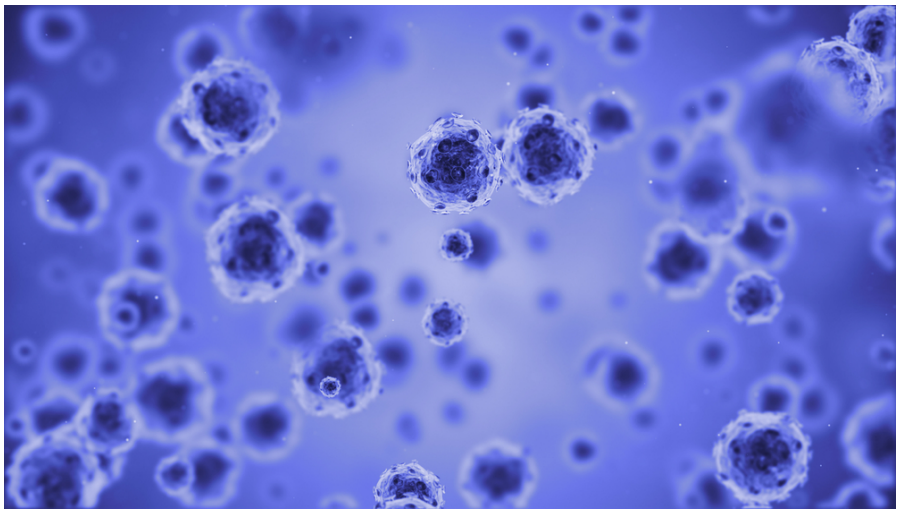
IT'S A SMALL WORLD: MICROBIAL FINGERPRINTS LEAVE THEIR MARK ON WINERY AND VINEYARD SITES

Posted by Deborah Parker Wong | Feb 28, 2017 | Production, Wine | 0 | ★★★★★



Beyond the antioxidant properties of Resveratrol, researchers in Belgium and the Netherlands studying the human microbiome have identified a new health benefit of consuming wine. People who drink wine, tea or coffee, and those who eat dark chocolate, were found to have a healthier and more diverse community of microbes in their gut. In particular, the consumption of red wine encourages the presence of a specific anti-inflammatory bacteria, which scientists believe may ward off digestive tract illnesses. While researchers haven't zeroed in on what defines a healthy microbiome, greater diversity has been associated with improved general health.

Winemaker Greg Allen: "It's well known that biodiversity is the key to a healthy ecosystem."

Discovering patterns in microbiome composition — and their implications in human health — is still a nascent field of research, but there's been considerably more progress made in the mapping and interpretation of microbial communities found in vineyards, wineries, must and wine.

Researchers at the University of California at Davis have published a number of studies that link the microbial communities from different points of origin, including vineyards, wineries, breweries and creameries, to the microbial fingerprints found in products (like wine, beer, saké and cheese) that are produced from them.

In a study of 200 commercial wine fermentations from the vineyards and wineries of Far Niente and Nickel & Nickel wineries across seven American Viticultural Areas (AVAs) in California's Napa and Sonoma counties published in the June 2016 issue of *mBio*, researchers used metabolite profiling of must and wine samples to identify marker metabolites that differentiated the unique microbial fingerprint of each AVA.

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Their research has confirmed three different patterns, or types, of metabolic interaction: The microbiota and metabolites in grapes/wine are regionally distinct; the must and wine microbiota correlate with the wine metabolome and fermentation performance; and the microbial composition of grape must predict the metabolite composition of the finished wine.

Greg Allen, winemaker at Dolce, a sister winery of Far Niente Winery in Napa Valley (who, with UC Davis' Dr. David A. Mills, was among the group of researchers to co-author the study), referenced author Michael Pollen, saying, "It's well known that biodiversity is the key to a healthy ecosystem. Here, for the first time, we can see concrete evidence of that diversity in winemaking."

Microbial Terroir

Findings of the wine grape microbiome study suggest that the microbial composition of grapes accurately predicts the chemical composition of wines made from them. Using these microbial biomarkers for individual vineyards and AVAs, researchers may be able to predict the metabolite composition of finished wine, which, in turn, is a quantifiable feature of terroir.

What researchers have yet to establish is the nature of the relationship between a vineyard's metabolic fingerprints and the metabolite profile and quality of the finished wine. While Mills is pragmatic, he concedes, "Our research to date indicates that connection is likely, but much more research is needed."

According to Mills, identifying which patterns or conditions are drivers for quality remains the subject of future research, as are sensory studies that would determine whether tasters are able to perceive any differences that occur in wine as a result of microbial associations. "With regard to quality, we're moving in the direction of identifying specific patterns and trying to determine what the market is for that data," says Mills.

Using DNA fingerprints from grape juice or must to predict the chemical composition of wine will likely be a source for new quality control methods. "There are so many inputs to micro-variability, but if you understand the patterns you can begin to predict and manipulate them," he says.

When asked about measures taken as a result of the study, Allen says, "It affirmed our belief that Far Niente and Nickel & Nickel have special vineyards that make distinctive wines by providing evidence that goes well beyond the commonly held understanding of location, climate, and choice of plant material."

Not that the company needed any additional evidence to adopt sustainable farming practices, which were well established prior to this study. Allen points to detailed findings that underscore the importance of strengthening that commitment: "We must do whatever we can to protect the microbial diversity present in our widespread and disparate vineyards, because whether contributing to a blend or held separately in a designated single vineyard wine, these vineyards have provided the foundation of our brands."

MicroTrek's Paul Richardson: "Microbial mapping is a feasible quality control measure for small and mid-sized wineries."

Commercial Applications

The ability to use DNA sampling to map microbes within a winery, brewery or creamery as a quality control method already exists. In a study co-authored by Mills and published in June 2013 in *PLOS One*, the teaching winery at the UC Davis Robert Mondavi Institute for Food and Wine Science was surveyed over the course of a single harvest to track microbiota. Results of the study found that, other than harboring large

populations of yeast before harvest, there was a near absence of spoilage-related organisms and the presence of other organisms not linked to fermentation.

Upon seeing the benefits of mapping and tracking microbes as they move through a winery, Mills and co-authors Paul Richardson and Nicholas A. Bokulich founded MicroTrek, Inc. (www.microtrek.net), a company that specializes in mapping the movement of microbes in food and beverage production facilities, especially as they relate to fermentations and spoilage. “Mapping is one way a winery can take stock of its facility and understand how its system operates on a microbial level,” says Richardson.

MicroTrek employees swab winery equipment to obtain samples for micro biome analysis.

Initially, MicroTrek inspects a winery to determine the scope of the project and decide how and when to sample the facility. Depending upon the size of the building, a site survey requires from 50 to 400 samples, with 50 to 100 samples being the minimum required. DNA samples are processed by isolating, amplifying and then using high throughput sequencing to identify the microbes. The resulting data is generated as spreadsheets and biogeographical heat maps for each organism. Using these maps, wineries can identify what Mills calls “hot spots” — or problem areas — in a facility, and the microbes that are causing trouble.

“The data and heat maps provide an incredible level of detail that can be used to determine where the spoilage organisms are hiding,” says Mills. “When you have that information in hand, you can put new hygiene protocols and workflows in place that addresses any problem areas.”

Once a winery has addressed problem areas, routine monitoring using swabs and sensors can be conducted monthly (or even weekly during peak times of activity such as harvest). The findings can help wineries effectively manage their microbial load. “Once you’re clean, the big question is, ‘Will the organisms repopulate?’ Bacteria and fungi form biofilms that can make them difficult to eradicate and you can’t overlook the role vectors play in transmitting spoilage organisms.”

Practical Applications

Allen sees microbial mapping as a tool that could help answer several questions and work as a preventive measure against instability. As an example, he routinely sees sporadic malolactic (ML) fermentation occur in about one in 30 barrels of Chardonnay where ML had intentionally been suppressed. And in the production of his late harvest wine, Dolce, controlled fermentations and the stability of the post-fermentation wines over an 18-month period is essential. “Having a better understanding of which yeasts cause some barrels to reach 16 percent alcohol and others to shut down at 8 percent would help guide some of our winemaking decisions.”

When considering using microbial mapping to proactively manage the microbial load or to address specific problem areas in a winery, Richardson cautions that it’s essential to know what question you’re trying to answer. “With a clear understanding of your goals and how you’ll interpret and apply the data we provide, microbial mapping is a feasible quality control measure for small and mid-sized wineries,” he says. For example, the estimated cost for a site survey with 50 to 100 samples for a mid-sized winery could run between $5,000 and $10,000.

According to Mills, “Wineries are now asking us for greater granularity. If we’re sampling for indigenous yeast populations within a winery, they want to know which species of *Saccharomyces* dominates.”

While Microtrek’s maps can show wineries where hot spots exist and where spoilage microbes are lurking, Mills and Richardson point to a need for better interpretation and broader application of the data their surveys provide. “We give wineries a significant amount of data and work with them to interpret them within the scope of their project,” says Mills, who sees a role for trained chemists and microbiologists in developing remedies that reach beyond a simple fix.

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