The evolution of beer

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A new study in the journal *Molecular Biology and Evolution* examined the innovations and origins of lager beer. Credit: A. B. Hulfachor, University of Wisconsin-Madison

From Austrian monks to American craft brewers, beer geeks are everywhere. But making a good beer not only depends on the best ingredients, but also the best yeast.

The beer world is divided into ales and lagers. The original and highly versatile yeast, *Saccharromyces cerevisiae*, has been used for millennium to make ales, wine and bread. But the second great beer innovation was the origins of lager beer during the 15th century, when Bavarians first noticed that beer stored in the caves during the winter continued to ferment (from the German lagern: to store). The result was a lighter and smoother beer that, after sharing it with their neighboring Bohemians, went on to dominate 19th and 20th century beers tastes, especially in America.

Lager yeasts are hybrid strains, made of two different yeast species, *S. cerevisiae* and *S. eubayanus*, which was discovered in 2011. Lagers now represent a whopping 94 percent of the world beer market. But the origins of different hybrid lineages has been a bone of contention for lager beer makers.

In a new study in the journal *Molecular Biology and Evolution*, graduate student Emily Clare Baker, corresponding author Chris Todd Hittinger et al., attempted to solve the mystery.

Taking advantage of a newly described wild yeast species from

Patagonia, *Saccharomyces eubayanus*, the research team was able to complete and assemble a high-quality genome of *S. eubayanus* using next-generation sequencing.

They compared it to domesticated hybrids that are used to brew lager style beers, allowing for the first time the ability of study the complete genomes of both parental yeast species contributing to lager beer.

They show two independent origin events for *S. cerevisiae* and S. eubanyus hybrids that brew lager beers.

The findings show that domestication for beer making has placed yeast on similar evolutionary trajectories multiple times. In this context, these results suggest that the Saaz and Frohberg lineages (named for their area of origin) were created by at least two distinct hybridization events between nearly identical strains of *S. eubayanus* with relatively more diverse ale strains of *S. cerevisiae*.

"Lager yeasts did not just originate once. This unlikely marriage between two species, genetically as different from one another as humans and birds, happened at least twice. Although these hybrids were different from the start, they also changed in some predictable ways during their domestication," said corresponding author Chris Todd Hittinger of the University of Wisconsin-Madison.

The blueprint of the powerhouses of the yeast cell, called mitochondrial genome sequences, proved that *S. eubayanus* served as the main donor of mtDNA for lager yeasts of Frohberg lineage. They also found that both the Saaz and Frohberg yeasts contained both *S. cerevisiae* (99.57 percent identical to strain S288c) and *S. eubayanus* (99.55 percent identical to FM1318) genomes. They also compared the mitochondrial genomes and found *S. eubayanus* to be 6.6kb smaller than Frohberg yeast and 21.8kb smaller than *S. cerevisiae*.

In addition, since being adapted for beer making, the *S. eubayanus* genomes have experienced increased rates of evolution, including in some genes involved in metabolism.

Some metabolism genes, especially those involved in fermentation and sugar metabolism, may have been shaped by domestication in brewing. In particular, the authors suggest that many evolutionary changes may have reduced the function of the Adr1 protein, which activates an alcohol dehydrogenase that consumes alcohol, rather than producing it.

The findings have now clarified the origins of the major lineages of the hybrid yeasts used to brew lagers, and will provide a roadmap for future research in the domestication of lager yeasts.

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