



HUMULUS LUPULUS

AND OTHER BITTER TRUTHS

The history of hop aroma research

When did hop aroma research actually begin? It's not at all easy to answer that question. Research into hop aroma, whether in hops or in beer, is of course closely connected with the history of hop breeding. After all, before you start to explore a hop aroma, you have to know which aroma of which hop variety you want to examine.

The history of hop breeding dates back to the 19th century when the first hop breeding facility was established in England. Up until that time, particularly in continental Europe, it was customary to refer to the region from which the hops came, such as Hallertau, Aischgrund, Alsace, etc. It was not until the middle of the 20th century that names for cultivars and varieties of hops established themselves. The current hop variety list published by the IHGC (International Hop Growers Convention) contains 269 different hop varieties that are grown in 21 different countries. And believe me, you'll find hop varieties in this list that you've never heard of before! At the same time, each hop variety does of course have its own life cycle, and varieties that could be described as market leaders 20 years ago are only to be found in museum gardens today.

The validity of hop aroma descriptions of certain varieties naturally stands and falls with this. When did hop aroma research begin? And what does hop aroma research involve? It is one thing to describe the aroma of a hop variety, which is in itself complex enough, but it is quite another thing to describe the hop aroma in a beer which depends on the hop variety, the form of hop product, the quantity, the time of hop addition, the method used and the temperature at which the hops were added. And these are by no means all the parameters on the list.


First milestones

Hop aroma research is part of brewing science. Since the 1960s in particular, more and more research groups

have devoted themselves to studying hop aroma, and the number of publications is increasing by the year. Currently, research projects are being conducted in this field at the technical universities of Munich and Berlin, VLB Berlin, the Catholic universities of Leuven and Louvain la Neuve, Nottingham University and Oregon State University.

Hop aroma research began in the early 19th century when hop oil was first distilled. By the middle of the 19th century it was known that hop oil consisted of a terpenic and an oxygenic fraction. In around 1900, Chapman succeeded in identifying individual structures including myrcene, caryophyllene, humulene, linalool and geraniol. As far as we know, the first use of a gas chromatograph to categorise hop oil constituents was by Howard in 1956. Up until that time, it was known that roughly 80% of hop oil consisted of terpenes and the other 20% could be included in the oxygenic fraction, including esters and carboxylic acids. Due to the volatility of these fractions, it was more or less tacitly assumed that virtually nothing was transferred to the beer through hop addition in the brew house.

Many of the research papers since the 1960s are milestones in the knowledge we have today concerning hop aroma. In addition to the painstaking task of identifying the aroma compounds, there was also immediate discussion as to how the sensory significance of the individual substances should be assessed. Tressl and Meilgard did a lot of work on this in the 80s, determining the perception threshold values of hundreds of substances. At the same time, research groups led by Narziss, Verzele and Tressl focused their research efforts on identifying hop aroma compounds that could also be found in brewed beer. Sharpe and Laws' statement (1981) was particularly apt: "It now seems certain that no single component is responsible for hop character in beer". And this statement predates the so-called Craft Beer Revolution!





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Always new questions

In the early 1980s, researchers focused on the question of the extent to which there are differences in aroma in beer brewed with European and American hop varieties.

In this context, the term “noble hops aroma”, which was used for the use of European regional varieties, was already associated with linalool and humulol and considered important. Until the mid-1980s there was no consensus at all on the part of the brewers as to whether a perceptible hop aroma was even desirable in lager beers! This is illustrated very nicely in a paper published by Verzele in 1986 on the occasion of the celebration of 100 years of hop chemistry.

In an exciting study published in 1992, the authors Engel and Nickerson proposed establishing a Hop Aroma Unit derived from a list of various hop aroma compounds. This Hop Aroma Unit failed to become established, however. In the case of many of the aroma compounds identified, the perception threshold measurement produced very high levels, which led to the conclusion that these aroma compounds – particularly those from the sesquiterpene fraction – could not be relevant in sensory terms. The recently deceased Belgian researcher Goiris published a paper in 2002 that received little attention but showed that a mixture consisting of oxidised sesquiterpenes had a joint threshold value of only 5 µg/L, whereas the individual substances in the mixture had thresholds that were a factor of 1,000 higher! The existence of additive, masking and synergistic effects between hop aroma compounds was reconfirmed by Hanke (Technical University of Munich) in 2009.

As early as 1994 Dr Keith Westwood (now head of our European Research Department) noted: “We must assume that hop aroma is the result of various interactions between hop oil constituents”.

Even though it had been known for some time that some aroma compounds in hops contained sulphur, it was not until 2006 that 4MMP (4 methyl-4-mercaptopentane-2-one) was identified in hops both by Kishimoto (Japan) and by Steinhaus. The aroma notes ranging from passion fruit to blackcurrant and even the smell of sweat, which are particularly intense in American and Australian hop varieties, can be attributed to this thiol. Since then, some hop researchers have studied the sensory contribution of different hop thiols in beer.

And, of course, ever since 2008 at the latest, hop aroma research has been conducted in connection with the technique of dry hopping. As you can see, over the decades not only have the hop varieties changed completely (e.g. from varieties like Cluster and Northern Brewer to Citra and Hallertau Tradition); so, too, have the methods and quantities used.

And so, it remains clear that nothing is in fact clear. Even though hundreds of aroma substances have been identified in hops, due to their multiple interactions it is not clear whether some can be clearly specified as being more important than others. In view of the fact that, depending on the substance, the perception threshold values of the different aroma compounds can differ by a factor of one million, a rough classification is of course possible. However, no convincing correlation has yet been established between hop aroma impressions in beer (or in hops) and aroma compounds measured.

In 2018, Kishimoto published a paper in which no fewer than 76 aroma compounds were required to truly reproduce the aroma of a pilsner beer to an acceptable degree...

You can therefore rest assured that there is still sufficient “substance” for hop aroma research to last another 100 years and that several future generations of PhD students will have sleepless nights trying to come up with a clear explanation of hop aroma ...

