BY DEBORAH **PARKER WONG**

Will Magnetized Yeast Revolutionize Riddling?

New technique promises to speed sparkling wine production

There's no mistaking a gyropalette at work, its top-heavy robotic arm twirling a wire palette of bottles like a baton. But you'll need a scanning electron microscope to see the iron nanoparticles that have the potential to make it obsolete.

The early adoption of the robotic gyropalette by Cava producer Cordoniu in the mid-1970s was a milestone that altered the course of the modern sparkling wine industry. Mechanized riddling reduced the amount of time required to move spent yeasts cells into the neck of a bottle from two months to a matter of days, all without any adverse effects on the sensory qualities of the wine.

The wholesale adoption of mechanization by traditional-method sparkling wine producers and many Champenoise dramatically reduced the production costs and time to market imposed by the labor-intensive technique of hand-riddling bottles. As such, bottle-aged sparkling wine became a viable and affordable alternative to still wine.

Almost despite technology, this time-honored method remains very close to its original form. Beyond the gyropalette and the technical advances in still wine production that have contributed to the overall quality of sparkling wine, innovation in the traditional method of production has remained focused on

Robotic gyropalettes are the industry standard for riddling sparkling wines, but researchers are working on an alternative method. Photo: J Vineyards & Winery

further reducing the time required for riddling – specifically, by modifying the forms of yeast inoculum used in secondary fermentation. Researchers began experimenting with modifying wine yeast in the 1980s, and current research has produced several forms of yeast that have reduced the mechanized riddling process from days to hours to minutes.

YEAST NANOTECHNOLOGY

A team of biochemists at the University of Ljubljana in Slovenia, working in conjunction with a nanotechnology researcher at the Jožef Stefan Institute, have introduced a riddling technique that uses magnetic nanoparticles and a magnet to riddle a bottle of sparkling wine in approximately 15 minutes. The process was first introduced in 2011 by Ljubljana professors Dr. Marin Berovic, who is also a biochemical engineer, and nanotechnology researcher Dr. Darko Makovec. Their technique won an award in 2011 at the International Technology Transfer Conference in Ljubljana and has since been published in the March 2014 edition of the Biochemical Engineering Journal.

Nanotechnology researcher Dr. Darko Makovec heads the Department for Materials Synthesis at the Jožef Stefan Institute in Ljubljana, Slovenia.

Berovic's team includes Matjaz Berlot and Slavko Kralj, faculty members of the Department of Chemical, Biochemical and Environmental Engineering at the University of Ljubljana, along with Makovec, who heads the Department for Materials Synthesis at the Jožef Stefan Institute. Together they developed an elegant and inexpensive method of bonding silica-coated nanoparticles of iron oxide to yeast cells (a mass ratio of 1:10), then using a strong permanent magnet to deposit as sediment the spent magnetized yeast cells.

"The method itself is 4,000 times faster than classical hand *remuage*," explained Berovic, who is currently a visiting professor at the University of Santiago in Chile. "Given the investment and energy requirements of gyropalettes, sparkling wine producers in Spain, Chile and Argentina are expressing a great deal of interest in the technology."

Potential uses for magnetized yeast nanotechnology extend well beyond sparkling wine produc-

AT A GLANCE

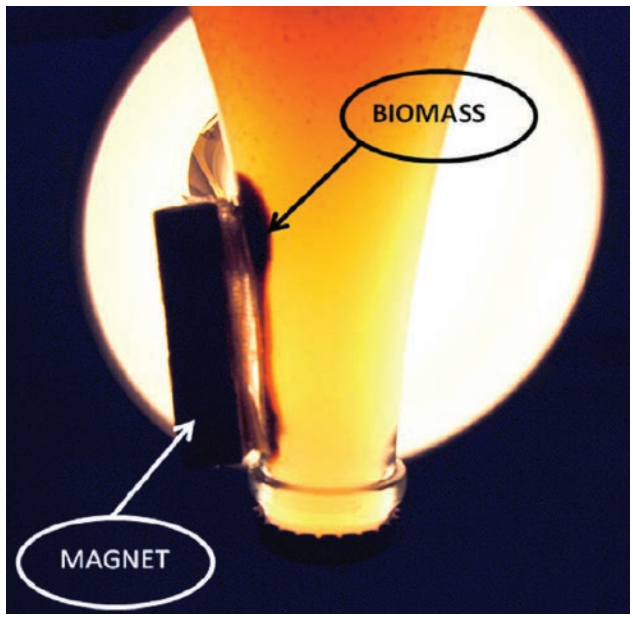
- Different forms of yeast inoculum have reduced riddling time for sparkling wines from days to hours to minutes.
- Magnetic riddling technology would eliminate the need for gyropalettes.
- In a blind trial, magnetized-yeast fermentation increased the intensity of aromatic compounds and mouthfeel.
- It also resulted in higher-than-average levels of iron in finished wines.

tion. Berovic and Makovec are also cooperating in the development of magnetic malolactic bacteria for white wines, have successfully used magnetic yeast separation in beer fermentation, and employed the technology in the separation of desired and undesired enzymes and particle purification in infant fruit juices.

The speed and efficiency of the process, which has been widely studied and applied in biotechnology and water purification, relies on the absorption of super paramagnetic amino-functionalized iron oxide maghemite nanoparticles onto both *Saccaromyces cerevisiase* and *Saccharamyces bayanus* yeast cells.

In a three-part process, magnetic iron oxide nanoparticles are coated with silica, which is grown around them in a thin layer. Molecules providing surface amino groups are grafted onto the positively charged nanoparticles, which are then introduced to the yeast cell culture. The nanoparticles bond to the negatively charged yeast cell membranes and are dispersed as the yeast cells divide and then cluster together after fermentation.

Once spent, the yeast cells are separated from the wine using a strong magnet at the neck of the bottle *(see Figure 1)*.



This image shows magnetized yeast sediment after placing a permanent magnet close to the surface of the bottle neck.

Chemical analysis of the process indicates that while the technology accelerated fermentation by 50 hours compared to the control wine, magnetization didn't have an adverse effect on the metabolism of the wine yeast. The pH level, however, was significantly higher at the start of fermentation for the magnetized yeast, at 3.94, and finished slightly higher than the control wine at 3.62.

The study points out that the level of iron present in the finished wine fell below the 10.00 mg/L range

allowed by the European Union in white wine at 8.30 +/-1.6 mg/L Fe3+. Researchers cannot discern if the measured concentration of iron ions in the finished wine originate from the iron-oxide nanoparticles that remain in the wine after magnetic separation or if the nanoparticles are partially dissolved during the process.

Although iron oxide nanoparticles are considered nontoxic by the U.S. Food and Drug Administration and they have been approved for use in living medical applications, standard winemaking chemistry identifies unstable levels of iron at above 6 mg/L in white wine, which can result in white iron phosphate deposits, or iron casse.

Arthur O'Connor, who directs winemaking for the Cordoniu-Raventos Group, the parent company of Cava category leader Cordoniu, and is president of Artesa Winery in California said, "We've spent years and years figuring out which yeasts give us the best results." While yeast trials have been costly and time consuming for Cordoniu-Raventos, the company continues to be an early adopter. "We follow current research and treat new ideas very seriously," he said.

Arthur O'Connor of CodorniuRaventos is an early adopter of technology that optimizes sparkling wine production.

After his initial introduction to Berovic's research, O'Connor said, "In addition to riddling, there also seems to be considerable potential for using magnetized metal and electromagnetic fields in developing new methods for sterile filtration and color extraction in still wines."

WINEMAKERS WEIGH IN

In their initial reactions to Berovic's magnetic riddling technique, O'Connor and other sparkling winemakers and academics, including UC Davis professor Linda Bisson, expressed concern about the potential for iron casse in finished wines. "We'd have to dig further with trials to determine if the elevated levels of iron present any real problems," O'Connor said.

"Iron is an active participant in oxidation reactions, which would result in more rapid aging of the

wine," said Bisson, who pointed to the need for research on longer periods of aging. "If the wine is to be aged on the yeast lees for one or more years, there will be breakdown of the cellular material releasing nanoparticles into the wine." Bisson questions whether the released particles would sediment as efficiently as they do in the intact yeast cell clusters.

Similar concerns have been expressed over the higher levels of calcium ion content present in wines made using yeast cells encapsulated in calcium alginate (a natural polysaccharide extracted from seaweed) gel beads or strands, which can reduce the time required for mechanical riddling to a matter of hours. Encapsulated yeast was first introduced in the 1980s and then modified with double-walled beads to better contain the calcium as recently as 1997. But according to O'Connor, the form hasn't met with large-scale commercial adoption.

To date, the fastest route from riddling to disgorging now takes about an hour. O'Connor is using a proprietary form of agglomerated yeast in conjunction with a special gyropalette that was developed jointly by Cordoniu and Freixenet. A study co-authored by Eva Bertran of Freixenet's Gloria Ferrer winery in California, published in the American Journal of Enology and Viticulture in June 2013, introduced yeast biocapsules, which are the co-immobilization of a *Saccharomyces cerevisiae* strain and a filamentous fungus (*Penicillium chrysogenum*).

This agglomerated yeast format has given the Cava producers an additional competitive advantage by further reducing riddling time from several days to one hour. "We're not holding onto tradition for tradition sake," O'Connor said. "When it comes to improving wine quality, we innovate and challenge every step of the process."

COMMERCIAL CONSIDERATIONS

According to Berovic's scenario, sparkling wine production using magnetized yeasts has the potential to be both cost effective and convenient. Producers would be able to magnetize their own native yeasts or any preferred yeast strains at the winery, eliminating the need to buy the technology from outside sources. Long-term costs will hinge on the price of the nanoparticles which, at current market prices, are estimated to increase the cost of yeast by 50%, though the cost of the technology is expected to drop as supply and demand increase.

Initial production costs would also include the adaptation of a standard finishing line by installing a magnetic separator before the disgorging station. With a sedimentation time of about 15 minutes, magnetic riddling would extend the time required for the finishing process and, as such, require a new workflow for the winery.

For the world's leading Cava producers, the return on investment of reducing riddling time from approximately one hour to the 15 minutes made possible by nanotechnology would rely on several factors, not the least of which would be the sensory qualities of the finished wine.

Given the multitude of potential applications, magnetic separation seems to be on a fast track to commercialization in one or more industries. The technology has been patented in Slovenia and is now making its way through the EU patent process.

Adoption by the sparkling wine industry would enable many producers to leapfrog several generations of yeast technology and forgo use of the gyropalette.

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Comments? Please e-mail us at feedback@vwmmedia.com.