INFLUENCE OF FILTRATION ON DRY-HOPPED BEERS

Observable changes in aromatic and bitter substances from hops as a result of standard beer filtration methods

Dry hopping has become popular due mainly to the craft beer boom in recent years. New hop varieties that bring special aromas to beer can be optimally exploited via the process of dry-hopping. However, the aromatic and bitter substances thus introduced undergo continuous change: from the time of introduction, throughout the brewing process and even during eventual containment. Filtration decisions play an important role here, and this role is described below.

Traditionally, hops or hop products are added to a brew for seasoning. A majority of aromatic compounds evaporate while a few compounds characteristic of late hopped beers, such as linalool, are captured in the bottle.

The primary goal when adding hops in the brewhouse, is to carefully add bitter substances in a controlled manner. When dry-hopping, the intention is to incorporate volatile aromas that won't evaporate readily in order to lend the beer a more intense aroma profile. For some beer styles (e.g. India Pale Ale) this is, of course, already part of the recipe, but even with classic beer types there is a lot of experimentation with dry-hopping nowadays. Most dry-hopped beers are sold as "unfiltered." In some markets, however, filtered beers are preferred. Furthermore, homogeneous turbidity is a feature that poses further challenges for brewers who offer dry-hopped beers yet strive to guarantee consistent product quality within the specified best-before date. For these reasons, even dry-hopped beers have been increasingly sent through some combination of filtration systems in recent times. Filtration can also be deliberately used to control aromas more deliberately. In this report, we examine how a classic silica and a disinfecting sheet filtration system can affect aromatic and bitter substance introduction in a controlled manner in dry-hopped beers.

Preliminary testing

Studies on a commercial scale have demonstrated that more than 80 percent of the aromatic compounds are lost when employing classic beer filtration methods. For example, a drop in myrcene from 440 micrograms per l in the storage tank to less than 75 micrograms/l in the filtered beer results in a perceptible change in the aroma sensory profile. Similarly dramatic decreases were also observed in caryophyllenes and humules while other aromatic substances such as linalool or terpineol remained nearly unchanged and were not affected by filtration. Other monoterpene oxides such as geraniol and citronellol also exhibited the same behavior. These filtration systems used a silica compound support layer filter and a disinfecting sheet filter. In addition, silica gel and PVPP were used for stability. The beer was examined after filtration. As a result of the changes observed, common filter aids and their influence on aromatic and bitter compounds in dry-hopped beers were investigated in greater detail.

Main trials

The main tests show the influence of silica in the Kieselgur filtration (KGF) and cellulose in the downstream disinfecting sheet filtration (EKF) on the aroma and bitter substances of the hops. For this purpose, filtration tests were carried out on a pilot scale. The two-stage filtration process was sampled and

Table 1: Filter system V1 and V2 overview

	V1 (KGF)	V2 (EKF)
Filter system	Kieselgur cylindrical filter	Sheet filter
Filter manufacturer	Bucher Filtrox Systems AG	Eaton Technologies GmbH
Filter type	SYNOX PF-100 Kerzenfilter (0,07 m^2)	BECO COMPACT® PLATE 200 SF-E (0,22 m^2)
Specific filtration parameters	> 2.5 hl/m^2h	> 1.1 hl/m^2h
Actual filtration capacity	0.2 hl/h	0.2 hl/h
Filter components/sheets	Large particles: BECO 3500 Fine particles: BECO 200	Sheets: BECOPAD 170, 0.2-0.4 µm
Sample from filter inlet	Unfiltered particles from storage tank	Ø sample over 3 h from V1
Post-filtration sample	Ø sample over 3 h	over 3 h: 1/h

analyzed at different phases over the entire period. Substeps V1 and V2 of the experimental setup are described in table 1.

The filtrate obtained from V1 was homogenized again after the silica-based filter and then used for V2. All filtration tests were carried out with a dry-hopped, unfiltered base beer after two-weeks in storage. A description of the pale ale used is given in table 2. Methods of analysis for determining bitter and aromatic substances are listed in table 3.

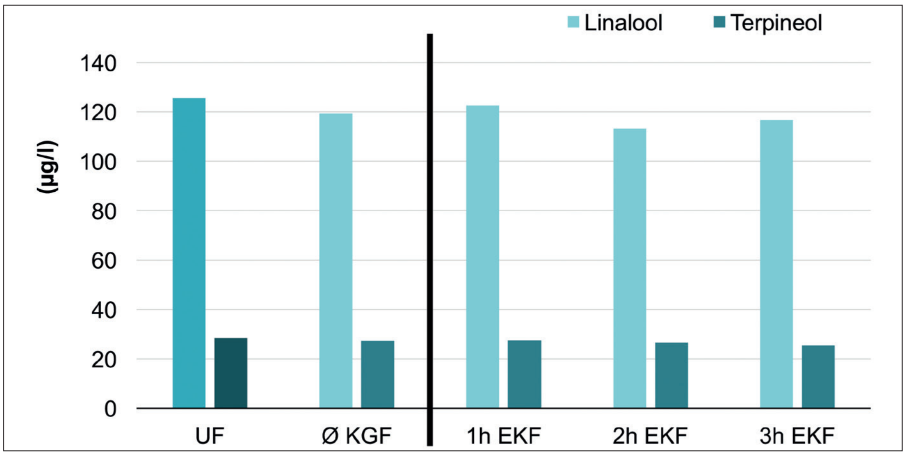

Fig. 1: Linalool and terpineol in the beer: Kieselgur filtration (left) and disinfecting sheet filtration (right)

Results

Figure 1 shows that concentrations of the monoterpene oxides linalool and terpineol mentioned above remain almost constant for both V1 and over the duration of V2. Initial values measured in the storage tank are to be regarded as identical to the concentrations measured in the beer, taking into account an analysis tolerance of ten percent. Thus, in these experiments, no change in filtration can be observed for the aroma group of monoterpene oxides. For the monoterpenes in general, the development of myrcene is shown in figure 2. Other aromatic substances such as the sesquiterpenes caryophyllene or humulene demonstrated similar behavior, albeit at a significantly lower, hardly relevant sensory level for the beer under investigation.

In V1, the silica filter sample revealed a drastic decrease of more than 75 percent of the myrcene measured in the unfiltered beer sample. Although the silica filter contents showed a sensorily relevant concentration in the beer [1], this process step is nevertheless followed by a massive sensory change. Since the adsorptive effect of diatomaceous earth is described as very low [2], there are other phenomena at work that cannot yet be fully explained. Certainly, part of the myrcene concentration can be attributed to its attachment to yeast cells, which are removed [3, 4].

When looking at the temporal course of the sheet filtration (EKF) from V2, an hourly increase in myrcene can be observed. Here, the cellulose of the sheet filter layers in this volatile, non-polar aromatic substance shows adsorptive behavior, described in a similar way for beer polyphenols [5] and during the filtration cycle of white wines [6]. After an initial period of material absorption into the filter sheets (0 to 1h), saturation takes place after approx. two hours. Higher myrcene concentration above the average value of the initial sample after a period of three hours is attributable to pressure surges detected at the end of the filtration cycle. Analogous behavior was also observed in the sesquiterpenes, some ketones and aliphatic aldehydes, which were also analyzed in this experimental series (not shown). Due to increasing concentrations during the several-hour filtration process, layer formation in the downstream pressure tank is to be expected. Subsequent bottling of this non-homogeneous, filtered beer can lead to varying degrees of sensorily "available" hop aromas at the beginning and end of the bottling process within a given batch.

The analysis results of the bitter substances are summarized in figure 3. This shows that the content of iso-alpha-acids and also the content of alpha-acids was slightly

Table 2: Hop volume and parameters of the tested Pale Ale using the ZU 09326 variety

Pale Ale with hop variety ZU 09326		
Hop dosage	Start of the boil (g α/hl)	8.0
	Whirlpool (g α/hl)	6.0
	Dry Hopping g pellets type 90/hl	250
Analysis	Original gravity (%)	12.4
	pH	4.54
	Alcohol content (% vol.)	5.5

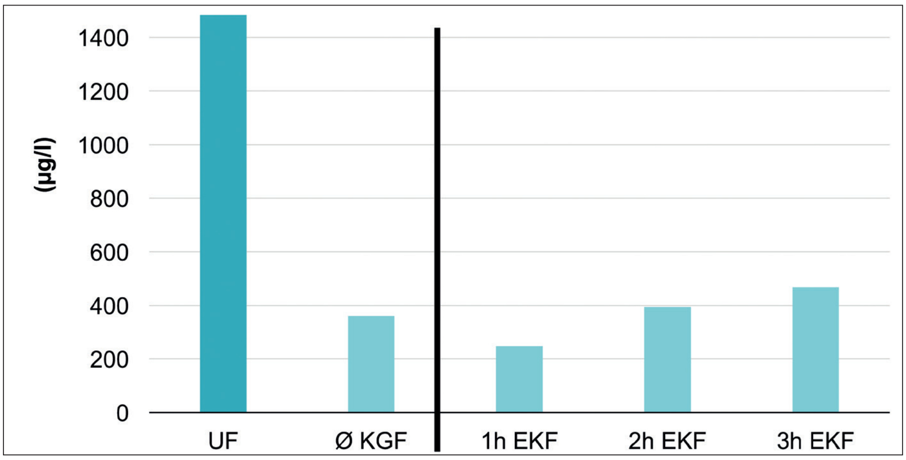

Fig. 2: Myrcene in the beer: Kieselgur filtration (left) and disinfecting sheet filtration (right)

reduced across both filtration steps. In the case of iso-alpha-acids, a difference of almost 4 mg/l could be observed in sum, in the alpha-acids only slightly less. As a result of these two decreases, the non-specific bitter units decrease in value from an initial 32 BU to slightly less than 30. A closer look at the hourly measuring points of V2 (not shown) shows a drop at the beginning of the sheet filtration (EKF) only for the alpha-acids, followed by a slight increase over time. Due to the poor solubility of alpha-acids, these also follow the concentration pattern of the flavoring substances investigated in this series of experiments:

1. Adsorption at the start of filtration
2. Saturation over time
3. Increase to at least pre-EKF-filtration levels.

Conclusion

The experiments show the behavior of aroma and bitter substances of a dry-hopped beer at the kieselgur filter (KGF) and at the disinfecting sheet filter (EKF). In addition to varying, decreased levels of concentration of important flavor-giving substances, other flavoring substances remain unchanged in the filtered beer. There are also slight losses among the bitter substances, which may be compensated in later brewing phases.

Due to adsorption and saturation in the final filtration step (disinfecting sheet filter, EKF)) measurable concentration differences over the duration of the filtration process have been observed. As a result, a lack of homogeneity within a filtered batch cannot be ruled out.

Since a dry-hopped beer undergoes further aroma changes in the filled container [7, 8], in which the volatile mono and sesquiterpenes are lost, filtration can be employed in advance to reduce concentrations of these sensorically relevant aromas and thus improve the taste stability and flavor profile of a given beer style. At the same time, the typical aroma of a particular hop variety can be targeted with confidence and included in the recipe.

An overview of the behavior of certain hop flavoring substances during filtration can be found in our newsletter #10-2016 under www.hopsteiner.de.

Table 3: Analytical methodology for aromatic and bitter substances

Principle	Components	Method
Spectrophotometry	Bitter units	EBC 9.8
HPLC	Iso-alpha-acids	EBC 9.47
HPLC	Alpha-acids	Internal method, calibration standard ICE 4
GC-MS	Linalool, terpineol, myrcene	Internal method [9]

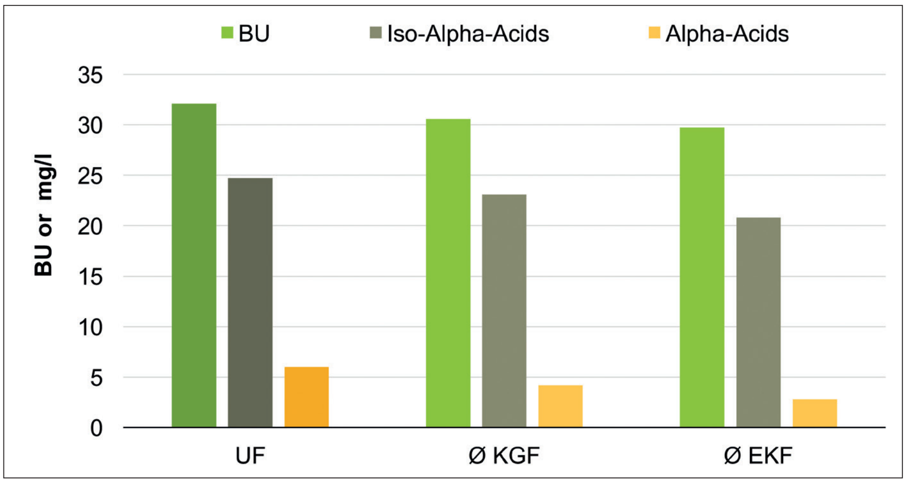

Fig. 3: Bitter components in the beer: Kieselgur filtration (left) and disinfecting sheet filtration (right)

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