Fermentation of wine: Natural fermentation versus commercial yeast

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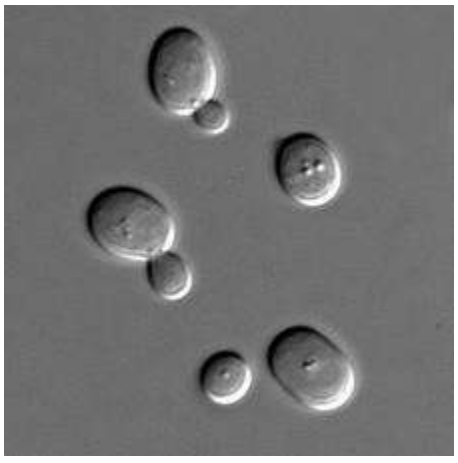
We have written this short essay to try to explain why we like natural fermentation as opposed to making wine with commercial, 'created' yeasts. We are not saying that there is anything necessarily bad about the use of commercial yeasts – in fact there are many advantages. We just prefer to drink wines that have been made with natural yeasts and we will try to explain why.

A widely-accepted requirement for a wine to be classed as a natural wine is for fermentation to be carried out using only the yeasts that are on the grapes and in the winery. These yeasts are termed natural yeasts or indigenous yeasts or wild yeasts or native yeasts depending on where you come from.

There is nothing revolutionary about this idea – it is the way wine has always been made! The tiny yeasts that are brought into the winery hitching a ride on the grape skins or found in the air and walls of the winery start chomping on the sugars (glucose, fructose and sucrose) in the juice and converting these sugars into alcohol and carbon dioxide and emitting heat.

There are many different types of natural yeasts that help to ferment wine. In fact studies have shown that up to thirty different yeasts can be present at various stages of the fermentation process.

Yeasts are tiny ovoid, unicellular organisms (which are actually tiny fungi) that are somewhat similar to bacteria in appearance. They reproduce by 'budding' which looks like a growth on the side of the cell and which eventually detaches to become a new cell (see photo below).



Saccharomyces yeast strain with budding - Source: Wikipedia

As we stated above there are many different types of yeast that help ferment grapes. At the beginning of fermentation it could be *Kloeckera apiculata*, *Candida*

pulcherrima, Candida stellata and *Candida colliculosa*[1]. These yeasts can add complexity and richness to wine if handled carefully. For example, *Kloeckera apiculata* can produce the precursors for ethyl acetate which, if present at low levels can give an added richness and sweetness to wine. At high levels it causes wine to smell like nail varnish. But they also provide some of the precursors for aromas and flavours that add to the complexity of the wine.

The source of these yeasts is predominantly the skins of the grapes picked that day from the vineyard provided they are healthy[2].

There has been much research carried out about the improved sensory perception of wines produced via fermentation with native yeasts such as the predictions of Heard (1999)[3] relating to the use of indigenous yeast species to improve the sensory quality of wine even though we disagree with his overall approach of using some commercial yeasts in the mix.

The yeasts mentioned above thrive in low alcohol environments and temperatures above 10°C but find it difficult to survive once the level of alcohol rises or the liquid reaches a temperature of 20°C[4].

This is where the main grape fermenting yeast with its tolerance of ethanol takes over and does the heavy lifting. Its name is *Saccharomyces cerevisiae* and it the yeast most commonly found in fermenting wine, especially towards the end of the process when the alcohol level is higher and the temperature is in the twenties (Centigrade).

The main source of *Saccharomyces* is not the grape skins (although tiny quantities have been found on grape skins in the vineyard[5]) but instead they lurk in the winery walls, on the winemaking equipment and in the air.

Yeasts are also responsible for the aromas and flavours that are present in wine and we shall discuss some ideas about that later in this article.

But, of course, the main job that the yeasts perform is the conversion of sugars to alcohol.

This gives rise to the question of what it is about yeast that it is able to catalyse this reaction. Well the answer lies in an enzyme called Zymase that is present in these tiny yeasts. Grapes contain sugars. The vast majority of these sugars are glucose and fructose although others such as sucrose can also be present. Zymase breaks down the glucose (and fructose) molecules to produce ethanol and carbon dioxide.

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[1] N.P. Jolly, O.P.H. Augustyn and I.S. Pretorius The Effect of Non-Saccharomyces Yeasts on Fermentation and Wine Quality. Institute for Wine Biotechnology and Department of Viticulture & Oenology. 2nd International SASEV Congress, 8-10 November 2000.

[2] ibid

[3] Heard, G., 1999. Novel yeasts in winemaking – looking to the future. Food Aus.51, 347-352.

[4] H. Erten Relations between elevated temperatures and fermentation behaviour of Kloeckera apiculata and Saccharomyces cerevisiae associated with winemaking in mixed cultures. World Journal of Microbiology & Biotechnology 18: 373–378, 2002

[5] Martini et al., Direct enumeration and isolation of wine yeasts from grape surfaces. Am. J. Enol. Vitic. 47, 435-440.

The chemical equation for this reaction is very simple. The chemical formula for glucose is $C_6H_{12}O_6$. Fructose also has six carbon atoms. When the yeasts release their enzymes the following multi-phase transformation takes place:

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2 + \textit{heat}$$

Now notice that the glucose has been broken down into two molecules of ethanol (C_2H_5OH) and two of carbon dioxide (CO_2). Ethanol is alcohol – the stuff that makes us mellow, exhilarated, excited or maybe depressed if we ingest too much of it.

By the way, we chose the example of glucose because most yeasts prefer to break this down in preference to fructose. This means that any residual sugar left in a wine is likely to contain a bit of fructose.

Yeasts are living things therefore they need nourishment to survive and to carry out their important work. Conversely some things also harm them. Paradoxically the substance that is most deadly for yeasts is the substance they produce – namely ethanol! Some yeasts cannot withstand 14% of alcohol and some can hang out until the level reaches 18% but very few survive beyond this.

Of course, if the yeast converts all the sugar to alcohol there will be nothing to sustain them and they will also die. They are also often killed by the addition of potassium sorbate or potassium benzoate to ‘stabilise’ a wine. We wouldn’t consider a wine that used these substances to be a natural wine.

The nourishment yeast needs to carry out the fermentation includes lots of nitrogen and fermenting wine can become poor in this element. Many winemakers add nitrogen rich substances to the fermenting wine to ensure that the yeast has sufficient nourishment to carry out the conversion of the sugars. Basically, they fertilise it! This is another process that would be spurned in natural winemaking.

In the New World and many wineries in Europe winemakers began using commercially prepared yeasts in the 1960s rather than rely on the yeasts from the vineyard. This was partly out of necessity due to an increase in the number of sprays being used. In this short space of time many winemakers have come to regard the use of commercially-prepared, ‘created’ yeasts as the only way that wine can be made.

There is a good analogy with bread making. At about the same time that these commercial preparations were infiltrating the winery they were also starting to dominate bread making. Bags of created yeast (along with an array of other additives such as bread ‘improvers’) became de rigeur for bakers throughout the world. And, of course, the quality of bread slowly nose-dived and it has only been since the resurgence of artisanal sourdough bread that there has been a move back to the use of natural yeast to ferment the dough.

Of course, in both wine making and bread making the created yeast is more reliable, more predictable and ‘safer’ even though the yeasts in both cases affect the taste and aromas in the final product.

But before we discuss this topic further we need to address some of the views of the technologists who dominate the New World wine industry thinking. Centres such as the University of California at Davis and the Australian Wine Research Centre are almost messianic in their promotion of commercial yeasts. They claim that there is a high risk of spoilage and that the onset of fermentation is unpredictable with natural yeasts.

Much of their concern arises because they are mainly dealing with vineyards where the grapes have been grown in less than optimal conditions.

Because parts of the industry also promotes the use of insecticides and fungicides and pesticides and irrigation and the use of artificial fertilisers, many grapes are grown in 'microbially-dead' soils that harbour disease and are often unhealthy and prone to rot and mould.

The use of artificial fertilisers and lots of water also increase yield and decrease the concentration of flavour within the fruit.

There is also another reason why created yeasts have become so common. In many cases in the New World there is a separation between the people who tend the vineyard and the people who make the wine – an unthinkable proposition to our natural wine makers. The owners of commercial wine making facilities get grapes from many vineyards coming through their doors. They must make the wine quickly and efficiently because there is a lot of pressure as different vineyards complete their picking. The last thing they want to do is wait for natural fermentation to occur. They need the certainty that created yeasts provide.

There is another factor about created yeast that is not discussed as much as predictability and that is the effect of these yeasts on aroma and flavour.

It is probably easier to discuss what we see as unnatural about created yeasts by understanding the import of one of many papers on the topic of adjusting aromas in wine through the use of different types of created yeasts.

In a paper published by staff at The Australian Wine Research Institute, the purpose of the research is clearly to produce yeasts that will modify the aroma of a wine. We quote directly from the paper[6]:

"This paper briefly reviews the metabolic processes involved in the production of important volatile sulfur compounds and the latest strategies in the pursuit of developing wine yeast strains as tools to adjust wine aroma to market specifications."

The clear implication is that whatever the market is asking for, a yeast can be created to deliver the aroma the market wants!

As we discussed in a previous newsletter, the Gamay grape is often described as having banana and bubble gum flavours and aromas. However we have drunk many wines from Beaujolais that have none of those characteristics. The wines we tried had all been fermented naturally.

[6] Swiegers JH, Pretorius IS. Modulation of volatile sulfur compounds by wine yeast. Appl Microbiol Biotechnol. 2007 Apr;74(5):954-60. Epub 2007 Jan 30

The banana aromas actually come from a yeast called 71B produced from tomato plants by the Dutch company Lalvin who actually promote the fact that using the yeast will produce tropical fruit flavours. They even talk about BA11, another created yeast, which in neutral white wines will create fresh fruit aromas of orange blossom, pineapple and apricot.

University of Auckland research[7] into the tropical fruit aromas and flavours of New Zealand Sauvignon Blanc shows that:

"Volatile thiols are a critical component of the distinctive aroma of New Zealand's most important grape variety, Sauvignon Blanc. The thiols are synthesized by yeast from aroma-less precursors found in the grape. Recent data suggests that esters form another important aroma chemical in New Zealand Sauvignon Blanc wines. These chemicals are formed in yeast strains during fermentation. New Zealand wines are typically fermented at low temperatures, which is reported to result in increased fruit character in the wines. "

Once again, the research shows that commercial yeasts are being used to promote those fruit flavours and aromas even though there is a wide variety of native yeasts in New Zealand that could be used for the same purpose including Pichia kluyveri, according to Anfang et al.

This effect of commercial yeasts and their effect on flavour is supported by research carried out by Denis Dubourdieu of the Institute of Oenology in Bordeaux[8]. In a paper entitled Bordeaux White Wine Aromas he reported a very similar finding also through the use of commercial yeasts on Sauvignon Blanc. His contention is that none of the asparagus and tropical fruit aromas present in the wine are present in the aroma of the grape – it is the fermentation that converts chemical pre-cursors present in the grape juice into thiols. He says:

"We knew that the yeast creates aromas, but not that it could reveal potential varietal aromas. At the same time as we were making this discovery, we demonstrated that the use of different yeast strains could have different effects on the creation of thiols, and hence significantly alter varietal wine aroma profile."

So, one of the reasons we don't like the use of created yeasts is that they introduce flavours into the wine that are not part of the local terroir and not from the fruit.

We will follow up this discussion in more detail in future articles. This is only a very small part of our views on the use of natural yeasts which we believe are essential to the production of wines that are capable of delivering the complexity and deliciousness that we crave.

[7] M.R. Goddard, N. Anfang, M. Brajkovich, "Co-fermentation with Pichia kluyveri increases varietal thiol concentrations in Sauvignon blanc", The Australian Journal of Grape and Wine Research 14 (2009): 1-8

[8] Denis Dubourdieu Bordeaux White Wine Aromas. Institute of Oenology, Bordeaux.2000.