



## BOTTLES VERSUS MAGNUMS: IS BIGGER ALWAYS BETTER?

Addressing the hottest topic in wine science – post-bottling wine chemistry – **Dr Jamie Goode** discusses the anecdotal evidence and scientific theory relating to the performance of bottles, half-bottles and magnums

**D**espite its familiarity, wine ageing remains a rather mysterious process. At the heart of fine wine lies the transformation, mediated by time and suitable cellaring conditions, of a young wine into a more complex and more desirable older one. It's a process shrouded in mystery and loaded with metaphor, mirroring the transformation that affects us all as we move from youth to adulthood to full maturity. Added to this, there is uncertainty, with pleasant surprises offsetting the many disappointments along the way.

It's remarkable that a process so integral to the appreciation of fine wine is so infrequently discussed and so poorly understood – at least from a scientific perspective. We know roughly from our experience how the sensory properties of wine change with time, and brave critics will confidently proscribe a drinking window for wines they rate, but we don't really understand the chemistry of wine ageing very well at all. It could be argued that a chef doesn't need to understand the science of cooking to be able to function at the top of their trade – and in a sense this is correct. Pragmatically

speaking, what is really important is that we have sufficient experience of drinking maturing wines so that we can assess fairly accurately their ageing trajectory and, most importantly, when they will be at their peak. Given this knowledge, we might question the utility of knowing the underlying molecular mechanisms.

There is a strong argument, however, that this sort of chemical insight would indeed be helpful. The current lack of a scientifically framed understanding of wine ageing has proved to be a limiting factor when it comes to the discussion of topics such as the role of closures, appropriate cellaring and warehousing conditions, or the effect of bottle size on ageing.

### The history of wine bottles

No one knows for sure the origin of the bottle size of roughly 65–80cl (now standardised to 75 cl). It has been suggested that this size was chosen because it was thought to be the ideal portion for one person at a meal. More plausibly, perhaps, it represents a lungful of air for a glass blower.

Bottled wine is a fairly recent phenomenon. The first wine bottles made their appearance several millennia after wine was first made, in the 17th century. It is interesting to note that until 1860, which was just before phylloxera decimated most of the world's vineyards (beginning in the South of France in 1862), it was illegal to sell bottled wine in the UK for reasons of consumer protection. While corks had previously been widely used to seal containers, it was with the shift to bottled wines of a cylindrical shape, which could therefore be stacked lying down, that corks came into their own as wine-bottle closures. Thus, although wine has a long history, it is only in the past 200 years that cork-sealed wine bottles have become the norm for quality wines: this is the context within which the current 'system' of fine wine has developed. Bottle sizes have varied somewhat over the years. The standard for a long time was 70cl, with the most common larger size being a magnum, which was somewhat less than the current size of two standard bottles. Now the sizes of both are fixed at 75cl and 150cl.

### Magnums: the optimal bottle size for fine wine?

Are magnums better than bottles, or is this just an untested piece of wine-trade folklore? There's no conclusive evidence of the sort that would satisfy a scientist, but the huge number of anecdotal reports support the idea that they do indeed perform better. That wine in larger-sized bottles ages better is strongly suggested by the remarkable degree of consensus on the topic among experienced members of the fine-wine trade.

Stephen Browett of Farr Vintners agrees with the view that magnums generally age more gracefully and less rapidly than standard bottles. 'In general, the bigger the bottle, the longer the maturation period,' he says. 'Half-bottles definitely mature quicker.' Respected taster and wine writer Steven Spurrier is even more specific: 'I think magnums age at half the speed of a bottle. The difference is accelerated with age – that is, magnums hold far longer, probably at least half as much again.' Spurrier adds, 'I still think, although it is patently untrue, that bottlers bottle their best wines in these larger sizes and their less good wine in halves.' David Elswood of Christie's is another fan: 'Although no conclusive magnum-versus-bottle tastings have ever been held to date, fine wine from well-cellared magnums must be the strong candidate for optimal bottle size, particularly in regard to mature vintages of Bordeaux.' So why doesn't everyone collect magnums? 'The

downside is that you only get six tasting opportunities per case, against 12 for bottles,' says Elswood.

'I've always felt that magnums are the optimum size,' says Sotheby's Serena Sutcliffe MW, 'and I much prefer them to larger formats. I can't say absolutely that magnums are always better than bottles, because with wines more than, say, 25 years old, so many other factors come into play, but overall you stand a greater chance of a magnum being better.' She adds, 'One of the reasons I like them is that a magnum is the ideal-sized bottle for two people!'

In auction catalogues there is no premium for magnums, and the proportion of magnums to bottles in any one sale varies: some wine lovers like collecting magnums, others don't. Usually, Sotheby's prepares a general index including the large formats, but then a second index specifically for the large-format bottles. 'We might see a premium when it's a large-format bottle of something that is already rare,' says Sutcliffe. 'But with trophy wines from the '40s and so on, be even more wary of large formats,' she warns. 'There are a heck of a lot of frauds around.'

There is also the important element of expectation. When we come to open a magnum, there is something special about the occasion just because it is a larger format. Our expectation that this will be better wine in some way primes our perceptual apparatus in subtle, subconscious ways that will then mould our perception in a positive direction, without us being aware of it. This sentiment is echoed by Christie's David Elswood: 'Wine from a magnum always impresses more, making the occasion more special, which might add to the experience.'

### Why are magnums better than bottles, and bottles better than halves?

Even though we lack proper data, the experience of the wine trade seems to suggest pretty conclusively that differently sized bottles age at different rates, with half-bottles ageing faster than bottles, and magnums more slowly still. All three bottle sizes have a similar standard neck bore and are sealed with the same corks. (We are discounting, for the moment, alternative closures, which have yet to make much of an impact on fine wine.) The logical conclusion from this is that the difference in ageing rates is due to an extrinsic factor that is invariant, while the size of the bottle, and thus the volume of the wine, varies: this extrinsic factor is almost certainly oxygen transfer via the cork, plus any oxygen retained in the headspace during the bottling process. So, while all three sizes – half-bottle, bottle and magnum – experience the same net oxygen ingress, this oxygen is acting on different volumes of wine in each case.

This is where we need to look more closely at post-bottling wine chemistry and the science of wine ageing. This is perhaps the hottest topic in wine science, and the key question now being posed is whether or not extrinsic oxygen is needed for the successful ageing of wine. In other words, is the ideal closure a hermetic one, providing a completely airtight seal? Or does successful ageing require some oxygen transmission through the closure?

This debate has become heated because of the discussions about the suitability of alternative closures – and specifically screwcaps – for fine wine. According to the robustly vocal screwcap lobby, wine ageing is a reductive process that takes place in the absence of oxygen, and because of this, the super-tight seal of screwcaps is ideal. Anecdotal reports of wines that were sealed with caps in the 1970s and still tasted fresh 30 years later are used to support these claims. The cork lobby has countered this,

suggesting that some oxygen transmission through the closure is needed for ageing wine and that screwcapped bottles are 'locked in time', developing at a fraction of the rate of cork-sealed bottles. Who is right?

The actual picture is a more complex one than either position recognises. First, we need to treat red and white wines differently. Red wines have a much higher polyphenolic content than whites. Polyphenol is an umbrella term used to describe a variety of chemicals made up of the phenol group as a primary building block, including anthocyanins (red/black coloured pigments) and tannins and various combinations of the two. Polyphenols act as antioxidants, protecting wine from the otherwise harmful effects of oxygen, and thus red wines probably have rather different requirements for successful ageing. It may be that some alternative closures are appropriate for fine white wines but not for fine reds; it may also be the case that we need to match closure and wine type more precisely than this.

Second, wine ageing isn't simply oxidation. If it were, it would be possible to accelerate the wine-ageing process by using a more permeable closure than cork. Wines sealed with more permeable closures do develop faster, but not in the same way that well-cellaried cork-sealed wines do. The more rapid ageing of half-bottles illustrates this point well: having the same closure on a bottle with half the volume of wine mimics the use of a slightly higher-permeability closure, and the conclusion is that while half-bottles don't age disastrously, they don't age as well.

This is where the gaps in the science become apparent and we start having to extrapolate and speculate. To reiterate, the complex chemistry of wine ageing is poorly understood. Ageing can take place in the total absence of extrinsic oxygen: this has been shown by as-yet-unpublished experiments at the Australian Wine Research Institute (AWRI) involving wines kept in sealed glass ampoules showing some development (together with sulphur-like off-odours, about which more later). Last year I had a chance to taste screwcap-sealed Rieslings from the Clare Valley over five successive vintages: this showed that the wines aren't locked in time, even when sealed with a very low-permeability closure such as a tin-lined screwcap. But it is also becoming clear that some oxygen transmission by cork is an important component of the successful ageing process of red wines, which leads on to the next point.

Third, we like the way that wine ages under a good (that is, taint-free) cork. The ideal alternative closure for fine wine would be one that replicates closely the performance of the average, taint-free cork. It is becoming clear that small changes in oxygen transmission make a big difference to wines. In a presentation at the recent New Zealand Screwcap Symposium, Peter Godden of the AWRI even went so far as to say that closure choice has more of an impact on wine than terroir, although he admits that he was being slightly tongue in cheek at the time. 'It is important to understand that the changes that occur in wine after bottling, which can be attributed to the closure and other bottling variables, are profound and can be of far greater magnitude than many vineyard and winemaking variables,' says Godden. Indeed, data in his Screwcap Symposium presentation backed up this idea: 63 months after bottling, the same Semillon wine in the AWRI closure trial was clearly taking rather separate developmental trajectories under the different closures used in the study.

A new paradigm is emerging: choice of closure and manipulations prior to bottling can be seen as part of the

winemaking process. As our understanding of the role of oxygen transmission via the closure grows, and closure companies offer products with specific varying permeabilities (for example, screwcaps with different lining materials), closure choice can become a winemaking decision. 'The future is to use oxygen ingress creatively, since small differences can have a big effect on how wine develops,' says Godden. 'The question, "Does wine need oxygen to develop?" is pretty well redundant. The amount of oxygen required for optimal development will be different for each wine, and understanding this, and other bottling variables, is the next step. Several producers are already working actively on this.'

With fine wines that already have a long track record of ageing well, it would seem foolish to play around with these sorts of winemaking decision without a great deal more information on the implications for long-term wine quality. Changing to an alternative closure with different oxygen-transmission properties will probably change the ageing trajectory of the wine and therefore its very nature — at least if it is a wine that is going to be cellared for any length of time. Putting this another way, if screwcap proponents argue that wines age better under screwcap than they do under cork, they are saying that wines age differently under screwcap. This is backed up by comparative tastings where cork- and screwcap-sealed bottles of the same wine are compared side by side. In these tastings, participants typically express a preference for the screwcapped bottle. They must therefore be detecting a difference. In the conservative world of fine wine, where tradition and track record are important, most people will not be receptive to the idea that fine wine needs changing, even if they are being assured by Aussie and Kiwi winemakers that their wines will be improved by switching closure type.

### The Australian Closure Fund Study

Readers familiar with the closures debate will likely be aware that there's an elephant in the room. It's the study by Andrew Kleinig and Allen Hart, funded by Jeffrey Grosset's Australian Closure Fund (ACF). In this study, three separate data sets were pulled together to reach the conclusion that oxygen is not necessary for the ageing of bottled wine.

The core of the paper concentrates on the evolution of a 1996 Penfolds Bin 389 under different closures: a 44mm reference 2 natural cork, a tin-lined screwcap, and two different synthetic closures. The bottles sealed with cork and synthetic closures were stored laid down, while the screwcapped bottles were stored upright. Prior to bottling, the wine was aged in American oak for 14 months and was copper-fined after fermentation to remove sulphide residues. The wine was subjected to chemical analyses while in bottle, and then at seven years post-bottling it underwent a thorough sensory analysis.

After seven years, the screwcapped bottles retained the highest levels of free and total sulphur dioxide (SO<sub>2</sub>), with the synthetics the lowest (no free SO<sub>2</sub> left by 2002) and the corks intermediate between the two. There were no significant differences in colour density or hue changes among the differently closed wines. In the sensory analysis, while the synthetics are significantly different from the other closures (more oxidised, more developed, less spicy and with less fruit intensity), the only significant difference between the screwcapped and cork-sealed bottles was that the screwcaps were significantly higher in 'reduced' characters. Various interpretations of these data can be made, but the most logical



Differently sized bottles age at different rates, and many experts favour the magnum as the optimal size

conclusions seem to be that: (1) synthetics are allowing larger amounts of oxygen into the wine, causing it to age more rapidly; (2) corks are sealing against oxygen entry very nearly as well as screwcaps; and (3) the only consequence of the tighter seal of screwcaps at this stage (given the small sample size; perhaps a larger one would have made more differences apparent) is the development of reduced aromas. The conclusion that the red wine in this trial has developed under screwcap similarly to the way it has under cork can also be supported by these data, although it's not the most obvious conclusion to emerge, and it must be made tentatively from such a small data set.

There are two other bits of data tagged on to these in this study. The first concerns a sensory analysis of four widely separated vintages (1984, 1987, 1994, 1999) of sparkling reds sealed with crown caps. This is an odd inclusion, because we don't know anything about the state of these wines when they were bottled, and there is no information about the permeability of the crown caps used – like screwcaps, their performance depends upon the lining.

The second concerns the permeability of corks, screwcaps and synthetics. These data are obtained by the use of what is known as a Mocon machine. Empty wine bottles are sealed with a closure, the necks are cut off, and the Mocon measures the

passage of oxygen through the closure. The results were that screwcaps sealed tightest (permeability of less than 0.001cc per day) and synthetics had a much higher permeability of around 0.1cc per day. Both these closure types seemed quite consistent. But for cork, the data in the paper illustrate that there is a range of permeabilities, from just over 1cc to less than 0.001cc of oxygen transfer per cork per day. Does this mean that corks exhibit a thousandfold variation in permeability? This conclusion, while currently being touted by some as a further nail in the coffin of cork, is a hard one to accept. First, the data show a distribution of permeabilities, with the majority of the corks falling between 0.01cc/day and 0.1cc/day. But beyond this, there is something odd about these results. The synthetics showed a consistent permeability of around 0.1cc/day, yet wines sealed with these closures develop much faster than those sealed with corks. Indeed, while the red wine in this trial showed significantly different evolution under synthetics and the other closure types, the screwcaps (permeability of less than 0.001cc/day) were not significantly different from the corks. The explanation may lie in the nature of the Mocon measurements. 'The oxtrans results quoted are for a non-wetted cork in a Mocon machine,' says Australian wine scientist Richard Gibson. 'In my experience, Mocon oxygen-transmission results for cork are consistent with performance in bottles stored upright. However, oxygen transmission of cork appears to be much lower and less variable when wine is in contact with the cork.' Gibson adds, 'The Mocon results for cork quoted in the ACF paper cannot be linked to the behaviour of the cork closures in the 38g trial. However, trials have shown that synthetics and screwcaps give similar oxygen transmission standing up and laid down. Links between the Mocon results and the behaviour of these closures in the 38g trial are likely to be valid.' Another Australian wine scientist, John Casey, is in agreement: 'Mocon measurements of the oxygen-transmission rate (OTR) of cork are interesting but irrelevant, and they confuse popular thinking about cork performance.'

So this is where the problem lies. The apparent conclusion of the paper – that because the 38g in bottles under screwcap and cork have developed similarly and yet the Mocon oxygen transmission of cork is much higher than screwcap, oxygen is therefore not a primary driver of red-wine maturation – is questionable.

Besides, if corks really do exhibit thousandfold differences in permeability, no two cork-sealed examples of the same wine would resemble each other after several years in bottle. New Zealand winemaker and PhD chemist Alan Limmer points this out. 'If, in fact, we had a thousandfold variation at these levels, individual wines would be unrecognisable. They would reflect the cork more than the wine. And yet we can generally agree on the character of a particular aged wine.' This said, there is clearly a level of variability between cork-sealed bottles that isn't seen with alternative closures, even when the bottles are laid down.

So while the ACF paper doesn't prove what it claims – that oxygen isn't needed for ageing bottled wine – the converse isn't necessarily true. Let me try to explain what I mean here, because this is a complicated but important discussion. We still lack data on the OTR of corks in the real-life contact-with-wine scenario that occurs with cellared bottles, and the AWRI ampoule trials mentioned above indicate that chemical reactions associated with wine ageing will take place in the absence of any oxygen ingress. Indirect measurements, such as the reduction of free SO<sub>2</sub> levels in wines after bottling, indicate that the average cork seals better

than synthetics but less well than tin-lined screwcaps. The orthodox opinion is that some oxygen transmission by closures is a good thing, and too little or too much is bad. Why too much is bad is simple: the wine oxidises. Why too little is bad is more complicated. First, the very tight seal of tin-lined screwcaps has caused problems with sulphur chemistry, and resulted in sulphur-like odours (also known as reduction) developing in some wines. Some commentators think these are avoidable with good winemaking techniques and copper fining; others argue that whatever winemakers do, there's still a risk of them showing up with very low OTR closures. (This is a huge topic, and it can't be covered adequately here.) Second, it could be that some OTR is actually needed for wines to age in the way we like. We just don't know for sure. Thus, the ideal closure is one that balances these objectives, and a sound cork seems to do this well.

But this is not a universal conclusion. John Casey has an intriguing, unorthodox view that deserves a mention in this context. He thinks that corks are suitable closures for quite different reasons. 'When a cork is compressed in the neck of a bottle, the cells and the gas that they contain are compressed, and the pressure of oxygen in the cells is about double that in the atmosphere. Under these conditions there can be no net entry of atmospheric oxygen into or through the cork,' he explains. 'After the bottle is sealed, air very slowly permeates out of the cork to the atmosphere over a decade or so, while at the other end there is ingress by the permeation of several hundred millilitres of ethanol and water vapour.' Casey thinks that corks seal just about as tightly as screwcaps. 'Any ingress of atmospheric oxygen into the wine has to be between the cork and the glass, just like a metal cap; this is probably why their performances are so similar.' Two questions are raised by this theory. First, if cork seals as tightly as screwcaps, why don't we run into the problem of sulphur-like odours (SLOs)? 'The circumstantial evidence suggests that the reason cork-sealed wines are much less prone to SLOs is because of the cork's ability to absorb minute amounts of hydrogen sulphide,' says Casey. 'Similarly, the absorption of fermentation esters by corks could account for the disappearance of the "raw" or "vegetal" character from some bottled wines.' Second, how do we account for the faster loss of free SO<sub>2</sub> in cork-sealed wines? Casey thinks it is because of the operation of the corking machine, resulting in more air contact at slower filling speeds.

### Summing up

So we return to the differential performance of standard bottles and magnums. If the orthodox opinion on closures is correct, and it is simply a matter of matching the appropriate OTR with the wine, then engineering a closure that is a little tighter than corks (for example, a screwcap with altered lining material or a technical cork such as Diam) will replicate the performance of magnums in a standard bottle. If we speculate that successful wine ageing involves both reactions that can take place in the presence of oxygen and those that need a very small amount of oxygen ingress, experience has shown that the balance between the two that occurs in well-cellared magnums is just about optimal for most fine-wine styles. The missing data point is the OTR characteristics of cork, which can't be measured by Mocon. But if John Casey is right, and the scalping of sulphur-like odours and other wine components by cork is important, then screwcaps with engineered permeabilities will never be suitable for fine wine as we know it. ■