Improving wine quality with the use of biological tools

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How can we define wine quality? One useful definition of the term 'quality' is 'fitness for purpose', and so it follows that quality will therefore be defined differently for each category of wine. That is, quality for a super-premium wine targeted at high-end consumers with a well developed interest in wine will be defined differently to quality for an inexpensive branded 'commodity' wine. While there's no absolute measure of wine quality, there are several contributing factors, each of which will be assigned different levels of importance depending on the target market for the wine in question. In this short article, we'll be looking at how the intelligent use of biological tools such as selected yeasts and bacteria, fermentation aids and yeast-derived maceration products can assist in achieving wine quality goals.

In these discussions, it is necessary to distinguish the two rather discrete segments of the market, because to consider wine as a homogeneous whole risks confusion. Customers in different segments of the market approach wine purchasing decisions from rather different perspectives. The 'fine wine' segment, consisting of prestigious wines from leading estates in the classic European regions, is a small but important segment of the wine market, and the prestige and glamour attached to it is reflected onto other market sectors. But to try to extrapolate principles and business models applicable to the fine wine segment to the volume end of the market is a misguided strategy.
In recent years the consumers' expectations with regards to wine have changed considerably. In the past, cheap wines were not expected to taste particularly nice; they had merely to be palatable. Now consumers have elevated expectations about their wines, and even the most inexpensive wines are expected to taste 'nice'. In part, this is because the growth in new world wines, which offer clean, ripe, fruity, accessible

flavours has raised the bar for all commercial wines. In this increasingly competitive arena, winemakers have to work hard to make sure their wines deliver in terms of flavour at every price level: there is no longer any significant market for characterless, industrial ‘plonk’ selling at little more than the cost of production. Thus because of the demands of the market, winemakers must find ways of delivering commercially relevant wines that offer the right sorts of flavours. It is our belief that intelligent use of biological winemaking tools is one of the most effective ways of achieving this goal, and has the potential to result in improved wines that are still ‘natural’, and are not confected, over-manipulated, or taste like all the other wines.

Selected natural yeasts

There’s a widespread assumption among some wine writers and consumers that the use of selected yeasts represents an industrial approach to winemaking; that it’s not really compatible with fine wine. And with the increased focus on natural wines that has come from the growing environmental awareness, there’s a subtle commercial pressure on high-end winemakers to move away from the practice adding yeast and embrace ‘wild’ ferments.

But what is actually the difference between 'wild' or ‘feral’ yeast and selected yeast? If we examine the way that natural selected yeast strains are isolated, characterized by scientists and then brought to market by yeast producers, it is possible to argue that the use of carefully selected yeast can be considered as an important part of the natural winemaking process. Using selected natural yeasts, which were once ‘wild yeasts’, allows winemakers to achieve healthy, well managed primary fermentation which, in turn, can result in wines that better express the terroirs they come from than those where no yeast cultures are added. The world of yeast is not static either. The research and development has helped understood the functionality of those bugs and has allowed for even more precise, almost custom-made products, respectful of the terroir—the future of selected yeast looks bright indeed!

Historical perspective

Before the mid-19th century, fermentation must have been a mysterious process. Until the work of the famous French scientist Louis Pasteur, the mechanism underlying the magical transformation of grape must into wine was totally unknown. But even after the yeast *Saccharomyces cerevisiae* was identified as the organism responsible for this transformation, winemakers relied on the yeast populations present in the winery and vineyard to carry out their fermentations, with sometimes less than successful results. It wasn't until the 1970s that active dried yeast became available that winemakers were offered the option of choosing which yeasts carried out their fermentations.

Since the 1970s, dried yeasts have been widely used by winemakers, and while it's difficult to come up with accurate figures, it is likely that today the majority of wines are produced using selected yeasts. Most yeast producers offer a range of perhaps 10–15 different commercial yeast strains, and one company offers around 130, with many more in its collection. In all, we suspect that there are more than 300 different strains of *S. cerevisiae* on the market, which can be chosen by winemakers depending on the wine style to be produced. In addition, some yeast producers work with and fund research at universities and institutes in different wine regions throughout the world. This has contributed greatly to our knowledge of the role of microbes in winemaking. This knowledge base has paid significant dividends in terms of new product development.

A natural product

The use of selected yeasts is sometimes misconceived to be an artificial approach to winemaking that is at odds with a natural, terroir-driven philosophy. Indeed, the popular conception is that selected yeasts are a tool for globalizing wine styles—an assumption that we believe to be incorrect. Nature offers a bewildering diversity of microbes, and selected yeast and bacteria that can be chosen by the winemaker to provide more control over the wine's final quality and style, and to bring out the best of the most important material, the grapes. Indeed, there's a sound argument that suggests that using selected yeasts gives the winemaker the necessary tools to maximize the 'terroir' characteristics and regional personality of the wine. In this sense, the choice to use

selected yeasts can result in wines that display more typicity and sense of place than those made without.

It must be recognized that the use of wild yeast ferments is a high risk approach that lacks control, often resulting in excessive levels of certain fault compounds. And, if anything makes wines taste more similar and uniform, it is when wines share the same faults. While at balanced levels these compounds can enhance quality, it must be noted that they can also mask primary and/or secondary flavour compounds. This is not such a problem if the winemaker is more interested in minerality and complexity in defining quality, but it is a serious one if fruit intensity and purity is the goal. Spontaneous fermentations can be a dangerous strategy for the winemaker wanting to safeguard the quality and consistency of their product. The winemaker also has only one chance each year to get it right.

Selected yeasts are isolated from nature, initially taken from fermenting musts. With the exception of ML01, which is now authorized for use in the USA and Moldavia, selected yeasts used in winemaking are not genetically modified.

Despite their importance, though, yeasts don't get the attention they deserve from winemakers and wine writers alike. If yeasts were as big as potatoes, we'd probably read as much about them as we do about grapes. It's a scale thing: we are visually driven, and we find it much harder to understand things that can't easily be seen, such as microbes.

Selecting yeast

All the wine producing countries, the new and traditional ones, search for, and collect their microflora and want to take advantage of all their potential. So, how is it that selected yeasts are brought to market? With serious yeast producers and their associated, the yeast selection process begins with isolating a promising yeast from a wine must, and then testing the genetic stability of the isolate. This testing ascertains whether the isolate really is a new yeast, as well as checking whether the clone is

genetically stable. If the result is positive, and the basic fermentation properties are respected (such as ability to complete fermentation, limited production of off-aromas, etc.) then the first production trials are initiated. Once this is obtained, trials in wineries can begin, but it is a long process between taking the initial isolate and producing a commercial product—one that typically takes three years to complete.

Evaluating yeast performance

Some private research laboratories have extensive facilities for evaluating yeast performance, a process known as characterization which aids quality conscious winemakers greatly as it provides them with a guide to manage the yeast's nutritional and physical requirements to optimise wine quality. Such systems allow researchers to follow fermentation rate and activity online, which is an interesting tool for validating the oxygen, nitrogen and nutrient requirements of various yeasts, helping define the yeasts' product specification so that winemakers know how to optimize their performance in the winery and doing so enhancing wine quality. After this initial evaluation the yeasts are typically taken to key winery partners around the world for more commercial trials. Not until the yeast has gone through this rigorous selection, and laboratory and winery trial processes, can it end up the market for general winery use.

Yeast nutrition

The knowledge of the nutritional requirements of each yeast taken from the laboratory evaluation process provides critical information for the winemaker. There is still a widespread lack of understanding throughout the trade of the importance of managing the nutritional requirements of various yeast for a healthy fermentation. The importance of a healthy fermentation has been emphasized by recent work on reduction defects and sulfur chemistry prompted by the increased use of tin-lined screwcaps. But in reality reduction defects are more widespread. Recent research carried out by the International Wine Challenge (IWC), a large competition that assesses some 10 000 different commercial wines annually, confirmed that 2.2% of all wines (irrespective of closure type) showed reduction defects as detectable by sensory analysis. When yeasts are

stressed, or lack nitrogen, they can metabolize the sulfur-containing amino acid cysteine, resulting in the production of sulphur-containing volatile compounds sulfides, disulfides and mercaptans. In addition, stuck ferments are a major headache for winemakers. A commonly used nitrogen addition, diammonium phosphate (DAP), can itself contribute to volatile sulfur compound production by the yeast: in a nitrogen-poor must, DAP—which has been described as junk food for yeasts—will encourage rapid population growth, but then when this is exhausted the large population of yeasts will begin metabolizing amino acids such as cysteine, resulting in the production of the very compounds that the DAP had been added to prevent. The recommended approach is to provide yeasts with a more balanced nutrition that results in steady population growth. Thus an integrated approach to fermentation management is needed to get the best out of dedicated wine yeast strains.

It's not just the yeast

Fermenting grape must is a relatively hostile and rapidly changing environment for yeasts. Initial conditions consist of very high sugar levels typically above 200 grams per litre. As fermentation begins the sugar levels decline as alcohol levels rise up to 12–15%. A lot is being expected of a yeast, which has to flourish in this difficult environment and then keep going. Researchers have pioneered a revolutionary process that gives the yeast a competitive advantage, called YSEO®. The principle behind this is that two lots of the same genetically identical yeast strain will perform differently if the conditions they are prepared under are different. The process involves a specific micronutrition of the selected yeast that enables it to be better adapted to the harsh conditions it will experience in the must, and this work has led to a fundamental revision of the way that the process of producing selected yeasts is carried out. Winemaking trials carried out by Charlie Edwards who helped to validate the technology at Washington State University, show that the yeast strains that are produced with the YSEO® process has a shorter lag phase, better fermentation kinetics and overall produce fewer off aromas due to fermentation problems.

Dead yeasts have a bright future

A current emphasis is on developing a range of dead yeast-based products, for both yeast nutrition and also replacing traditional fining products for a more specific and natural solution. Yeast cell walls can act like sponges, taking out both negative and positive molecules from the wine. Various research teams have been working on making this adsorption process more specific, fine tuning the adsorptive capacity of the yeast. Inactivated yeast products are available which when added before bottling can give more weight and definition of flavour to red wines, while lessening the perception of astringency and bitterness. Other products aim to reduce the sensory impact of sulfur compounds. Yeast cell wall products also show potential for removing taints such as geosmin, volatile phenols and ochratoxin A.

New product development

The potential of non-*Saccharomyces cerevisiae* yeasts, also known as 'wild' or 'indigenous' yeasts, has always been an interesting subject of research. Typically, in a non-inoculated fermentation a range of non-*Saccharomyces* species will be implanted at the beginning of fermentation but will be rapidly dominated by *S. cerevisiae* because of its better resistance to alcohol. However, some of these wild ferments are described as having aromatic and textural complexity. It is expected to be an interesting niche product.

A similar initiative has been to offer cultures of complementary, synergistic mixed yeast strains, such as BM4×4. Two compatible yeasts are blended in this product. First, there is BM45, a yeast isolated from Italy's Brunello di Montalcino terroir, which reveals and protects the aromas of many red varieties as well as influencing tannin perception, which remain supple and round, contrary to other yeasts from this terroir. However, it is a relatively slow grower and doesn't always finish well. As a result it is combined with a more reliable partner. In the future it is likely that we'll see more mixed combinations of yeast strains.

Another goal of product development is to produce yeasts with a lower alcoholic yield. All *S. cerevisiae* strains currently have a similar sugar to alcohol conversion rate, with

one degree of alcohol being produced from 16.8–16.9 grams of sugar in the must. One of the most frequent requests, in particular from New World wine regions, is for wine yeasts that will yield less alcohol for the same must sugar content. Research is well underway, and a molecular pathway has been identified by which sugar metabolism by yeast can result in a lower final alcoholic content. This project shows great promise, but is some way from commercialization. If it reaches the market, such a yeast could have a remarkable positive impact on wines made from warmer regions, and would have an enormous potential market.

The real thing

Investments in research and product development face a serious problem: copying. It is common knowledge that yeasts cannot be protected by patent or copyright. It's a simple process for other producers to pick up products in the market and make copies. Obviously, with less investment, they can offer similar yeast at a much lower price. For the winemaker looking for a bargain, the next consideration would be whether quality and performance is as reliable as that of the original products, because only some facilities also conduct continual research to optimize production techniques to identify critical fermentation management issues and to define yeast nutrient requirements. Perhaps it can be emphasized that buying copies also circumvents royalties paid to universities and institutes who researched the strains and help update the database about the strains they isolated and characterized. This will be like downloading pirated copies of music depriving creative authors from their rewards and reduces and eventually eliminates the inducement to continue research and database updating. If winemakers believe in the need for continuously updating information about the strain's experience and potential, and if they want more research to be done, they should avoid supporting those who circumvent the 'just reward' system by buying copies. It should also be borne in mind that these copies are also not necessarily good and the cost of wine yeast for them is less per bottle than the cheapest possible closure even though the impact on wine value is arguably more.

Conclusion

An increasing range of biological tools is now available for winemakers. These represent perhaps the best option for winemakers looking to improve the flavour of their wines in the face of an increasingly competitive marketplace, without opting for less natural methods that can result in confected, forced, industrial-tasting products.

Producers of biological tools must offer winemakers a growing portfolio of well characterized, reliable yeast and malolactic bacteria strains that can be tailored to specific winemaking goals. In the future it is likely that yeast-based fermentation aids and maceration products will also become more widely adopted by quality-focused wineries as valuable tools for fermentation management.

Winemakers are faced with a large array of biological products. Not all are the same: they should take care to choose microorganisms from manufacturers who support their range with research, characterization and development work.

The use of selected yeasts, which are exactly the same genetically as they were when they were isolated from nature, is no more ‘unnatural’ than using vine cuttings from a nursery to establish a vineyard, although ferments that take place without yeast additions will have a somewhat different stylistic impact, in part because of the time taken for the low inoculum of indigenous yeasts from the winery and vineyard to multiply at the start of fermentation.

Using selected natural yeasts allows winemakers a level of control that can help them to make wines that more fully reflect their sense of place, and is compatible with ‘terroir’-driven approaches. The idea that selected yeasts are only compatible with large volume commercial wines, where safety rather than character is the goal, is a false one.

Notes on the authors
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