Use of Isomerized Hop Extract as a Replacement for Conventional Hop Extract and Its Influence on Beer Flavor

Willi Mitter and Sandro Cocuzza
Hopsteiner, Simon H. Steiner, Hopfen, GmbH, Mainburg, Germany.

ABSTRACT
The procurement of raw materials has become an increasingly important factor for brewers. Depending on the crop year, not only malt, but also hops could be available in limited supply. Brewers using conventional hop products have limited options for reacting to this situation by optimizing their hopping formulations. One option for working around possible hop shortages might be the use of isomerized hop products. IKE (isomerized kettle extract) is one of the products that could be used as a replacement for CO₂ hop extract. However, in addition to any financial benefits, it is essential to preserve the sensory characteristics of the beer. To obtain reliable data, numerous commercial-scale brewing trials were carried out. Analyses of hop products, wort, and beer samples were performed. Bitter compounds were quantified using specific (HPLC) and nonspecific (UV-spectro) methods. For hop aroma components, especially the compound linalool, which has a major impact on beer character, a method using GC-FID was applied for analyses of wort and beer samples. Samples were taken at different stages of wort boiling, which made it possible to obtain exact information about the solubilization of α- and iso-α-acids and the evaporation of hop aroma compounds during wort boiling. Beer samples were evaluated by a trained tasting panel. The trials demonstrated that IKE is a suitable kettle hop product that can be used to reduce hopping costs without affecting the sensory characteristics of a beer.

Keywords: beer flavor, hop extract, IKE, isomerized kettle hop extract

Introduction
The procurement of raw materials has become an increasingly important factor for brewers. Brewers using conventional hop products have only limited options for reacting to substandard crop yields by optimizing their hopping formulations. One option for working around a hop shortage is the use of pre-isomerized hop products. Isomerized kettle extract (IKE) is one of the products that could be used as a replacement for CO₂ extract. In addition to any financial benefits, however, it is essential to preserve the sensory characteristics of the beer.

Material and Methods
To obtain reliable data, numerous commercial-scale brewing trials focusing on changes in hop bitter and aroma compounds during wort boiling were carried out, and the resulting beers were compared. The bitter compounds found in the hop products, wort, and beer samples were analyzed using specific (HPLC, EBC 7.8) and nonspecific (UV-spectro, EBC 8.8 and 9.8) methods (1).

Analyses of hop aroma components in wort and beer samples were performed using GC-FID (4). Special attention was paid to the compound linalool, which has a major impact on beer character (2,3). Samples were taken at different stages of wort boiling. To achieve the same bitterness in the final product, the addition of IKE was reduced by 25% (based on HPLC) compared
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with the regular dose of CO₂ extract. Both products were added at the beginning of the boiling process. A trained tasting panel assessed the bottled beer produced from the brews.

Results and Discussion

The brewing trials focused on the following parameters: iso-α-acids yield, resulting bitterness, and hop aroma. Figure 1 compares changes in the iso-α-acids analyzed from wort boiling to the final concentration in bottled beer. The figure shows the average for all brews tested. All analyses were performed in duplicate.

The hop product IKE dissolved very quickly in wort. While the iso-α-acids concentration in wort with IKE reached its maximum level after only 5 min, the isomerization process for wort with CO₂ extract increased continuously over a period of 80 min. This is in line with previous tests in which delayed dissolution was also noted in the case of pure resin extracts (4).

Brews with IKE showed no significant change in iso-α-acids concentration (mg/L) during the later stages of wort boiling. Consequently, the use of IKE would allow brewers to reduce wort boiling time significantly. Shorter boiling times result in better flavor stability and can be implemented without incurring iso-α-acid losses. Energy costs can also be reduced. Care must be taken to assure that all other flavor-influencing compounds are considered when reducing boil time.

As shown in Figure 1, IKE brews experienced a high loss of iso-α-acids during fermentation. (This phenomenon will be subject to further investigation.) The corresponding plots of the resulting bitterness (BU) are shown in Figure 2. The curve of the IKE brews was quite similar to the curve displayed in Figure 1. The resulting bitterness in the wort with CO₂ extract was significantly higher compared with the specific iso-α-acids measured by HPLC (Fig. 1). This was due to the use of the nonspecific BU method that measures not only the iso-α-acids, but also the majority of nonisomerized α-acids. It is well known that when adding conventional hop products, bitter acids are first dissolved in wort and isomerized during the later stages of boiling. IKE and CO₂ extract produced the same analytical bitterness (BU and HPLC) in the final beer. The reduced dosage of IKE was enhanced by its improved utilization compared with CO₂ extract. Further brewing trials confirmed this improved utilization (based on HPLC; Fig. 3), which varied depending on brewing technology and equipment.

In the breweries shown in Figure 3, the utilization improvement factor ranged between 1.37 and 1.57. The main differences in the results for the three breweries were observed after wort boiling. The pH appeared to be very influential, but other parameters, such as yeast strain, number of yeast cells, fermentation conditions, etc., clearly also contributed to utilization of hop bitter acids.

Figure 4 shows the changes in linalool concentration during wort boiling. The higher solubility of IKE resulted in a higher linalool concentration at the beginning of boiling. However, due to continuous evaporation, this difference was compensated for...
within a maximum of 30 min. Thereafter, the concentration remained constant in each brew through to the finished product. In both beers, the linalool concentration was below its threshold. If a hoppy aroma is desired, it could be achieved by adding IKE later during boiling without any loss of bitterness (Figs. 1 and 2).

**Tasting Results**

As expected, our tasters detected no hop aroma. Therefore, we continued the investigation by evaluating and discussing only beer bitterness. Figure 5 shows the bitter profiles of a beer produced with IKE compared with a beer produced with CO₂ extract. While the IKE beer seemed to be a bit milder, the CO₂ extract beer was slightly more harmonious. According to the results of the individual tasters, the differences were not significant. Neither product gave any negative sensory impressions.

**Summary**

The brewing trials demonstrated that IKE is a suitable kettle hop product that reduced hopping costs without affecting the sensory characteristics of a beer. Based on the results of the brewing trials, the following benefits are evident:

- The same quantity of beer can be produced using at least 25% less hop in the form of IKE compared with CO₂ extract.
- There are no significant flavor differences between beers produced using IKE or CO₂ extract, making a product change straightforward.
- Using IKE, hop aroma can easily be achieved by late hopping, with no loss of iso-α-acids.

**REFERENCES**