The swirling of wine helps bioreactors to run better (w/ video)

November 30 2011, By Emmanuel Barraud

Every wine aficionado knows that wine has to be swirled in a glass in order for it to release its aroma. Applied to biotechnologies over some fifteen years, this ordinary gesture has made it possible to develop more efficient machines for culturing proteins in animal cells. The phenomenon has been studied in detail at EPFL (Switzerland).

First, slowly pour. Then sniff. Then, keeping the base of the glass anchored, apply a very light circular movement. Inhale again. Start over, each time swirling the glass a little more strongly to aerate the wine. This is how one goes about appreciating the complex bouquet of a fine vintage.

Nobody's contesting the legitimacy of this protocol; it's something that everyone just does more or less intuitively when presented with a grand cru or a cup of coffee without a spoon. But as for precisely explaining the fluid mechanics involved in this operation, known as "orbital agitation," – well, that's another story!

Orbiting bioreactors

Professor Florian Wurm, head of EPFL's Laboratory of Cellular Biotechnology, has been developing bioreactors that work on this principle for many years, based on the intuitive understanding that orbital agitation results in a mixing action that is both gentle and effective. The spin-off company that he has created to use reactors of this type, ExcellGene, has just celebrated its tenth anniversary. “We now are using small as well as large volume machines, to manufacture high value recombinant proteins in animal cells,” he announces. “Most recently, in collaboration with Kühner AG, the EPFL and the ExcellGene, one of the world's largest bioreactors based on orbital shaking has been constructed, with a total volume of more than 3000 Liters.”

In traditional bioreactors, the contents are mixed by a rotating platform that sits underneath a container. By replacing these with orbital shakers (in which the entire tank is moved), Wurm says he is able to significantly reduce the cost of manufacturing proteins, which are used widely in the pharmaceutical industry. “The cultured cells receive fewer shocks, the mixture is more homogeneous, it can be done in a normal air rather that in pure oxygen, and this technique allows us to construct wider and shorter bioreactors, that are thus easier to install in rooms of standard dimension, he adds. Moreover, we now use disposable plastic bags inside the reactor, which cut most of the maintenance costs.”

Complex waves

To go beyond empirical knowledge and better understand what is really happening in an agitated container, Martino Reclari, a PhD student in EPFL’s Hydraulic Machines Laboratory (LMH), studied the movement that wine enthusiasts apply to their glasses. “The form of the free surface, that which is in contact with the air, is much more complex than we expected,” he explains. “As a result, the aeration of the wine, that is, the exchange phenomena between the liquid and the atmosphere, are very difficult to model.” Many different waveforms have been described. “There is an infinite number of them,” he adds.

His work, presented last week at a meeting of the American Physical Society, has made it possible to understand the effect of two variables –

the rotational speed and the amplitude of the movement, both as a function of the dimension of the container and the height of the liquid in it – on the waveform that will be generated. By using video imaging, the scientists were able to determine that the liquid was mixing not only from top to bottom along the wave that was forming on the edges of the glass, but also from the center out to the edges. Reclari, who has been in contact with the oenology section of the Engineering School in Changins, has designed models to determine what kind of swirling motion is most appropriate for a particular kind of glass and a particular kind of wine.

This small scale research can be extrapolated to meet the needs of those in the biotech industry. "We have already determined that with three constant parameters, we can reproduce the same waveform, no matter what size the container is," explains LMH Senior Scientist Mohamed Farhat. "Our numerical models, developed with the Chair of modelling and scientific computing (prof. Alfio Quarteroni) will enable us to calculate the optimal parameters to apply in every specific case, including that of cell cultures."

Provided by Ecole Polytechnique Federale de Lausanne