BIOTRANSFORMATION

YEAST INFLUENCES THE HOP CHARACTER OF THE BEER

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.

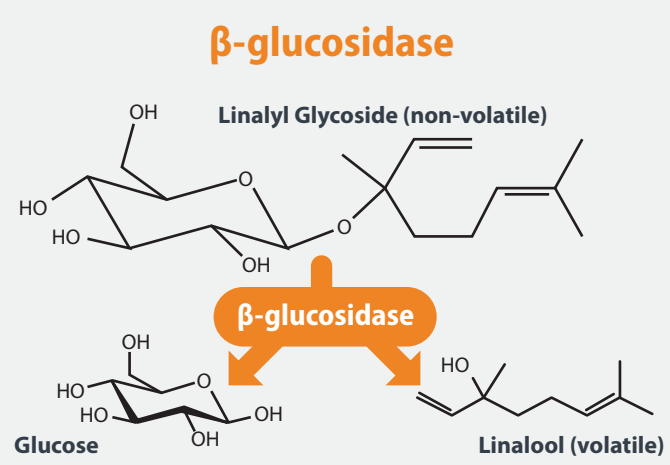

Figure 1. β-glucosidase enzyme mechanism. In this example, linalool (an aromatic terpene) and a glucose molecule are released from a non-aromatic linalyl glycoside.

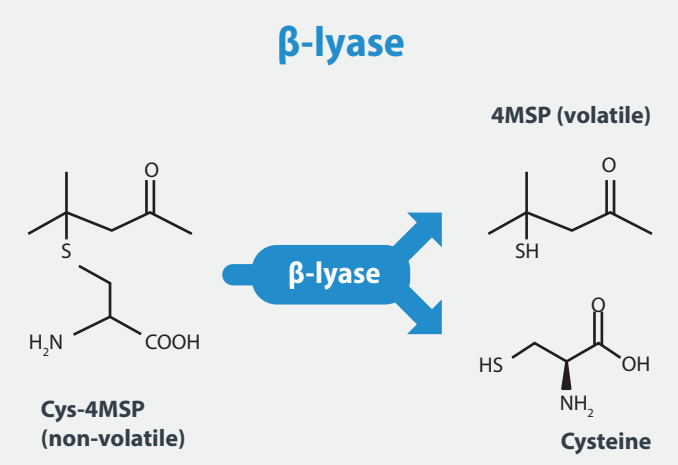

Figure 2. β-lyase enzyme mechanism. In this example, 4MSP (an aromatic thiol) and cysteine are released from a non-aromatic cysteinylated precursor.

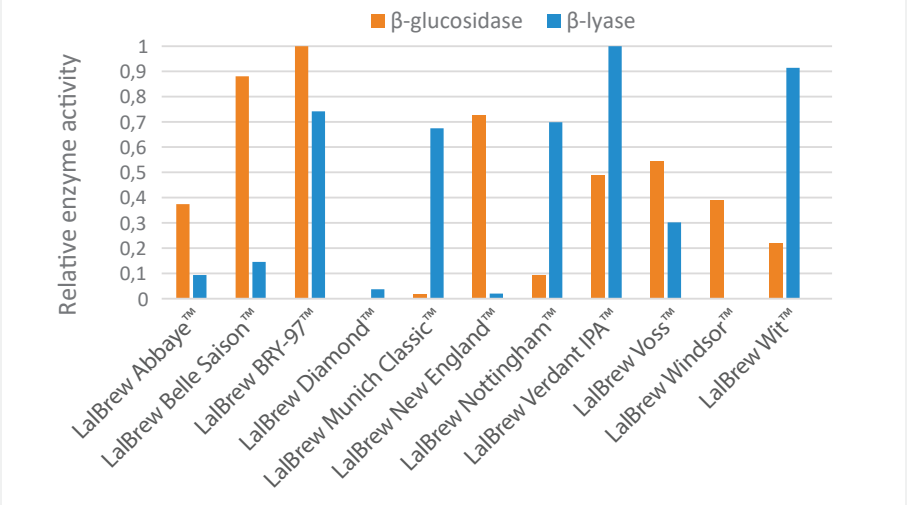

Figure 3. Relative biotransformation activities of β-glucosidase and β-lyase enzymes in LalBrew® Premium brewing yeast strains. β-glucosidase was measured as secreted enzyme activity using a standard chemical glycoside substrate. β-lyase activity was measured by growth on selective media containing a specific sulfur-based precursor. Relative activities are shown for comparison, but β-glucosidase and β-lyase activities cannot be directly compared with each other.

BIOTRANSFORMATION

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:

- **CO_2 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**

Biotransformation pathway of monoterpene alcohols by brewing yeast

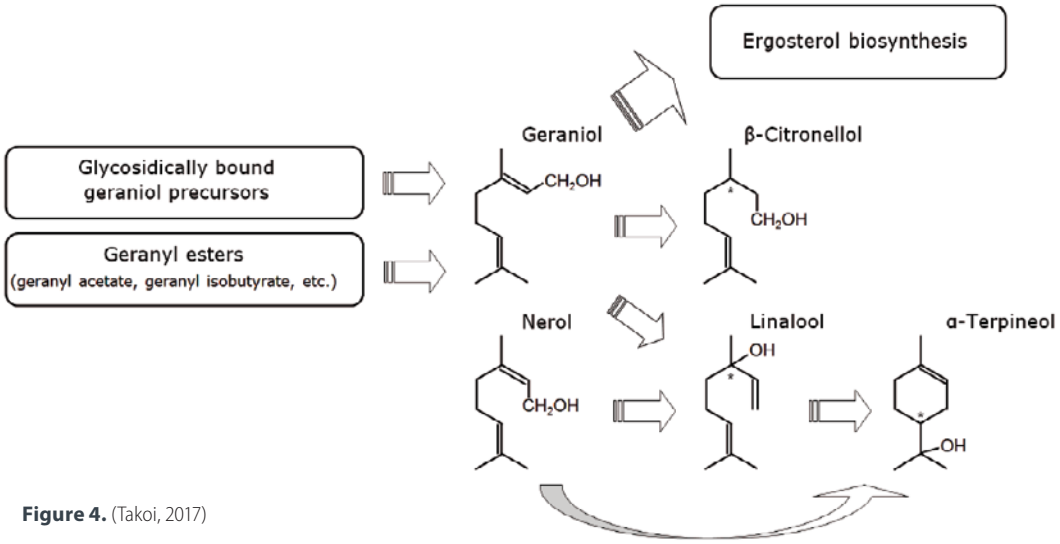

Figure 4. (Takoi, 2017)

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 O_2 is driven off by the CO_2 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 CO_2 stripping.

REFERENCES:

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- Sharp, Daniel and Shellhammer, Thomas. Recent advances in controlling flavor and aroma in hoppy beers. Presentation at the Craft Brewers Conference 2016 (Philadelphia, PA)

- Takoi, Kiyoshi. (2017). Systematic Analysis of Behaviour of Hop-Derived Monoterpene Alcohols During Fermentation and New Classification of Geraniol-Rich Flavour Hops. BrewingScience. 70. 177-186