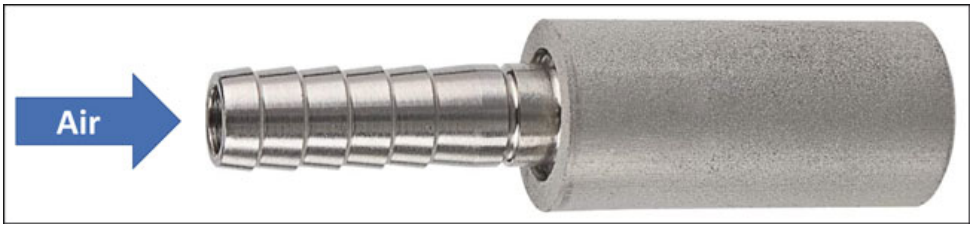

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Fig. 1 Ceramic aeration stone with a 7 mm barbed fitting

After the hop addition, the first wort was aerated with a ceramic aeration stone (fig. 1) in the wort kettle. Air was injected into the wort at a rate of 2.5 l/min, a volume that was reproducible. The objective was to saturate the first wort with oxygen, and this was achieved and significantly surpassed by aerating the wort with 200 l/h of air per hectoliter.

Results from the trials

Since the general beer analyses yielded very similar results, they are not provided. In addition, the results of the three series were almost identical for the attributes measured in the three trials. Therefore, for the sake of clarity, only the mean values are discussed here.

Bitter substances

The bitter substances, measured in the form of bittering units, iso-α-acids, humulinones, and cohulupone are depicted in figure 2. The bittering units measured in the control beers and first wort beers were identical; however, the IBUs in the beers brewed from aerated first wort were slightly elevated. By contrast, the concentrations of iso-α acids in the beers brewed with aerated first wort were slightly lower, which is attributable to oxidation. Particularly striking were the higher values for humulinones and cohupulone in the aerated first wort beers. Apparently, moderate oxidation of the α-acids, iso-α acids and β-acids takes place. This is also the reason for the increase in IBUs.

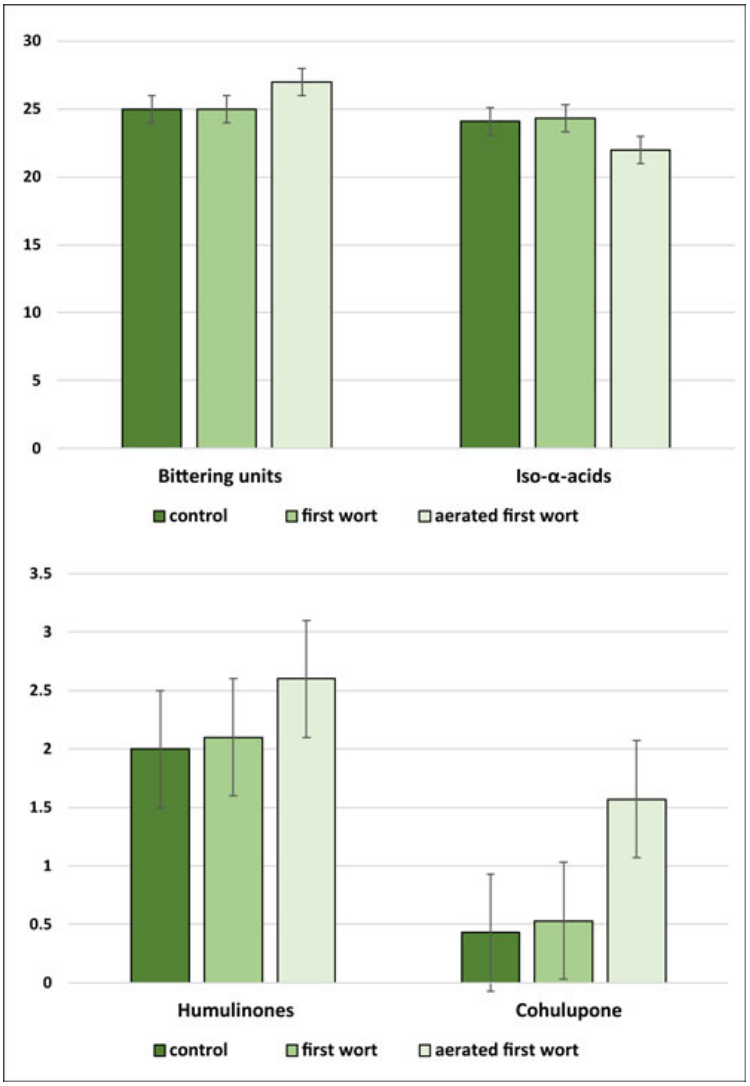

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Fig. 2 Mean values for bittering units (IBU), iso-α-acids, humulinones and cohulupone (mg/l) for the three series, including ranges of analytical error for the statistical standard deviation

Aroma compounds

The relevant aroma compounds derived from the hops are shown in figure 3. In a discussion of the results, the analysis error for linalool of ± 2 µg/l must be taken into account. Thus, the difference between the first wort beers and the aerated first wort beers lies slightly outside the range of the analysis error. It appears that aeration was able to reduce the concentration of linalool through oxidation. However, given the linalool flavor threshold of 10–20 µg/l, the differences may not have a sensory impact [5]. The carboxylic acid methyl esters vary only within the limits of the analysis error. The epoxides of β-caryophyllene and α-humulene, on the other hand, behave differently: they increase from the control beer to the first wort beer to the aerated first wort beer. The difference compared to the aerated first wort beer lies outside the range of the analysis error (± 3 µg/l). Nevertheless, the differences are too small to have a sensory impact. For example, the sensory threshold of humulene epoxide II is 450 µg/l [6].

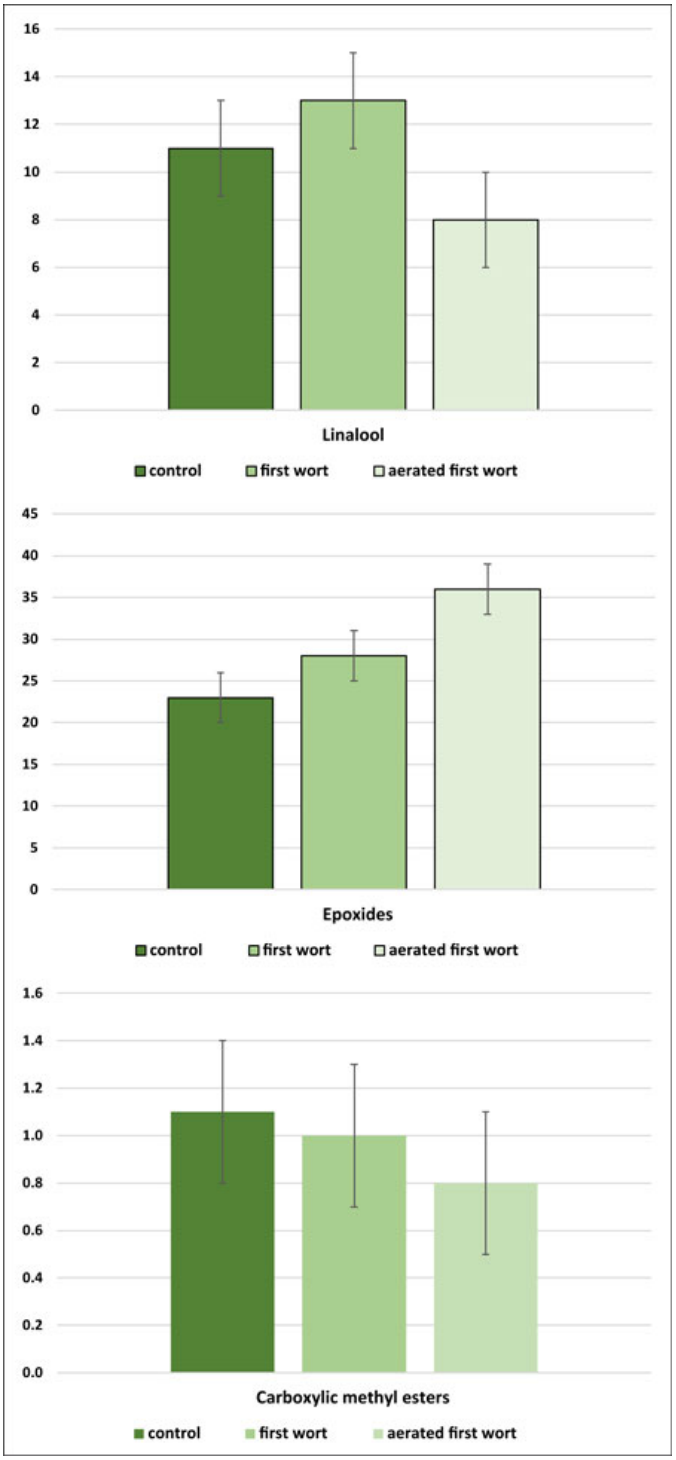

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Fig. 3 Mean concentrations of linalool, carboxylic methyl esters and epoxides in µg/l for the three series of trials, including ranges of analytical error for the statistical standard deviation

Polyphenols and foam stability

Table 1 shows the values for polyphenols and foam stability. No influence attributable to first wort hopping was observed. At most, aeration slightly favored the precipitation of polyphenol-protein complexes. Aeration of the wort did not result in an increase in the polymerization index, which is an indicator for the oxidative state of the wort polyphenols. The values for foam are also within the permissible range for analysis error.

ANALYSIS RESULTS FOR FOAM STABILITY AND POLYPHENOLS

		Control	First wort	Aerated first wort
foam stability	s	89	88	92
polyphenols	mg/l	237	239	225
anthocyanogens	mg/l	80	79	73
polymerization index		3.0	3.1	3.1

foam stability according to Steinfurt, total polyphenols, anthocyanogens and polymerization index (= ratio of total polyphenols to anthocyanogens)

Table 1

(/images/BWI_Artikelbilder/BWI_2023/BWI_01_2023/brauwelt-tab1-foam-polyphenols-2023.jpg)

Table 1 Analysis results for foam stability and polyphenols

Aging compounds

In order to monitor the influence of aging of the beers, key aging compounds were analyzed at the Weihenstephan Research Center for Brewing and Food Quality (BLQ) in both freshly bottled beers and in beers stored at 30 °C for six months. In the fresh beers, the values were consistently <10 µg/l. Figure 4 therefore only presents the results for four of the substances of interest after aging.

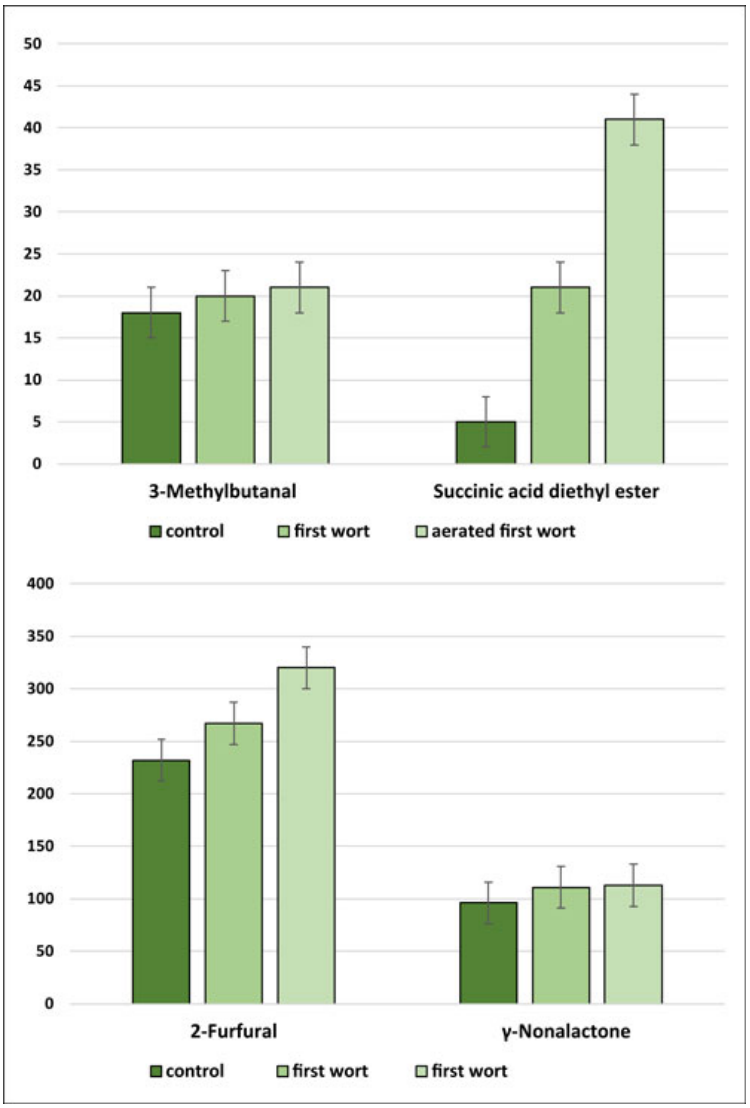

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Fig. 4 Concentrations of selected aging compounds in µg/l after six months of aging at 30 °C

The values for furfural, an indicator of heat stress, and for succinic acid diethyl ester, an oxygen indicator, differ between the beers, which is especially true for the beer brewed from aerated first wort. This provides confirmation that aeration can negatively affect the flavor stability of the beer.

Sensory analysis of the nine beers

The nine beers (3 × C = control, 3 × FW = first wort, 3 × AFW = aerated first wort) were evaluated using the following sensory tests:

- Nine triangle tests with a direct comparison of the beers C : FW, C : AFW, FW :AFW; tasters were asked to pair the samples correctly; additional questions about their preferences regarding the quality of the bitterness were evaluated.
- Tastings were conducted according to the DLG scheme with points for foam, aroma, flavor, fullness, quality of bitterness and the overall score.
- Tastings were conducted according to the CMA scheme with assessment of the four aromas common in hop-forward beers: “fruity”, “floral”, “citrus” and “hoppy”; the quality of the bitterness was also assessed.

Triangle tests

Table 2 provides the results from the triangle tests. In the pairing of the control beer with the first wort beer, no statistically significant difference was evident in the results for correctly matching any of the three in the series; the beers were obviously very similar. In series 2, a statistically significant distinction emerged between the control beer and the aerated first wort beer. There were even two significant results between the first wort beers and the aerated first wort beers.

RESULTS OF THE TRIANGLE TESTS

	C : FW	C : AFW	FW : AFW
statistically significant results for the triangle tests	0 of 3	1 of 3	2 of 3
preferences as a percentage of correctly paired samples	80 C : 20 FW	71 C : 29 AFW	74 FW : 26 AFW
preferences for bitterness as a percentage of correctly paired samples	76 C : 24 FW	84 C : 29 AFW;	66 FW : 34 AFW

Triangle tests for comparisons of C : FW, C : AFW, FW : AFW

Table 2

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Table 2 Results of the triangle tests

The evaluation of the additional questions for the correctly paired samples in the triangle test revealed a preference for the control beers over the first wort beers. A preference for the control beer was likewise seen in the comparison of the control beer and the aerated first wort beer. In the comparison of the first wort beers with the aerated first wort beers, a preference for the non-aerated first wort beers was evident in the results. The evaluation of the quality of the bitterness coincides with this general preference. The aerated first wort beers received lower scores while the control beer scored slightly higher.

Tasting according to DLG

The tasting according to the DLG scheme did not exhibit statistically significant differences for any of the characteristics. Table 3 therefore lists only the overall scores and the percentages of beers ranked first with regard to preference. The aerated first wort beers came in slightly behind the most highly ranked beers in terms of preference.

EVALUATION ACCORDING TO THE DLG SCHEME

	Control	First Wort	Aerated First Wort
DLG points	4.34	4.31	4.28
preferred beer [%]	38	37	25

Overall scores according to the DLG sensory evaluation scheme, beer ranked first in preference in % (rel.)

Table 3

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Table 3 Evaluation according to the DLG scheme

Tasting according to CMA

The evaluation of the individual aroma impressions according to the CMA scheme did not reveal any significant differences in the aroma and flavor of the three beers. Therefore, only the mean values for all four aroma characteristics are shown in figure 5. Since there were no conspicuous differences in the aroma compounds and the duration of the boil was identical in each case, a similar rating for aroma is not surprising. All of the first wort beers had slightly higher aroma scores than the control beer. The scores for the quality of the bitterness were comparable; however, those for the aerated first wort beer were slightly lower.

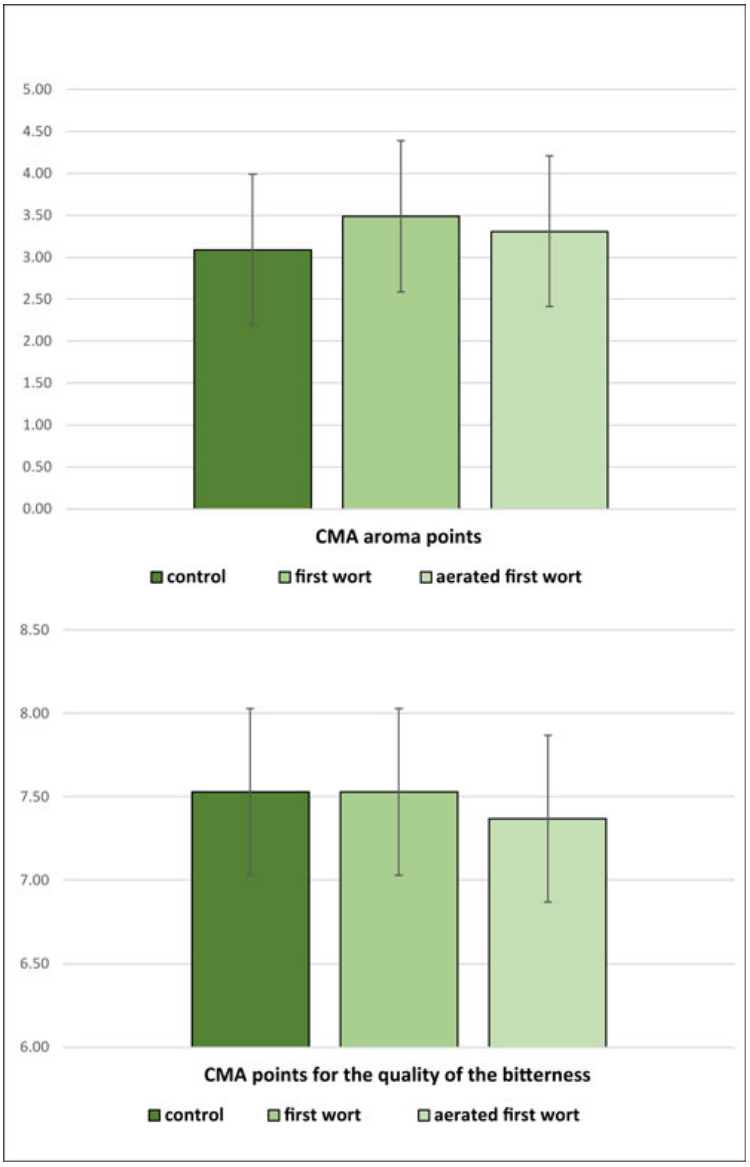

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Fig. 5 Mean values for CMA aroma points for aroma and flavor as well as points for the quality of the bitterness

Summary

The central question addressed in these trials was to compare the effects, if any, of hop additions to the first wort during lautering versus hop additions at the beginning of the boil. To this end, three beers were brewed with three different hop pellets. Identical quantities of hops were added to wort at the beginning of the boil, to first wort and to significantly aerated first wort.

The results showed slightly higher values for the bittering units in the beers brewed from aerated, hopped first wort. This was associated with a modest increase, e.g., in humulinones and cohulupone through oxidation of the α-acids, iso-α acids and β-acids. There was no substantial increase in the yield of bitter substances. The concentrations of linalool were nearly identical, ranging from 8 to 13 µg/l but were somewhat lower in the beers brewed using aerated, hopped first wort, suggesting an oxidative reaction. However, this did not affect the overall impression of the beer since the values for linalool were far below the sensory threshold. The carboxylic acid methyl esters exhibited no differences. From their values in the control beer, the epoxides of β-caryophyllene and α-humulene increased moderately in the first wort beer and significantly in the aerated first wort beer. This form of oxidation is consistent with assumptions found in the literature. However, it occurred in a range that was far below the sensory thresholds for the compounds analyzed. No differences were observed in terms of polyphenols and foam stability.

In aged samples, the aerated first wort beers possessed higher values for several aging indicators, which supports the reasoning behind protecting wort from oxidation due to its effects in the finished beer.

Sensorially, the beer brewed from aerated, hopped first wort was a bit less acceptable according to the triangle test, while the control beer was preferred somewhat more often than the other two. According to the tasting conducted according to the DLG scheme, there were no clear trends in the overall rating and in the harmonious character of the bitterness. In the CMA tasting, slightly more points were awarded for aroma in both first wort beers compared to the control beer.

The experimental trials conducted as described above do not support the assertion that first wort hopping produces a discernible effect in beer. Also, aeration during the lautering process did not have a positive effect on the beer. In particular, the established principles of low-oxygen lautering and boiling as a means for improving flavor stability is in direct opposition to any conceivable effect of first wort hopping on the beer.

Based on the results from our experimental trials, we can deduce that first wort hopping does not have a positive effect on the yield of bitter substances or on the quality of the beer. This is also in agreement with the fact that isomerization of the alpha acids is determined first and foremost by the duration of the boil and the temperature of the wort. The terpenes are oxidized only to a very limited extent in the wort. We are left with the assumption that the older technology in brewhouses dating from the first half of the 20th century may have delivered higher yields for bitterness. This may have been further enhanced by the use of whole hops which were common at the time.

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