Influence of different boiling bitter and aroma substances

ENERGY SAVINGS | In recent years, a large number of innovations have been introduced in the brewhouse equipment sector, the primary objective being to save energy. The technical details of these new systems have been described extensively in the literature and in company brochures ([1], [2], [3], [4]). Some breweries kindly provided, as far as possible, samples produced in accordance both with conventional processes as well as in the new or converted brewhouses. At a minimum, double brews from each of the different brewhouse types were used in the evaluation of results.

NATURALLY, these boiling systems cannot be compared because each brewery produces different beers with different hop additions. But in any case, a certain overview of the anticipated effects on hop components (bitter and aroma substances) was possible. It should, however, be borne in mind that identical systems will not necessarily lead to identical results in all breweries.

Data on the various hop additions was intentionally omitted because the same alpha acid based addition was always assumed in the comparisons, to the extent that this was possible.

Analysis

When investigating the various brewhouse types, the following analyses were used: bitterness units according to EBC 8.8 and EBC 9.8; alpha and iso-alpha acids using HPLC EBC 7.8 after prior liquid-liquid extraction; aroma substances measured by the HHV05 method [5].

Authors: Willi Mitter and Dr. Dietmar Kaltner, Simon H. Steiner, Hopfen GmbH, Mainburg, and Timo Lambertsen, Hopsteiner-Hallertauer Hopfenveredelungsgesellschaft m.b.H., Mainburg

Classical internal and external boiler or copper heating

Classical boiling (Fig. 1 as a system with external boiler) is increasingly being converted or replaced by new plants. However, by way of introduction, typical processes during wort boiling, relating to hops, are described again below.

Fig. 2 shows a plot of bitter substances during wort boiling with three hop additions. It also shows a comparison with the resulting beer. Bitterness units increase significantly faster than specific iso-alpha acids measured by HPLC. This phenomenon is common because, after addition, bitter acids first go into solution and then are isomerised. Moreover, a certain portion is excreted during boiling. As the spectral photometric BU method determines a major portion of non-isomerised alpha acids in addition to iso-alpha acids, the values for same are significantly higher compared to the specific iso-alpha acids determined using HPLC. In this case, after fermentation, the values of bitterness units and iso-alpha acids are the same because the major portion of non-isomerised bitter acids is excreted due to the pH drop. However, the level at which the values of the various methods settle can vary, depending on the hop product used and the beer matrix.

The development of aroma substances in classical brewhouses has been described in great detail [5]. In this commercial example, the emphasis is extensively on the last addition. Anyway, this has the biggest influence on the subsequent hop aroma in beer. Fig. 3 shows two different points in time of addition (2 and 10 min before end of boiling/casting) and the development of the hop aroma component linalool which correlates very well with sensory perception of hop aroma [6]. A comparison with the finished beer is also given. Two things should be mentioned:

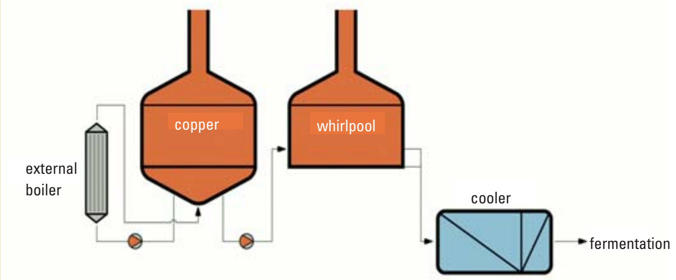

Fig. 1
Classical wort boiling system

systems on development of

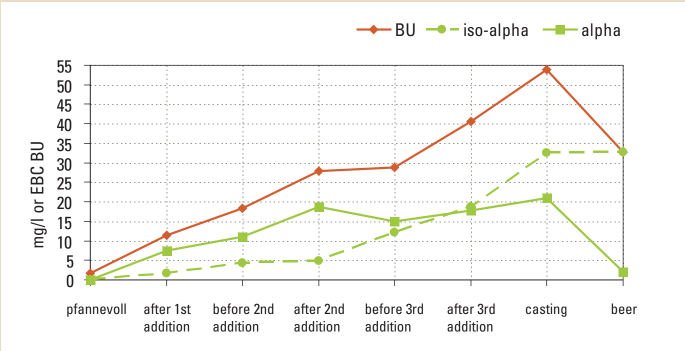

Fig. 2 Plot of bitter substances in conventional boiling (internal boiler – 3 hop additions)

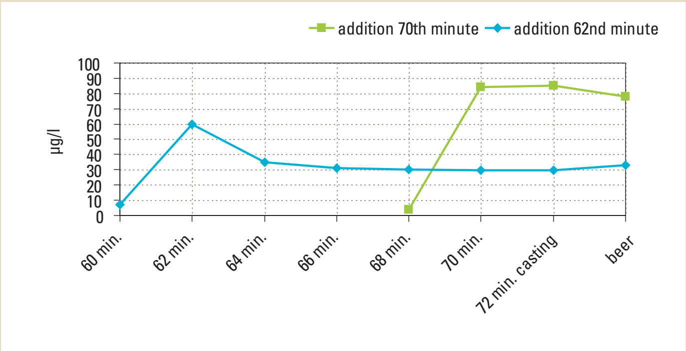

Fig. 3 Plot of linalool in conventional boiling (internal boiler – late addition)

- The point in time and, naturally, also the type and amount of addition are decisive for the subsequent hop aroma of the beer;
- Roughly the same linalool concentration remaining after boiling is also found in the beer. This is a typical element of classical boiling systems.

Dynamic low-pressure boiling (Huppmann)

Dynamic low-pressure boiling can – depending on the design pressure of the wort copper – be installed in a conventional brewhouse without any problem. In the commercial test described here, the cycle shown in Fig. 4 was followed exactly. The copper does not differ from a conventional copper with external or internal boiler. It was possible to compare dynamic low-pressure boiling and conventional boiling in this brewery.

Fig. 5 shows that bitter substances react in exactly the same way, except for some minor deviations as a consequence of sampling or analytic evaluation. Yield of bitter substances was also the same in the various beers.

Aroma substances show an identical picture (Fig. 6). The deviations apparent in the diagram are mainly due to sampling because concentration may change significantly within a few seconds, especially after addition. The pitching wort and finished beer do not show up significant differences. It can thus be demonstrated again that the linalool level obtained in the cast wort largely remains in beer.

Stromboli (Steinecker)

This newly developed internal boiler can be integrated in an existing conventional brewhouse. Unfortunately, no real-time tests could be carried out in conventional operation in order to compare this boiling system.

Fig. 7 shows changes in bitter substances during boiling with Stromboli up to the finished beer. The development is exactly in line with what is known from classical boiling systems.

Linalool was also quantified from beginning of boiling to the finished beer as being representative of aroma substances. Fig. 8 shows how the value evolved. As had been expected, the high linalool content immediately after addition and the relatively rapid drop a short time after addition are typi-

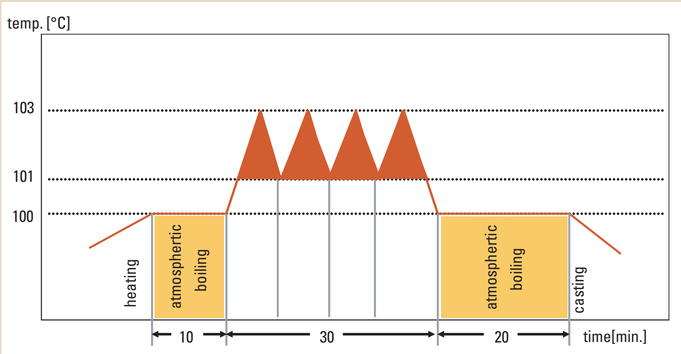

Fig. 4 Dynamic low-pressure boiling: special run for hop tests

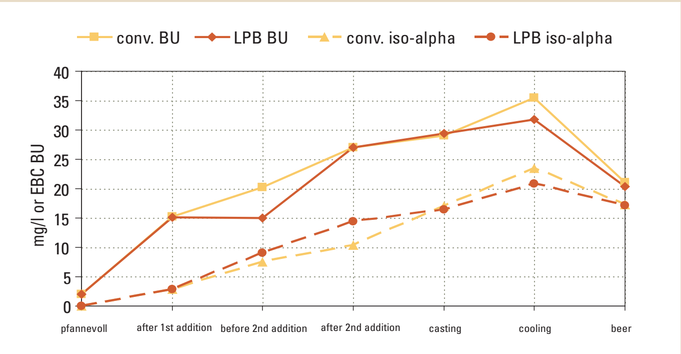

Fig. 5 Bitter substances in low-pressure boiling (according to Fig. 4) compared to conventional boiling

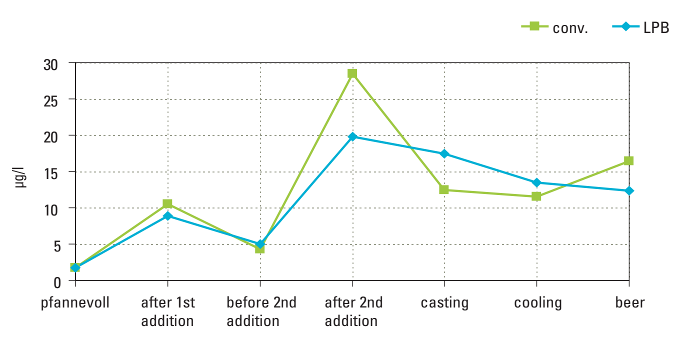

Fig. 6 Linalool in dynamic low-pressure boiling (according to Fig. 4) compared to conventional boiling

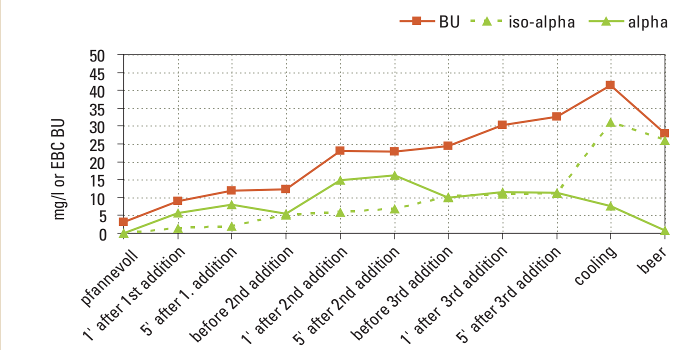

Fig. 7 Plot of bitter substances during boiling with Stromboli

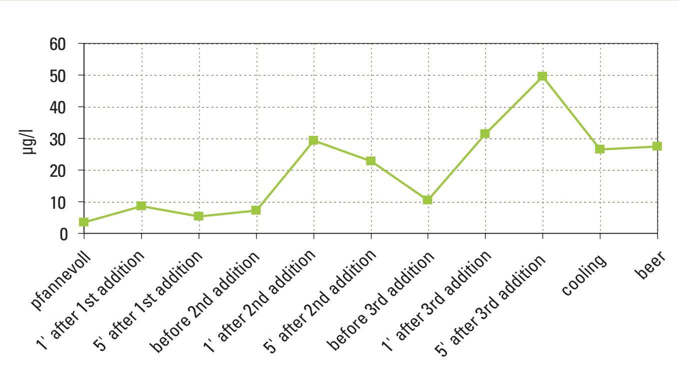

Fig. 8 Plot of linalool during boiling with Stromboli

cal characteristics, also in this test. Minor changes are observed only after the first addition, using hop extract where quantities dosed were also lower. This is in line with previous tests where delayed dissolution and evaporation were also noted in the case of pure resin extracts [5]. It is important to note that linalool content remains practically unchanged from the wort after casting through to the beer.

Merlin (Steinecker)

Merlin was one of the first boiling systems that deviated substantially from the conventional boiling process (Fig. 9). The main difference is that the wort goes through the Merlin again after the whirlpool and thus aroma substances are evaporated again. Unfortunately in this case, we were not in a position to test comparative brews originating from the conventional process. We could determine from previous tests in which only the finished beer was analysed that yields of bitter substances were not affected. With the same hop addition, iso-alpha acids in the beer were 28.5 mg/l (with Merlin) and 28.9 mg/l (without Merlin), both measured by HPLC. As the bitter substances develop along conventional lines, these are not dealt with separately. Fig. 10 shows the hop aroma substance linalool from casting to beer when using a Merlin system. While there were no longer any major changes from casting to finished beer in conventional boiling systems, a pronounced jump can be observed here from whirlpool to wort after the Merlin. Naturally, the absolute linalool content, relatively high in this case, also plays an important part. In worts with linalool contents around 10 to 15 µg per litre, reduction in the same percentage range is of no consequence because this can no longer be perceived in sensory terms.

If it is important to produce a beer with a hop aroma, the necessary parameters have to be set in advance during addition by selecting suitable varieties and by the amount dosed. However, it was not possible to run corresponding commercial tests. No comment can be made about the percentage decrease in the case of higher linalool levels. But it must be assumed that the relative decrease will be larger at higher levels.

When one wants to produce a beer with an emphasis on hop aroma, the decrease can be controlled by a bypass circumventing the Merlin. The DMS value should also be taken into account in order to find the golden ratio for the quantity being bypassed.

Schoko (Schulz)

As in the Merlin, wort is subjected to another evaporation step after the whirlpool, also in the Schoko process (Fig. 11). Tests involv-

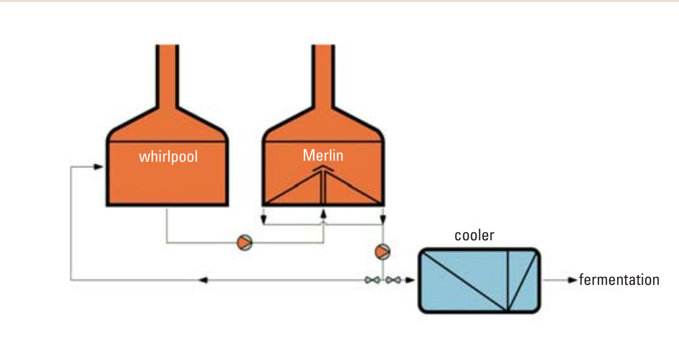

Fig. 9 Merlin wort boiling system (Steinecker)

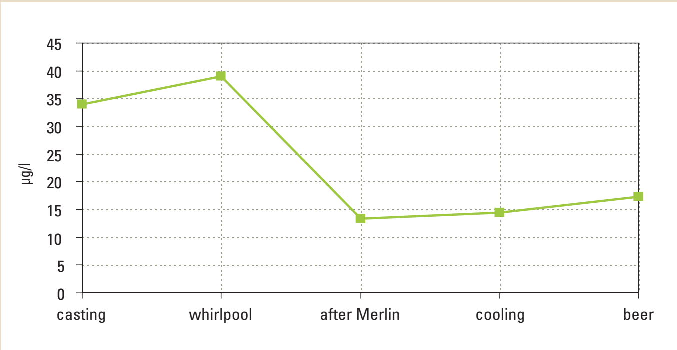

Fig. 10 Plot of linalool from cast wort to finished beer in the Merlin system

ing the Schoko have already been published extensively [7]. It should be noted that there are also no significant differences in terms of bitter substances with this system. The yield is slightly higher in the Schoko process, based on bitterness units, compared to the conductometer value whereas conventional boiling was slightly superior when comparing the specific bitter acids measured by HPLC.

An interesting development of aroma substances is shown in Fig. 12. With identical hop addition, less is evaporated during boiling in the Schoko system. One would assume that the flash evaporator does not take out any linalool. But when looking at the finished beer, a distinctly smaller difference is observed when comparing Schoko and conventional boiling.

If the intention is to achieve a more intensive hop aroma, a special addition ahead of the plate cooler represents an option, this has been successfully applied in commercial tests [8]. Care is, however, required to avoid obtaining an excessively "unclean" hop aroma in the beer.

It is known that hops require a certain hot holding time to be freed from unpleasant odour substances. It goes without saying that such a process could also be used in other boiling systems.

Flash evaporator (Ziemann)

In this system, the wort also goes again through an evaporator after the whirlpool (Fig. 13). As in all other boiling systems, yield of bitter substances remains unchanged. With identical hop addition, a bitterness of 20.7 BU and 19.0 mg/l of iso-alpha acids (conventional) and 21.2 BU and 19.9 mg/l of iso-alpha acids (evaporator) was obtained.

In the commercial brews, hops was added only once at the beginning of boiling. Moreover, there was no emphasis on obtaining a special hop aroma. Consequently, there is no clear difference in Fig. 14 between conventional boiling and the new system with a flash evaporator. There is a minor trend towards slightly higher values for linalool, which is in no way significant. This trend could be more pronounced in the case of higher levels of aroma substances. Similar to the Merlin, a partial bypass would be a solution for production of beers with an emphasis on a more pronounced hop aroma, also in this case.

Summary

When looking at these tests, it should always be borne in mind that they represent snapshots in individual breweries. Yields of bitter substances are generally not adversely affected by energy savings associated with the new brewhouse technologies. In principle, brewhouses can be generally divided into two groups, with or without an evaporation step after the whirlpool.

In the first process, more or less hop aroma substances are lost though there are possibilities to compensate for these losses. But outside Germany, there are unfortunately only few beer types with a pronounced hop aroma. Loss of hop aroma substances is thus of secondary importance in many breweries. Ongoing additional tests with new brewhouse equipment will be covered in a future report. ■

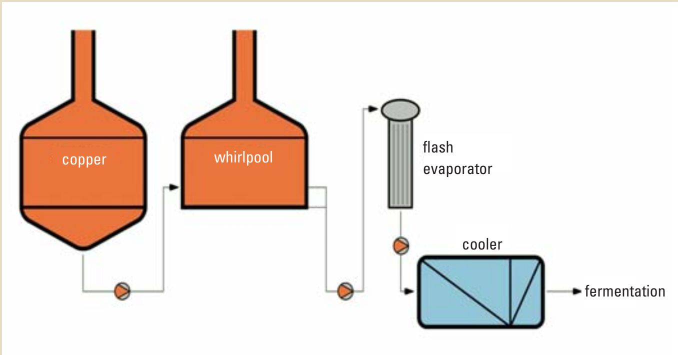

Fig. 11
Schoko wort boiling system (Schulz)

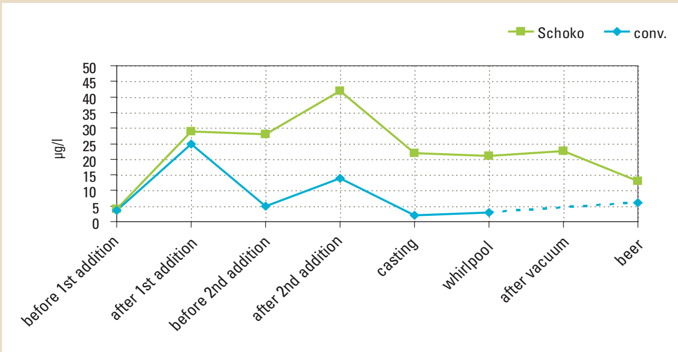

Fig. 12
Plot of linalool when comparing Schoko with conventional cooling

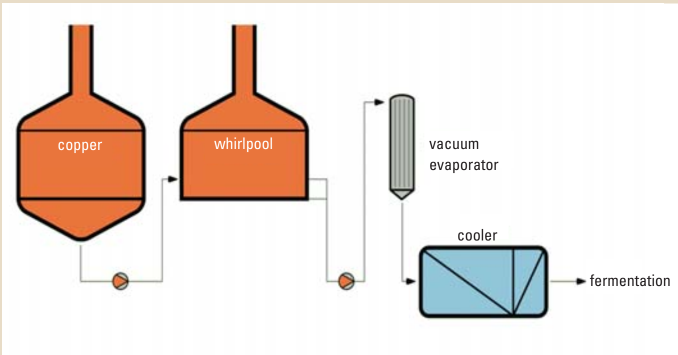

Fig. 13
Wort boiling system with flash evaporator (Ziemann)

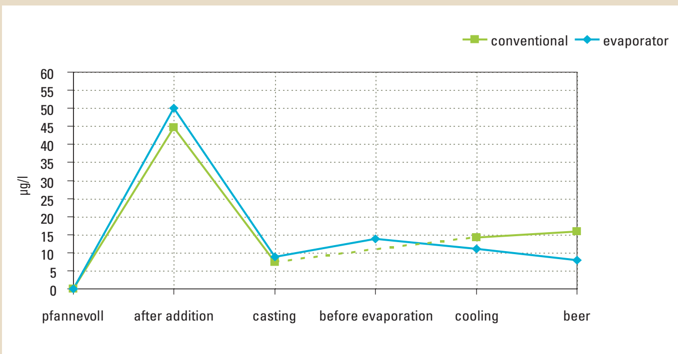

Fig. 14
Plot of linalool when comparing flash evaporator to conventional boiling

References

1. Evers, H.: Würzekochung im Wandel der Zeit, *Brauwelt* No. 5 (2002) pp148-155.
2. Schu, G. F.: Brauindustrie 10 (2002) pp22-29.
3. Mezger, R., Krottenthaler, M., Back, W.: Moderne Würzekochsysteme – ein Überblick, *Brauwelt* No. 4-5 (2003) pp93-99.
4. Englmann, J.: Getränke Technologie und Marketing 4 (2005) pp4-12.
5. Mitter, W., Biendl, M., Kaltner, D.: "Behaviour of hop derived aroma substances during wort boiling", Monograph 31, EBC, Symposium Flavour and Flavour Stability, Nancy, France, Oct. 2001.
6. Fritsch, H., Kaltner, D., Schieberle, P., Back, W.: Entschlüsselung des Hopfenaromas in Bier, *Brauwelt* No. 39-40 (2004) pp1206-1207.
7. Kaltner, D., Mitter, W., Binkert, J., Preis, F., Zimmermann, R., Biendl, M.: Würzekochsystem SchoKo und Hopfenkomponenten, *Brauwelt* No. 46-47 (2004) pp1562-1567.
8. Kaltner, D., Mitter, W., Binkert, J., Preis, F., Zimmermann, R., Biendl, M.: Variationsmöglichkeiten der Hopfengabe beim Würzekochsystem SchoKo, *Brauwelt* No. 19-20 (2005) pp582-588.

Reducing costs by increasing the degree of mobility

CALCULATIONS ASSISTING IN DECISION-MAKING | The objective of a mobile configuration of information flow within company processes is to reduce costs. Expenses calculated for a stationary configuration of information flow can thus be compared with those for a mobile configuration. A detailed analysis of actual and target state form the basis, both for the decision itself as well as for monitoring during the period of use.

THE OBJECTIVE OF FACTORY DATA ACQUISITION is to collect data where it arises. In order to avoid interruptions of media supply and duplication in data collection, industrial computers that are integrated directly into the material flow serve both to provide information as well as to collect information.

The so-called information points (I-points) are integrated into the material flow. Fig. 1 shows possible I-points within a schematically represented material flow in the process industry. The number of available I-points in a company is limited when using a stationary configuration. The number of I-points and the input made in order to use the I-points within the ongoing process define the economics of a mobile process configuration (Fig. 3).

The primary cost factor analysed in an evaluated comparison between a stationary and a mobile configuration is based on time spent and associated and evaluated production factors for transfer of information between existing I-points.

Paths to be bridged and associated costs in the case of a smaller number of I-points have to be set out in a comparison. The number of I-points is unlimited in a comprehensive mobile solution. Paths for information transfer are fully substituted by the use of mobile technologies.

Cost analysis

Each process is subdivided into a multiplicity of activities with individual unit operations and the respective inputs that tie up

Authors: Dipl.-Kfm. Oliver Marz, Martin Miller, CSB-Systems AG, Geilenkirchen

COMPARISON OF ACTIVITIES USING INVENTORY STOCKTAKING AS AN EXAMPLE

Activity	Time stationary (in min)	Costs stationary	Time mobile	Costs mobile	Substitution
Print list of numbers	5 min	$\frac{5\text{*hourly rate}}{60}$	0 min	0	✓
Transfer data to PC	180 min	$\frac{180\text{*hourly rate}}{60}$	0 min	0	✓
Additional activities					

Table1