

# Wine, chemistry and song\*

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## 1. Origins

[The lecture starts with a video of Carl Orff's *Carmina Burana* (1937) showing the section "In taberna quando sumus", in the 1975 production by Jean-Pierre Ponnelle. The men's chorus describe what is going on in the tavern: the drinking, the gambling, the nudity – especially the former. Everyone drinks: the mistress, the master, the soldier, the cleric, the man, the woman, the servant, the maid-in-waiting, the quick man, the lazy man, the white man, the black man, the regular and the stray customer, the greenhorn and the wise man, the poor man, the invalid, the exile and the man nobody knows, the boy, the greybeard, the president and the deacon, the sister and brother, the old man, the mother, that woman, this man, a hundred drink, a thousand drink.]

I began the preparation of this lecture by looking into an old edition of the *Encyclopædia Britannica*, always a good starting point. There I learned that the three most commendable drinks are water, milk and wine. (Three is, of course, a biblical number and the proverb tells us that good things, as well as bad ones, come in threes.)

"Wine is as old as civilization, and no drink except water and milk has won such commendation through the ages. It is used to perform rites in churches; to observe memorable occasions; to launch ships; to minister to the sick; to welcome guests; to inspire the mind. It

is essentially a drink of moderation; when used to excess, wine itself is abused."

Water is so common that it is almost taken for granted. Seventy per cent of our bodies and three quarters of the surface of the terrestrial globe (which should really be called Water instead of Earth) are water. As for milk, many of us have forgotten what it tastes like. The general perception is that milk is for children and wine for grown-ups.

Wine is an old creation, probably over 10 000 years old. Egyptian papyruses from 2500 BC refer to the use of grapes for making wine. Vineyards existed and wine was cultivated in the Middle East as far back as 4000 BC, most likely even

earlier, around 8000 BC. The evidence of cultivated vines in Georgia goes back to 7000 BC. China, too, appears to have known wine around 4000 BC. In *Paradise Lost* (1667), John Milton seemed to have entertained the idea that the fruit that Eve and Adam had eaten was of an intoxicating nature – arbutus-berries rather than apples, perhaps?

*Soon as the force of that fallacious fruit,  
That with exhilarating vapour bland,  
About their spirits had played, and  
inmost powers  
Made err, was now exhaled.*

It is well known that the Bible ascribes the discovery of wine to Noah, maybe as

fig. 1 The Mystic Press, Bavarian painting, c. 1500



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a thanksgiving celebration after the Flood and the safe landing of the Ark on Mount Ararat. According to the Book of Genesis, "And Noah began to be an husbandman, and he planted a vineyard. And he drank of the wine, and was drunken; and he was uncovered within his tent" (9:20-21). After forty days and forty nights of torrential rain and one hundred and fifty days of the Flood he had more than earned the novel pleasure of wine tasting!

Plenty of vineyards, wine miracles, transmutation of water into wine and vinous metaphors can be found in the Bible, particularly in Isaiah. A good example is the Mystic Press – fig. 1 – with its clear identification of wine with Christ's blood: "Who is this that cometh from Edom, with dyed garments from Bozrath? This that is glorious in his apparel, travelling in the greatness of his strength? I that speak in righteousness, might to save. Wherefore art thou red in thine apparel, and thy garments like him that treadeth in the winefat? I have trodden the wine press alone; and of the people there was none with me: for I will tread them in mine anger and trample them in my fury; and their blood shall be sprinkled upon my garments, and I will stain all my raiment" (63:1, 2, 3).

The drink is also expressed by a simple, beautiful word, made up of only four or five letters, a bit like a molecule with a small number of atoms. That word has a similar sound (and look) in a number of languages: Wine, Vin (French), Wein (German), Wijn (Dutch), Wino (Polish), Vynas (Lithuanian), Vino (Spanish), Vinho (Portuguese), Vinum (Latin), Yayin (Hebrew), etc. All these denominations derive probably from Oinos (Greek), an indication that wine came into Western Europe from Greece, through Italy. Most likely it originated in the Middle East or even further East, in Asia. Wherever it came from, the truth is that cultivation of the vine and wine production are synonymous with civilization. The culprit is the common vine or *Vitis vinifera*, seen here in an unusually pictorialist photograph by the great landscape photographer, Ansel Adams – fig. 2. This is a picture full of life, with

the young leaves shooting out like the wings of a butterfly ready to take flight. Vines bear grapes and the rest, as in photography, is chemistry – the chemistry of wine.

## 2. The Drink of Gods

Ambrosia and nectar were the food and drink of the Gods, but wine must have run a very close second to nectar in the Gods' preferences. Bacchus/Dionysus would have made sure of that. During the Renaissance, as Edgar Wind wrote,



fig. 2 ANSEL ADAMS, *Vitis vinifera*, 1959

"to laugh at the pagan gods with understanding became a sign of humanist grace". This is precisely what some great Renaissance artists did. I am particularly fond of a famous painting by Giovanni Bellini, *The Feast of the Gods*, now in the National Gallery of Art, in Washington, DC – fig. 3. The painting has an interesting story. Although signed and dated 1514 by Bellini, it was partially repainted (background landscape, changes and additions to the main figures) by Titian, most probably in 1529. We know this from Giorgio Vasari's *Lives of the Artists* (1568): "and as, being an old man [Bellini was an octogenarian in 1514], he was not able to finish the work completely Titian was sent for to do so, as the most capable of all the other painters".

*The Feast of the Gods* had been created to decorate the private rooms of Alfonso d'Este, Duke of Ferrara, at the instigation of his sister, Isabella d'Este. It shows the Gods involved in much drinking and groping, in what looks like the beginning of a bacchanalia! They are easily recognizable by their symbols and attributes: the staff of Mercury, the trident of Neptune, the wreath of wheat in Ceres's hair, the laurel wreath and lyre of Apollo, the eagle of Jupiter, the flute of Pan, etc. As usual, Priapus (all dressed-up) is abusing a half-naked Ceres. Nymphs and satyrs complete the composition. The odd thing about this painting is that the Gods do not look happy and do not seem to be having a good time. Maybe Bellini's heart was not in the picture – he was an old man, and had made a name as a painter of saints, not of profane scenes. More likely, the wine (or nectar) the Gods were drinking was not of a good vintage year...

Grapes were a popular subject for painting throughout the nineteenth and eighteenth centuries. The main reason for this was obvious: coming in bunches or abundantly endowed clusters, grapes stood for wealth and fertility. They were common components of still lifes and also provided good topics for trompe-l'oeil paintings. There is a story that Apelles, the greatest painter of antiquity (4th century B.C.), created such a realistic picture of grapes that birds would come through the open window to peck at them. A recent (1999) exhibition at the Musée de Beaux-Arts in Bordeaux, *The Grapes of Silence*, was devoted to grapes in painting.

## 3. Drinking Songs

Alfonso d'Este's wife was the (in)famous Lucrezia Borgia. According to legend, she often did away with her enemies by poisoning their drinks. She was the daughter of a Spanish cardinal (later Pope Alexander VI). Despite her several betrothals and marriages, her last, to Alfonso, seems to have been a tranquil one and she spent a life devoted to charitable works and the education of her eight children. Her bad reputation is totally undeserved, but it has made for



fig. 3 GIOVANNI BELLINI, *The Feast of the Gods*, 1514

great fiction and great art. Titian painted a famous portrait of her. In Gaetano Donizetti's opera, *Lucrezia Borgia* (1833), she unknowingly poisons her long-lost son, Gennaro.

There is a tradition of drinking songs in opera that goes back to the very beginning of the form. In Claudio Monteverdi's *L'Incoronazione di Poppea* (1643), the Roman emperor Nerone and his friend the poet Lucano carouse and get drunk while singing a madrigal. Donizetti's opera, *Lucrezia Borgia*, is no exception, for it boasts a famous drinking song; it is sung by one of Lucrezia's enemies, Maffeo Orsini (a mezzo in a trouser role). At Princess Negroni's party the roisterers praise the wines of Madeira, Cyprus, Syracuse and the Rhine. Little they know that soon they will die in agony – the wine having been poisoned by Lucrezia. The title of the song is "Il segreto per esser felice" and it goes like this:

*The secret of happiness  
I've learned by living – I'll teach it to my  
friends.  
Whether the sky be cloud or clear,  
In any weather, hot or freezing,  
I frolic and drink and laugh at the fools*

*Who worry about the future.*

Wine drinking causes both enjoyment and derangement. In Giacomo Puccini's *Il Tabarro* (1918) the stevedore Tinca drinks to forget and drown thoughts of revolt. He who drinks does not think; he who thinks does not laugh – and the 'improviso' ends in a burst of syncopated laughs. Likewise, Turiddu, in Pietro Mascagni's *Cavalleria Rusticana* (1890), in a moving farewell to his mother, attributes the nonsense of his words to the wine that he has just been drinking. He then rushes out to meet his rival, Alfio, in a duel that will prove fatal.

The most famous drinking song is, perhaps, the so-called (erroneously) 'champagne aria', sung by Don Giovanni to urge his servant Leporello to round up all the pretty girls in the village and bring them to the super-party he is holding at the palace. The aria "Fin ch'han dal vino" bubbles with energy, confidence and zest for life, and is a challenge – among many others – to the baritone who sings the title-role in Mozart's opera.

*Now prepare  
a great feast*

*until the wine  
makes all heads reel:  
any girls you may find  
in the square  
bring them  
along too.*

It is often said that Don Giovanni is the Hamlet of operatic characters – so multifarious that no single singer can do it justice. I was lucky to hear, as a young student of chemical engineering, one of the best interpreters of the part, the Austrian baritone Eberhard Wächter. He came to Teatro de São Carlos, Lisbon, in 1960, for a famous production of *Don Giovanni* conducted by Michael Gielen. At the age of thirty, he was at the peak of his career and totally convincing in the role. The rest of the cast was no less distinguished: Montserrat Caballé, Teresa Stich-Randall, Erich Kunz, Waldemar Kmentt. This is a production fortunately preserved on disc. It should be remembered that one of the greatest Don Giovannis of all time was the Portuguese singer Francisco de Andrade (1859-1921), who was immortalized by his friend, the German expressionist painter Max Slevogt (1868-1932), in a series of paintings and drawings – fig. 4.

Song and wine are interwoven. You may be too shy to speak the truth, but after a few glasses of wine, you can go further and blare it out in song. It is said that the best way to appreciate our national song, 'fado', is in the company of a bottle of good wine. Singer and listener establish a bond through drink. An example is a picture by one of our latter day realist painters, José Malhoa (1855-1933), *O Fado* (1910) – fig. 5. The abuse of wine (mentioned in the initial quote from the *Britannica*) is just around the corner... Nothing new in this: as Anacharsis, the philosopher, said, the vine bears three clusters, "one for pleasure, the second for drunkenness and the third for repentance".

Already in the 16th century, it was said that there were five good reasons for drinking wine: the arrival of a guest, because you are thirsty, because you may be thirsty later, because it is good and ANY OTHER reason. François

Rabelais (c. 1494-1553), who was an expert on these matters, advised us to be prepared and drink before thirst stroke. That way we would never feel thirsty... Drunk in moderation, wine provides a life-enhancing experience. It is drink that revives Falstaff after his dunking in the Thames. In Verdi's opera, after the incident, he calls the innkeeper and asks for a tankard of mulled wine ("un bicchier di vin caldo"). He can then relax and look at life and the world with renewed pleasure. Wine reaches parts of his body that no other fluid can attain.

#### 4. A Bit of Chemistry

What is wine? Why is it so good? These are essentially chemical questions. The first is the identity problem, to be solved by analytical chemistry; the second lies in that gray area between chemistry and perception which is at the very root of the experience of being alive. The answer to the first question is never simple because in the real world nothing is ever pure and many of the impurities – most of them, in fact – may exist in concentrations well below the detection limit (with the standard methods of analysis). We tend to associate crystals with the purity of the solid state, but even the most beautiful crystal has been contaminated with an alien atom or ion here and there, and is blemished with defects and dislocations. Purity is a divine attribute and does not belong in nature. The drama is that some of those traces of impurities may contribute to our appreciation (or distaste) of the product. (We should remember that we love people for their faults as well as for their qualities.) It is essential to find out what those impurities are. In modern wine technology, better and better techniques are needed to identify the crucial components responsible for wine's colour, texture and taste.

Natural products – and wine is, certainly, a gift of nature – are even more impure than synthetic ones. The complexity of natural things (in terms of structure, composition, etc) is a corollary of evolution. Ultimately, everything derives from nature. Even synthetic materials have to be made from what already

exists on our planet. Stainless steel can be eventually traced to iron ore and coal; cellulose and rayon come from wood. The adjective 'synthetic' usually means that nature has been helped by the hand of man (which is often the hand of woman).

What is the chemical composition of wine? Since wine is made from grapes, we have to look into the different components of this fruit. Grapes contain a lot of water and also sugars (fructose and glucose), acids (tartaric, malic, citric, tannic), phenols (in red grapes), pectins, aromatic compounds (terpenes, like geraniol) and metals – mainly potassium (but also calcium and magnesium). The by-products of yeast activity during fermentation should also be con-

sidered. Sucrose, whether natural or added, is enzymatically split into glucose and fructose. Alcohols are formed, mostly ethanol but also glycerol. Tartrate salts (mainly of potassium) crystallize and tend to precipitate as wines age in bottles and old casks. All in all, quite a substantial body of chemistry.

For the imaginative chemist, tartaric acid is probably the most interesting of all the major wine components, for it can serve as the introduction to a new molecular property, that of chirality. Molecules exist that are composed of the same atoms connected in a similar way, and yet they are different in the same way that our right hand (or foot) differs from our left hand (or foot). (To feel the difference, try to shake the left hand of a

fig. 4 MAX SLEVOGT, *Francisco de Andrade as Don Giovanni*, 1902





fig. 5 JOSÉ MALHOA, *O Fado*, 1910

friend with your own right hand!). Chiral molecules, like a pair of hands, are similar but not identical. They are mirror images of one another but not superimposable. Two such objects – hands, shoes, molecules, etc – are said to be chiral (from the Greek,  $\chi\epsilon\iota\rho\omicron$  (cheiro), for hand; the same root as in chiro-mancy or chiropractice). Because of their similarity, some of their properties will be the same, but not all the properties. It was Louis Pasteur (1822-1895) who, literally, shed light upon the amazing structure of this organic compound – butane-diol-dioic, better known as tartaric acid, fig. 7.

### 5. In Praise of Pasteur

At the beginning of the 19th century people knew a lot about light but very little about chemical bonds. The properties of light, investigated by Isaac Newton (1642-1727) and Christiaan Huygens (1629-1695) in the 17th century, had a tremendous impact on language and man's perception of nature. Unlike the *Principia* (1687), Newton's *Opticks* (1704) was written in English and as such became much more accessible to the layman (also because it dealt with natural phenomena involving light and colour, familiar to all). Old figures of

speech came back with a vengeance. Henry Brooke's philosophical poem, *Universal Beauty*, written in 1728, refers to light as "the spark, the lamp, the ray, Essence or effluence of Essential Day". A new style of poetry arose – that of the "Scientific" poets (to which Brooke belonged). In the late 1700s and early 1800s, light had few secrets for both scientists and artists. Phenomena like double refraction, polarization and interference were well known. The painter Joseph Wright of Derby (1734-1797) specialized in the depiction of scenes where primary and secondary light sources (both natural and artificial) played a central role.

The phenomenon of polarization had been known since the time of Huygens (who discovered it, but was unable to find an explanation for it). Newton, too, had affirmed that a ray of light may have "sides". Polarized light looks no different from normal light (it has the same frequencies or colours), but in it the electric and magnetic fields each oscillate on a single plane. In time, it was found that certain crystals – like quartz – and solutions of certain substances – like sucrose – had the ability to rotate, by a certain angle, the plane of polarization of light: some to the right (dextrorotatory) and some to the left (levorotatory). The

corresponding property is called "optical rotation". Jean-Baptiste Biot (1774-1862), a very imaginative French professor of mathematics, applied these tools to the analysis of sugars, thus founding modern saccharimetry. For this work he was awarded, in 1840, the Rumford Medal of the (London) Royal Society.

Pasteur completed his first startling piece of research, on racemic acid, in 1848. He was then twenty-six. It was known that racemic acid, found during wine-making, had the same chemical formula and composition of commercial tartaric acid; however, whereas the latter is optically active and rotates the plane of polarized light, racemic acid is, in that respect, inactive. Being interested in crystals, Pasteur prepared and studied some nineteen different tartrates, but concentrated his attention on a particular salt of racemic acid – the sodium ammonium one. By close observation under the microscope, he discovered that its crystals were of two geometric types, mirror-images of one another. He carefully separated the two classes of crystals, and later found that their solu-

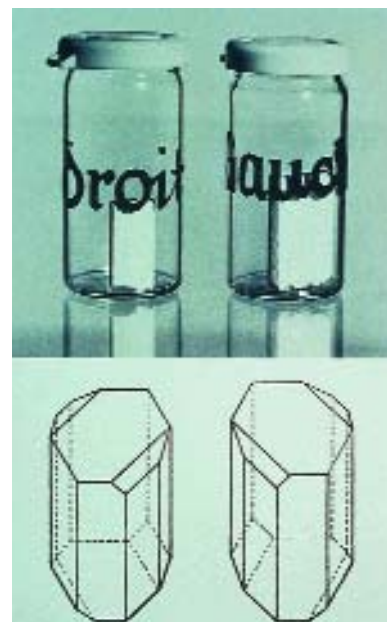


fig. 6 Mirror-image crystals of sodium ammonium tartrate, synthesized by Pasteur, and drawings of similar crystals

tions had opposite optical rotations: one was dextrorotatory and the other levorotatory. This explained why racemic acid, being an equal mixture of the two, was optically inactive. A new molecular property had been discovered: chirality. Pasteur was so excited by his discovery and conclusions that he told a chemistry assistant: "I am so happy that I am shaking all over and am unable to set my eyes again to the polarimeter!"

Pasteur was, indeed, very lucky, for most substances that are a mixture of enantiomers (the jargon for structures which are nonsuperimposable mirror images of one another) do not separate so easily into crystals that contain only molecules of one type (say, left-handed molecules) or another (right-handed ones). In the case of racemic acid, the left-handedness of a microscopic molecule was carried over into the macroscopic crystal (and the same with the right-handed molecule and corresponding crystal). To make his case clear, Pasteur prepared large, beautiful crystals of each form and stored them in bottles that he labelled "droit" (right) and "gauche" (left) – fig. 6. Later he repeated the optical rotation experiment for Biot, who was so excited that he declared: "My dear child, I have loved science so deeply throughout my life that this stirs my heart."

What is behind the chirality of tartaric acid is the fact that the carbon atom is tetravalent, with the four valences in a tetrahedral arrangement. Each one of the two middle carbon atoms of tartaric acid is linked (in a tetrahedral disposition) to four different groups: H, OH, CO<sub>2</sub>H and the other half of the molecule – fig. 7. If only two of these groups were the same – say, A, B, C, B – then all the possible tetrahedral structures would be superimposable and no chirality would occur. Screws and helices are also chiral – a fact well known to machine operators. Also all proteins are built up of amino acids of one specific handedness – they are all lefthanded! God, who may or may not play dice, is surely lefthanded.

Righthandedness (and lefthandedness) are also important in our appreciation of

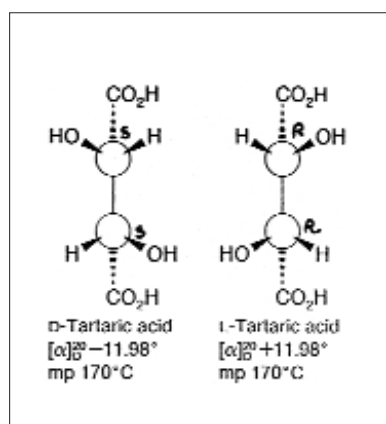


fig. 7 Mirror-image structures (enantiomers) of tartaric acid

paintings. In the West, we read and analyse pictures both clockwise and from left to right. As an example, look again at Bellini's *The Feast of the Gods* – fig. 3. Obviously, it does not make sense to examine it from right to left, as it does not make sense to tell a tale backwards (flashback). The effect usually follows the cause, not the other way round. Even if there is no lettering involved, it is often easy to notice that a projected slide is back to front. On a two-dimensional screen, this is yet another form of chirality. Looking at a painting of the Madonna and Child, the Child appears on the right (close to the heart of the Holy Mother) and our eyes describe a clockwise rotation, going from the head of the Virgin to that of young Jesus.

If the picture is back to front, it does not feel right, for the movement is now anti-clockwise. It should be noted that the Japanese read from back to front and from right to left, so their cultural appreciation of a picture is the opposite of ours. This is why a print such as *The Great Wave of Kanagawa* (1830-31) by Hokusai is so much more terrifying to a Japanese than to a European. By reading it from right to left, a Japanese is facing head-on the destructive power of such a gigantic wave. A European, on the contrary, looks at it from the safe side of the wave's back – fig. 8

## 6. Wine Goes Bad

Pasteur's contributions to the development of the wine industry did not stop with his investigations of tartaric acid. After all, he came from Arbois, in the Jura plateau (a wine-producing region) and considered wine to be "the most healthful and most hygienic of beverages". In 1862 he was called by Emperor Louis Napoléon to the Palace of the Tuileries to solve a pressing national problem: while in storage, wine was turning vinegary – a disastrous event for French exports. By this time, Pasteur had already studied several fermentation processes and discovered the important role played by micro-organisms in such processes. Later he was able to show that the minute organisms causing fer-



fig. 8 HOKUSAI, *In the Hollow of a Wave off the Coast at Kanagawa*, c. 1830-1

mentation were not spontaneously generated, but came from similar organisms that impregnated ordinary air. The spoiling of wine could then be prevented by what came to be known as "Pasteurization" – a heating treatment (to about 57°C, for a few minutes) that kills the bacteria without affecting the flavour and aroma of wine. Pasteur's contributions to chemistry, food science and medicine are immense, and he richly deserved all the honours bestowed upon him – fig. 9. He was also an accomplished draughtsman and painter.

The abnormal fermentation of wines was not the only problem affecting the wine industry in the 19th century. Three (a biblical number) plagues devastated the European vineyards: oidium and mildew, which are parasitic fungi; and the phylloxera or grape louse, introduced into Europe between 1858 and 1863 when American vines were brought over for grafting purposes. Very few castles in Europe escaped the phylloxera plague – one of them was Quinta do Noval in Portugal, nowadays a famous brand of Port Wine.

## 7. Ten Thousand Secrets

Over nine hundred volatile aroma compounds have been isolated from wines. More than 160 esters alone have been identified. Most of those 900 substances occur at concentrations between  $10^{-4}$  and  $10^{-9}$   $\text{g l}^{-1}$ , well below the limit of sensory perception (which lies around 0.1  $\text{g l}^{-1}$ ). Rabelais was probably referring to all those compounds when he wrote

*Bottle, whose mysterious deep*

*Does ten thousand secrets keep.*

However, all those small concentrations add up, and in combination they may be very significant. Besides ethanol, ordinary wine contains about one gram of aromatic (in the common sense of smell, rather than the chemical one of having a benzene ring) compounds per



fig. 9 To the glory of Louis Pasteur

liter. As Griffith Edwards has remarked, "it is the dirt in the drink which makes it attractive to the nose and the palate".

In many cases it is possible to associate an identifiable chemical substance (or group of substances) with a specific sensory attribute, like the odour or flavour of a particular type of wine. Once that has been established, the gates are open to forgery: the substance or substances in question can then be added to an inferior wine with the aim of recreating the more superior (and dearer) one. Analytical chemistry techniques, which can distinguish between naturally produced substances and synthetic ones (or originating from other sources), have to be devised. One such a technique, appropriately named SNIF-NMR (from site-specific natural isotope fractionation by NMR), looks at isotope ratios, for instance the deuterium/protium ratio, D/H, wherever a Hydrogen atom appears in the molecule. Another useful ratio is that

of the carbon isotopes,  $^{13}\text{C}$  and  $^{12}\text{C}$ . These ratios vary with the type of grapes, wine region, etc. A European isotopic data bank has been set up at the Institute of the Environment in Ispra, Italy, and SNIF-NMR has become the officially recommended technique to spot the addition of sugar in wines. The radioactive  $^{14}\text{C}$  content is another revealing indicator: natural substances have  $^{14}\text{C}$ , but synthetic products, made from petroleum derivatives that have decayed ages ago, do not. Forgers already spike the right substances with the required amounts of  $^{14}\text{C}$  or  $^{13}\text{C}$  to imitate the natural components, but for obvious reasons they put it where it is cheapest to, not over the whole molecule, as it would be expected in a natural product. Another strict method, good for detecting forgery, is IRMS (isotope ratio by mass spectrometry) which yields the spatial distribution of oxygen isotopes,  $^{18}\text{O}$  /  $^{16}\text{O}$ . Values of  $^{18}\text{O}$  /  $^{16}\text{O}$  ratios for water from musts and wines show variations according to

vine growing site, harvest season and vintage year.

## 8. Playing with Statistics

One of the aims of the wine industry is to characterise and preserve the wines' individual tastes and qualities. Hence the old advice of never putting new wine in old bottles. It comes from the Bible (Mark 2:22): "And no man putteth new wine in old bottles: else the new wine doth burst the bottles, and the wine is spilled, and the bottles will be marred: but new wine must be put into new bottles;" ("and both are preserved.", added Luke 6:30). Being the top producer of cork, Portugal has made a contribution towards the preservation and distribution of wine – fig. 10. The use of corks in wine bottles seems to have become common towards the end of the seventeenth century, in large part as a result of the work of Dom Pierre Pérignon, a Benedictine monk appointed treasurer of the Abbey of Hautvillers in 1668, at the age of twenty-nine. He is universally considered to be the father of the champagne trade.

An important development was the accidental discovery in 1775 that grapes left to rot on the vines produced a sweetness and bouquet unobtainable otherwise – the so-called "pourriture noble". Wine tasting is a ceremony. Conducted properly and slowly, it amounts to what we call, in thermodynamics, a fractional distillation. The first components to escape when we rotate the glass in anticipation of a good drink are the more volatile and ethereal substances; as we drink the wine and the volume decreases, the heavier, fattier odours come out; at the bottom of the glass, the rancid esters and residue are better left alone.

In what regards wine quality control, instrumental methods of analysis are accurate and objective, but they are not sufficient for a proper evaluation, in line with customer's preferences. They should be complemented by a descriptive sensory analysis, involving attributes such as appearance, colour, odour, flavour, body, etc. In the 1980s, A. C. Noble and collaborators developed a

sensory vocabulary that has proved useful in the characterization of a whole variety of wines. Einer Risvik and Hanne Sivertsen, from MATFORSK (the Norwegian Food Research Institute), have chosen seventeen sensory attributes – including nine from the standard aroma terminology of Noble – to describe thirty French red wines, selected from the main regions of France. The used terms divided into twelve sensory attributes and five integrated terms, as follows

Colour intensity  
 Colour tone  
 Astringency  
 Fruit acidity  
 Fruitberry aroma  
 Vegetal aroma  
 Spicy aroma  
 Wood/vanilla aroma  
 Animal aroma  
 Floral aroma  
 Chemical aroma  
 Earthy aroma  
 Suppleness  
 Body  
 Harmony  
 Potential  
 Elegance

These attributes were assessed, for each wine, by a panel of eight wine tasters using a scale from "none" to "strong" (except for *colour tone*, which ranged from "yellow/red" to "red/blue"); as for the five integrated terms, they were

simply listed as "present" or "not present". A two-way analysis of variance (ANOVA) was run. Principal Component Analysis (PCA) was used to examine the overall pattern among wines. It became obvious that it was possible to obtain a good separation of the various wines by region and vintage year utilizing those techniques. Fruity attributes like "fruity acidity", "floral aroma", "fruitberry aroma" and "colour tone" are negatively correlated to "chemical aroma", "earthy aroma", "wood/vanilla aroma", "animal



fig. 10 DIDEROT (Ed.), *Encyclopédie* 1751-72, *The corkmaker*

aroma", etc – fig. 11 (Ref. 5). Two principal components accounted for 65% of the variation: the first, PC1, an aroma axis, progressing from fruit and berry aromas to vegetal aroma and the more ripened animal and vanilla aromas; the second, PC2, could be described as a mouthfeel and colour axis, going from suppleness to astringency, potential, colour intensity and colour tone. As can be seen from fig. 12 (Ref. 5), Bordeaux and Rhône wines score higher in astringency, colour intensity and colour tone than Burgundy and Beaujolais wines, which are suppler. Curiously, a rotation of 180° around the horizontal axis of the diagram – an operation chemists are expert at – replicates the geography of

France's wine producing regions: Rhône south of Burgundy and Bordeaux west of Rhône.

It was Bordeaux wine, of course, that revived Nemorino's fortunes in Donizetti's *L'Elisir d'Amore* (1832). The best love potion is, very often, a good wine. Wine liberates the spirit and turns people into daring heroes. As Dr. Samuel Johnson (1709-1784) said, "He who aspires to be a hero must drink brandy". On the other hand, if you pretend to look innocent or prudish, you claim that you do not drink wine. This is what Mariandel does in the last act of Richard Strauss's *Der Rosenkavalier* (1911): "Nein, nein, nein, nein! I trink' kein Wein". Of course, the audience knows better. The singer is a double impersonator: a female soprano playing a man disguised as a woman (who is, in turn, being courted by a 'real', boorish man). Only in opera!

### 9. Time for a Waltz

In 1869 Johann Strauss Jr. composed a waltz for the Festival Ball of the journalists' association, 'Concordia'. Jacques Offenbach, then living in Vienna, won the competition with *Abendblätter*. Strauss's entry, *Wein, Weib und Gesang* – in other words, "Wine, Woman and Song" – became, however, of his most popular waltzes. The title comes from a famous saying of Johann Heinrich Voss

*Wer nicht liebt Wein, Weib und Gesang  
Der bleibt ein Narr sein Leben lang.*

or

*He who doesn't love wine, woman and  
song  
Remains a fool his whole life long.*

It is one of Strauss's most elaborate waltzes, consisting of a long introduction, a march, four little waltzes and a coda. The unusually long orchestral prelude evokes the romanticism of Mendelssohn and Weber and stretches through ninety-one bars, running into seventeen pages of the score; the march has something of the pomposity which we

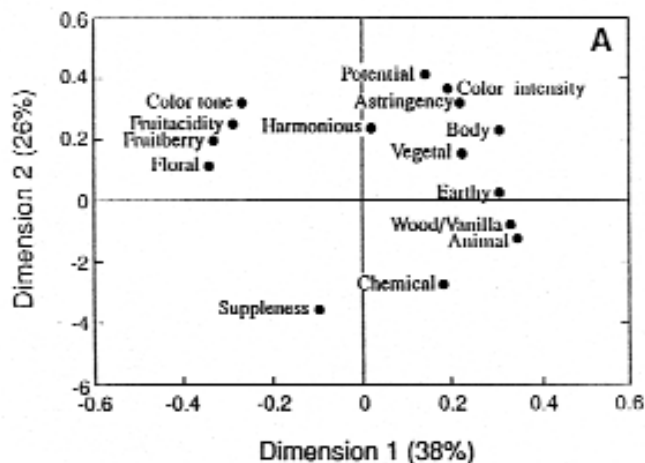


fig. 11 PCA loadings for PC1 and PC2 (ref. 7)

associate with Wagner's *Die Meistersinger von Nürnberg* (1868); the second of the four waltzes is a quotation from his own *Geschichten aus dem Wiener Wald* (1868) or "Tales from the Vienna Woods". Richard Wagner, never known for his generosity towards fellow composers, called Johann Strauss Jr "the most musical brain I've ever known". *Wein, Weib und Gesang* was Wagner's favourite waltz. There is story that on his sixty-third birthday (1876, the year *Der Ring des Nibelungen* was premiered at Bayreuth), while he was being fêted by an amateur orchestra conducted by Anton Seidl, Wagner became impatient, got up, took the bâton and led the orchestra in a stirring account of "Wine, Woman and Song".

As Peter Conrad has observed, "opera generally contents itself with raising glasses; operetta is fond of showing what happens afterwards". This is the difference between, say, Verdi's *La Traviata* (with its famous "Brindisi") and Strauss's *Die Fledermaus* (The Bat, 1874). At the end of the II act of Strauss's operetta, Prince Orlofsky (usually played by a female singer) proclaims champagne the king of all wines. Champagne bubbles are little stars; drinking champagne, is surely the quickest way to Heaven.

*In the grape's fiery stream,  
tralalalalala  
a heavenly substance is sparkling  
tralalalalala*

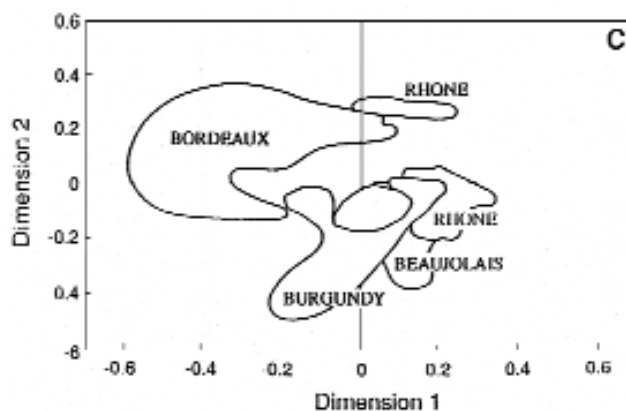


fig. 12 PCA consensus scores for PC1 and PC2 (ref. 7)

*kings as well as emperors  
are fond of laurel wreaths  
but as the same time they are equally  
fond  
of the grapes's sweet juice.  
Raise your glasses, then,  
and together drink a toast  
to the king of all wines,  
to the king of all wines!*

Its imperial majesty, King Champagne the First, commands allegiance throughout the world, and a kind of communion is forged between all drinkers, men and women. Falke, the original batman of the operetta's title, realizes that each person has found a partner, so it is time to celebrate the delights of brotherhood and sisterhood. It all gets rather sentimental and syrupy, but soon the "Thunder and Lightning" polka animates everyone into a frenzy. Needless to say, the third act takes place in a prison! Wine should indeed be enjoyed but not abused.

*[The lecture ends with a video of the Finale of the II act of Die Fledermaus, in the Otto Schenk production for the Bayerischen Staatsoper in Munich, with Eberhard Wächter, Pamela Coburn, Janet Perry, Wolfgang Brendel, Brigitte Fassbaender, conducted by Carlos Kleiber in 1985.]*

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