Recent research is uncovering how different yeast strains can influence flavor and aroma by interacting with specific hop-derived flavor compounds, a process called biotransformation. Non-aromatic compounds derived from hops are transformed by yeast enzymes to release aromatic flavor compounds in the beer. Certain yeast strains are known to have higher levels of enzyme activity associated with biotransformation, including β-glucosidase and β-lyase.

**β-glucosidase activity** results in the release of an aromatic terpene (and a glucose molecule) from a non-aromatic terpenyl glycoside (Figure 1). Terpenes can have diverse flavor impacts (citrus, floral) and higher levels of terpenes are associated with greater overall hop aroma intensity (OHAI).

**β-lyase activity** results in the release of volatile sulfur compounds called thiols (Figure 2), which are usually associated with tropical aroma and are active at very low flavor thresholds.

The β-glucosidase and β-lyase specific enzyme activities have been characterized in all LalBrew® Premium brewing yeast strains (Figure 3). Armed with this data, the brewer is well equipped to choose the best strain to promote biotransformation. Lallemand Brewing is at the forefront of hop flavor and aroma research and we are ready to help you with any questions about brewing hoppy beer styles.

**Biotransformation Activities of LalBrew® Premium Brewing Yeast**

![Biotransformation Activities of LalBrew® Premium Brewing Yeast](image)

*β-lyase activity not determined for LalBrew® London.*

For more information, you can reach us via email at brewing@lallemand.com
**COMPLEX BIOTRANSFORMATION NETWORKS AND SECONDARY EFFECTS**

Yeast metabolism is complex. Aromatic terpenes and thiols released by β-glucosidase and β-lyase enzymes respectively can be further transformed by the yeast into other compounds with different flavor characteristics, increasing the complexity of the finished beer (Figure 4). The overall aroma in the finished beer is determined by the total quantity of volatiles as well as the diversity and relative composition of terpene and thiols compounds. The levels of terpenyl glycoside or thiol precursors found in the hops also vary based on the producer, harvest year and storage time. Furthermore, secondary effects may influence the aroma profile of the finished beer through non-enzymatic processes:

- CO₂ stripping – Loss of aromatics during active fermentation
- Masking – Fermentation compounds (esters, phenolics) may mask the hop oil aroma
- Adsorption – Hop oils adhere to yeast cell walls and are removed with the yeast during flocculation or filtration

**OPTIMIZING BIOTRANSFORMATION**

Due to the variation between hop strains, the complexity of yeast metabolism and other secondary effects, it is necessary to optimize the brewing process to maximize biotransformation. When optimizing biotransformation, consider the following:

1. Dry hop during active fermentation when yeast enzymes are most active. Convection currents during fermentation will help to stir the hops and the warmer fermentation temperature and presence of alcohol results in greater extraction of hop compounds. Oxygen pick up is reduced since O₂ is driven off by the CO₂ being produced.
2. Dry hopping early in fermentation will result in greater extraction of precursors.
3. Dry hopping later in fermentation will minimize loss of volatiles due to CO₂ stripping.