Improving Hop Aroma and Flavour Utilisation in beer

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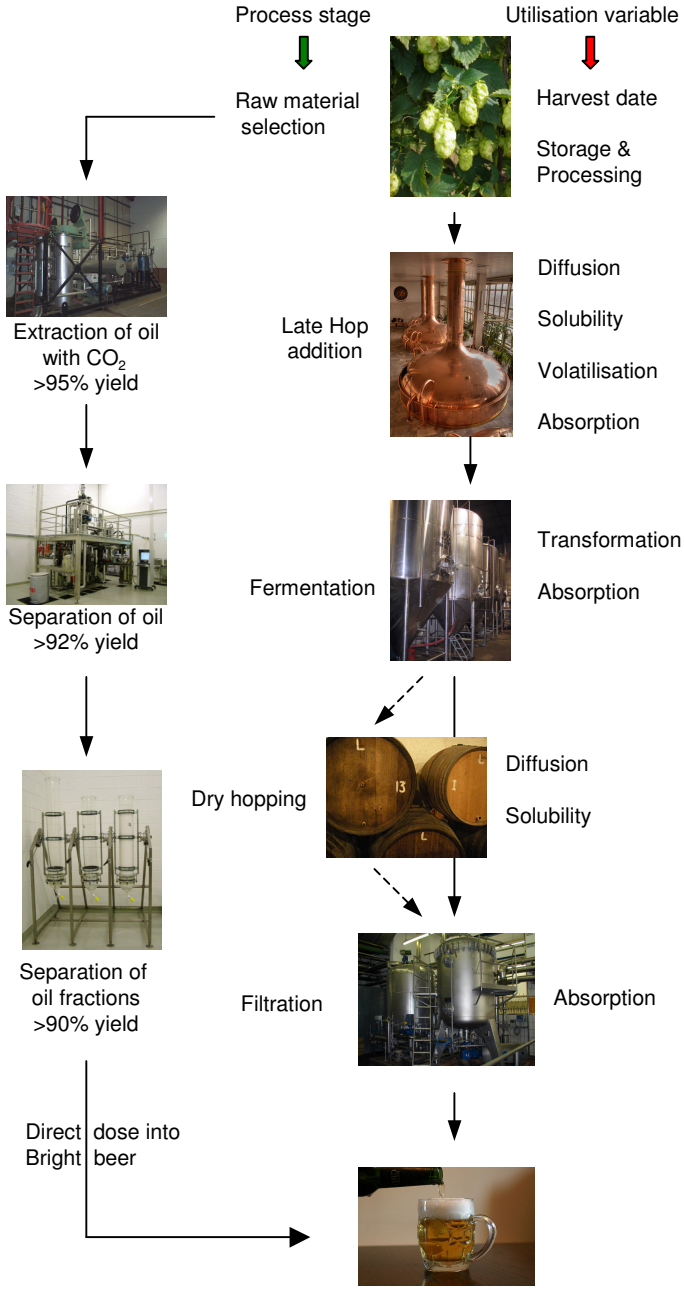
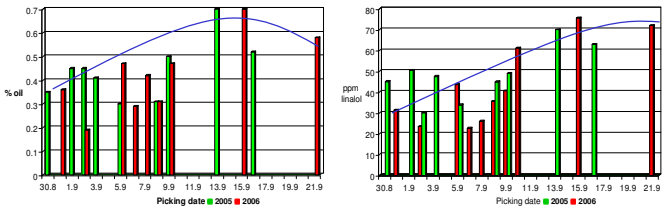
Introduction

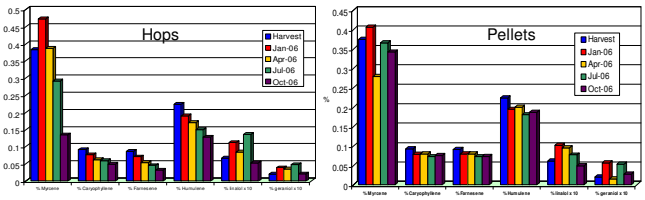
Hop utilisation is more usually considered in relation to the isomerisation of α-acids in the wort boil and the subsequent survival of the iso-α-acids through to the final product. The process variables that determine α-acid utilisation are well understood and over the last twenty years significant improvements have been made both in optimising the wort boiling and also in the development of isomerised and reduced extracts. Although it has long been accepted that the hop aroma of beer is derived from the essential oils found in the lupulin glands the utilisation of hop aroma molecules in the brewing process has been studied much less. It is only recently that the effect of process variables on key aroma molecules such as linalol has been reported and in part this is due to the difficulty in obtaining reproducible analysis of molecules in the low ppb range. In practice the utilisation of hop aroma molecules from hop to final beer begins with the hop harvest and is affected by almost every process thereafter as shown below.



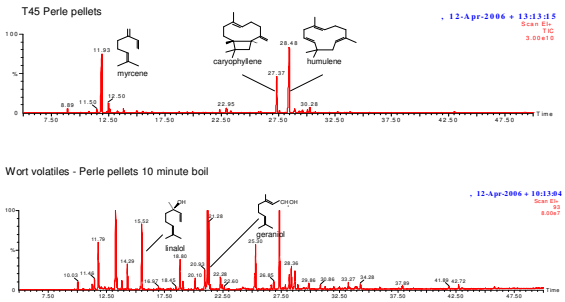
Overall utilisation of all hop aroma molecules from hops to bright beer = 79%

Figures 1 &2. Change in oil content and composition relative to harvest date (Goldings)





Figures 3 & 4. Change in oil composition in stored hops and pellets (Cascade)



Figures 5 & 6. Differential retention of hop volatiles in wort (Perle)

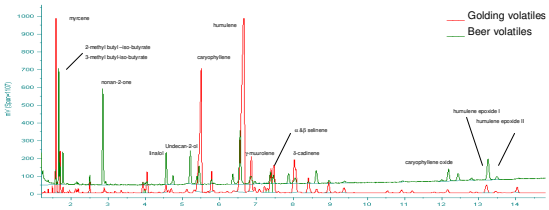


Figure 7. Dry hopping English ale at 5% ABV (Goldings)

Summary

The utilisation of hop aroma molecules from hop to final beer is affected by many variable mechanisms. Figures 1 & 2 show that the date of harvest can influence oil content and composition by 100% and selection of the raw material is critical. Peak levels of hop aroma often occur when the physical appearance of the hops is not at its best. Figures 3 & 4 show that once selected hops need to be stored carefully, preferably as pellets under refrigerated conditions. Hops stored in bales at ambient will have lost 50% of their aroma within one year of picking.

Late hopping exposes the hops to a variety of mechanisms by which aroma molecules are selectively lost. Figures 5 & 6 show that only the most polar molecules, predominately terpene alcohols survive this process, utilisation is typically 50% in a well designed kettle. Volatiles that survive the wort boil will be further absorbed onto yeast cells during fermentation and some transformation can also occur. Most polar aroma molecules that reach filtration will pass through without loss, however if additional hop aroma is introduced through dry-hopping the more hydrophobic molecules will be absorbed onto the filter. Dry-hopping utilisation measured as total hop oils transferred from hops to beer is typically 10-15% and figure 7 shows that again it is the more polar molecules that are transferred to the beer.

Although overall utilisation will depend on many variables it is reasonable to suggest that late kettle hopping will achieve <25% and dry-hopping <10%. In contrast extraction of the aroma molecules from hops at the optimum time and delivery as soluble hop aromas in the bright beer will show an overall utilisation of <80%.