Hopsteiner

# How to predict the hop aroma profile in dry-hopped beers?


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## Introduction

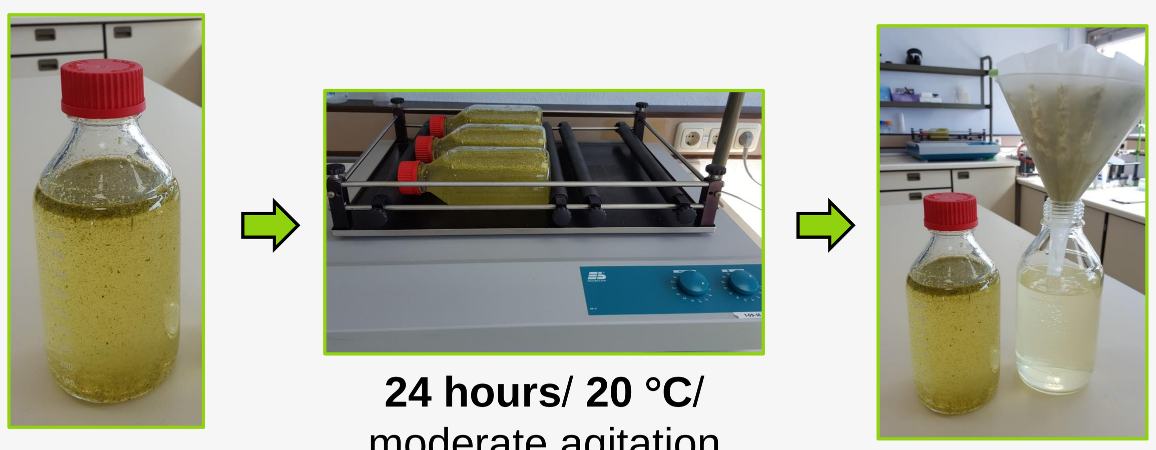
Dry hopping is a technique of choice to introduce the special hop aroma into beer after the fermentation step. Different parameters like hop variety, amount of hop dosage or contact time influence the aroma profile of the final product. So far, the well-known approach for prediction of hop aroma profile in beer uses previously determined transfer rates.

The present study investigated the possibility of cold water extraction of hop pellets for predicting the hop aroma composition in dry-hopped beers. Therefore a lab scale evaluation method for the determination of the dry hopping potential of different varieties was tested. This work goes in for the cold water extraction of the hop variety Experimental # 09326 [**1**]. After extraction, the hop aroma substances were analyzed using the HS-Trap GC-MS technique [**2**]. The achieved results of this approach were compared with the outcomes of real brewing trials.

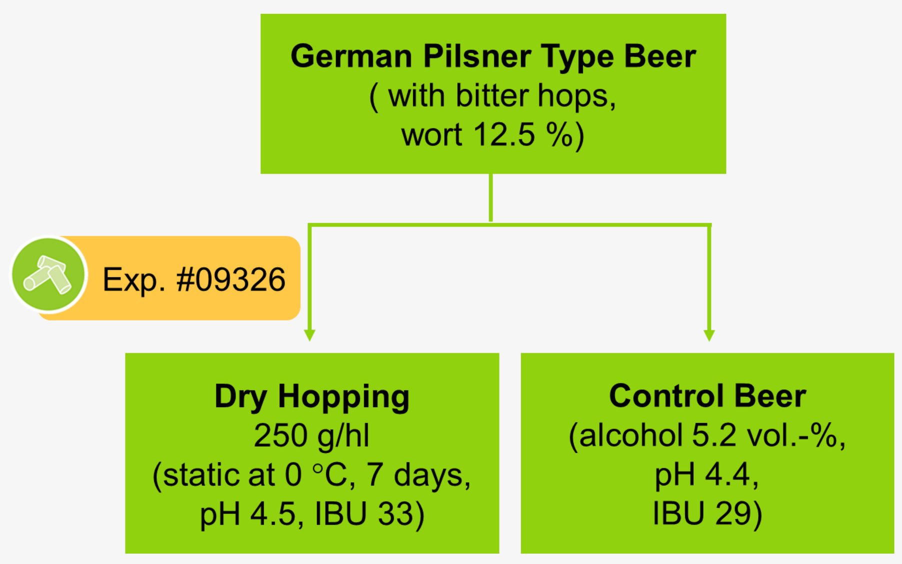
**Figure 1. Hop cone Exp. #09326**

## Materials and methods

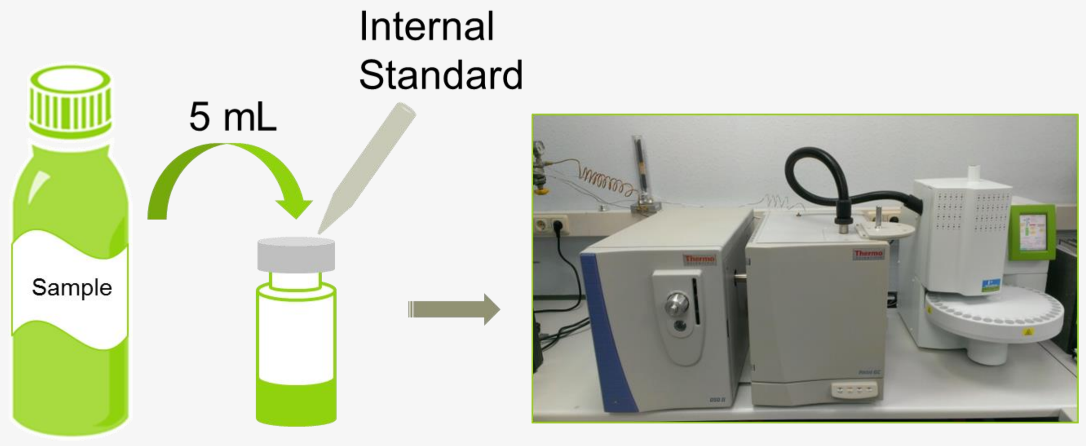
### Cold water extraction




### Brewing trial




### Sample preparation/ equipment for hop aroma analysis




## Results

The filtrated aqueous solution prepared with the hop variety Experimental # 09326 was analyzed using Headspace-Trap Gas Chromatography Mass Spectrometry method. Also the dry-hopped beer produced with the same hop variety as well as the control beer of this trial were tested to compare the results of the cold water extraction with a real brewing trial. The findings of typical hop derived aroma compounds are given in **Table 1**. Chemical structures of selected hop aroma compounds are shown in **Figure 2**.

The **terpene alcohols** linalool, geraniol and α-terpineol were detected in the cold water extract. The concentrations were comparable with those of the amounts in the dry-hopped beer. Citronellol wasn't detectable in the cold water extract. It is known from literature that a part of geraniol convert to β-citronellol during fermentation [**3**], that fact explains the absence of this compound in the lab scale experiment.

The amounts of **mono- and sesquiterpenes** were higher in the cold water extract. Only myrcene was determined in beer but with a lower amount.

The 4 **esters** ethyl isobutyrate, isobutyl isobutyrate, 3-methylbutyl isobutyrate, and 2-methylbutyl isobutyrate are hop derived compounds and were not detected in the control beer. The concentrations of ethyl isobutyrate and isobutyl isobutyrate found in the water extract were comparable with the findings in the beer. Whereas the concentrations of 3- and 2-methylbutyl isobutyrate were significantly lower in the dry-hopped beer.

The concentrations of the **ketones** (2-nonanone, 2-decanone, 2-undecanone, and 2-dodecanone) in the cold water extract were 3fold higher than in the dry-hopped beer.

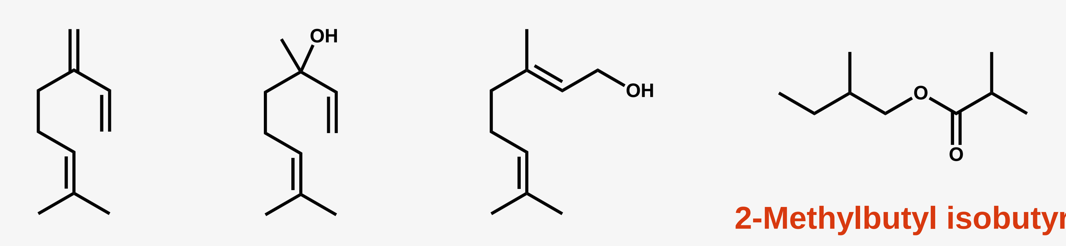



**Figure 2. Chemical structures of hop aroma compounds**

**Table 1. Amounts [µg/L] of hop aroma compounds in cold water extract and beer.**

| Compound | Cold water extract | Control beer | Dry-hopped beer | Impact dry-hopping in beer |
|---|---|---|---|---|
| | µg/L | | | |
| *terpene alcohols* | | | | |
| linalool | 95.2 | 3.2 | 91.0 | 87.7 |
| geraniol | 82.2 | 8.4 | 86.1 | 77.7 |
| β-citronellol | n.d. | 2.5 | 2.7 | <1 |
| α-terpineol | 4.9 | 3.7 | 10.8 | 7.2 |
| *mono- and sesquiterpenes* | | | | |
| myrcene | 717 | n.d. | 106 | 106 |
| β-limonene | 16.4 | n.d. | <1 | <1 |
| β-caryophyllene | 18.3 | n.d. | n.d. | no impact |
| α-humulene | 35.7 | n.d. | n.d. | no impact |
| farnesene | 5.9 | n.d. | n.d. | no impact |
| *esters* | | | | |
| ethyl isobutyrate | 2.9 | n.d. | 2.0 | 2.0 |
| isobutyl isobutyrate | 42.9 | n.d. | 30.7 | 30.7 |
| 3-methylbutyl isobutyrate | 42.8 | n.d. | 14.5 | 14.5 |
| 2-methylbutyl isobutyrate | 228 | n.d. | 107 | 107 |
| *ketones* | | | | |
| 2-nonanone | 8.7 | n.d. | 3.2 | 3.2 |
| 2-decanone | 8.9 | n.d. | 3.0 | 3.0 |
| 2-undecanone | 15.2 | n.d. | 4.4 | 4.4 |
| 2-dodecanone | 3.5 | n.d. | n.d. | no impact |

## Conclusions

The cold water extraction as a lab scale evaluation method gives the maximum concentrations of hop derived aroma compounds depending on the aroma composition of a hop variety. It represents a helpful and fast tool to predict the hop aroma profile of dry-hopped beers. In practice, further parameters like the influence of malt, different filtration agents and/or the presence of yeast during dry hopping have to be considered.

After this lab scale extraction, the analysis of bitter substances (α-acids, humulinones, hulupones) and hop flavonoids (co-multifidol glucoside, xanthohumol) are also possible. This allows the prediction of the bitter profile of a dry-hopped beer, too.

### References


1. Data sheet hop variety Experimental #09326 (https://www.hopsteiner.com/variety-data-sheets/Experimental--09326/)
2. Schmidt, C. and Biendl, M.: Headspace Trap GC-MS analysis of hop aroma compounds in beer. BrewingScience – Monatsschrift für Brauwissenschaft, **2016**, 69: 9-15.
3. Takoi, K.; Itoga, Y.; Takayanagi, J.; Kosugi, T.; Shioi, T.; Nakamura, T. and Watari, J.: Screening of geraniol-rich flavor hop and interesting behavior of beta-citronellol during fermentation under various hop-addition timings. J. Am. Soc. Brew. Chem., **2014**, 72: 22-29.