

A CLOSER LOOK AT YEAST STRAINS

FOR DISTILLED SPIRITS PRODUCTION

WRITTEN BY PATRICK HEIST, PH.D

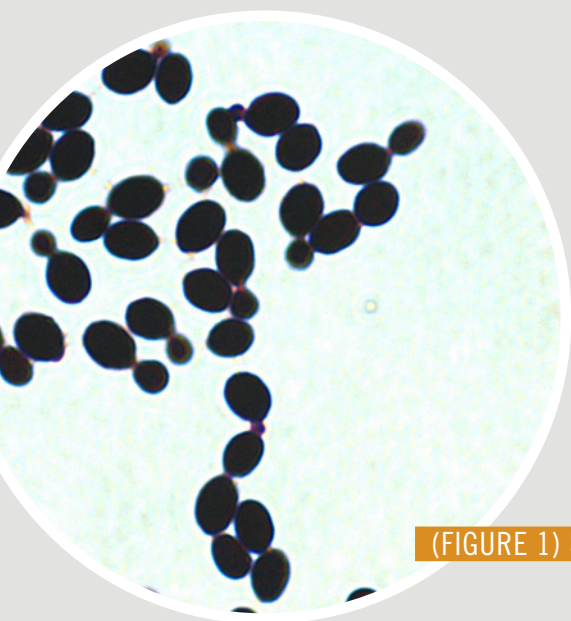
PHOTOGRAPHS PROVIDED BY FERM SOLUTIONS, INC.

Often when touring a distillery, the yeast are mentioned very briefly as simply an ingredient used in the fermentation process. In actuality, the yeast are highly sophisticated microorganisms responsible for creating complex flavors that carry over from fermentation into the distillate. Thus, in contrast to a mere ingredient added to fermentation, the yeast are a living entity requiring specific growth conditions and must be handled with care, and employed in very specific ways to maximize positive flavor contributions. Here we look more closely at yeast and dissect some of the differences between various yeast strains used for distilling, how they contribute to the flavor of the distilled spirit, associated environmental factors, and expectations from a production standpoint. We will focus mainly on spirits produced from grain-based fermentations, but many of these same principles apply to other distilled spirits.

YEAST STRAINS USED IN DISTILLED SPIRITS PRODUCTION

The scientific name for distillers yeast is *Saccharomyces cerevisiae* (Figure 1). This same species of yeast is used in baking as well as beer and wine making, but different strains are selected for each use. For example, in baking, yeast strains are chosen based on the flavor profiles that they create and for CO₂ production responsible for making dough rise. In beer making, whether or not the yeast settle out of solution or remain suspended (a.k.a. “flocculation”) is an important criterion when choosing the right yeast. In distilled spirit production, yeast are also chosen for the aroma that they produce in fermentation, but there are also certain production requirements that must be met relating to sugar consumption and ethanol production.

Looking at yeast macro- and microscopically, one can see differences. What they look like growing on an agar plate (colony morphology) can be different



(FIGURE 1) *SACCHAROMYCES CEREVISIAE*

than what they look like under the microscope (cell morphology). There are also differences in susceptibility to certain inhibitors like cycloheximide, which is often used to select for growth of bacteria in a substrate with high yeast populations. Most *S. cerevisiae* are sensitive to cycloheximide, but some strains are resistant. These differences can be used to group yeast strains together or to differentiate one strain from another. It is unclear how these differences contribute to flavor profile when comparing yeast strains.

Other differences include production of various flavor compounds collectively known as “congeners.” These are produced during fermentation and are discussed in more detail below. Another difference between yeast strains is their origin, or where they were first isolated. Yeast can be routinely cultured from fermenting fruits and grain and other environmental surfaces and are considered ubiquitous in nature.

FLAVOR PROFILE

Yeast contribute significantly to the flavor profile of distilled spirits. In addition to ethyl alcohol, they produce other chemicals (aka congeners) that contribute to the flavor of the spirit. Examples of congeners include alcohols, acids, esters, and aldehydes, many of which are produced by the yeast during fermentation. The level of congeners is influenced by the yeast strain, but there are also other factors that come into play that are independent of the yeast. For example, cooking temperatures of grains resulting in different sugar or protein profiles can lend to the flavor profile. This is one reason why corn is cooked at a higher temperature than small grains like wheat, rye and barley. Other environmental factors like temperature of the fermentation and presence of toxic byproducts like acetic acid can also influence the level of congeners produced by a given yeast strain, which can change the flavor of the distillate.

How the yeast is added to fermentation is another variable. Some distilleries start from single yeast colonies on an agar plate and then subculture into broth or grain mash. After several passages from smaller to larger vessels an appropriate amount of inoculum is generated, sufficient to seed the fermentor. This process of growing yeast to create suitable inoculum for fermentation is called “yeast propagation.” There are many facets of yeast propagation that can influence the final spirit and there are a variety of methods used in different distilleries. Oxygen and sugar availability are two very important factors that influence the yeast and are considered both in yeast propagation

and in fermentation.

OXYGEN influences how quickly the yeast will divide and is linked to aldehyde production. Oxygen is also important to the yeast for production of unsaturated fatty acids and sterols that are important for cell wall integrity, yeast viability and how well they can survive, which is especially important towards the end of fermentation when ethanol is high and residual sugars are very low.

SUGAR availability is also important and should be regulated during yeast propagation. Since one of the primary goals of propagation is to maximize cell populations, lower sugar (maltose and/or glucose) concentrations should be targeted to promote aerobic respiration. For further reading look into the “Crabtree Effect.” These are just some kibble of information on this topic as we could very quickly get lost in details beyond the scope of this article.

Yeast is also available in different forms, including active dried yeast (our favorite!) as well as wet-cake and liquid formulations. The latter two require refrigeration and are more prone to spoilage. In contrast to inoculation using a yeast propagation, these different yeast formulations can be added directly to the fermenter, a process called “dry batching.” It is the simplest way to inoculate the fermentor and avoids the extra steps required for propagation. However, using propagated yeast versus dry batching results in different fermentation kinetics, which could influence the final flavor. For example, a fermentation inoculated with propagated yeast starts faster as it has already acclimated to the fermentation mash and is actively growing. In contrast, when dry batching, the yeast undergo a lag in growth for the first few hours as the cells are rehydrating and repairing after being in a packaged form (active dried, wet cake, or liquid). It is unclear what effects this may have on flavor, but there are several distilleries that use either method and produce fine spirits. As long as the process results in an excellent spirit and the yeast is capable of depleting sugars, either method is acceptable from a production standpoint.

Multiple yeast strains are sometimes used to create more complex and unique flavors and is an interesting area for further research and highlights how different yeast strains can be used.

Some non-yeast factors that contribute to flavor of the finished spirit include grain quality, mash bill, cooking methods (temperatures, pH's, etc.), sour or sweet mash process, method of distillation (pot or column still), final proof of the spirit coming off the still, the water used to gauge the spirit for barreling or

bottling, and any contributions from wooden barrels or other storage vessels, to name a few.

STRAIN-RELATED PRODUCTION FACTORS

While flavor contribution often gets the most attention when discussing yeast strains, the right yeast strain for your distillery must also meet certain production criteria. Many distilleries are well-known for the flavor of the spirits they produce, but there is also a production side that is tied into profitability of the business, and yield (gallons of ethanol produced per bushel of grain) is often the measuring stick used to determine success.

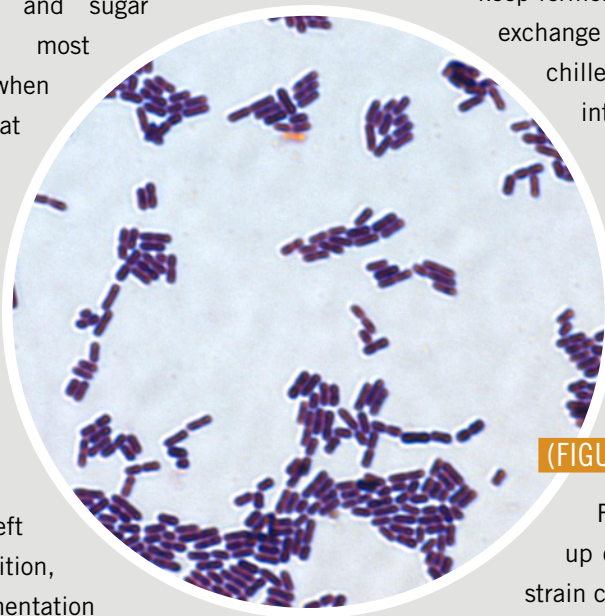
Ethanol production and sugar utilization are the most important factors when calculating yield at a distillery. For optimized production you want to see maximum ethanol production and almost complete depletion of sugars. Any sugars left over at the end of fermentation is viewed as money left on the table. In addition, leftover sugar in fermentation can cause ancillary issues such as burning onto distillation and evaporation equipment.

Not all yeast strains are capable of fermenting to completion, thus the right yeast strain must not only produce the desired

flavor profile, but it must also be capable of finishing sugars in fermentation. While deficiencies in ethanol production and leftover sugar at the end of fermentation can be directly translated into calculable losses, there are other ancillary factors associated with the yeast that can further affect profitability, namely temperature, briefly mentioned above.

Since yeast is a living organism, there is a specific temperature range required for optimized performance in fermentation, normally between 80-95° F. Higher or lower temperatures can result in lower ethanol and/or higher residual sugar, which can be directly tied to monetary losses. During fermentation, the yeast produces heat, which raises the temperature often to the point of affecting performance. Cooling capacity is required to keep fermenters from getting too hot, which is provided by heat exchange systems using incoming water or through use of a chiller, both of which cost money to operate and factor into the operating cost of the distillery.

There are differences in the amount of heat a yeast strain will tolerate before fermentation is adversely affected. Thus, the best yeast strain is one that will produce the desired flavor profile, reaches the target ethanol production, depletes sugar, but also can withstand higher temperatures. If you are forced to keep your fermenters below 85°



(FIGURE 2) LACTIC ACID BACTERIA (LACTOBACILLUS)

F because of the yeast strain you are using it will end up costing a lot more in the long run than if the yeast strain could have operated successfully at 95F, for example. This is even more important if your distillery is located in an area with warmer average temperatures. While extreme temperatures can adversely affect fermentation from a yield standpoint, it can also boost production of certain congeners that may negatively



Hammered Kopper Works

We Build Em, You Distill Em

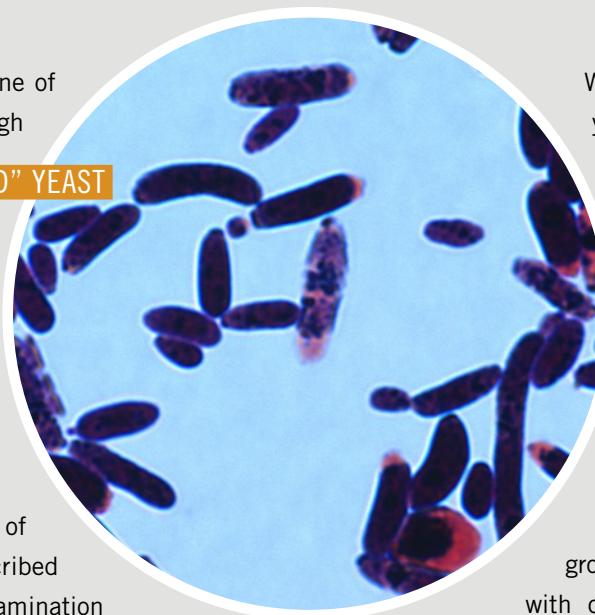
We specialize in custom still orders and design, copper pot stills, and column stills. As well as advanced home brew systems, keg kmokers, and other R&D fabrications.

Starting a distillery is **EXPENSIVE!** But a good still doesn't have to be, let us show you how!

hkworksllc@gmail.com www.hammeredkopperworks.com

affect the flavor of the finished spirit. Diacetyl is one of the undesirable compounds produced by yeast at high temperatures and imparts a buttery flavor to the finished spirit. Thus, temperature is important for multiple reasons with respect to flavor and yield and temperature tolerance is an important criterion when selecting a yeast strain.

(FIGURE 3) "WILD" YEAST



While bacterial and wild yeast contamination is primarily a sanitation issue, yeast strains with poor vigor or ones that are slow growing are less able to compete with bacteria and wild yeast in a fermentation environment. Inability to grow quickly and compete with contaminating microbes can be problematic. Poor yeast vigor

MICROBIAL CONTAMINATION

It is important to mention microbial contamination of fermentation as it ties into several of the areas described above including yield and flavor. Bacterial contamination can greatly affect yeast performance in fermentation and often results in a more acidic beer with elevated organic acids, namely lactic and acetic. Some believe the organic acids produced by bacteria contribute positively to the flavor profile of the finished spirit and as mentioned before, organic acids are one of the several congeners that influence the flavor profile. However, growth of bacteria and production of their byproducts are difficult to manage consistently from batch to batch. Bacteria that contaminate fermentation in distilleries are most often lactic acid bacteria (*Lactobacillus* and related species; Figure 2), but there are several others that are found, each producing its own cocktail of different metabolic byproducts that can take the flavor in multiple different directions, some bordering on putrid.

In addition to bacterial contamination there are wild yeasts (meaning other yeasts besides the one you intended to be there; Figure 3) that can contaminate fermentation and can cause issues including off flavors from metabolic by-products. Wild yeast are less likely to be an issue compared to bacteria, but it does happen so you should be aware of the possibility.

is compounded by additional factors like temperature, nutrient deficiencies, etc. Different yeast strains possess differing levels of vigor or the ability to complete the mission of ethanol production and complete sugar utilization in fermentation.

CLOSING REMARKS

While we have just barely scraped the surface of the complexity of distillers yeast, hopefully we have hit on certain areas that will be helpful for differentiating yeast strains and the criteria to consider when selecting a strain for a particular application. Continued research into new yeast strains, their biochemistries and how different environmental factors can influence quality of distilled spirits is needed to unlock the full potential of these interesting and widely used microbes. 🍷

Patrick Heist, Ph.D. is chief scientific officer of Ferm Solutions, Inc. and co-founder of Wilderness Trail Distillery. For more information visit www.ferm-solutions.net or call (859) 402-8707.



imdesign.me
989.402.1199

PREMIER
PROMOTIONAL
PRODUCTS,
APPAREL &
DESIGN

