



The Yeast Strain Toolkit

For as long as yeast has existed, domestication and nature have altered yeast strains, but now we have the capability to guide and even drive these changes. In the modern age of brewing, can we create "new" strains?

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THE YEAST STRAIN TOOLKIT

Digging Through the Yeast Strain Toolkit

Yeast is everywhere. It's on your clothes, scattered across the garden, and more than likely also present on the paper you're reading right now. Hundreds of strains have been used in brewing over centuries, but the actual number of yeast strains in the environment is unfathomable. For as long as yeast has existed, nature and domestication have altered it. Now, we also have the capability to guide and drive these changes with even greater intentionality. In the modern age of craft brewing, how are we finding, making and using new strains? What makes a strain “new”?

People have been domesticating yeast for centuries, resulting in the diversity of industrial brewing strains we have today. As brewing strains have become differentiated from non-brewing strains, they have acquired important traits, like the ability to utilize maltose and flocculate. And most are negative for phenolic off flavors (POF-).

Though the majority originate from English, German, and Belgian brewing traditions, the industry has recently welcomed other world heritage strains, too. These strains developed many of the same traits as other brewing strains did—but also include some important and useful differences. Kveik from Norway, for example, shows what domestication in different environments can do. Norwegian farmhouse brewers traditionally fermented at temperatures as high as 108°F. These conditions allowed strains that had high-heat tolerance to be successful, while they also happened to feature no phenolics. When introduced to the brewing world outside of Norway, kveik's capabilities seemed like an impossible dream come true. Kveik is not new to brewing. Norwegian brewing history is long established. But it may be new for many modern brewers outside of its place of origin. And there are likely many more “new to us” strains that were domesticated through other traditional fermented beverages, or foods, that may have interesting applications in beer.

In a more directed way, scientists engage in a sort of lab domestication called “adaptive lab evolution” (ALE), which takes existing strains and makes them more suitable for industrial brewing by applying different and new selective pressures to evolve traits.

They have been able to generate strains with higher ethanol tolerance, higher ester synthesis, and lower off-flavors like acetaldehyde and diacetyl in this way.

Genetically engineering yeast to make new brewing strains has only recently been introduced to craft beer. Brewing scientists in the 1980s were the first to apply engineering to a strain, looking to make it a more optimal machine for the efficient production of low-calorie light beer. Glucoamylase enzyme was already in-use as a brewing ingredient, but they wanted to enable the strain to make it itself. At around the same time, scientists were also uncovering more about yeast genetics in general, and discovering how some brewing strains, like diastatic Saison strains, can already make the glucoamylase enzyme (STA1). Saison strains acquired this trait through domestication. Both domestication and engineering can approach the introduction of very similar traits and applications.

Now, in 2024, we know that diastatic brewing strains (strains that hyperattenuate) have the potential to wreak havoc in the brewery. When used intentionally, they have to be carefully managed. A more favorable tool for brewers today probably wouldn't be to make any strains newly diastatic, but, rather, to change a diastatic strain into a non-diastatic version (for saison profile, it could be used with exogenous glucoamylase enzyme). This is an example of something that would be achievable, in theory, with a breeding approach. We could mate a diastatic strain and a non-diastatic strain and then screen through the offspring to see if we find one that has mostly the same characteristics as the diastatic parent, but inherited the other parent's non-diastatic nature. With genetic engineering, however, the change could be more targeted. It could be made only to the STA1 gene, leaving the rest of the strain's features intact.

Hybridization is a powerful tool for generating new strains nonetheless. One very famous example of hybridization is the lager strain. Its existence resulted from a hybridization event between two *Saccharomyces* species, *Saccharyomyces eubayanus*, which gave it its cold tolerance, and *Saccharomyces cerevisiae*, which gave it maltose utilization.

In other naturally occurring hybrids, some Belgian brewing strains are the offspring of two, three and even four different *Saccharomyces* species.

Omega Yeast has a couple of hybrid strains that were intentionally bred to combine certain favorable traits—like Saisonstein, whose parents are a very robust saison strain called French Saison, and Belgian Saison I, which is known for its tendency to stall out under some conditions. Saisonstein has some of the flavor and aroma of the parent that stalls out, but the fermentation behavior of the reliably fermenting parent. Saisonstein didn't have a specific target of gene combinations. It was something that was found from mated offspring. Part of what makes hybridization so robust as an approach is that it can be used to generate hundreds or thousands of new strains with a random assortment of genes that can be studied for novel combinations of traits. The challenge there is screening through the haystack of hybrids to find something desirable.

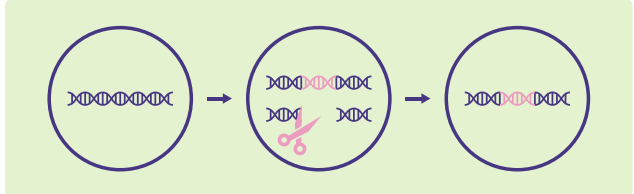
Examining what a new strain might look like from both an R&D and a brewer's perspective, the concept of a new strain could be distilled down to two broad categories:

- 1 A sharpened tool:** A strain whose traits represent an improvement on the behavior or characteristics of a strain that is already in-use—something that builds on its capabilities to add a new layer of utility in line with how it is already being used.
- 2 A whole new tool:** A strain whose traits introduce a new functionality or feature—something that no other brewing strains can do.

Thinking of the strains you use in the brewery, do you wish one had less clove aroma, or another had more tropical aroma, or a third contributed a little less haze? These traits can be engineered into the strains you know and love. Yeast scientists can bring about these changes in a variety of ways. With the past several decades of yeast genetics research, and access to new technologies—like full genome sequencing, and gene-editing tools like CRISPR/Cas9—it is possible to use genetic engineering as a much faster and more specific method to make these strains.

DOES GE YEAST MEAN A BIOENGINEERED LABEL IS REQUIRED?

Long story short: No. Beer is regulated through the TTB and there is no requirement for labeling any genetically engineered ingredient on a beer label. The FDA regulates food, so, animals and crops are all regulated and those require labeling. If you have engineered corn on the produce shelf, it needs a bioengineered label. But if the DNA is no longer detectable in the finished product, like in corn syrup, a label is not required. On the beer side of it, though, none of this applies.



Gene Editing in Yeast with CRISPR/Cas9 Technology. CRISPR/Cas9 cuts genomic DNA which is then repaired by donor DNA.

We can use targeted modifications to sort novel strains into two groups: those that are “sharpened” tools, and those that are a new tool entirely.

SHARPENING OUR TOOLS

In the 1990s, there was a virus spreading around the world that decimated papaya crops. Researchers found ways to modify the papaya crop to be resistant to this virus, and effectively saved papayas from extinction. By building in this resistance, modification “sharpened” the performance of the papaya tree and its ability to successfully produce healthy fruit given its environment. The quality and character of the papaya fruit itself remained exactly the same. It was simply now able to survive an environmental challenge. We wouldn't consider this modification to have created a “new” papaya, really. It simply improved the existing papaya.

Through genetic modification with yeast, we have a similar ability. We can improve upon a given strain's traits in order to optimize its abilities in brewing and fermentation processes in line with how that strain is already being used. For example, if a strain is known for being sluggish or for producing unwanted levels of a certain flavor, we can modify that strain to ferment more efficiently or reduce (or even eliminate) its capacity for producing certain compounds.

Diacetyl Knock Out (DKO) is a great example of a modification that “sharpens” a strain's abilities rather than changes it into a whole new tool. DKO-enabled strains can themselves produce ALDC. Integrating the ALDC enzyme directly into cell production greatly reduces diacetyl in finished beer brewed with these strains. This is just one example of an improvement. Practically speaking, there are endless possibilities for sharpening the tools we have at our disposal. It comes down to what brewers find the most useful and what changes would have a meaningful impact.

Another great opportunity for strain improvement is with haze. Both the presence and absence of haze are a hot topic for brewers. A haze-reduced version of an already familiar strain commonly used to make non-turbid beer would give brewers the chance to try a new spin on a favorite strain, or even improve clarity in a tried-and-true non-hazy recipe. And a hazy strain made to be even more reliably hazy means the strain would be more effective for producing hazy beer. These changes reinforce how the strain is already being used.

BUILDING NEW TOOLS

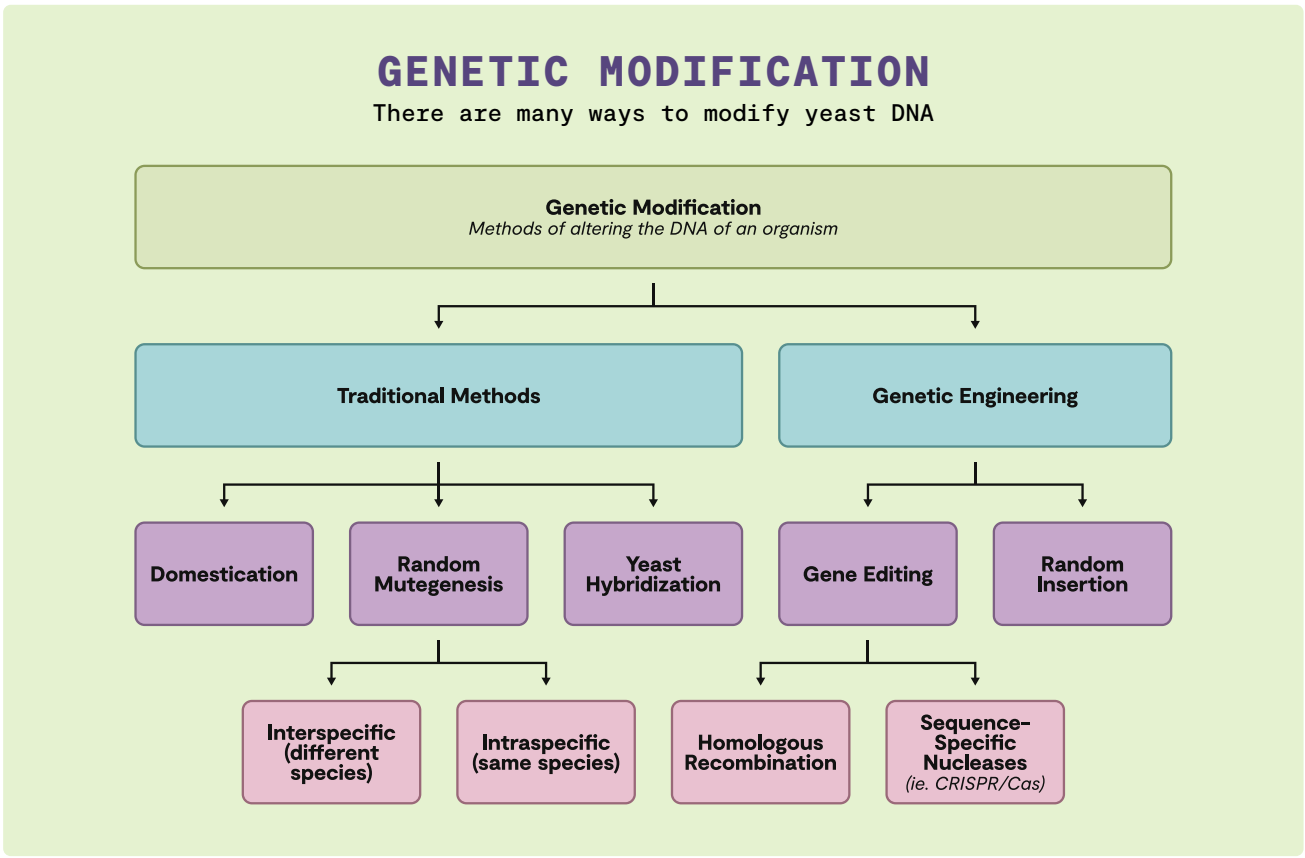
Let's look again at fruit to understand the concept of a new tool compared to a sharpened one.

Imagine you've just brought home a pineapple from the store, and you're preparing to chop it up for a little snack. You make your first slice and find that the fruit isn't the vibrant yellow that you expected, but pink! In the early 2000s, researchers used genetic modification to cultivate a pineapple with increased levels of lycopene. This turns the fruit pink. The pink pineapple, described as sweeter and less acidic than its traditional counterpart, doesn't necessarily replace typical pineapples. The pink flesh is not an improvement, per se. It gives consumers the variety of choice in pineapples. The pink pineapple could be used in place of regular pineapple for a different profile in your pineapple upside down cake, or could inspire a whole new dessert that showcases its novelty or new characteristics.

Just so, with yeast we can also modify strains in such a way that it creates an entirely new world of functionality and flavor combination. This is a bit more of a visionary step, requiring us to look beyond the traditional, toward a never-before-imagined future.

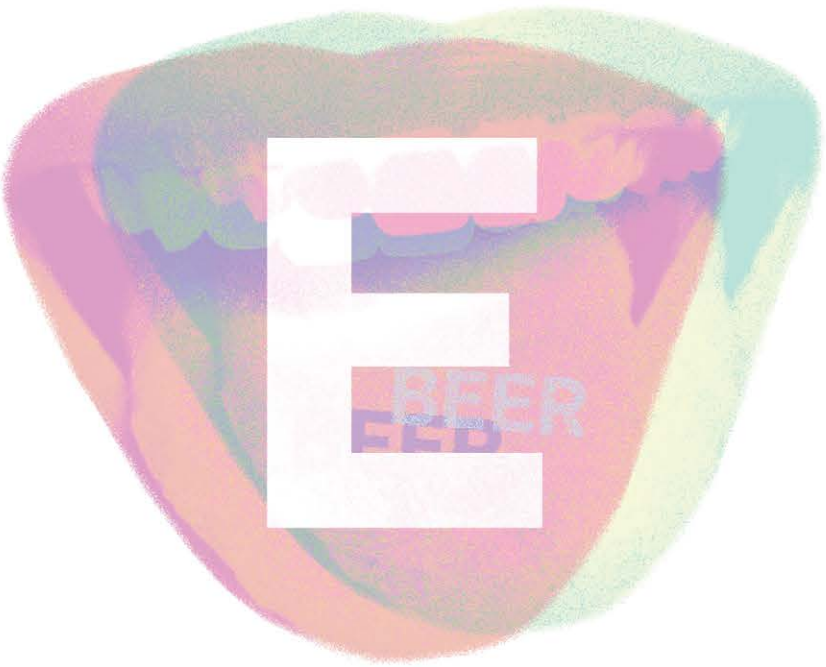
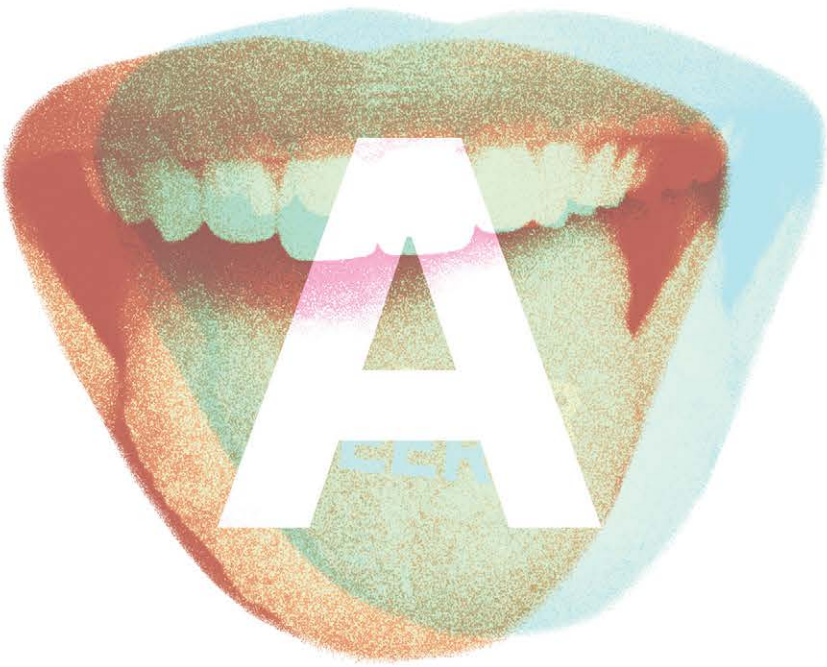
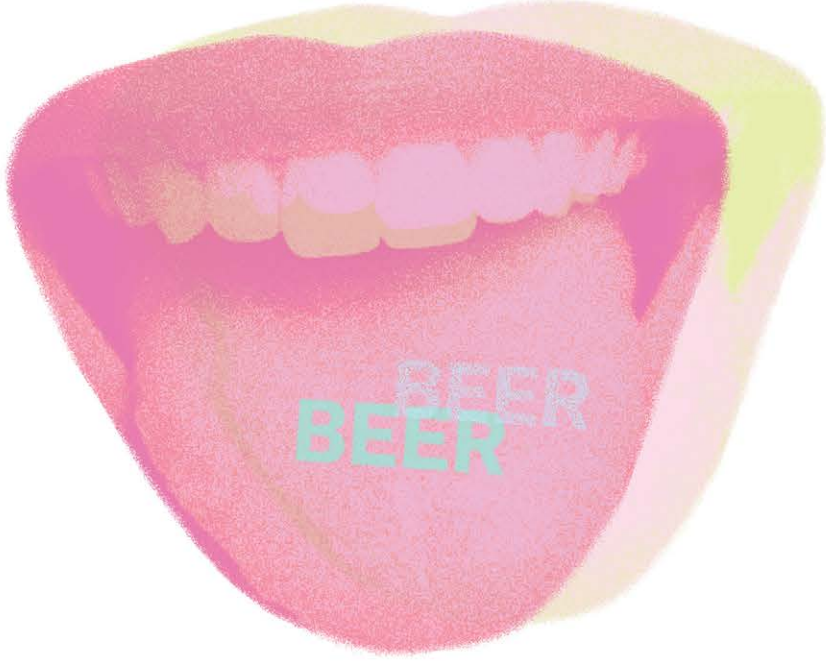
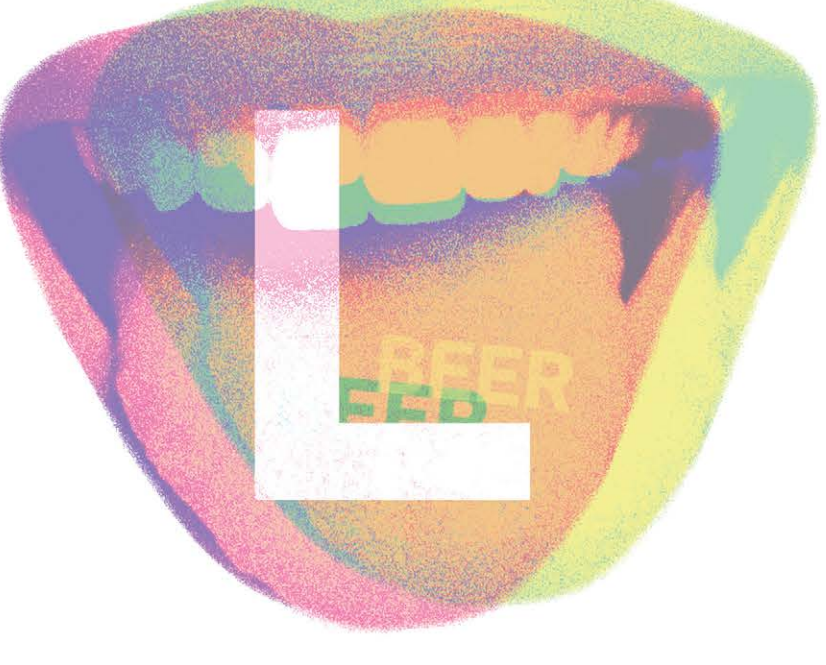
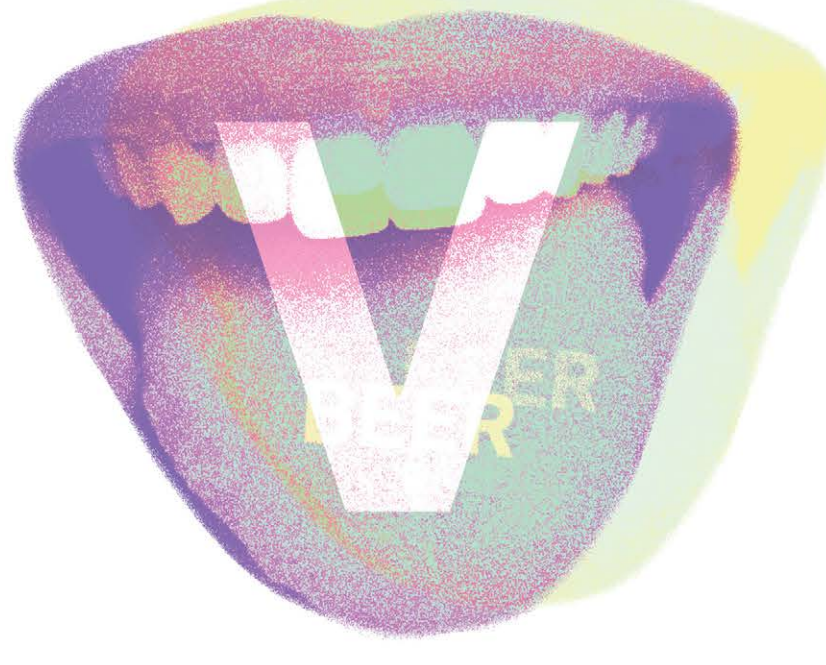
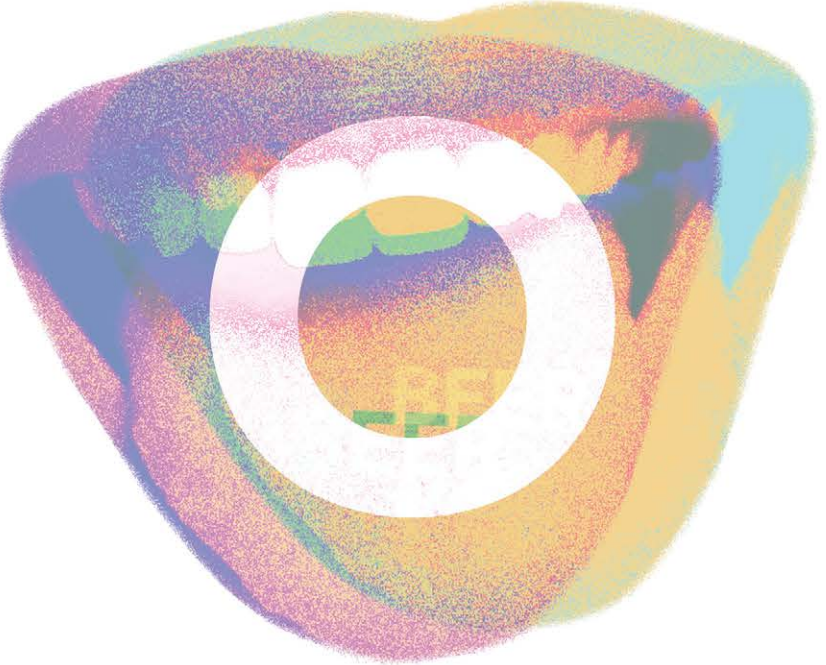
The Thiolized series of strains is an example of this. These strains represent a new component in the recipe-building process. For some brewers, the addition of thiol-generating capability add layers of flavor to their existing recipes, while others embrace them as the primary driver of aromatics in their beers. These are whole new tools.

Combining tools
One of the more prominent uses of Thiolized strains has been in fragrant dry-hopped beers. Thiols add a new layer of tropical fruit-like flavor amid a bouquet of floral and fruity hop aromatics, but these beers always come along with the risk of dry hop-induced diacetyl formation. By combining a new tool, a Thiolized strain, with the tool-sharpening capabilities of DKO technology, the fermentation will result in new and novel tropical aromas, and it will also prevent diacetyl from forming throughout the entire fermentation and maturation process.





KNOW YOUR YEAST



KNOW YOUR YEAST

ATTENUATION

Know Your Yeast: Attenuation

Brewing yeast is a domesticated beast. Researchers estimate that we have been selectively choosing and breeding yeast to produce specific outcomes since the 1500s. And we still do so today: we choose a certain yeast strain in order to get a specific type of beer as a result. There are a number of characteristics that yeast can impart to a beer. Let’s focus on attenuation.

The various attenuation ranges listed for brewing strains are not absolute. Brewing strains have been domesticated to metabolize maltose, but the degree to which they metabolize maltotriose and dextrins varies widely.

What is attenuation?
Attenuation is a measure of the amount of sugars that have been consumed by yeast during fermentation—basically the difference between starting gravity and final gravity.

British Ale V for example, would be capable of 100% apparent attenuation if the recipe consisted of 100% dextrose (like in a seltzer), but its attenuation range in beer is more like 71–75%. Attenuation ranges give you an idea of what to expect, especially when comparing strains, but results can change according to a number of factors.

“Real” vs. “apparent” attenuation
Apparent degree of fermentation (ADF) and real degree of fermentation (RDF) are two terms also used to describe attenuation. ADF is the same thing as apparent attenuation. RDF takes into account the density-change that results from the addition of ethanol. “Apparent extract” (AE) is only a density measurement and does not. “Real extract” (RE) requires you to know the absolute amount of ethanol to calculate the actual amount of extract remaining.

For example, when absolutely 100% of the sugar is consumed, RE would be zero, while AE would be a negative value. That is why seltzer and wine fermentations finish below zero. The density of ethanol is less than water and results in hydrometer measurements below zero. Beer will typically only finish below zero if there is diastatic yeast present, or if the brewer has added exogenous enzymes to break down the remaining dextrins.

Factors influencing attenuation
Attenuation ranges vary from strain to strain. There are also factors that can contribute to higher or lower attenuation than expected:

HOT SIDE

Mash temperature
One of the primary ways to influence your overall wort composition and its overall fermentability is mash temp. Consider the “sweet spots” where α-amylase and β-amylase activity coincide (about 146–158°F/63–70°C).

Generally, the lower the mash temp within that range, the more fermentable the wort will be. Mashing at the high end of the range may denature those enzymes, leaving you with a less fermentable wort.

Mash pH
Just as enzymes have ideal temperature ranges, they also have pH ranges for optimal activity. The β-amylases in malt prefer a pH range of 5.1–5.3. α-amylases prefer 5.3–5.7. Want a dry finishing gravity? Target 5.1–5.3 for β-amylase. Want a higher finishing gravity? Target 5.5–5.7 for α-amylase. Want a middle ground? 5.3–5.5 is a good compromise.

Water-to-grist ratio
Mashes that are too thin or too thick can lead to poor conversion. In a thin mash, enzymes and substrate interactions are limited and can lead to lower enzymatic activity. In a thick mash, they are at a high concentration and very active, but at some point the high accumulation of sugars can reach a point of diminishing returns, also leading to lower enzymatic activity. Aim for the middle.

Wort composition:
The available sugars in your wort affects attenuation potential. If only 75% of the wort is fermentable, you’ll max out at 75% attenuation assuming no other issues during fermentation. Note that brewers can also modify the wort composition in the kettle by adding things like dextrose or lactose, which will affect the overall fermentability.

Read more about an experiment involving oxygenation

COLD SIDE

Pitch rate & yeast health
While overpitching could lead to attenuation issues, underpitching is a more likely culprit for stalled fermentations. Unhealthy and/or stressed yeast is less efficient and may under-attenuate. Fresh yeast is always best. When in doubt, make a starter.

Oxygenation
Certain strains have higher oxygen demands than others. We tend to see a direct correlation between under-oxygenation and under-attenuation. Since oxygen is primarily used for yeast growth, low oxygen levels will not only reduce growth but also inhibit performance for those cells that are present.

Nutrient
Low nutrient levels can stress out yeast. Opting for a yeast nutrient can ensure a healthy fermentation. Take seltzer fermentation for example: even happy, healthy yeast in the presence of 100% fermentable sugar will massively underperform without the proper nutrients.

Alcohol tolerance
High-alcohol environments are stressful for yeast. Once the yeast approaches the limit of how much alcohol it can tolerate, fermentation will slow down even if there are still unfermented sugars in the wort.

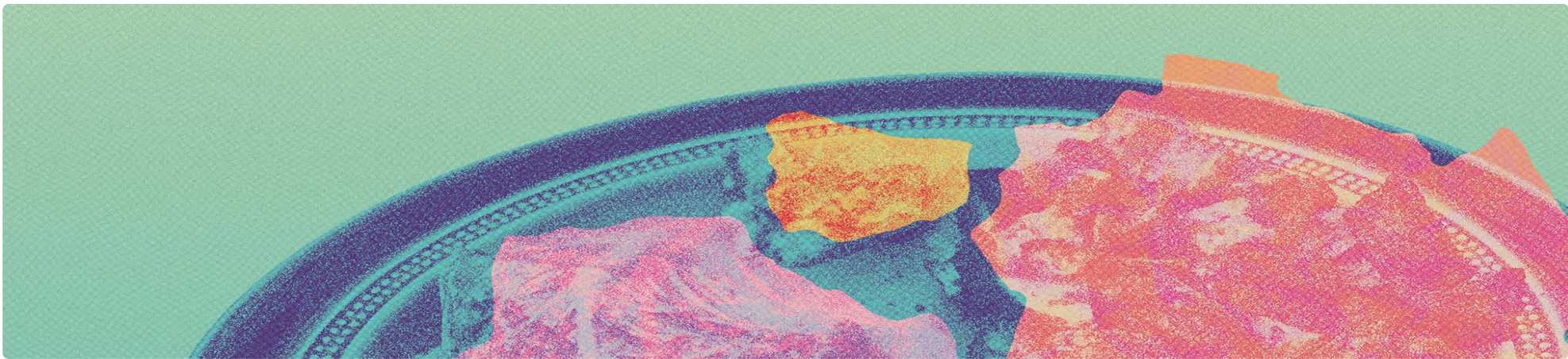
Dry hop creep
Adding hops on the cold side can introduce enzymes that liberate more fermentable sugars. Yeast can now consume those sugars and further attenuate the beer.

Temperature:
Fermentation temperature typically won’t have as much of an effect on attenuation as the rest of these factors. However, fermenting too cool could cause yeast to flocculate too early, leaving behind some unfermented wort, and resulting in a lower rate of attenuation than desired.

TROUBLESHOOTING ATTENUATION ON THE COLD SIDE

Under attenuation	Over attenuation
Underpitched yeast	Hop creep
Fermented too cool for strain limits	STA1+ present
Under-oxygenated wort	
Unhealthy and/or stressed yeast	

These items represent some potential issues on the cold side, assuming that you’ve set up the “dinner plate” perfectly. See below.



The Dinner Plate

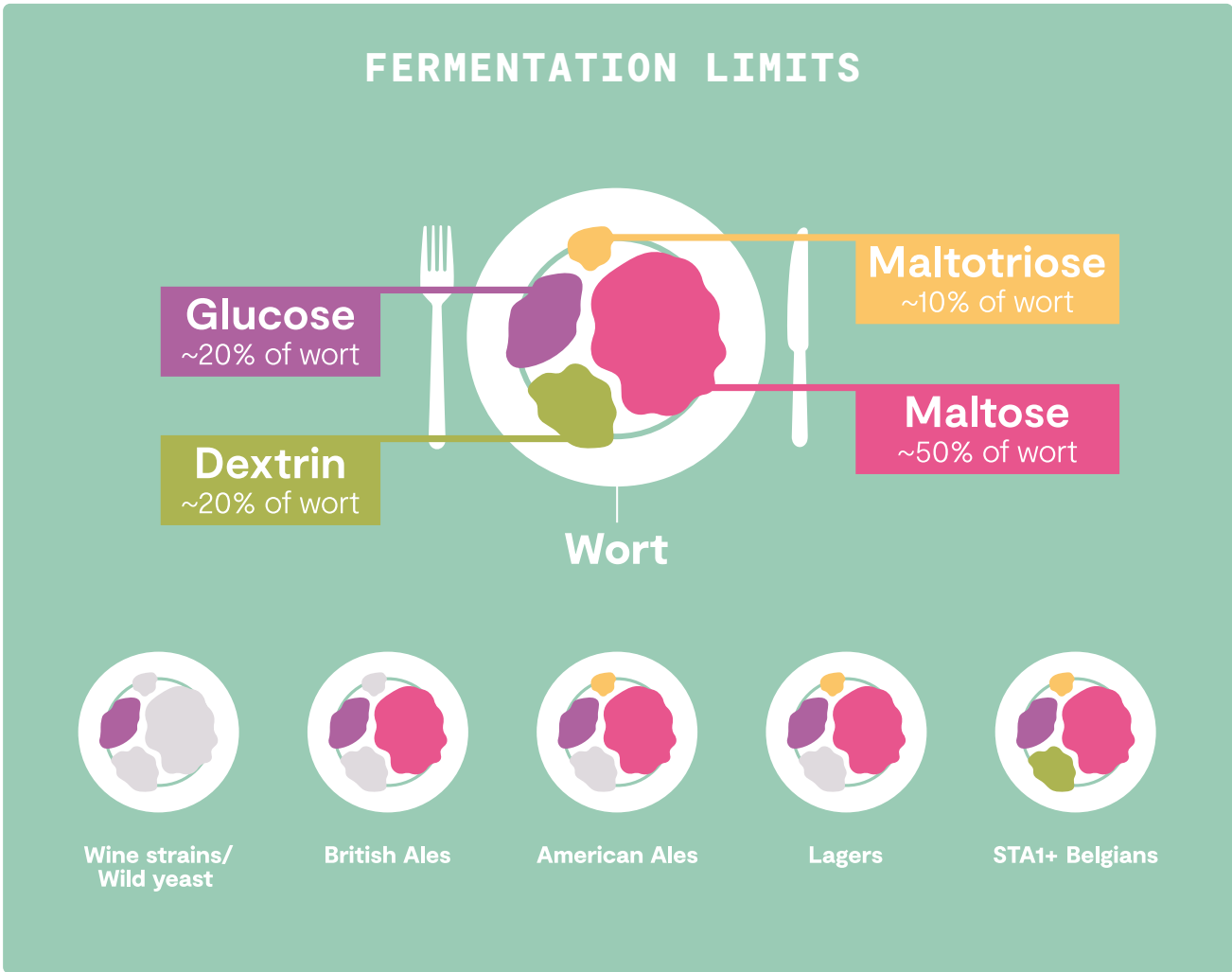
Set your yeast up for success by maximizing fermentable sugars for a given yeast strain. The dinner plate on the right represents the sugar makeup of a typical wort. Each broad family of yeast strain consumes those sugars differently.

The percentage of attenuation a yeast strain is capable of depends on how well they take up sugars, and most strains of brewing yeast consume sugars in a specific, predictable way—beginning with the smallest, simplest sugars (glucose, fructose, maltose) and moving to the larger, more complex ones next (maltotriose, dextrins, etc.).

With this knowledge, you can design your recipes to maximize your fermentables according to what strain of yeast you plan to use. Many British-type strains, for example, do not take in maltotriose. Others, like West Coast Ale I, handle maltotriose fermentation pretty well.

Advice for managing and controlling attenuation
It’s important to keep all of these factors in mind when designing a recipe, brewing the beer, and managing fermentation. Diligent note taking will help you track your successes, as will checking that your thermometers and pH probes are calibrated to ensure consistency. While yeast attenuation is largely predictable, it all comes down to dialing in what works on your system, and that will sometimes take a few brews. Keep at it and find what works best for you.

What about when the beer is done and you’re finding that it’s off by <0.5°P?
Sometimes it happens. Ultimately, it’s usually not a big enough difference to cause concern, but if it is happening regularly, it may be time to adjust your processes.



Clearing Diacetyl Before it Starts

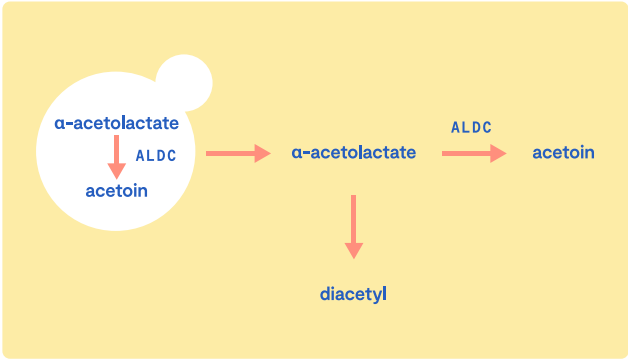
Brewers opt to use ALDC to help control diacetyl in situations where it can be more effective than a yeast strain’s native diacetyl control, like when brewing with known high diacetyl–producers, to safeguard lagers and other styles that reveal diacetyl–related faults more easily, and/or in heavily dry–hopped styles.

ALDC can be a strong option also when non–ideal repitching practices compromise yeast health, or when colder temperatures are challenging to yeast activity.

ALDC enzyme can be added manually or delivered via yeast that has been enabled to make it. Using yeast that produces ALDC can be more effective than adding it manually to wort.

Let’s clear something up
Your typical yeast strain is clearing up diacetyl throughout fermentation. How successful it is at getting rid of more than is being formed varies when either yeast’s rate of clearance and/or diacetyl’s rate of formation increases or decreases during different stages of fermentation. This is what results in highs and lows in overall concentrations of diacetyl.

Yeast’s process is slow, and it is sometimes ineffective at reducing diacetyl levels to entirely below sensory threshold. At the end of fermentation, the diacetyl rest is an essential step for encouraging the faster transformation of lingering α–acetolactate into diacetyl, so yeast can take care of it before dropping out.



Skip to the good part
Unlike yeast’s own process for clearing diacetyl, when we use ALDC enzyme, we’re targeting excess α–acetolactate before it ever becomes diacetyl. This gives yeast one less job to do at the end of fermentation when there are a lot of demands on it, just as it’s tiring out. Anything we do to help yeast health can have all kinds of benefits for beer.

It’s crucial that ALDC is present in effective concentrations before α–acetolactate gets out of the cell, so the ALDC can get to it before it turns into diacetyl. And ALDC also needs to stay present in effective concentrations throughout fermentation to defend from further diacetyl formation (once α–acetolactate becomes diacetyl, ALDC is no longer an effective solution).

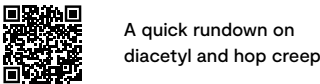
If you’re adding ALDC manually, timing and dose rates are very important. If you’re letting a yeast strain produce it, you can sit back and relax after you pitch yeast: α–acetolactate is being cleared before it even leaves the cell. As an added bonus, ALDC in the cell is protected from the occasional things that inhibit it when it’s dispersed in wort, which happens in dry hopped beers and low pH environments.

A yeast strain’s engineered ability to produce ALDC is stable across generations, so harvesting and repitching is an effective economical option.

Sources of ALDC
Manufacturers of the kind of ALDC enzyme that you add separately to wort usually use bacterial cells as little factories to produce it. They then harvest, purify, sterilize and package the enzyme that these organisms produce for use.

Different manufacturers may input different genetic sequences to get bacteria to produce the enzyme, and can even use different organisms to express it. So, just be aware that specs can vary a little by manufacturer.

Farming and packaging enzymes for later use makes perfect sense for most in the food and beverage industry, and even other industries, like cosmetics, but in the brewing world we have another option: yeast are also capable of being made to produce ALDC. So, we could just be enabling our yeast to make it while we’re brewing, instead of bringing it in from a similar process elsewhere.

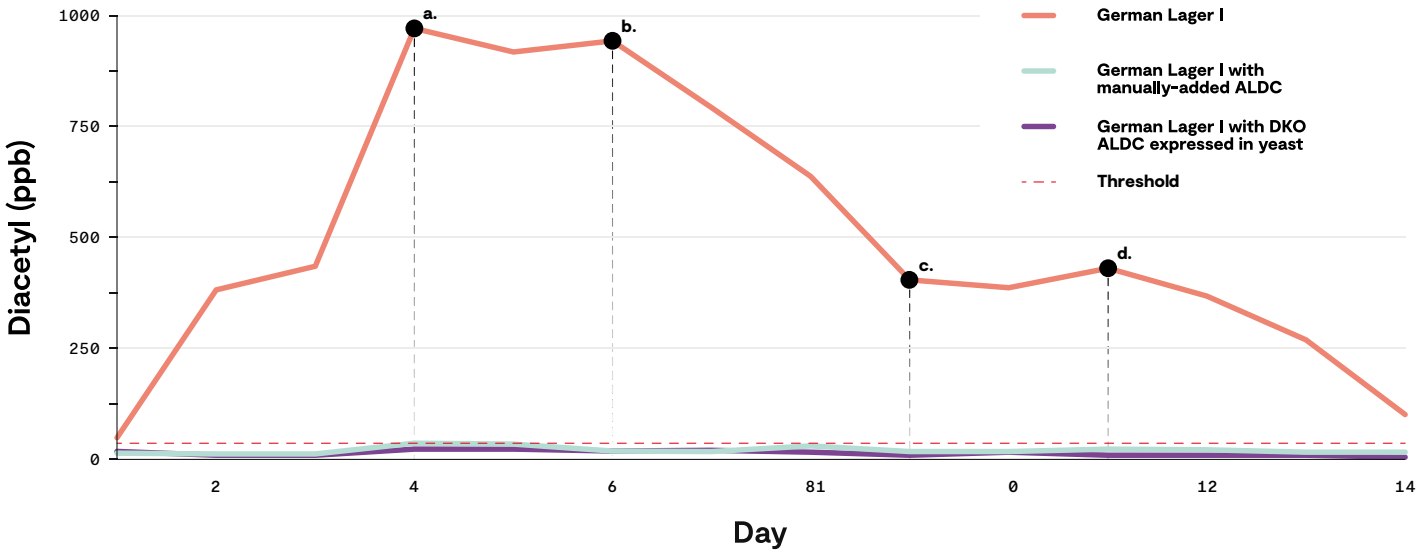


A quick rundown on diacetyl and hop creep

What causes diacetyl? Yeast creates diacetyl’s precursor, α–acetolactate, on purpose from its food. α–acetolactate is used by yeast for amino acid synthesis—something that’s crucial for yeast health and growth. But yeast tends to make it faster than it can be used up for that purpose, resulting in excess that diffuses out of the cell and into wort where it reacts with oxygen to become diacetyl.



Diacetyl Control v. ALDC-assisted Fermentation



AN EXPERIMENT

Brewers traditionally have used techniques like a diacetyl rest to control diacetyl at the end of fermentation. In the graph above, the orange line represents the diacetyl present in a simple German Lager I fermentation with a classic lager strain using a diacetyl rest. It serves as a baseline of how diacetyl typically accumulates—and is cleared—without the help of the ALDC enzyme. You can see that diacetyl levels are still above sensory threshold at day 14. Additional time would be needed to clear diacetyl in this fermentation. That is not so for the fermentations with ALDC. Let’s explore more by stages:

Early on in fermentation, generally, off–flavors are forming and yeast is very actively clearing them up. Yeast cells are producing aroma compounds like esters as part of their metabolism, and they are also making α–acetolactate.

German Lager I without ALDC
See the orange line in the graph above. From day zero to around day four the rate of α–acetolactate production by yeast cells exceeds its rate of use, and the excess is becoming diacetyl in the wort.

We can see that the rate of the formation of diacetyl is also pretty quickly exceeding yeast’s rate of clearance, and, so, diacetyl concentrations are cumulatively rising.

Mid fermentation, something begins to change. We see yeast’s rate of clearance exceed the rate of diacetyl formation for the first time (a.). After a sort of plateau (a.–b.), diacetyl concentrations then begin falling in earnest (b.–c.).

The dramatic success in clearing diacetyl here is probably because α–acetolactate production by yeast cells is slowing, and there is therefore less precursor available to become diacetyl. That means diacetyl’s rate of formation is slowing at the same time yeast continues to be pretty effective at clearing it.

Nearer the end of fermentation, however, there’s a rise in accumulation of diacetyl compared to yeast’s effort to clear it. This is in part because diacetyl is still in the process of forming from the remaining α–acetolactate in wort, even though yeast has slowed in producing new α–acetolactate; but now yeast’s rate of clearing has begun to slow, too.

Finally, increasing temperature during the diacetyl rest (c.) helps all remaining α–acetolactate convert to diacetyl more quickly, raising diacetyl concentrations briefly (d.) and with that, also gives yeast a little extra oomph to clear it up, too.

By day 14, diacetyl levels have tapered off to very low levels, though not entirely below threshold.

German Lager I with manually-added ALDC and yeast-expressed ALDC “DKO”
The dotted line on the graph represents the sensory threshold for diacetyl. Below that are lines representing the two ALDC–enzyme assisted fermentations. The blue represents diacetyl concentrations in the fermentation where ALDC was added manually, while the purple shows diacetyl levels in the fermentation using the DKO version of the German Lager I strain, which expressed ALDC on its own. With both ALDC–assisted fermentations you can see that diacetyl formation never accumulates at all, and therefore the beer is clear of any perceivable diacetyl levels faster and more completely.

Note: The amounts that you do see represented in each line are more reflective of instrumental limits of detection, rather than perceivable quantities. That means diacetyl may be present, but at levels so low that they can only be detected by gas chromatography (GC). A trained sensory panelist generally can begin to detect diacetyl in a pale ale starting around 40–50 ppb. That’s where we placed our threshold line. But in a lager, detection might be as low as 20.

DKO TECHNOLOGY

Innovations-based strains at Omega Yeast can be said to fall into two broad categories: strains that have entirely new characteristics, like an aroma expression or a souring ability, and those where we’ve made an improvement, sharpened the tool so to speak, making it more effective within the context that it is already used. **Diacetyl Knock Out (DKO) technology** is most beneficial when applied to strains that brewers use for the majority of their production, where quality and efficiency considerations are very important. ALDC–expressing yeast is a “sharpened tool.” A strain’s ability to make ALDC makes it more resilient for how brewers commonly use it.

Omega Yeast strains available with DKO:

- British V +
- DIPA +
- Extra Special +
- Kolsch II +
- Point Loma +
- West Coast I +
- Bayern Lager +
- German Lager I +

Kolsch II, German Lager I and Bayern Lager:
The movement toward cleaner focused IPAs has pushed people to using Kölsch and lager strains. Try the DKO version of the Kolsch strain especially when dry hopping.

Extra Special: Historically this is one that people used a lot for IPA in the classic craft beer boom era. It’s still a core classic.

What other strains would you like to see produce the ALDC enzyme?

How Low Can You Go? An Overview of NAB/LAB beer

The people have spoken: non-alcoholic beer is popular. What used to be widely disliked and sometimes avoided, NA beers have followed a trajectory similar to that of the craft beer boom, with new flavors and styles coming to market faster than ever. As a result, consumers have begun to expect an NA selection on the menus of their favorite bars and taprooms. And many brewers are interested in meeting the demand. However, it can be a challenge to make them look, taste and feel like the real thing, not to mention the additional safety concerns that the absence of alcohol brings. NA beer isn't inherently unsafe, but the lack of various layers of protection against human pathogens makes brewing it a bit more of a challenge.

What makes beer safe

Regular-strength beer and non-alcoholic beer have a number of safeguards in common, but these defenses work better when multiple safety measures are present. Hops are often credited as the ingredient that makes beer safe to drink, but they work in conjunction with alcohol and pH to keep your beer tasty and prevent it from being harmful.

- **Heat:** Art of the brewing process involves boiling, which in addition to contributing to flavor, serves to eliminate any microbes that might have been present on the raw materials. Heat can also come into play at the end of the brewing process in the form of pasteurization, a final act of thermal processing that kills any remaining organisms in the beer, even yeast. It's worth noting that spore-forming bacteria (like *Bacilli* and *Clostridium* bacteria) are even harder to kill, requiring sterilization-level temperatures to prevent future spore growth, so heat alone is not enough to ensure that your NA beer is safe.
- **Hops:** One of beer's core ingredients, hops are one of the most essential safeguards we have against pathogens. The alpha acids present in hops isomerize into iso-alpha acids during the boil, which not only contribute bitterness but also act as an antimicrobial agent.
- **pH:** Acidifying is a classic method for preserving food items—think pickles, kimchi, etc.—because low pH inhibits microbial growth. To avoid most pathogens, a pH below 4.6 with the addition of other safeguards (like the ones discussed in this section) is acceptable. However, without pasteurization or the presence of hops and/or alcohol, normal beer pH levels alone are not necessarily safe—brewers of NA beer need to control pH throughout fermentation (keeping it below 4.6) and finish the beer with a pH below 4.2 to ensure a safe product.
- **Alcohol:** The alcohol produced during fermentation is a major reason why beer is safe to drink, especially in conjunction with other safeguards. It is difficult for many species to reproduce in the presence of ethanol, making low- and no-alcohol beers a potentially ideal environment for pathogen growth.

Overcoming new hurdles

Remember, we're not making beer as we know it, we're making NA beer, which brings with it a laundry list of new challenges now that we've lost a number of our usual safeguards:

- **Saccharomyces contamination:** Wild yeast contamination is a concern with any sort of beer making endeavor, but maltose-positive *Saccharomyces* strains can also make their way into sugar-rich wort that was intended for a maltose-negative strain and enact normal fermentation.
- **Hop creep:** Dry hop-induced hop creep doesn't just apply to traditional beer fermentation, it can also happen in NA beer. Remember that dry hopping can send yeast chomping on new sugars and creating alcohol, and it raises the pH of your beer which can potentially move it out of a safe pH range.
- **Diminished hop character:** Getting hop aroma into NA products can be challenging, as researchers are finding hop oils to be less soluble with a decreased presence of alcohol. Many brewers are currently experimenting with various hop extracts which help to avoid any issues with refermentation.
- **Flavor balance:** While over-sparging is a concern with all brewing, it can bring especially unpleasant astringency when brewing NA beer because the grain bill is smaller than usual. Brewers may want to avoid sparging entirely when brewing NA beer.
- **Stabilization:** Even if the liquid is pasteurized, all components of the packaging system—pipes, tubes, tanks, cans, lids, etc.—present opportunities for harboring bacteria that can run rampant once it comes into contact with NA beer. Chemical solutions like sorbates and benzoates are an option that require training and validation to be used effectively.
- **Package vs. draft:** Many brewing experts highly discourage draft NA beer because of the potential contamination down the line. Even with extremely effective stabilization, NA beers still have high amounts of residual sugars, which can quickly lead to a feeding frenzy for any bacteria present. Once the kegs leave the brewery, there's no way to ensure that food safety protocols are being followed at the point of service.

Methods of NA beer production

How do you make NA beer, anyway? Many non-alcoholic beer makers are secretive about the methods they use to make their products. There are a few different approaches brewers can take, whether they choose to avoid producing any alcohol or take steps to reduce or remove it entirely.

No fermentation - producing no alcohol

Conceptually, one way to make a non-alcoholic beverage is to produce wort without ever adding yeast, which prevents the formation of alcohol. There are numerous downsides to this method, as it results in a sweet beverage without any of the typical fermentation-derived flavors found in beer and has none of beer's inherent safeguards against microbial contamination. This is extremely uncommon.

Biological methods - limiting the production of alcohol

Arrested fermentation puts the brewer in the driver's seat, halting fermentation typically through the use of temperature control. Brewers reduce the temperature of the fermentation vessel to the point where yeast activity is reduced and eventually ceases.

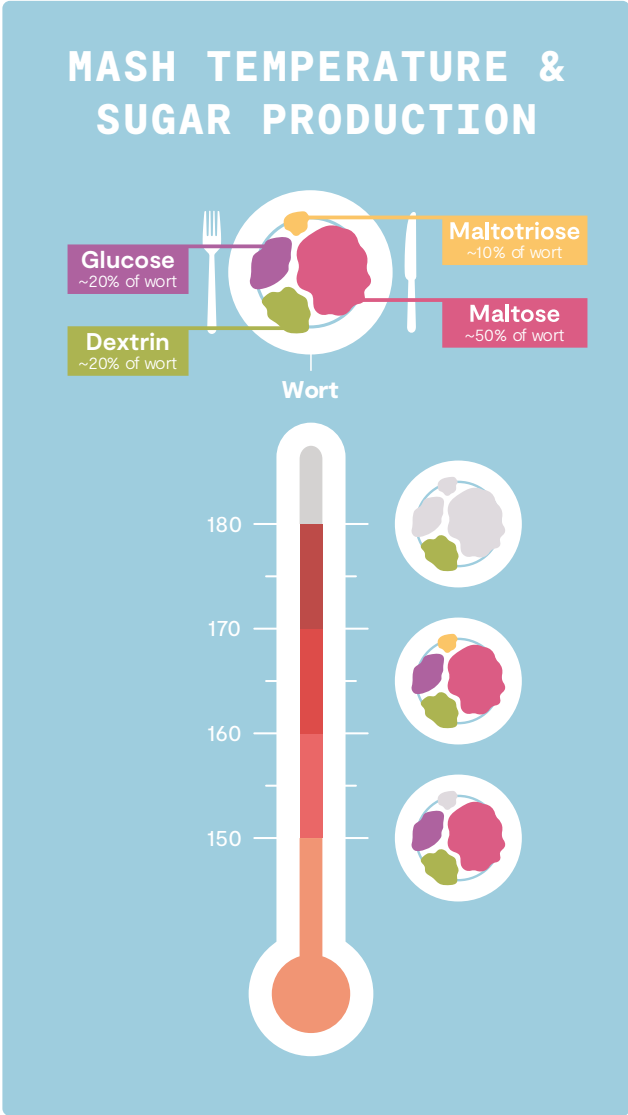
Cold contact fermentation is a fairly common process, with the main benefit being that it is quite simple: after the boil, wort is crashed to cold temperatures (normal cold crashing temperatures, all the way down to 0°C but taking care not to freeze the wort) before pitching yeast. Very little fermentation actually occurs, so a small amount of flavor is produced and little to no ethanol forms. In both cold contact and arrested fermentation, there will often be residual yeast present in the beer, so brewers must stabilize the final product to prevent additional fermentation in the future.

Limited fermentability of wort means that brewers are designing a recipe so that the wort developed on the hot side is rich in dextrins, but has little maltose available for fermentation. This allows brewers to use a traditional brewing strain that can create some fermentation-derived flavors, but won't ferment to full strength due to the lack of available consumable sugars. Mashing at higher temperatures can help encourage dextrin production and limit wort fermentability.

Limited fermentation requires brewers to select a **maltose-negative** strain of yeast, meaning one that is unable to ferment maltose, which is typically the majority of wort's composition. While these strains do keep alcohol levels low, leaving behind all of this maltose can create a wort-like flavor, which can lead to the development of stale, cooked wort flavors.

There are some maltose-negative strains on the market currently, and while they do help ensure that alcohol levels stay low, they are also very easily out-competed by traditional brewing strains. Any kind of cross-contamination with another brewing strain will result in alcohol production, as those strains will suddenly have access to a maltose-rich environment where they can ferment freely.

Maltose-negative strains tend to be low flocculators, and some are phenolic, which may limit the styles brewers are able to produce. Because there is little to no fermentation taking place, the ester profile will also likely be restrained. In the grand scheme of brewing strain domestication, maltose-negative strains are relatively new to the brewing world, and as such lack the finesse and behavior expectations we've been able to coax out of traditional brewing strains over centuries.



It's what's for dinner: Mashing at certain temperature ranges encourages various types of sugar production, which you can use to predict how your fermentation will be limited. Here we show what's being "served" at various mash temps.

Physical methods/Dealcoholization - removing alcohol

Because ethanol boils at about 78°C, **boiling** to evaporate alcohol is one method of bringing a beer into non-alcoholic territory. However, flavor is a major consideration with this practice, as boiling will bring a strong cooked wort flavor to the beer. It will also cause the beer to lose volatile aroma compounds and may accelerate staling due to the long exposure to heat.

Similar to boiling, **vacuum distillation** is another method for removing alcohol. The presence of the vacuum reduces the boiling point for ethanol from ~78°C to ~34°C, which in turn reduces the flavor impact of boiling.

Membrane filtration involves running a beer along a filter that uses pressure to separate alcohol from the remainder of the liquid. Reverse osmosis is a type of membrane filtration in which beer is forced through a membrane under pressure, removing ethanol and water and leaving behind flavor compounds. Water is then added back to the final product to make up for the water lost during the filtration process.

Both vacuum distillation and membrane filtration require costly equipment; these methods are most often employed by the largest producers and co-packing facilities.

Tasting activity

Given that most NA beer makers don't disclose their production methods, it can be difficult to discern how certain brands were made. We can use sensory clues to help us understand how some of these non-alcoholic and alcohol-free beers came to be. Pick up a few brands and make a note of the flavor characteristics in each using the chart below. See if you can sort out which processes are used to make the beers you chose, then check to see if the manufacturer shares their methods.

Method	Production method	Worty	Cooked	"Beer" fermented character
Limit alcohol production	Arrested/cold contact fermentation	● ● ●	—	● ● ●
Limit alcohol production	Maltose-negative strain	● ● ●	● ● ●	● ● ●
Limit alcohol production	High temp mash + low gravity, full fermentation with traditional brewing strain	—	—	● ● ●
Alcohol removal	alcohol removal by boiling	—	● ● ●	—
Alcohol removal	vacuum distillation	—	● ● ●	● ● ●
Alcohol removal	membrane filtration	—	—	● ● ●

Taking a hybrid approach

Combining production methods can help brewers get closer to the ideal finished product: real fermentation-derived characteristics, low residual wort sugars, and <0.5% ABV. For example, by taking advantage of biological processes to create flavorful beer with limited alcohol (up to 2-3% ABV), taking the next step to remove alcohol can be easier and less resource-intensive. While each method has its drawbacks, a hybrid approach is a great way to mitigate those concerns and make a more flavorful beverage.

In our own trials, we found that nailing at least one very "beer-like" aspect of the flavor profile helped a sample perform better in our tasting panels. IPAs with strong fresh hop aroma and blonde ales with refreshing carbonation and dryness made it a bit harder to tell that the samples weren't the real deal.

Making it work for you

When it comes to making NA beer, why not leverage the brewhouse to do as much of the heavy lifting as possible? Before handing off your wort to the yeast, use mashing techniques to develop more dextrins and malt flavor, but avoid allowing starches to be broken down into maltose. Wort destined to become full-strength beer is typically made up of about 50% maltose, with the rest being split among glucose (20%), dextrins (20%), and maltotriose (10%). If you were to get less conversion in the mash and fill your yeast's "dinner plate" with mostly dextrins and just a bit of maltose, you get the opportunity to use a more traditional brewing strain that will consume the maltose and ferment it, but with less available "food" it won't create nearly as much alcohol. Following that up with an alcohol removal method may result in just the flavorful non-alcoholic beer of your dreams.



Why is “non-alcoholic” beer allowed to have up to 0.5% ABV?

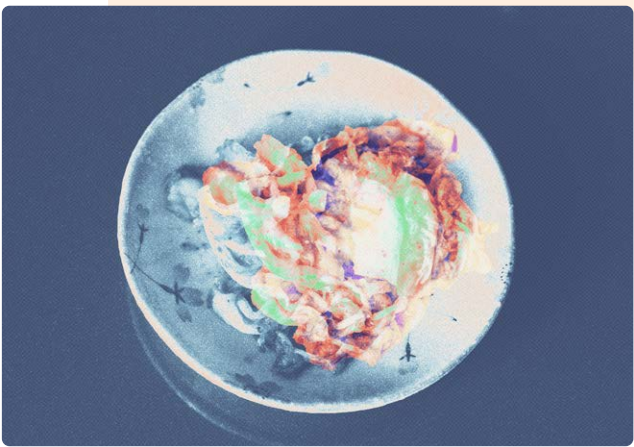
In the United States, a beer is considered “non-alcoholic” if it contains at most 0.5% ABV. While it may seem counterintuitive to allow for even the smallest amount of alcohol yet still be called non-alcoholic, the limit isn't entirely arbitrary.

Most human health researchers agree that the body can process between 10-18 mL of alcohol per hour, depending on factors that differ among individuals. If we assume a processing rate of about 15 mL of alcohol per hour, then a 355 mL serving of 0.5% ABV beer would have about 1.77 mL of alcohol in that serving. You'd need to drink eight NA beers in an hour to meet that hourly processing limit—the same as if you were to drink just one 4.5% ABV beer in that same hour.

Keep in mind that non-alcoholic (NA) is not interchangeable with alcohol-free (AF): in order to be considered AF, the beverage must contain 0.0% alcohol.

Other foods/consumables with trace amounts of alcohol:

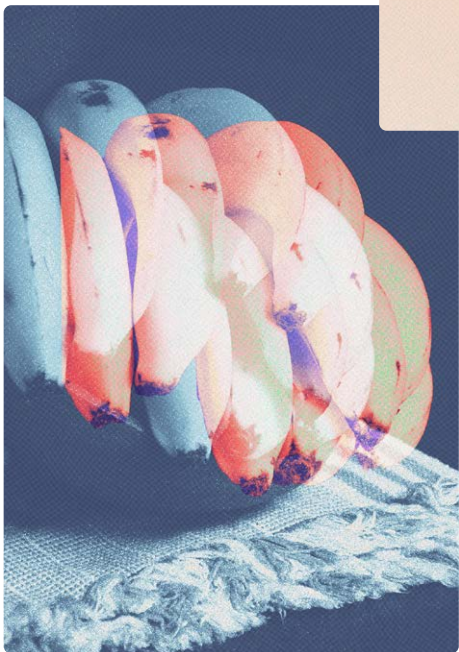
- **Apple juice:** 0.06% ABV
- **Kimchi:** 0.5–2% ABV
- **Ripe bananas:** 0.2% ABV
- **Soy sauce:** 1.5–2% ABV
- **Vanilla extract:** at least 35% ABV by law



Kimchi

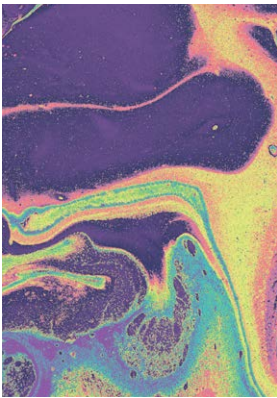


Apple juice



Ripe bananas

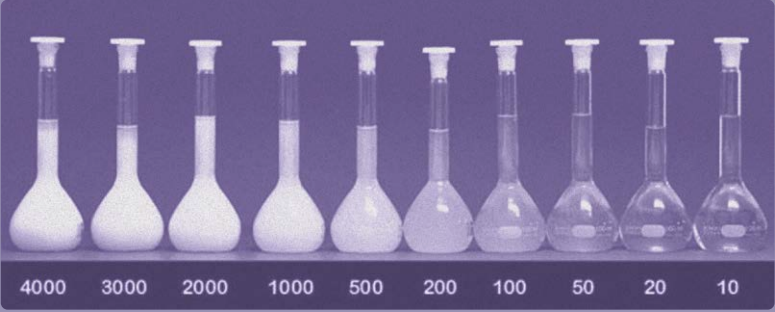
HAZE REDUX



What is Haze?

In a liquid like beer, when particles that are originally invisible to the naked eye group together, they show up to us as cloudiness—or turbidity. This is haze.

MEASURING HAZE



Haze is measured in Nephelometric Turbidity Units (NTUs), which is a measure of how much light scatters as it passes through a liquid. A lager has very little turbidity so it measures low in NTUs. A hazy IPA, on the other hand, can be as turbid as orange juice. Its NTUs can range from about 200–1000. Something like milk, for example, comes in over 4000.

When the goal is rich colloidal haze as opaque as milk or orange juice—haze that makes a beer’s body appear to glow when lit and sticks around smoothly in suspension—particles have to be of certain sizes and composition. That’s not always so easy to orchestrate. Brewers spend just as much time these days working on capturing haze as they do refining for clarity.

For all the attention hazy beers get, the exact mechanisms for haze are not well understood. Omega Yeast is helping to change that. Omega Yeast researchers have discovered some new levers, some in combination with yeast, and some despite it, that can help you to control both haze and clarity, practically. To do that, it’s important to understand there are multiple sources for haze in beer.

Though malt, yeast and hops each have independent haze-determining factors, leaning on haze that forms in one way rather than another could make your beercraft significantly easier. Whether you’re clearing haze or building it, knowing what’s driving it will save you from uphill battles.

Malt
001

Hops
003

The Haze Complex

Yeast
002

What We Knew First: Malt Haze

There are a handful of sources for haze originating from malt inputs to wort and beer. Some significant ones are carbohydrates—like long-chain dextrins not broken down during the mash, and β -glucan, which is a viscous, gummy fiber mostly derived from malt barley (or other cereals, like oats). Its gummy quality can be a production nightmare.

Another significant haze source from malts are proteins and polyphenols. Protein-polyphenol haze is probably the most significant haze-contributing factor on the malt side. Proteins (from malts), and polyphenols (from malts and hops) can join up and create larger-sized polymers.

A smaller subset of the malt proteins are haze-active (like hordein). They have amino acids (like proline) at certain bonding sites, which attract polyphenols more actively (like proanthocyanidins, and various diverse catechins).

Different malts and malt products, and other factors like mash temperature, affect how much haze-active protein and polyphenol ends up in wort.

The way the component particles bond under certain conditions defines whether the haze will be stable in beer over time. Protein-polyphenol haze sticking around in the way brewers want depends a lot on balance:

Balancing proteins and polyphenols

Setting the stage for haze based on protein-polyphenol linkage can be a little hairy: too little of some things or too much of others, and it can fail to show up like we want it to (if we want it to). Here are some things to consider:

Researchers found that when haze-active proteins and polyphenols were present in about the same proportion, they could combine well to create large molecules that appear as haze. But if proportions were imbalanced, haze tended not to form because the more abundant compound tended to get in the way, keeping the relevant binding sites apart.

When the system is cold and slower-moving, the large protein-polyphenol polymers that do form tend to stay bonded together, but when the system is more energetic (warmer) they fall apart, breaking up. This is what is thought to create the phenomenon of **chill haze**.

Sometimes, however, instead of falling apart, the same protein-polyphenol bonds can strengthen and form permanent haze. Things like repeated changes in temperature, pasteurization, light irradiation, oxidation, age and vibration during storage and transport can cause temporary haze to become permanent.

Protein-polyphenol bonding can also be so successful that the size of the polymers tips over to colloidal instability, resulting in the haze going chunky and falling out.

Minimizing malt haze

Trying to get rid of protein-polyphenol and other malt-influenced haze? Some best-practices—and clarifying agents—can help.

Here are some common approaches:

First, brewers could try avoiding malts with high β -glucan and protein content. But for dealing with β -glucan, lower mash ranges can help break them down. Proteins can be more difficult. Yeast needs soluble protein (FAN), but too much can create off flavors. And too many proline-rich proteins can lead to haze.

For polyphenols, care in malt handling, like avoiding high temperatures and high pH in the mash and lauter, and steering away from over sparging can keep you from over extracting from the malt (barley husk is loaded with polyphenols).

Hot-side clarifying agents are often used to remove malt proteins and polyphenols in the kettle. Fining agents, such as carrageenan and PVPP are helpful in removing hot break and separating trub. Cooling the wort quickly helps remove cold break.

In the cellar, adding proline-specific endopeptidases takes proline-rich malt proteins (haze-active proteins) out of the mix before fermentation (like barley hordeins, and wheat gliadins). Post-fermentation, adding silicic acid can further remove proteins—and yeast. PVPP can be added post-fermentation to get rid of more polyphenols.

What We Know Now: Enter Yeast Haze

Some people still associate yeast haze with poor yeast health. Think propagations and fermentations lacking nutrients, temperatures that are too high, cells damaged by autolysis or sheared by pumps and centrifuges—haze that’s linked to yeast’s cell-wall β -glucans, mannans and/or glycogen from cell ruptures. But what other brewers suspected, but no one really knew about for sure until now is that yeast is responsible for a “good” kind of haze, too—the rich, colloidal kind that brewers actively want for hazy styles. It has to do with the fact that fermentors are now regularly loaded up with hops. What do hops have to do with it? There is a yeast-determined haze produced by healthy yeast in conjunction with hop compounds. Hop compounds seem to interact to increase or decrease the haze that “haze positive” strains put out.

This yeast-determined haze is proving to be a reliable way to keep a solid foundation of stable haze when you want it—or a crucial way to remove obstacles to clarity when you don’t. Some strains have way more haze potential than others, so strain choice is important.

Strains that have haze ability are called **haze-positive**. They can both create haze and be restrained from it, which makes them versatile for any haze outcome. **Haze-neutral** strains don’t have significant yeast-contributed haze levels. So, they’re good for safeguarding bright styles, so you don’t have to battle against yeast haze to get the clarity you want.

AN EXPERIMENT

This experiment was designed to illustrate the differences in haze outcomes when dry hop timing varied with a haze-positive strain (British V) and a haze-neutral strain (West Coast Ale I).

For each series, we inoculated nine identical flasks of wort with the same yeast on the same day, and then dry hopped them at different times during fermentation.

- The control flask was not dry hopped.
- The central flasks were dry hopped on progressive days
- (day zero, one, two, three, four and seven).
- The last was double dry-hopped—half early in fermentation and half late.

Can you spot which is which?

Which series was fermented with British V (very haze positive) and which with Chico aka West Coast Ale I (haze neutral).

TIP: look for increasing haze with later dry hop timing to find the haze positive strain.



Early dry hop, double dry hop

Dry hopping at the same time as pitching yeast resulted consistently in an **additional clarifying effect**, even when there was also a later dry hop, for both haze-positive and haze-neutral strains.

When helping brewers troubleshoot a hazy beer that mysteriously dropped clear, we’ve sometimes discovered a dry hop was moved up, or a hop product was changed. These are both things that can affect haze.

TIP: If you’re having haze problems with the strain you’re using for your West Coast IPA, try a small dry hop load at yeast-pitch ($\frac{1}{4}$ lb/bbl).

Sorting strains by haze potential

The amount of haze that any strain generates is not so much a yes-no binary as an a-little-to-a-lot spectrum.

In testing, if a yeast strain could cause more than 200 NTUs of turbidity when the wort was dry hopped on day seven of fermentation (this is when it should be contributing its maximum haze potential), we considered that strain to be haze-positive. If it didn’t, we categorized it as haze-neutral.



How haze-positive is it? Scan here to see a graph representing the spectrum by strain.

Other hop variables that affect haze levels with haze-positive yeast
We’ve seen additional elements of the dry hop also affect the intensity of yeast-derived haze with haze-positive yeast. Any of the following can also amplify or diminish haze:

Hopping rate	Hop variety	...And more
More hops, more haze. Haze increases along with higher hopping rates.	Different hop varieties seem to enable yeast-determined haze differently.	Differences between concentrated lupulin pellets and hop extracts are likely to make a difference, too. There are a lot of variables introduced by different hop products.

What have you noticed changes haze outcomes in your recipes?

Future Study: Signs of Independent Hop Haze

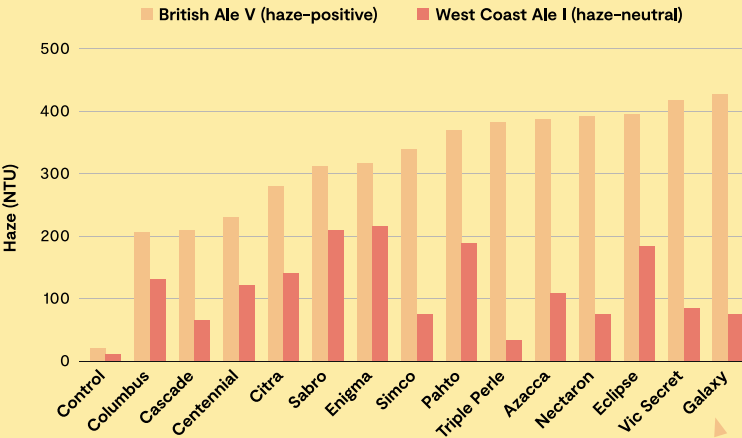
We’ve described two ways hops have a supporting role in haze—they can add polyphenols to protein-polyphenol polymers, and dry-hopping can trigger haze with haze-positive yeast—but there is something else about the dry hop that is impacting haze that’s independent of the yeast type, too.

It might be linked to differences in polyphenol composition between varieties, or it may be something else entirely—something that we haven’t uncovered yet:

AN EXPERIMENT

We used a late-fermentation dry hop in 15 fermentations where the variable was hop variety—first with a haze positive strain, then with a haze neutral strain. We measured haze output for both.

Some hops were able to help promote haze even with haze-neutral strains. This complexity across varieties suggests that dry hopping leads to multiple forms of haze.



Here you can see that haze varies differently in haze-neutral fermentations than it does in haze-positive fermentations. That’s a good illustration that this hop haze is working independently of the haze that shows up in conjunction with haze-positive yeast.

Galaxy was one of the hops that made extremely hazy beer in combination with haze-positive yeast, but did not produce much haze at all with a haze-neutral yeast. Other hops, like Columbus, promoted haze to a lesser degree with haze-positive yeast, and could still lead to haze with haze-neutral yeast.

Knowing which hop and yeast best promote or reduce haze are another thing you can consider for reliably hazy or non-hazy beers in recipe design. In our experiments, for example, we saw that for haze Galaxy and British V are a great pair. And for a bright style, like a West Coast IPA, Simcoe and West Coast Ale I are good at keeping haze minimal.

HAZE REDUX

More to Come

Haze has more layers than initially thought. In short, malts, yeast and hops all have important roles to play in different sources of haze. And it matters where your haze is coming from if you want to be able to control it. In terms of reliability, consistency, and ease of process a haze-positive yeast strain will do a lot to lay a foundation for haze, and a haze-neutral strain is going to go a long way in paving the way for clarity.

This is what we can do to optimize what exists—but that’s not all we can do. Omega Yeast researchers also found the particular gene that’s responsible for haze. Its discovery means they are also creating new solutions in new tools for brewers. *This* is what’s new in haze.

Doors open with the *HZY1* gene
Observations in experimentation about yeast-determined haze suggested to Omega Yeast’s researchers that there was a genetic cause, so they set out to look for it—and they found it. The gene had previously been without a known function. Omega Yeast’s R&D team named it *HZY1*.

Examining the gene’s structure for clues on how it engages with haze, there were massive expansions made up of repetitive sequences in haze-positive strains. Comparatively, haze-neutral strains’ version of the gene were smaller, and showed fewer repetitions.

When the Omega Yeast team went back to the whole yeast strain catalog and categorized strains by how much haze they contribute with a later dry hop, some strains were more strongly haze-positive than others.

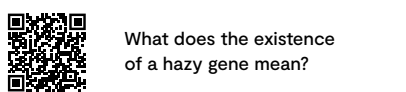
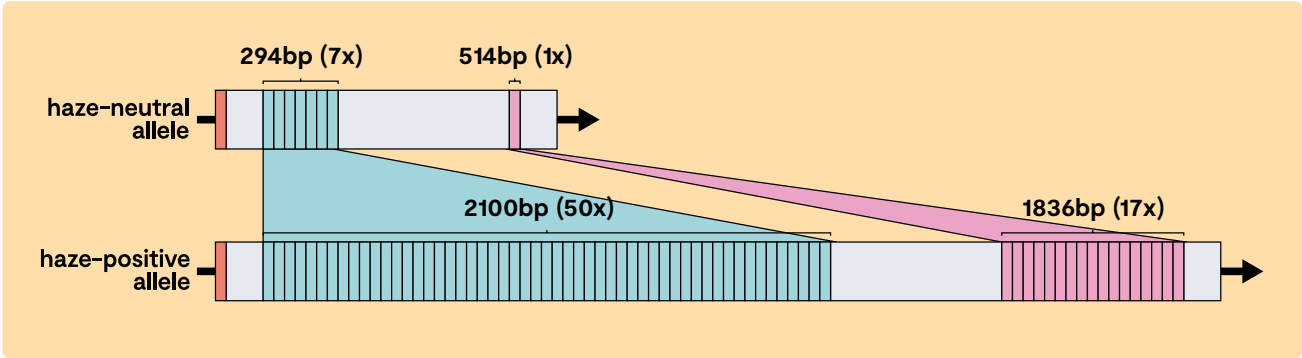
We see the diversity that occurred there reflected in the genetics, too: there are different degrees, locations and sizes to the repeats.

- 1 — **The long and short of it**
There was a good correlation between the size of the expansion in the *HZY1* gene and a strain’s ability to make haze in a haze-positive manner. That meant selecting a strain by its *HZY1* signature was predictive of how it performed. This was a great sign they’d found the right gene.
- 2 — **Knock it off**
They next knocked out the hazy version of the gene in haze-positive strains, which successfully resulted in the loss of haze. That was another great sign that Omega Yeast’s brewing scientists found the right factor.
- 3 — **Opportunity knocks**
Being able to knock out the *HZY1* gene also meant there was now a perfect isogenic system for testing how haze affects flavor. It was now possible to brew identical beers with only a haze difference.

The future is now
Now that Omega Yeast researches have the genetic target for haze, there are a lot of opportunities. They can design strains to be more reliable based on how brewers want to use them.

They are already trialing strains with brewers in which they’ve disabled yeast-determined haze. Hazy versions of previously non-hazy strains are also on the horizon after that. Are there any strains on your hazy or non-hazy wishlist?

- **A juicy non-hazy?**
British V is known for being good at making haze and has juicy esters. If we disable its *HZY1* gene, we could make a juicy strain that’s great for clear styles.
- **A chico fino?**
The haze Chico makes is low, but it isn’t zero. When Omega Yeast deletes its *HZY1* gene, we get a further reduction in haze. This could be a great option for reliably clear beer with minimal fuss.



Troubleshooting Haze by Strain Selection

Often when brewers get in touch with Omega Yeast’s experts, Omega Yeast starts by asking the brewer what yeast they’re using, especially when it comes to haze. Whether you’re looking to clear up or make more haze, here are a few scenarios that are common topics for troubleshooting:

Brewing clear beer while unknowingly using a haze-positive strain
Some brewers have been using strains that they didn’t necessarily realize were haze-positive. One example of this is Point Loma (OYL-043): considered by some to be an offshoot or “better version” of West Coast Ale I (OYL-004) aka Chico, but it also comes along with some haze-generating capabilities that makes it a useful tool for brewing hazy beers, and might work against the brewer in a clear beer, depending on certain factors.

Difficulty generating haze while using a haze-neutral strain
Extra Special (OYL-016) and West Coast Ale I are popular strain options for their reliability, and many brewers have tried and struggled to make hazy beers with them. As one brewer once told us, “no matter what we do they always seem to drop clear.” We generally suggest reserving these strains for your non-hazy beers. While it isn’t impossible to achieve stable haze with these strains, it will be hard work to make it stick.

Sometimes it’s hazy, sometimes it isn’t
Another case is the DIPA strain (OYL-052), commonly known as Conan. DIPA was one of those interesting scenarios in which brewers were finding that their beers sometimes dropped clear and other times remained hazy. This is a scenario in which dry hop timing can aid your process. Omega Yeast’s research has found that later dry hopping tends to produce stronger haze.

Other questions we’ve received from brewers:

- **What clarifying agents can we use and still make hazy beer?**
People often use Whirlfloc and it still makes a hazy beer, but Clarex and Biofine would reduce haze considerably.
- **Does yeast contact help retain haze?**
As of right now, Omega Yeast’s research team is running experiments to see how the presence of yeast in the cone affects haze stability (if at all). Early results are leaning towards “no”.
- **What’s next for haze?**
Next on the horizon, haze reduction. A reliable, haze-neutral strain like Chico can have its haze reduced, making it even easier to make West Coast IPAs super bright. Reducing haze on an already haze-neutral strain can help reduce the need for clarifying agents and may even allow some additional dry hopping without the concern for new haze formation.

hzy1Δ in Practice

Even haze-positive strains can become haze-reduced, giving brewers the opportunity to make their classic juicy IPAs without the haze. We ran one such trial with the team at Cincinnati’s Rhinegeist Brewery.

Rhinegeist ran a split fermentation with Voss Kveik (OYL-061) and its haze-reduced counterpart (OYL-061 *hzy1Δ*) and presented their process and findings at the 2024 Ohio Craft Brewers Association conference.

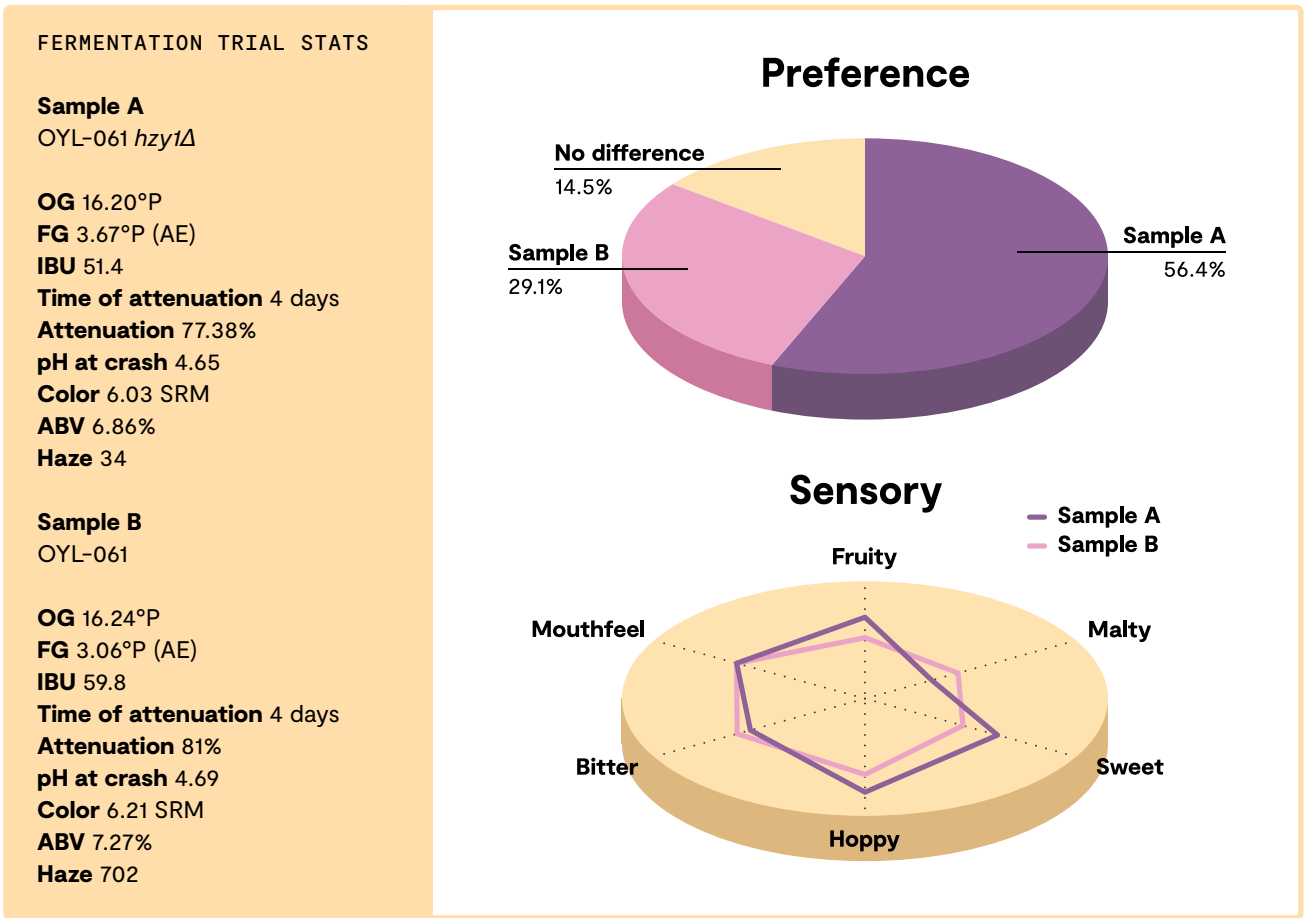
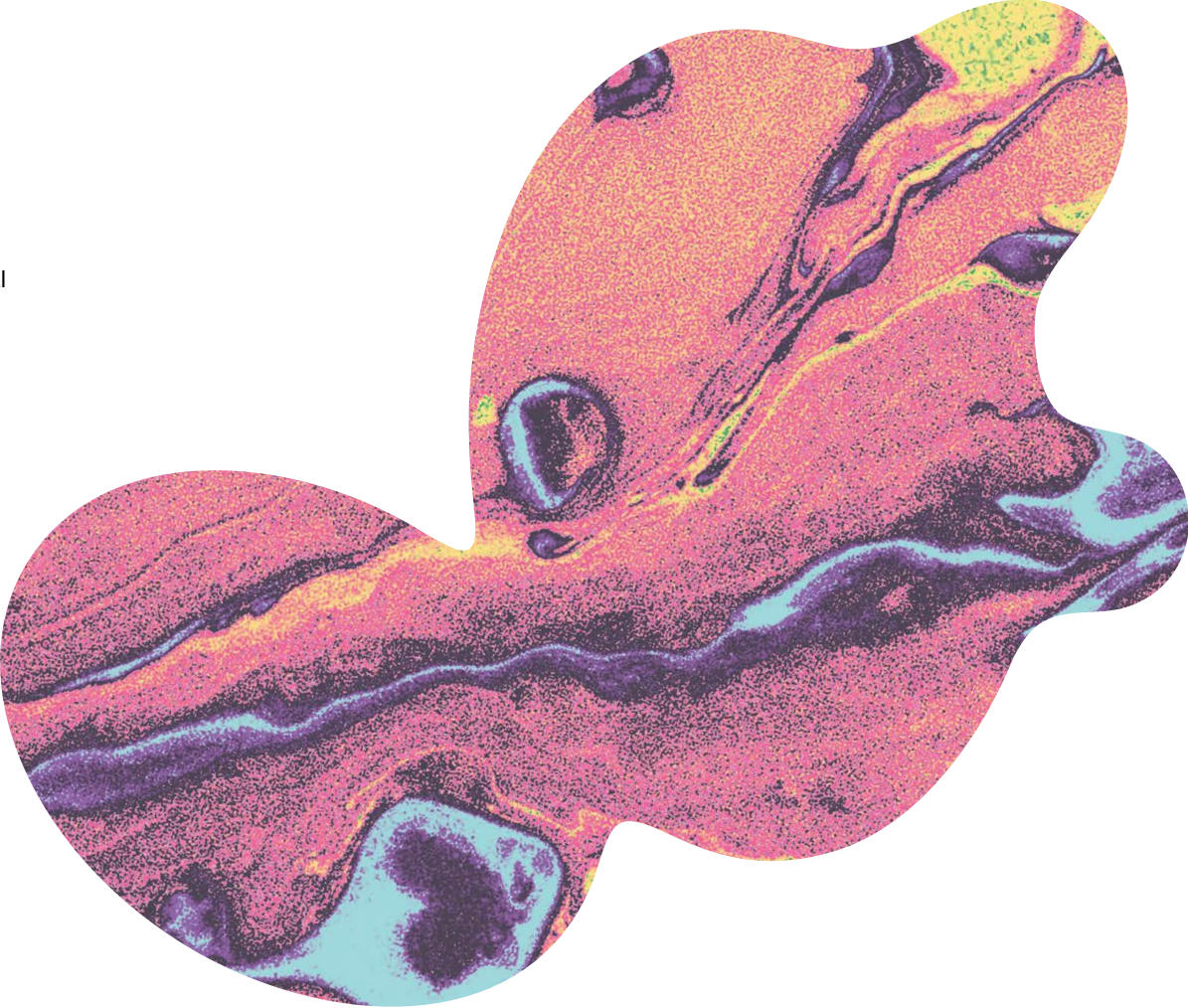
- Their goals were threefold:**
- 1 — Set up a malt base that will contribute minimally to haze.
- 2 — Late dry hop only to promote haze.
- 3 — Ferment with OYL-061 vs. OYL-061 *hzy1Δ*.

In the end, panelists both at Rhinegeist and in the audience for the OCBA presentation rated the beers as having very similar sensory profiles—lightly fruity and moderately hoppy. Across all panelists, preference was a fairly even split.

What we can take away from this is that haze is not necessarily making a large contribution to the beer’s flavor profile, so brewers should see haze as a component of the overall tasting experience when determining how they’d like to present the beer and its flavors to their target audience.

RECIPE DETAILS

- Batch Size 7 bbl
- Malt 100% 2-row Origin Pilsner
- Strain OYL-061 and OYL-061 *hzy1Δ*
- Pitch Rate 1.0 million cells/°P/ml
- Temperature 68°F
- Fermentation end point 14 days
- Whirlpool hops Amarillo (4lb), Citra (2lb), and Centennial (2lb)
- Dry hop 5lb each Amarillo, Citra, Centennial
- Cold crashed at Day 14 for one week and transferred to keg

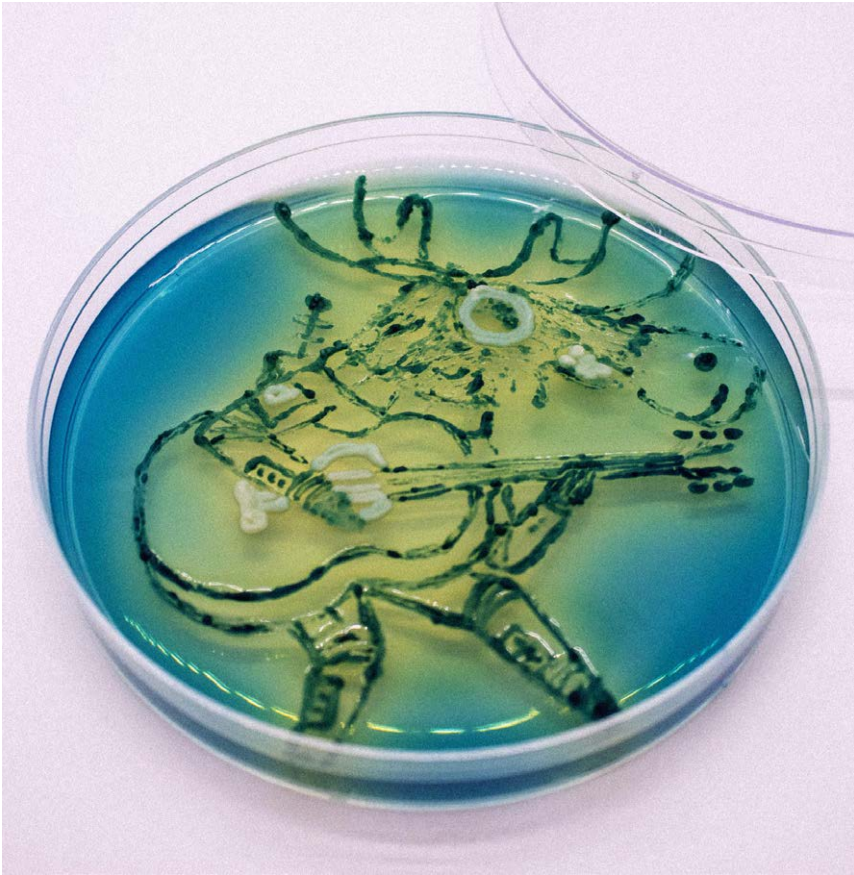




THE FUTURE OF HAZE IS NOW

THE BREAKROOM

Yeast <3 Vossa Nova moose
by Bianca Alley



Orders & Process Coordinator (and resident yeast plate artist) Bianca Alley starts with a blank WLN plate and draws anything from seasonal art to personal portraits. Here we can observe a yeast colony taking up the bromocresol green dye as it develops and grows into the Vossa Nova moose. Vossa Nova is a new Omega Yeast strain which marries Voss Kveik's ester characteristics (and kveik's speed and versatility) with Thiol capability. What a moose-terpiece.

CONNECTIONS

Find groups of four items that share something in common. Each word is part of only one group. Category example: FARM ANIMALS: Cow, Pig, Chicken, Sheep.

NONIC

DOUBLE

MILKSHAKE

STANGE

PILSNER

BRACT

CONE

KNOB

STAGE

COLD

FLOWER

ARM

BLACK

TULIP

BINE

LENS

An educational engine from the curious minds behind Omega Yeast, Top Crop delivers relevant, informative content for brewers and fermentation enthusiasts in a way that's engaging, sometimes entertaining, and always easy to digest. Our insight is inspired by our own creative experimentation and the work Omega Yeast does with thousands of brewers every year.

Our team of contributors is made up of writers, researchers, brewers, photographers, scientists, home cooks, beer drinkers, and more. We thrive on digging into the fine details, poring over research papers, designing assays, conducting experiments, and putting it all together to bring our readers the latest insights into all things fermentation. We encourage you to get in touch with us and let us know what's driving your curiosity.

Contact us
hey@topcrop.co

Editor in Chief
Danielle Sommer

Writers
Shana Solarte
Danielle Sommer
Laura Burns

Contributors
Laura Burns
Chris Bernardo
Adi Hastings
Keith Lacy
Allison Lange
Rita Mormando
Lance Shaner
Rhinegeist Brewery

Design Director
Kyle Eertmoed

Designer
Dexter Stevens

Photographer
Lisa Beck

Yeast Plate Art
Bianca Alley

Special thanks to:
Rhinegeist Brewery

CROSSWORD

- ACROSS

 - Yeast's response to cold crash (abbr)
 - U-boats and temp. teachers
 - Yours is on Hall & Oates' "Best of" list
 - Westvleteren 12 or Pliny the Younger
 - One more than a couple, in Chicago ____ 51
 - Balanced
 - "Wicked" for New England was this for NorCal
 - Preconception that informs an opinion unfairly
 - Compass fungus
 - Unlike expenses, these are usually one-time
 - Type of 14-across
 - Sean's Bar in Athlone is the oldest
 - Nut ____
 - Not if you microdose
 - Org. for taxing beer, cigs and guns
 - Mown cones
 - Of the tiger or the storm
 - Short, spare and back
 - Sources of bitterness
 - Kveik blend from Grodas
 - Annual accumulation?
 - Sparge charge
 - Meas. of acidities developed by a Carlsberg scientist
 - Bonobos, orangutans, gorillas, chimpanzees—and humans
 - They're big on little pitchers, proverbially
 - One of the two main types of beer
 - With mai or Chi
 - Grain, time and money, when used
 - Blame grain
 - Chill (with friends)
 - Buzzer
 - German word for brew; it rhymes with ploy not prow
 - In-crowd at 52-down
 - Beer capital of Switzerland
 - Hop yard unit
 - A fruit fly or a 51-across, for example
 - Shoots, to Gen X; Lies, to Gen Z
 - Requests
- DOWN

 - One of the best kinds of beer
 - Molten rock
 - Concentrations of valuable minerals
 - Penny
 - Some cities offer this as a utility
 - Addresses starting with http
 - It is redundant if you wear suspenders
 - Body of water between ocean and land
 - Doner or shish (US var)
 - It controls pupil size
 - Keister, politely
 - Rude or playful speech
 - Light-colored German lager (var)
 - Infamous venue for customer reviews
 - Red Solos are iconic ones
 - Fruit seeds or stone, in Kent
 - What monks wear
 - What commenters call posters on Reddit (abbr)
 - " ____ what he said"
 - Flower aroma possible in beer
 - Forced diacetyl, wort stability and iodine
 - Key words?
 - Wobbly pop
 - Poor quality, colloquially
 - 12% in ABV
 - What the Julian format encodes
 - What forms where you score your sourdough
 - Stop
 - Friendly thought-to-be-midwestern exclamation
 - Royal-sounding word for a Minecraft server
 - "If you don't like the weather, just ____ five minutes"
 - Emo emotion
 - Batches of beer produced in a day
 - Use img. editing software to alter a pic
 - The "P" in NEIPA
 - What justify the means, for some
 - Unwelcomed dog companion?
 - Not just for 60-across, apparently; membership to this org. starts as young as 18!
 - Respected professional scientific org. dedicated to brewing research
 - Semicircles
 - Type of bird
 - After Mon.
 - Motivational phrase for sales team of film (abbr)



Scan code for answers

