Annual fluctuations in hop quality – options for adjustment in the brewhouse

HOP AROMA IN BEER | Year to year fluctuations in the alpha acid content of hops is a common occurrence. However, variations in hop oil content are rarely considered. This can lead to significant changes in beer aroma, so much so that it does not go unnoticed by consumers. Appropriate measures taken in the brewhouse can be implemented to adjust the hop flavor in the finished beer.

THE OBSERVATIONS DISCUSSED BELOW are generally associated with linalool. Of course, there are also other hop oils which influence the aroma of the finished beer and lend a unique character to particular beer styles. It is possible, however, to measure the linalool content reliably using gas chromatography. Furthermore, it is known that other hop aroma compounds behave similarly to linalool in the brewing process [1].

Linalool content also correlates very strongly with the intensity of the hop aroma in beer ([2], [3]). The linalool concentrations contained in selected aroma hop varieties were measured over several years and are depicted in fig. 1 and 2. It is clear, that very strong fluctuations occur from year to year. This is obviously true for all other European aroma hop varieties.

The variety Perle seems to be the least affected, as it showed an increase of approximately 30 ppm only for the 2007 harvest. On the other hand it should also be noted that Perle is not a variety that is typically chosen for late aroma hop additions. The varieties which are more commonly used at this stage in the brewing process exhibit much greater fluctuations.

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Alpha Acid Content

As mentioned previously, not only does the concentration of hop oils and linalool vary, the amount of alpha acids fluctuates as well. Since a brewer generally adds hops based on alpha acid content, it would be practical if the aroma compounds behaved in the same manner as the alpha acids.

In an ideal situation, this would mean that the same amount of linalool would be added when the brewer added a similar amount of alpha acids, resulting in a constant relationship over time. Theoretically, the quotient of linalool to alpha acid should always remain constant.

This discussion pertains only to hop pellets or whole hops, because by nature, hop extract products dissolve slowly and therefore are not suitable for late hop additions. To determine the quotient, we have calculated the ratio of linalool (ppm) to alpha acids.

Alpha acid content is expressed in terms of the conductometer value (EBC 7.5), as this more accurately describes the brewing value of hop pellets or whole hops and is generally used for everyday calculations of hop additions (fig. 3, 4). It is generally known that alpha acids and linalool possess the ability, however, to react in entirely different ways.

When utilizing hops from a new harvest, a different amount of aroma compounds is contained in the hop addition as compared to the previous harvest. Depending on the time of the addition and the amount added, the intensity of the hop aroma in the finished beer can differ greatly. The harvests in 2006 and 2007 were analyzed for the Saphir variety, and the following calculation was made:

Aroma hop addition:	3 g alpha acids per hl	
	Harvest 2006	Harvest 2007
Alpha content in pellets:	3.7%	4.2%
Linalool content:	28.8 ppm	86.4 ppm
Pellet addition per hl:	81.1 g	71.4 g
Linalool content per l:	23.3 µg	61.7 µg

In the example above, the difference between utilizing hop products from the 2006 harvest and the 2007 harvest triples the

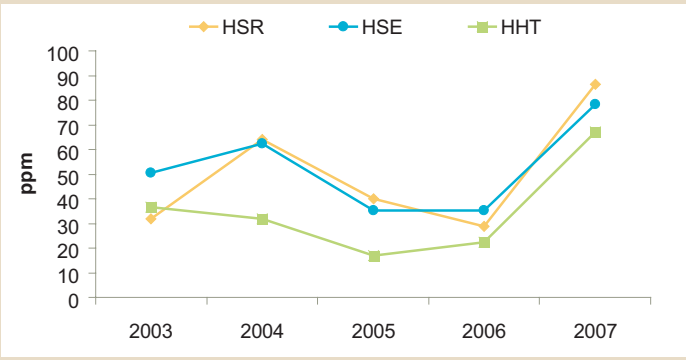

Fig. 1 Linalool concentration in Saphir, Spalter Select and Hallertauer Tradition with respect to harvest year

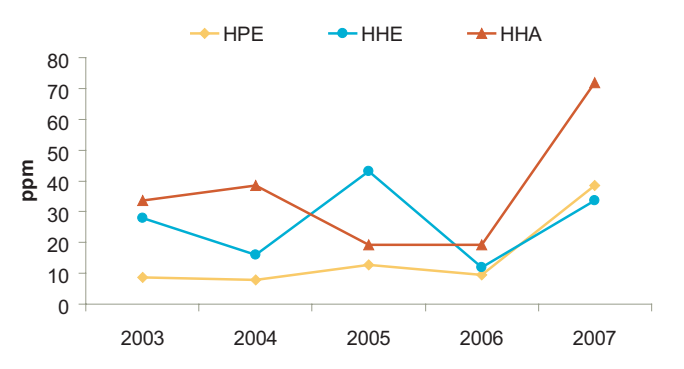

Fig. 2 Linalool concentration in Perle, Hersbrucker and Hallertauer Mittelfrüh with respect to harvest year

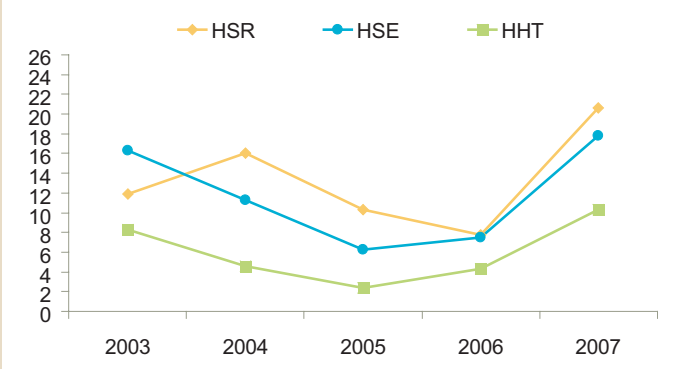

Fig. 3 Relationship of linalool to alpha acid content in Saphir, Spalter Select and Hallertauer Tradition with respect to harvest year

amount of hop aroma in the finished beer. In this way, noticeable changes can occur in the flavor profile of a beer.

Correctional Measures

What measures can be taken to balance variations in the aroma compounds? One possibility is to adjust the last hop addition based on the alpha acid content; however, this has an effect on the previous additions [2]. Based on prior experience, it has been determined that changes in aroma, which occur during the boiling process, happen more quickly than those which involve bittering compounds [1]. Figure 5 shows the typical changes in linalool and iso-alpha acids during wort boiling.

Naturally, there are differences originating from the type of wort boiling system in use. The zero point on the graph is the time at which the last hop addition was given. One can trace the changes in iso-alpha acids and linalool along the time axis of the graph.

Depending on the time at which boiling is stopped, different concentrations of linalool and iso-alpha acids are present. For example, 80 percent of the original linalool content is lost within a five minute period, while only 2.5 mg alpha acid is isomerized per liter (fig. 5).

This introduces the concept that different concentrations of hop aroma compounds can be balanced by changing the time of the hop addition slightly, without noticeably influencing the bitterness. Naturally, the key to success here would be to calculate the time for the hop addition very precisely.

This would mean in the example with the Saphir variety above, that the pellets would be boiled three minutes longer in order to adjust the linalool concentration accordingly. Within this time period, the linalool content should be reduced from 60 µg/l to 20 µg/l. Simultaneously, the isomerization of 1.5 mg of alpha acids would take place. This amount of isomerization is negligible, as sensory detection is not possible. Furthermore, isomerization continues in the whirlpool which reduces the difference even more. Exact changes must be determined under the specific conditions present in the brewery.

Conclusion

In summary, it has been established that the ratio of aroma compounds to bittering compounds does fluctuate from year to year. Since hop additions are made based primarily on alpha acid content, different aroma profiles are present depending on the year of harvest.

Clearly, this is of special importance for beers characterized by their aroma. Through a slight change in the time of the hop addition, it is possible to achieve a consistent hop aroma. No further changes are necessary. It is essential that the hop addition for each batch be performed at exactly the same time. ■

References

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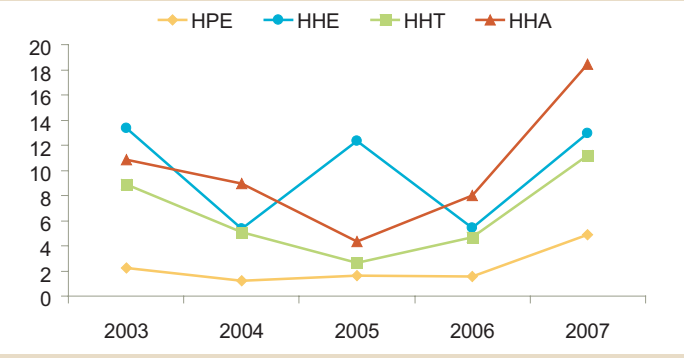

Fig. 4 Relationship of linalool to alpha acid content in Perle, Hersbrucker and Hallertauer Mittelfrüh with respect to harvest year

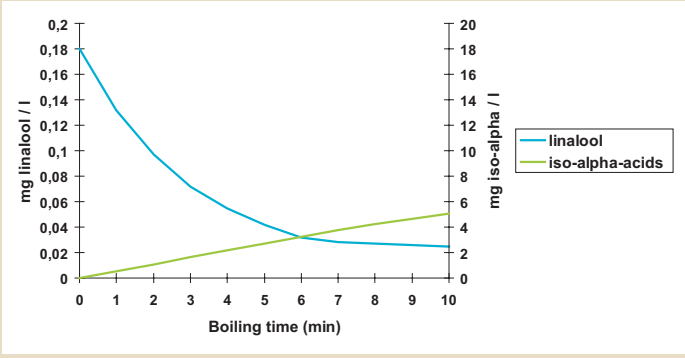

Fig. 5 Changes in iso-alpha acids and linalool during wort boiling